A model for quality-related valuation and accounting of road capital

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Foreword

The commission given to the Internal Audit Department (IA) of the Swedish National Road Administration (SNRA) to develop a model for the valuation and accounting of road capital was drawn up in early autumn 1992 by the authority’s Director-General at that time, Doctor of Economics Per Anders Ortendahl. In his directive and during the course of discussions, the Director-General and sometimes also his Press Secretary Bengt-Göran Jönsson described the problems associated with the monitoring and control of state road management and communicating it to the authority’s political principal. First and foremost, he and his press secretary emphasized the problem of describing road management status and financing needs.

The radical decision to expose all operational activities to competition was accompanied by increased difficulty in operatively monitoring and controlling road management and developing the road capital accounting principles, and an even greater need to do so. The model that was being demanded would be transparent and easy to understand, so that the prerequisites for developing the road management processes together with road users, trade and industry, and other players in various areas of society would also be improved. The assignment was carried out during autumn 1992 and a final report submitted in December the same year. A draft report with application examples was presented in May 1993.

The people responsible at the National Audit Office for the regulations for governmental accounting, Director Claes-Göran Gustavsson and Director Lennart Mårding, and the National Audit Office’s Audit Director Filip Cassel, the auditor responsible for the SNRA, supported the IA’s proposed model for the internal accounting of road capital. In his review of the proposed model, Professor Roland Arle of the University of Berkeley emphasised the fact that the road capital would be clearly linked to the expectations of road users and other stakeholders.

In 1994 the SNRA decided to implement the accounting of road capital that the IA had proposed. The planned control model for state road management in Sweden was presented in the form of short papers at the PIARC congress in Canada in 1995.

Director Dick Jönsson, who had experience of Asset Management (AM) in other countries, including the USA, began the work of getting people interested in the model. Doctor of Economics Nils Bruzelius, Director Ulf Niregård and Director Jaro Potucek contributed valuable comments on the PowerPoint presentations of the IA’s model during this “launch period”.

In his doctoral thesis, Doctor of Technology Peter Ekdahl found that the proposed model for accounting road capital together with the SNRA’s decomposition models satisfies the needs that exist with regard to the monitoring and control of performance contracts in the pavement area in an appropriate manner.

In-depth discussions of the model have been carried on throughout the course of the study with Associate Professor Hans Lind, Professor Börje Johansson, Professor Åke E Andersson and CDU Director Hans Cedermark. These discussions have improved the model’s system and the document’s structure and led to a closer linkage to the national-economic conditions and road users’ expectations. The model’s structure, set of rules, and principles have thus been made more easily accessible. The great support given by Hans Lind and the other supervisors has served to give the paper a modicum of academic value that it would never have had without them.
Deputy Director-General Lena Erixon and Directors Janeric Reyier, Håkan Wilhelmsson, and Lennart Lindblad also contributed valuable comments at meetings of the steering committee and the reference group.

The Ministry of Industry, Employment and Communications ran a trial of the model at the SNRA during the latter half of 2003. The test comprised four different sections of road. A fifth section was added during the course of the SNRA’s extended trial that ran over the first six months of 2004. The many presentations and discussions that have taken place over the course of the project with the project members Susanne Skovgaard, Lars Bergman, Stina Hedström and others, have also given experience that has contributed to clarify the descriptions in some parts of the model.

A similar trial was run simultaneously at the National Rail Administration. In this context, Deputy Director of Finance Leif Hanson contributed suggestions as to how the accounting could be done at T-account level.

The basic data used in the model’s application examples concerning road 71, as they are reported in this paper, were drawn up by Road Engineer Jörgen Nordenberg, Provincial Information Manager Mona Vestman, economist Berit Jansson, Project Manager Kjell Söderlund, Construction Supervisor Jan-Erik Lindqvist and Head of Section Bo Skogwik at the SNRA’s Central Region. A visual inspection was made of the Näs – Björbo section of road 71 together with Road Engineer Hans Lirde man. It would not have been possible to present the example without the participation of all these people.

The basic data for the application example of the E4 as it is presented in this paper was put together by Project Engineers Moussa Alioui, Bruno Bergstedt, Victoria Ericsson, Johan Granlund, and Lars Persson. Issues related to indexes have been discussed with Professor Rune Wigren.

The paper, which was originally written in Swedish for a Swedish audience, has been translated into English by the Bachelor of Arts Ian Hutchinson – a very important contribution to the project and so is all the literature search support from the Librarian Anna Hultqvist at the SNRA’s Library.

I would like to express my sincere thanks to all the people mentioned above, mentioned in the paper and to everyone else, who made valuable comments and contributions, gave pedagogical advice, provided data and information and in other ways facilitated the development of the model by providing presentation materials and examples.

Finally, my beloved wife Ingela and my children Ylva, Petra, and Jonas deserve recognition. The six of us – Ingela, Ylva, Petra, Jonas, the Road Capital, and I – have been living together for about fifteen years now. I have found myself wondering at times how my beloved could bear all my talking about road management and all efficiency possibilities in using appropriate information about the Road Capital. Without her active support and great patience, the project would never have come about and this paper would never have been written.

Falun, January 2005

Berth Jonsson
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Essay 3  A model for quality-related valuation and accounting of road capital to the transport asset management process
Abstract

This paper deals with the issue of implementing a model for valuation, accounting and reporting of the road capital appropriate to transport asset management focusing on actual road capital values and costs (including life cycle costs). The first essay gives a background and a short overview of the thesis. It includes, for example a short review of the principles of the Swedish road management during the last thirty years, a description of the problems, the requirements, and hypotheses.

The second paper broadens the perspective to international road management; the idea of Transport Asset Management (TAM) process as a whole and three focus areas gathered under the names of Asset-related questions, Action-related questions (appendix 1), and Cash-related questions (appendix 2). The essay illuminates the actual situation and the needs of support for the TAM processes in general and the existing models and the development of valuation and accounting of the road capital in particular.

The purpose in the third essay is to make the 1992 model for quality-related valuation and accounting of the road capital clear and to by full examples and discussions show that the model is feasible. The paper details some significant requirements that such an accounting method must be able to meet. One type of requirement deals with adequate internal control, simplicity, controllability, transparency, relevance, and reliability (quality). Another type has to do with being able to deduce from the accounts the cost of road management, the value of the road capital, deficiencies, risks, and changes in standard and condition. Information is also needed as a basis for specifying targets, performing different analyses, including projects, components’ life cycle costs, differences in road management and effects, but also for understanding of road management’s cost drivers.

The model for internal quality-related accounting presented here is based on road components’ acquisition values, in order for it to tie in with external financial reports. The model mainly makes use of the SNRA’s existing computer programs, report generators, and data in the accounting systems and technical road databases. Knowledge of components’ standard deficiencies, rectification costs, and replacement values, allows standard target values to be set for the road capital. A component’s current physical condition is translated into a financial condition value using what is known about rectification costs and the component’s current condition in relation to it’s “lowest acceptable condition”. Conditions are described systematically according to defined description models. A component’s “lowest acceptable condition” is determined on the basis of knowledge of known effects for road users, society and road management, and of risks and other, political, considerations.

The accounting model has been studied in three case studies, of which the Ministry of Industry, Employment and Communications has been responsible for one (of the National Road Administration’s road capital and the National Rail Administration’s track capital respectively). This paper compares the model’s accounting of the component pavement in one of the studies with how it is traditionally accounted. Some consequences of the differences for control, monitoring, and different types of analysis are also detailed and discussed.

The paper also analyses a “valuation problem set” with regard to the existing road network, and issues of quality problems about the implementation and keeping data up to date. New techniques for data capture are among other things discussed. In conclusion, the question is raised of whether implementing a quality-related model for valuation and accounting of the road capital does not constitute the beginning of a paradigm shift in the field of road maintenance.
Essay 1
Quality-related valuation and accounting of road capital:
A background and an overview

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I A Brief Swedish Historical Road Management Review

Up until the 1990s, the management of road maintenance in Sweden followed the principles of a planned economy, without any real interest in the expectations of customers, the surrounding world, or the results of follow-ups of measures taken. Central control focused on securing the supply of statistics to the planning systems, which were then used to allocate resources. Standard prices were used as a matter of course with regard to the offices and workshop stations of the operational areas, machinery, vehicles, friction materials, salaries and so on, without any consideration to the real price situation. A great many contracts with haulage contractors and suppliers of salt, steel and other commodities were closed at a central level. Annual price adjustments were often based on the price development of all kinds of resources, ignoring or minimizing synergies and improvements in productivity.

The analyses that were made were based on statistics of low quality from operations activities and on standard prices. The need for organisational changes, especially in cases where regional-economic consequences would arise, led to extensive political discussions before decisions were made. The principles of control eventually led to a generally low development of efficiency (and also productivity) in road management, insufficient financial exploitation of the opportunities to plan production volumes, and a lack of knowledge of the different activities involved in road management, and products’ real costs and benefits1. The inevitable result was a decline in confidence in road management.

In the planned economy model of road service and maintenance, all activities were carried on by the Swedish National Road Administration (SNRA) itself with the support of hired resources (rented trucks and construction plant on the basis of price lists or standard price lists in central agreements). Calculations at the central level and the number of trucks, road graders, wheeled loaders, and other resources allocated to each operational area essentially fixed at the central level. (There were approximately 280 such areas in the country as a whole).

A road manager who put his case sufficiently well could win advantages and exemptions from the general distribution model. Resource consumption was followed up against budget per job account, and an explanation for any deviation was required. The follow-up model could sometimes result in most accounts being in good agreement with the budget, one account being burdened with all net deviations. Another consequence that could occur was that purchasing and manufacturing to stock would increase towards the end of the year if there was a risk of a significant surplus in the budget.

1 There were of course shining examples at the administration both with regard to information and the endeavour to improve productivity and rationalisation measures. In some operational areas, the financial follow-up of operations and maintenance was linked to individual roads. Road manager Karl-Anders Karlsson in Ätvidaberg was one of the leading lights in this respect in the 1980s. The high-productivity concept called “zone divided maintenance of gravelled roads” is another good idea developed by, among others, the road manager Göran Gabrielsson. In development of the area technique of measurement the great innovator Elis Lundin must be mentioned and so also the former Director-General, Doctor of Engineering Carl-Olof Ternström for his valuable technical work among other things to cause a functioning road data bank. By the way, already in the early 1950s you could in reports by the statistician Eric Ericsson find well-structured thoughts of the needs of the better knowledge of the road capital. The organization of the SNRA have for a long time worked with engineering and production development, capacity studies (one of the pioneers Professor Rune Eriksson), analyses of materials, the choice of the plant etc., and a suggestion scheme along organized lines. Of course there were a great number of skilled and clever engineers, economists and others in the organization. What is being referred to here are deficiencies in financial follow-ups, analyses, planning and budget systems, focusing at customer needs and benefits, incentives and wages and salary systems, which in some decisive way led to the low development of efficiency.
Another result of the control model’s negative effects was that productivity measures in production could mean that the resources were reduced the following year, since fewer funds were deemed to be needed and the resources were instead transferred to other areas which did not apply any productivity measures and whose need for resources was therefore judged to be greater. A reason could always be found for not implementing this or that productivity measure. On the local level, people were always worried that a budget surplus would later have a negative impact on the volume of work and how much of their own production resources they would be allowed to keep.

The question of whether the road capital should be entered in the accounting, i.e. whether the road installations should be activated in the Balance Sheet was discussed on any number of occasions during the 1970s and 1980s. The term “capital destruction” was often heard in the debate over the low appropriations for road management.

The Internal Auditing Department (IA) of the SNRA had the extensive experience of management from an efficiency audit of three well-managed road maintenance work sites (one in each of the North, Center and South of Sweden). In spring 1988, IA presented, among other things, an analysis of the road maintenance production costs and the capital tied up. IA pointed out the opportunity to achieve a higher productivity (at 1986 price levels; a capital rationalisation with a decrease in capital tied-up of at least 40% or about 500 million SEK, an action productivity increase of at least 20%, and improvements in cash management amounting to at least 10 million SEK annually). It was also claimed that improvements could be made in steering road management towards the overarching objectives in the national transport policy.

In the course of a discussion at the end of the 1980s, IA took up the question of an alternative economic model, where “road capital” and information about roads’ standard and condition (i.e. relating them to quality and function) would have a central role in financial control and internal accounting.

IA’s analyses from 1988 added an objective basis to the question of the SNRA’s improvement potential. The SNRA’s management was given a mandate (a political licence) to decide to expose all production to competition and have a new organisation in place by 1992. Subsequent costing by the financial department has shown that the productivity increase in Operations after 1992 has freed up an annual production capacity equivalent to at least a billion SEK (somewhat more than IA’s forecast).

To prepare for the reorganisation in 1992 and to change the style of administration and the way of working, management instituted a programme to develop the authority’s employees, corporate culture, control, and processes, partly on the basis of its vision and strategy document, Vägvisaren (The Signpost) and eight identified prioritised areas. This effort continued during 1994, due to the fact that the activities of the National Road Safety Office had been taken over by the SNRA in 1993.

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2 Some people who should be mentioned in this context are the earlier Directors of Finance Karl-Jan Walck and Dan Nässman, and planning economist Lars Hemmendorf. The two latter also made a presentation of the development of "road capital" over a period of forty years based on a forty-year linear depreciation on investment appropriations and part of the maintenance appropriations.


The vision document also includes such issues as putting the customer first, focusing on results, and creating prerequisites for learning in the organisation in practice. The development of the authority’s corporate culture and organisation also included process-orienting all activities, making road management’s products and services clearer, and gradually improving procedures, administration, and production.

One challenge in this development effort was to prepare the organisation for converting the SNRA’s Production division into a company on 1 January 1996\(^5\). Management had also begun to discuss the issue of how to monitor and control functional construction contracts better\(^6\).

In 1990 the IF\(^7\) studies took up deficiencies in the accounting with regard to the need for control. In the words of the study:

"11.1 GENERAL ORDER

The National Road Administration and the National Rail Administration are the only two producing infrastructure administrations that do not have their accounting organised according to customary corporate accounting principles. Unlike the Civil Aviation Administration and the Swedish Maritime Administration, for example, the administrations do not have their accounting organised in such a fashion that it is possible to make correct economic assessments in respect of assets, results and efficiency. This is also unfortunate because it makes it difficult for the State authorities to make any overall assessments as to an optimum distribution of investments in infrastructure.”

The asset accounting that the IF studies demanded was essentially introduced at the SNRA starting with the final accounts for 1994. In the accounting, the economic life of all types of road investments is set at 40 years. It is, however, hardly possible to use the Fixed Assets item in the Balance Sheet for control purposes. In principle, it is an expression of political ability to finance road investments in relation to the chosen rate of depreciation.

The opening up of Operations to competition that began in 1992 required some forms of flexible support for the monitoring and control of the whole process from procurement to quality follow-ups of the completed work. The ambition was that it should be possible to procure service both of single components and of whole road networks covering large areas and still maintain control of how condition developed.

The Director-General\(^8\) requested permission to find a better way of allocating resources, following up the real changes in the road network’s standard and condition, and of obtaining objective information to support the reporting and the discussions with the politicians. There was a need for consistent, controllable, reliable, and comprehensible reporting of the road maintenance and construction, the roads’ standard and condition, the development of their standard and condition, and the effects for road users and society. In 1992, by order of the Director-General, the IA described a model for the accounting of a quality-related road capital\(^9\), which would be able to be used for reporting and monitoring and control purposes.

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\(^5\) By decision according to Government Proposal (Prop 1993:94:180).

\(^6\) According to the ideas of Professor Torsten Grenberg et al.

\(^7\) Infrastrukturens Finansiering, K 1990:04, [Financing the Infrastructure], led by Tony Hagström, Director-General of the Swedish Telecommunications Administration.


\(^9\) Published with application examples as Draft final report on road capital in May 1993 by Berth Jonsson et al.
IA’s model was examined by external experts, who made several valuable comments. Professor Roland Artle, for example, in his review, emphasised the fact that a quality-related road capital would link the model more clearly to the national economy and the expectations of road users and other stakeholders. In 1994, the SNRA’s management decided that control of road management would be developed and be based on the objectives of the national transport policy with regard to road management, customers’ expectations and the IA’s model for quality-related valuation and accounting of the road capital.

Over a period of fifteen years, the SNRA has changed over from a distinctly planned-economic way of working, via the programme document with its so-called 8S model for a focus on objectives and customers, to a structured, quality-assured, process-oriented way of working based on the Swedish Institute for Quality’s thirteen basic values and seven main criteria for the Swedish Quality Award, and using so-called balanced scorecards.

The accounting in use today has developed from the needs and economic model that applied during the years the SNRA carried on extensive operations independently in its own right. At that time, detailed information was needed mainly for calculation purposes. In the initial planning, that at that time was done before investment projects and other measures had been financed, a thorough study was made of how production could best be done with regard to excavating and transporting the excavated material. Detailed plans (network planning) were drawn up, for example of how the excavator should be positioned in the pit, where dumpers should be located so that the distance the excavator would have to turn would be minimal, excavation capacity as high as possible, and the unit price as low as possible.

Calculations were also made of where to locate the tips, in order to transport the earth as short a distance as possible. Types of soil, capacities, and hourly rates for excavators, transportation, receiving plant and all the other resources were taken into consideration, along with materials usage, prices of materials etc. The amount of detailed information required was enormous. Traces of this level of detail can still be seen in road management.

A construction contract contains a great many adjustable items (quantities) that affect the distribution of risk between client and contractor. It is perfectly possible today for a project manager to have economic responsibility for around 15 objects and have to keep control of more than 2,000 adjustable quantities - subjects for discussion. If the prerequisites given by the SNRA are not correct, then the unit prices themselves can also become subjects for discussion. One experience that SNRA has is that the more adjustable prices there are in a price negotiation, the harder it is to hold back price increases and to control and forecast projects’ costs. That knowledge should cause a reduction of the great number of adjustable quantities in the contracts of today.

The decision made in 1994 to base control of road management and its processes on the objectives of the national transport policy, customers’ expectations, and information about quality-related road capital taken form the accounting has still not yet been fully realised.

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10 The people responsible at the National Audit Office for the regulations for governmental accounting, Dir. Claes-Göran Gustavsson, Dir. Lenart Mårding and the National Audit Office’s Audit Director Filip Cassel and Professor Roland Artle (University of Berkeley, USA).

11 Japansk företagsledning. Vad kan vi lär? [Japanese Management. What can we learn?], Richard Tanner Pascale, Anthony G Athos. Contains a presentation of a 7S model, on which the SNRA’s 8S model is based.
Anyhow, in 1995, a report was presented about this alignment at the PIARC Congress in Montreal, Canada\textsuperscript{12} in line with the planned Swedish textbook about road management and quality-related valuation and accounting of the road capital. The ideas were in all essentials in harmony with the development of Transport Asset Management (TAM) around the world.

Experience gained from the IA review (presented 1988) has guided the creation and development of this model for quality-related accounting of road capital. National-economic monitoring and control of road management, however, comprises all capital – all values that the transportation system concerns. An outline structure of a road manager’s internal values or capital items is shown in figure 1.

Figure 1: Outline structure of a road manager’s (the SNRA’s) internal values – capital items

In respect of monitoring and control, the model focuses on fixed assets in the form of roads (road capital) and the organisation’s structural capital in the form of road management’s processes, networks, customer relations, systems, procedures and aids. Internationally, in the road management context, this type of monitoring and control is known as TAM.

The model for valuation and accounting road capital in the third paper will be used as a reference model in the continued research. Here it will be compared with the traditional Swedish external accounting model. Differences in the accounting of infrastructure will be elucidated, sometimes with regard to countries where requirements similar to GASB 34\textsuperscript{13} apply. In the following, model and reference model are used as synonymous concepts.

It should be noted that the reference model principally uses existing computer programs and report generators, existing information in the SNRA’s road data bank and other road-related databases, and information from the internal and external accounting. The difference compared to today is that the information is structured, combined, systematised, coordinated, and used in a different way.

\textsuperscript{12} Berth Jonsson, Performance management of road administration in Sweden – We are committed to serving our customers. In: PIARC XXth World Road Congress, Question 1 (20.21.E), Montreal, September 3-9 1995

\textsuperscript{13} Statement 34, published in June 1999 by the Governmental Accounting Standards Board (GASB).
2 Problems

Many problems still remain to be solved in order to realise the ambitions outlined above. One of the most serious -- and fundamental -- of these, and one that the SNRA needs to solve has to do with the accounting of the road capital. Every year the SNRA declares the size of the road maintenance backlog, a figure that is growing year by year.

The politicians, who are often city-dwellers themselves, think that they can see that the road network’s condition is not so very bad, although it is sometimes clear that the standard is in need of improvement. If they travel in rural areas, they may find roads that are in fairly bad condition, but traffic loads are obviously lower there. It is thus perfectly natural for politicians to believe that the SNRA is exaggerating the problems with the roads. Perhaps the SNRA lacks credibility.

The overarching need to improve the accounting of road capital has its origins in a desire to be able to reflect roads’ and road networks’ condition and changes in condition better, and to be able to improve the descriptions of different types of need for physical action. There is also an expectation on the part of politicians that this will give them a better opportunity to monitor and control the road network’s deficiencies, risks, and need of funds for maintenance and investment, and the consequences of taking or not taking maintenance measures and making investments.

Political monitoring and control needs better reporting. There is an explicit desire for a simpler, more comprehensible, systematic, transparent, and controllable way of reporting. Two of the most important reasons for improving the accounting are the need to obtain a more accurate measure of road management cost and the necessity to raise the credibility of reports and the basic information required when discussing financing needs.

The situation today is that the cost of road management falls as appropriations fall and that the opening value for the year of the road network in the Balance Sheet, regardless of the maintenance measures taken during the year, is reduced by at least 2.5% every year (depreciation according to plan over 40 years). All roads not financed through investment appropriations are assigned zero value but are maintained in a similar fashion to other roads.

The internal ambition with financial accounting is to produce final accounts (Profit and Loss Account, Balance Sheet and Source and Application of Funds Statement) that the external auditors will accept (and make out a “clean auditors’ report”). The regulations governing the accounting and the external auditors’ ambitions do not require very much, despite the statement about “accepted accounting principles”.

“Accepted accounting principles” in Sweden means “an actual existing praxis on the part of a qualitatively representative selection of those organisations obliged to keep accounts”, principally in respect of the three aspects relevance, reliability (accuracy and currency), and prudence. If any conflict arises between these aspects in a concrete valuation context, it is normally the principle of prudence that takes precedence in Swedish accounting. The SNRA’s financial accounting is done according to the regulations, and the procedures are subject to relatively good internal control\(^{14}\). As regards monitoring and control of road management, however, the results of the accounting are misleading.

\(^{14}\) RRV, Improved Internal Control, Internal Auditing etc. in the Swedish Authorities, ISSN 1104-7364;1994:34, (SNRA was ranked as number one of four authorities with an IA).
Because this is a known fact inside the organisation, important financial analyses to do with road management quite simply do not get done. On the other hand, the information in the accounting is of “normal quality” for monitoring and controlling administrative activities. However, whether the cost of accomplishing today’s accounting and the price for a clean auditors’ statement is commensurate with the benefit is indeed an open question that should be analysed and discussed.

Instead, the organisation uses information from technical systems, for example the Pavement Management System (PMS) with regard to pavements and the Bridge Management System (BMS) for bridges. These systems also contain financial information, which is mainly interpreted by specialist engineers. The specialists compare data against established regulations and sometimes they conduct special investigations to get more detailed information regarding the magnitude of some deficiency in the road network and draw up a basis for deciding the most appropriate action to take.

Management’s basic information for controlling maintenance activities consists of well-formulated information from specialists and engineers who have a more or less subjective perception of the road network. This basis, together with “general, accepted knowledge of road management and its effects” is what leads to the decision as to what action to take.

Taking the country as a whole, it is clear that the view of and choice of action can vary a great deal. All the different types of measures that are taken can hardly be regarded as Best Practice, but the measures chosen do not necessarily deviate very much from the “optimum” measure. The problem, however, is that no one really knows what the actual situation is. Checks and costings of the measures taken are not made to a sufficient extent. Follow-ups and analyses are necessary if the SNRA is to develop into a “learning, quality-oriented organisation”.

With better cost accounting, it should be easier to make different types of analyses, such as internal and external benchmarking, monitoring of the development of road management’s productivity and cost drivers. It should also be easier to analyse the quality and prices of road management’s products and services and the life cycle costs of the various road management components.

Weighing investment against continued maintenance, replacement calculations, and analyses of the road network’s geographical differences in condition, standard, risks, and prerequisites for transportation, also require a better system of accounting. Companies would be able to plan their transportation and operations better if they had access to transparent information about the road management status, based on a generally accepted accounting of standard, condition, and different kinds of deficiencies in the road network.

Road Management’s own motives for a better system of accounting of road capital are above all to improve resource allocation, monitoring and control of road management, its players, and production results, and to facilitate the interaction and dialogue with road users, trade and industry, authorities, and political decision-makers, and thus support the improvement of the processes. Information must also provide an adequate basis for working efficiently with preventive maintenance and for analyses.
3 Requirements and Hypothesis for a TAM Accounting Model

There is no praxis governing the accounting principles that will be applied in a road capital model. It is therefore especially important as regards credibility for the model to have a simple structure and be able to be checked easily by independent external personnel without help from technical experts. The accounting data must not appear as if it is issuing from a "black box". An accounting model must satisfy stringent requirements and the demands with regard to accepted accounting principles and internal control.

As knowledge of condition grows or when principles and systems are to be improved, it is important that the changes do not lead to historical data being rendered unusable. In this respect the model must have a solid foundation as regards properties and facts. New knowledge and improvements should therefore to a large extent also be able to be applied to historical material.

The aim of this project is to describe a way of thinking about principles and content in a model for estimating the road capital which corresponds to needs and wishes with regard to an improved system of accounting and fulfils the requirements described. Strengths and weaknesses, and the possibilities to implement the model in Sweden and the effort that would be needed to do so should also be clear from the paper (compare with R. J. Gerke, 199315).

The transition of road management in Sweden from largely following the principles of a planned economy and autonomous production to goal-orientation and exposure to competition has been a gradual one. It has not been possible to implement it throughout the whole organisation at the same time. For practical and personnel reasons, it is sometimes out of phase. Parts of the organisation with complex systems, procedures and established patterns, that have engendered a sense of security in the present, have fallen behind.

One example is accounting, that is also controlled by an established set of regulations that apply for all public (State) administrations. The problem of getting the go-ahead to develop the external accounting was made clear in the investigation made in 1992. A further investigation in 2003 showed that the prerequisites had not changed. The development that can take place therefore concerns the internal accounting.

The hypothesis to be tested in this project as a whole (licentiate and doctoral thesis) is that a developed internal accounting of the road capital should result in:

- better documentation of the road network’s condition and standard deficiencies (including assessment of risks and maintenance and investment needs) among other things to prepare for financing discussions.

- better valuation of components’/roads’/road networks’ deficiencies, standard, and condition, and of the effect of maintenance and investment both carried out and not carried out.

better opportunities for analysing the road network’s geographical differences with regard to condition, standard, risks, and transportation prerequisites.

- better monitoring and control of risks in road management, of planning and production in road management, of the various players involved in road management, and of production results.

- better supporting documents for resource allocation.

- Simple, systematic, transparent, controllable, and credible accounting and reporting in comprehensible economic terms that can be discussed and are also easily understood by people who are not specialist engineers.

- better interaction and a better dialogue with road users, trade and industry, authorities and political decision-makers.

- a basis for planning preventive maintenance that serves its purpose.

- better opportunities for analyses of deviations from budget with regard to unit price, quantity and time-dependent causes.

- better accounting of costs, which with regard to road management can facilitate
  - follow-ups and costing of measures taken,
  - analyses of component’s life cycle costs,
  - analyses of how components’ and services’ quality and price develop,
  - analyses of road management’s cost drivers,
  - analyses of how road management’s productivity and efficiency develop,
  - opportunities to perform internal and external benchmarking (against Best Practice),
  - opportunities to assess investment against continued maintenance,
  - opportunities to make replacement calculations.

The requirements that the improved internal accounting should meet are:

- that data and accounting information be systematic, adhere to simple, fixed principles, and not be devised in a “black box” and that they can be checked by external, independent personnel without extensive help from technical experts,

- that changes in the accounting model do not lead to historical data being rendered unusable,

- that procedures and accounting model live up to the intentions of good internal control and accepted accounting principles.
4 Overview of the Essays

A “state of the art” study is presented in the essay Asset management in the transport sector: A review. The essay begins with a description of the aim of the study, states the sources of information, and briefly describes the arrangement of the essay. This is followed by the chapter Definition of TAM and the Structure for the Study, which describes how the review is structured. The literature study covering the field of valuation and accounting of road capital for Transport Asset Management (TAM) includes the three focus areas of Action-related questions, Cash-related questions and Asset-related questions, which are partly interdependent.

Fundamental Ideas behind Transport Asset Management takes up the articles and discussions etc about the TAM concept as a whole. This elucidation of the TAM concept is intended as a support, to increase understanding of the whole of which valuation and accounting of road capital constitute a significant part. For the same reason, Action-Related Questions and Cash-Related Questions are clarified and illustrated. These sections, however, can be found in separate appendixes.

The fourth main chapter, Asset-Related Questions, deals with the central issue with regard to the aim of the thesis. From the survey conducted by PIARC it is clear that systematic, dedicated development of the accounting of road capital is being carried around the world – including in Norway and Finland. In the USA, for example, a requirement to account road capital at one of two possible levels of ambition was introduced in GASB 34 in 1999\[6].

One – the depreciation method (state value and depreciate the asset each year) – means that fixed assets in roads are depreciated.

The other – the modified approach (state value and prove that it is not depreciating) – means that fixed assets in roads do not need to be depreciated if a maintenance plan exists to preserve the quality of the road network and if it can be proved in a well-documented fashion that quality is maintained at least according to that plan.

GASB 34 (the modified approach) states that an AM process should contain current, updated inventories of the assets, and their condition inspected and recorded at least every three years, with summarised results, based on a measurement scale and the estimated maintenance cost to maintain the assets’ condition. Examples given of assets (including subsystems) in the road infrastructure include pavement, road structures, bridges, tunnels and physical appurtenances such as guardrails, road signs, lighting, barriers, collision cushions, traffic signals, electronic monitoring systems, traffic sign installations, and operating devices.

All the articles studied about GASB 34 recommend the higher level of ambition (the modified approach) – which fits well into the framework of the TAM concept. The literature is full of descriptions of the improvements that follow from actually applying the accounting requirements in GASB 34, for example with regard to authorities’ reporting of road management, dialogues with road management’s stakeholders, transparency, political control, and monitoring and control.

It is also clear that a discussion is going on between, first and foremost, accountants who defend the traditional principles for valuing and accounting fixed assets based on using historical acquisition values for investments and depreciation according to plan on the one hand; and engineers, business economists, planners and the people responsible for road management on the other. The latter group are proponents of reforming accounting so that it can be used for resource allocation, monitoring and control, reporting, and dialogue to do with road management activities. Very often, their desires are borne out by the discussion around the modified approach in GASB 34. One article takes up the arguments that can be used to convince accountants of the need for development.

Articles also describe examples of how technological developments allow vast amounts of data to be easily collected and processed. External resources and GPS technology, for example, have been used to inventory a road network’s components and their condition in a very short time. It is possible today to incorporate dedicated data capture and delivery into the quality assurance systems, reporting, and invoicing for which contractors and consultants involved in road management are responsible.

The last essay is called *A model for quality-related valuation and accounting of road capital to the transport asset management process*. It begins with a chapter entitled *Method and Approach* which describes the scientific approach applied in the paper to concretise a model for valuation and accounting road capital and show that such a model can be implemented in practice.

Chapter 2 *An Accounting Model for Road Capital*, begins by looking at some general aspects of the concepts of road capital and valuation, before turning to definitions, basic economic concepts, views, and indexes. The components of the road network are an issue with many aspects. The chapter therefore continues by giving a comprehensive review of the subject. Developments in the accounting field have led to a good accounting of component depreciation today, and division into components is no longer the controversial issue in SNRA it was during the 1990s.

The section *General principles for a quality-related valuation and accounting* deals with how replacement value, target standard value, condition value, standard deficiencies, and deficiencies in condition are defined and considered in the model. It also shows how these values are connected to the values in the traditional accounting.

Central to the model is what is described under the heading *Models for describing components’ condition*. Six approaches have been identified. Some are already in use, while others would definitely be suitable in a road management context. The section describes the principle of translating the condition description of a component into a condition value for component in question as a matter of course. The concept of “lowest acceptable condition” is taken up in a separate chapter.

The results obtained using the model are presented in the chapter *Examples and Applications* using three examples, of which the first is from one of the four sections of road (the E4 European Highway between Järna and Södertälje) that were studied in connection with the test run at the SNRA by the Ministry of Industry, Employment and Communications. The Ministry has also tested the model at the National Rail Administration. Valuations were made using actual values.
The second example is from road 71 (Näs – Björbo) in Dalarna. A small test was made in 2000 on a 15-kilometre section. Roughly a third of the section is so-called 'unbuilt road', part of the section was opened to traffic in 1964, and a third part was opened in 1998. Valuations were made using reference standards. The basic information in the example is taken from the SNRA’s existing systems. The section was inspected visually and measurements carried out. Certain data deficiencies were detected during the course of the inspection. The value of these deficiencies was determined using the same model and principles.

The third example shows how quality-related accounting could be implemented at T-account level in the internal accounting. The example is a pavement on the same section of the E4 as in the first example. The pavement was considered to have deficiencies, and measures to rectify them were taken during the accounting period. The opening balance for the period therefore shows a low condition value, while the closing balance a higher one. The annual costs and different values of the road capital are also shown in the example.

Indicators that can be constructed as a result of the model and as combinations of, differences between, and quotients of road capital values, and in combinations with for example traffic flow values. The chapter concludes with an example of such an indicator, viz. Maintenance backlog. The “maintenance backlog” concept is described from an essentially theoretical perspective. In the context of this paper, it is its use in the reference model that is considered. However, the model can not be used in isolation to determine the size of the backlog. This problem will be analysed more closely in a later paper.

Chapter 4 Analysis and implementation, takes up problems and challenges arising out of using the reference model. The basis of the discussion is both the experience gained from the described examples but also all the discussions of the model that have taken place over the years. The “valuing-in” problems with regard to quality problems with data and data maintenance are also discussed and so is the issue of exploiting new technology for capturing data. Costs and values for the tested model based on quality-related valuation and accounting are compared with those of the traditional accounting model. Conclusions are presented in the Concluding Discussion.

It is quite clear from the evidence that there is increased pressure for efficiency in road management around the world – a pressure that has led to the development of or a demand for the development of ways of monitoring and controlling road management processes, financing, and opening up production to competition, including new forms of contracts with a redistribution of responsibilities and risks between client and contractor, with incentives built-in. The forms and techniques for reporting and maintaining a dialogue with governments, road users and taxpayers are currently under development and many of the reports and articles studied emphasise the advantages of the TAM concept in these endeavours.

The literature study shows quite clearly that traditional accounting is being developed to meet requirements with regard to depreciation by component and valuations of higher quality. There are convincing arguments that the quality improvements with regard to valuation and accounting of road capital need to be even more extensive. No evidence has been put forward of the existence of a properly functioning, open market for trading in road installations.

Therefore it is, in an international perspective, most common today to develop cost based valuation techniques. It is also emphasised that installations’ condition (and maintenance) must have an impact on the value of road capital.

It has been shown that the structure of the tested model is systematic and that it fulfils stringent requirements with regard to internal control, and that it provides a more accurate basis than the current form of accounting for monitoring, control, reporting, and dialogue. The model can consider transport policy requirements and supports the development of the TAM process. Its structure has also proved to be so universally applicable that can be adapted to the valuation and accounting of other physical infrastructure such as streets, footpaths and cyclepaths, railways, airports, coastal shipping installations, telecom networks, electricity grids, fibre networks, water supply and sewage systems, etc.

Compared to GASB 34, the reference model in principle contains both accounting methods. It corresponds in all essentials to the content of the modified approach, but allows both reductions and increases in road capital based on actual changes in standard and condition. One important reason for constructing a valuation and accounting model that deviates from the modified method is that a state-controlled road authority does not often have financing instruments at its disposal and can not therefore in its own right express a commitment to adhere to established maintenance plans.

Once implemented, the model will provide new prerequisites for developing road management. The development opportunities are not described in this paper but will be discussed in more detail in a later paper on the monitoring and control of road management. It is, however, quite clear that the reference model’s overall merits together with models like the modified approach are of such magnitude that the question arises of whether their introduction do not constitute a paradigm shift in the field of road maintenance.

Continued research should also focus on the linkages between components’ standard and condition on one hand, and the effects for society, road users, politicians, and road managers on the other.
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# List of Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AASHTO</td>
<td>American Association of State Highway and Transport Officials</td>
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<td>AM</td>
<td>Asset Management</td>
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<td>AMS</td>
<td>Asset Management System</td>
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<td>BMS</td>
<td>Bridge Management System</td>
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<td>CBO</td>
<td>Construct, Build, Operate</td>
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<tr>
<td>CDU</td>
<td>Center for operation and maintenance research (Centrum för Drift och Underhåll)</td>
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<td>DOT</td>
<td>Department of Transport</td>
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<td>FHWA</td>
<td>Federal Highway Administration</td>
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<td>GASB</td>
<td>Governmental Accounting Standards Board</td>
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<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>IA</td>
<td>Internal Audit Department</td>
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<td>IAS</td>
<td>International Accounting Standard</td>
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<td>IFRS</td>
<td>International Financial Reporting Standard</td>
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<td>IRF</td>
<td>International Road Federation</td>
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<td>MMS</td>
<td>Maintenance Management System</td>
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<td>MRWA</td>
<td>Main Roads Western Australia</td>
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<td>MTC</td>
<td>The Metropolitan Transportation Commission</td>
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<td>NCHRP</td>
<td>National Cooperative Highway Research Program</td>
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<td>NVF</td>
<td>The Nordic Road Association</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
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<tr>
<td>PIARC</td>
<td>The World Road Association (Permanent International Association of Road Congress)</td>
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<tr>
<td>PMS</td>
<td>Pavement Management System</td>
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<tr>
<td>PPP</td>
<td>Private Public Partnering</td>
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<td>RDB</td>
<td>Road Data Bank (in SNRA it is called VDB)</td>
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<tr>
<td>RRV</td>
<td>The Swedish National Audit Office</td>
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<td>SNRA</td>
<td>The Swedish National Road Administration</td>
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<tr>
<td>SVF</td>
<td>South Countryside of Lake Vättern Folk High-School (a conference centre)</td>
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<tr>
<td>TAM</td>
<td>Transport Asset Management</td>
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<tr>
<td>TMD</td>
<td>Traffic Measuring Data</td>
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<td>TMS</td>
<td>Transportation Management System</td>
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<tr>
<td>VITS</td>
<td>SNRA’s Information system for traffic safety (data about traffic accidents, course of events, vehicles, drivers, roads, etc., and tools for statistics and analysis)</td>
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<tr>
<td>VVIS</td>
<td>SNRA’s automatic stations for information of weather and state of the road</td>
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Essay 2
Asset management in the transport sector:
A review

Berth Jonsson

Stockholm 2005

Building & Real Estate Economics
Department of Infrastructure
Royal Institute of Technology
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<td>Appendix 1 Action-related questions</td>
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<td>Appendix 3 More on accounting according to GASB 34</td>
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1 Introduction

1.1 The aim of the paper

This review aims to illuminate, in an international perspective, the requirements that exist with regard to accounting appropriate to monitoring, control, reporting and maintaining a dialogue in relation to road management. Important issues as a broad basis for the research project are therefore road management’s:

- prerequisites, for example with regard to objectives, control, dialogue, and reporting,
- way of working, for example with regard to types of construction contract and financing,
- different bases for decisions, for example information about the infrastructure’s quality, value, and changes in value,
- necessary improvements and development and the need to identify research in the area.

The aim of this review is to draw a well-founded picture of the fundamental issues related to an accounting model on the basis of the concept of Transport Asset Management, and a general knowledge of road management’s prerequisites, environment etc according to the points listed above.

- What are the requirements governing the accounting of road capital in road management?
- What reasons have been brought to light in the public discussion for and against a new form of accounting as opposed to the traditional method?
- What accounting models exist, i.e. what road components, valuation methods, and accounting principles can be discerned, are applied, or are claimed to be under development?

1.2 About the sources of information

The information that has been used to describe the state of the art in the field of Transport Asset Management (TAM) comes partly from studies undertaken and initiatives taken by international co-operation organisations in the roads and transportation sector, and from countries that are considered to have advanced further as regards development, and partly from scientific journals and other scientific literature.

Such international co-operation organisations in the roads sector include: PIARC (The World Road Association), IRF (The International Road Federation), OECD (The Organisation for Economic Co-operation and Development), AASHTO (The American Association of State Highway and Transportation Officials) and NVF (Nordiska Vägtekniska Förbundet). Australia, the USA, Canada and England are regarded as having advanced furthest as regards TAM. Both research and application have been studied. The basis for the work in this chapter includes:
websites, documents, articles in scientific journals, studies, and presentations prepared by road authorities, researchers, and international co-operation organisations, on occasion in connection with conferences, seminars and workshops,
- national and international discussions with responsible officers at road authorities and with researchers,
- rules and regulations governing authorities,
- documentation concerning application in property management and the manufacturing industry.

1.3 Arrangement

The introduction above, that describes the aim of the study and the information sources, is followed by a run-through of the most commonly used definitions of the central concept of Transport Asset Management (TAM) and the structure of the study is described in detail.

The Results section focuses on the study’s observations with regard to TAM and the accounting of road capital. TAM describes the whole of which accounting and road capital are components.

Observations with regard to road maintenance activities and financing are contained in an appendix. These observations are important in order to be able to analyse the whole improvement potential that may exist in different models of TAM and its processes in a future doctoral thesis.

This paper on the state of the art concludes with a short analysis and discussion before outlining the conclusions drawn.

2 Definition of TAM and the Structure of the Study

Definition of Transport Asset Management, TAM

There are many different definitions of asset management. The Office of Asset Management of the Federal Highway Administration (FHWA) used this early “working definition” for a while:

“Asset Management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practice and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning.”

PIARC has adopted an OECD definition of asset management, which in turn was derived from an FHWA definition. This presentation refers primarily to the formulation made by the OECD:

“A systematic process of maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing tools to facilitate a more organised and flexible approach to making decisions necessary to achieve the public’s expectations.

The term “asset management system” (AMS) embraces all the processes, tools, data and policies necessary to achieve the goal of effectively managing assets.”

A great many diagrams related to asset management have been presented at PIARC congresses. One such diagram (Figure 1 below), presented by Madeleine Bloom, the director of the FHWA’s Office of Asset Management, shows the broad scope of asset management within the transportation sector.

In this paper, Transport Asset Management (TAM) embraces AMS and all the other processes, tools, data, and policies necessary to achieve the goal of effectively managing the transportation system.

![What is Asset Management? Broad Range of Assets](image)

**Figure 1** A broad range of assets in the focus of Asset Management (FHWA, 2003)

This study of the state of the art is structured around four issues. The primary, overarching issue is the holistic perspective in Transport Asset Management that interacts with the other three, which can be related to Operations (including the effects that arise for society, the road user, and the road manager), Financing, and Road Capital. Operations, Financing, and Road Capital have a number of points where they interact and affect each other.
Typical for the TAM process and its various decision processes is that they largely have a very general character. They concern aspects related to the customer, the world around, and policy; standard, condition, and effect aspects; strategy and goal aspects; financing, planning, and budgeting aspects; and reporting and accounting aspects, among many others. The TAM process can at its highest level be seen as a coherent process covering everything that is done and needs to be done to attain the transport policy objectives, but it can also be viewed broken down into a number of sub-processes, for example decision processes.

This review of the state of the art covers the entire TAM process and three important areas on which to focus in this work. Each of the focus areas corresponds to a “reporting area”. In a theoretical and very broad sense, the results of the TAM process can be compiled into extensive reports or accounting documents such as Balance Sheets and Profit and Loss Statements and in the form of financial analyses (Cash Flow Statements). Figure 2 is an illustration of the interaction between the whole and the three focus areas in an imaginary structure for this review of the state of the art.

![Figure 2 Outline sketch of interactions between different aspects of Transport Asset Management](image-url)

Figure 2 Outline sketch of interactions between different aspects of Transport Asset Management
The three focus areas are named Action related questions (Profit and Loss Statement), Cash related questions (Cash Flow Statement), and Asset-related questions (Balance Sheet).

3 Fundamental Ideas behind Transport Asset Management

The perceptions and discussions that became apparent during the course of the study have been compiled under the appropriate chapter; Transport Asset Management, Asset-related questions, Cash-related questions and Action-related questions.

In most countries, the road networks constitute one of the major assets of society and these are for the most part owned by the community. In general, the road administrations or equivalent authorities are assigned to attain the road and/or transport policy goals with regard to improvement, maintenance, and management of the road installations with limited financial and human resources. All this can be done in an efficient manner and with a good level of quality as regards objectives, measurement, information (e.g. systematic data describing technical condition, defects, and finances), and as regards the analyses used in developed and integrated management systems. This chapter takes up the reasons for and the holistic perspective and content of the TAM processes; the application of and experience gained from TAM; and expectations, for example those of various stakeholders.

3.1 Why transport asset management?

Taxpayers, trade and industry, and road users, who more or less explicitly pay for the services supplied, demand improvements in for example comfort, safety, accessibility/trafficability, transport quality, and the environmental impact of road traffic. One clear trend that can be seen around the world is that governments are exerting increased pressure for improvement at the road authorities to adopt a businesslike attitude, maintain/increase efficiency, and take responsibility for service and products. This is contributing to large-scale adoption of the TAM concept around the whole world.

Public road and transport administrations around the world have held several seminars on TAM during the latter half of the 1990s. International interest has therefore been extensive and no fundamental critique has been raised about the process as a whole that the TAM concept represents. The problems and the development that are discussed also seem in substance to be same the world over in this particular field. The international cooperation organisations have also been working with TAM in their various committees for a long time. This has often taken place simultaneously in several of the organisations’ committees but based on different premises.

A number of issues that are important to development have been formulated over the years. Why is asset management important? Why is it more important than it has ever been before?

Kane (1999) answers these questions in the following words:

"My premise is that we are in a rapid period of change. Change is all around us -- in our political system, in our economic system, in our institutional relationships, in technology, in public attitudes, in our customers' expectations. We not only need to be a part of change; we better be leading the change. Otherwise, we will be following; we will be falling behind; and we will not have the support that we need for highway programs in the future."

If we can imagine a road authority as a company with assets amounting to billions of Swedish crowns, it would, according to Kane, be quite natural for shareholders to ask the following questions:

What have you done with those assets?
What is your rate of return?
What is the economic value of that system relative to last year?

In the private sector they worry about the bottom line, about margins, about how much money they have to run their business, and they worry about how much profit they are going to make.

The nations have invested trillions of dollars in highway systems and have multibillion-dollar balance sheets. Should the Road Authorities be responsible for that? Do they ought to check how well these assets are doing? Should they report to the politicians, drivers and taxpayers and if so, how should it be done?

Kane summarises his discussion and draws conclusions as follows:

“I contend that a good asset management framework is understanding what you have, its value, what you need to do to make improvements, the marginal gains from different investments and from different things you do to that system, and the whole host of players who are involved in managing the system. You need to have an integrated focus. You need to have a database system. You need to have the engineering and economic analytical tools. You need to have the methodology to understand that system.”

Following its review of Asset Management, the OECD recommends that Road Authorities consider the development and implementation of an integrated Asset Management System as a means of achieving improvements in the roads sector’s “management policy”. There is consensus among OECD countries as to the content of an AMS. According to the OECD’s working group, it should include

- Asset Inventory – condition, use, features.
- Maintenance methods
- Pavement deterioration and road user cost models.

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Prediction models  future conditions, including traffic forecasts, growth rates, etc.
- Life cycle cost analysis.
- Remaining life determination.
- Decision-aid tools – multi-criteria analysis, risk analysis, trade-off analysis, ranking projects, strategy.
- Heritage management.
- Accounting principles.
- Capitalisation of road infrastructure.

The OECD’s investigative group has formulated the expected results of AMS as follows:

- Improved budget analysis and decision making which provides a higher level of service to the community.
- Increased operational efficiencies arising from easier interpretation of data and better analysis tools.
- Increased strategic planning within budget constraints.
- Increased productivity of the Road Administration due to reduced information fragmentation and better access to higher quality and more consistent data.
- Determination of funding levels required to maintain assets at specified levels of service.
- Improved allocation of expenditure between individual assets to give the best value for the overall asset.
- Improved prioritisation of work requirements and funding allocations to achieve the goals and objectives of the Road Administration.

The investigative group also recommends that road authorities consider the following points when implementing an AMS:

1. The implementation of an Asset Management System generally begins with the integration of previously separate systems for managing the principal individual assets of the Road Administration.
2. The Asset Management System should be designed to encompass the location and condition data for the asset, relationships describing the performance of each part of the asset, methods for selecting the maintenance work giving best value for money based on the policies of the Administration, and a means of monitoring the performance of the asset following the introduction of the new system.
3. Analysis capabilities developed for the Asset Management System should include techniques to enable maintenance options to be selected on the basis of the life cycle cost of the assets.
4. An important capability to be included in an Asset Management System is the evaluation of the value of the asset and the depreciation of the value with time of use.
5. One of the valuable benefits of an Asset Management System is the ability it provides to monitor the performance of the assets. Performance Indicators can help with such monitoring.

In a memorandum dated 19th April 2004, the Swedish Government Offices (the Ministry of Industry, Employment and Communications, The Department for Infrastructure and Regional Development), through its Director Ulf Lundin, requested from the SNRA information regarding operation, maintenance, bearing capacity, frost-proofing and reconstruction. The request singled out previously reported material in five reports that had been published earlier.
“In order to be able to make a plausible and well-founded balanced assessment of the funds invested in operation, maintenance, bearing capacity, frost-proofing and reconstruction, more information is needed”. Seven extensive sections detail issues with a typical “asset management” content – issues that prove that the Swedish Government is also seeking a system that matches the requirements in TAM.

3.2 Integration of existing management systems

One of the key aspects in Asset Management systems (AMS) is the integration of existing technical information systems for specific parts of roads with economic information. In an AMS, administrative costs, the costs of the operations, road users’ costs, and environmental and societal costs, are all treated in a holistic perspective. Integrating the systems will make it possible to use a similar approach to determine how different parts of the road system should be treated (a holistic perspective).

Examples of existing management systems in Sweden for handling different individual components include the Pavement Management System (PMS), Bridge Management System (BMS), Tunnel Management System (TMS), and Maintenance Management Systems (MMS) for many different types of road installations and Operations Systems

An AMS gives the road authority consistent, uniform information and permits available funds to be distributed efficiently over for example pavement, constructions of various kinds and other infrastructural needs.

What, then, are the typical characteristics of an AMS?6 This question has been dealt with in several documents and in general it can be said that an AMS must:

- Contain information collected in situ about the road installations and their condition and deficiencies.
- Contain values of the installations in respect of their condition.
- Contain future assessments of how the installations’ performance will develop.
- Ensure systematic data of high quality.
- Ensure good accessibility to compatible data.
- Contain all relevant data for life cycle cost analyses.
- Allow obsolete systems to be replaced and unproductive installations to be phased out.
- Take both the whole system and individual products into consideration when optimisations are made.
- Produce usable periodic information, preferably with real-time solutions.
- Facilitate regular iterative analyses of the transport system’s function.

TAM integrates not only different systems for handling individual types of asset horizontally, but also integrates information vertically within the organisation.

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Management works necessarily also on the basis of different kinds of perspective such as traffic, freight, and the values of mobile equipment, financing, planning, engineering, quality, personnel, organisational units, functions, and processes. There is therefore a need to include, also with a holistic perspective, a number of other, separate management systems, for example Highway Usage Systems (HUS), Public Transportation Management Systems (PTMS), Customer Information Systems (CIS), Intermodal Management Systems (IMS), Congestion Management Systems (CMS), Safety Management Systems (SMS) etc. Examples of other management systems used in the USA include Drainage Management System, Storm Water Management System, and Airport Pavement Management System, and a TAM system that provides a strategic approach to maximising transportation investments.  

3.3 A business-like approach

TAM also encourages road managers to adopt a more “business-like approach” to the administration of the installations (road networks) for which they are responsible. A business-like approach requires an appropriate valuation of the road capital, sound management of capital/assets as regards such factors as use and customer benefit, and that engineers, economists and decision-makers all speak the same common language in the planning and budget process. These values are significant factors when prioritising future investments for example.  

The valuation process, with an emphasis on economy and customer benefit leads to a foundation that permits a different approach than that which is traditional in the engineering view of developing transport plans etc. TAM will also encourage road managers to make use of function-based requirements and follow-up methods.

It is quite clear that road installation values can be expressed in several different ways. For example, every road installation can have a value of its own based on the efficiency that the installation has with regard to passenger and freight transport, considering the transport system in its entirety. Alternatively, every installation can have a capital value calculated either on the basis of the cost of restoring the installation to an “as constructed” condition, or the cost of physically restoring the existing asset’s condition to “as new”.

“As constructed” comprises the technical improvements and adjustments in standard that would apply for the installation in question if it were constructed as a new installation. The installation values expressed in this type of terms are considered to be significant for the development of the common language used by engineers, economists, controllers, and the organisation’s leaders in their dialogues and discussions.

An OECD report emphasises that it is important for an AMS to maintain a dialogue with ordinary citizens to get a clear picture of road users’ demands and the expectations of the general public. There must therefore be a focus if the road authority is to achieve the goals set for results, adapted to these expectations, with stringent monitoring of performance, indicators of critical success factors and other measurements that ensure positive development towards stipulated goals.

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3 New York State Department of Transportation, Blueprint for Developing and Implementing an Asset Management System, New York, 1998.  
There are many examples of activities, decisions, knowledge and similar, the quality of which, according to the literature studied, would be considerably improved with an efficient TAM process. The groups that are stated to be affected by the improvements are system users, stakeholders, state government officials, and managers concerned with day-to-day operations. The improvements have their origin in the more objective data that the decision bases consist of. Examples of such improvements include:

- The quality of the strategic goals with regard to the resources available to road management.
- The efficiency of the decision processes (better data and analyses lead to shorter process times). When allocating resources and drawing up short- and long-range transport plans (computer-aided trade-off analyses), several alternative options as regards investments and maintenance can be evaluated at a lower cost, which will result in a greater benefit to society, higher level of service etc.
- A more effective, objective description of the funding required for individual types of fixed assets and for the road network as a whole, to achieve the goals stipulated for road management.
- A Road Administration with higher productivity through providing access to current, consistent data of high quality using rational routines.
- The availability of qualitative, quantitative, and compatible data for analyses of the road management and its consequences provides e.g. knowledge of differences in road management between different parts of the country and of the resulting prerequisites for transport for separate groups of road users and for trade and industry.
- The development of business-oriented transport programmes through the integration of engineering data and financial data, including current values as regards the infrastructure.

Key elements of TAM as a strategic planning approach should include:

- **Comprehensiveness** – A broad view of the agency, including a range of assets. All options and tradeoffs are made for investment decisions.
- **Applicable to all functional areas of an organisation** – Asset management can be applied to all functions and levels in an infrastructure organisation. It is adaptable to different needs in the organisation and is flexible in nature.
- **Long-term view** – Cost-Benefit analyses are made throughout the life cycle of the asset.
- **Proactive** – Preventive maintenance strategies are a key to efficient asset management.
- **A way of doing business** – Asset management can influence the business practices of any organisation, in many functional applications.

It is argued that in practice, TAM has provided a solid foundation from which to manage and monitor the transportation system. TAM is basically a process of resource allocation and a utilization evaluation tool. It is essential to define resources in the context of this process. Resources refer to all the assets at an agency’s disposal that can be applied to managing the physical transportation infrastructure (revenues, human resources, equipment, materials, real estate, and corporate information). The TAM process also can and should include communication with stakeholders.
This can largely be managed via a website—a possibility that is discussed in one article.\textsuperscript{11}

The American Association of State Highway and Transportation Officials and the Federal Highway Administration have developed a virtual Community of Practice (COP) via a website. This facilitates communication among the different stakeholder groups in TAM programmes.

The website provides access to related links and a calendar of events for a self-defined group of practitioners with an interest in asset management. Individuals can also register for topics that match their personal interest, view reference materials, and post their thoughts on discussion boards.

The elements of TAM that make the creation of an Internet COP an appropriate method for advancing its education and practice are also evaluated. After only about six months in existence, the website has nearly 2,000 visitors a day and over 250 registered users. It is expected that the steady increase in growth will continue and more information will be shared. The question of effective communication with stakeholders via a website leads to the next question, which has to deal with implementation, data, and information technology (IT).

3.4 TAM implementation, data capture, and the role of IT

The OECD report contains a recommendation that road administrations should consider the following points when implementing an asset management system:

- The implementation of an AMS generally begins with the integration of previously separate systems for managing the principal individual assets of the road administration.

- The AMS should be designed to encompass the location and condition data for the asset, relationships describing the performance of each part of the asset, methods for selecting the maintenance work giving best value for money based on the policies of the administration and a means of monitoring the performance of the asset following the introduction of the new system.

- Analysis capabilities developed for the AMS should include techniques to enable maintenance options to be selected on the basis of the life-cycle cost of the assets.

- An important capability to be included in an AMS is the evaluation of the value of the asset and the depreciation of that value with time of use.

- One of the valuable benefits of an AMS is the ability it provides to monitor the performance of the assets. Performance indicators can help with such monitoring.

The typical flow into and out of a generic road asset management system is shown in figure 3.

\textsuperscript{11} Winsor-J; Ramasubramanian-L; Adams-LH; McNeil-S, Transportation Asset Management Today: An Evaluation of an Emerging Virtual Community of Practice, Conference Title: Mid-Continent Transportation Research Symposium, Ames, Iowa, 2003.
Figure 3 Typical flows into and out of a generic road asset management system (OECD 2000).

The key to an effective TAM system is quality information (Pagano et al, 2004). Information technology (IT) plays an important role in managing data systems for the collection and evaluation of information. IT is also important in establishing data collection procedures and in data integration and the development of supporting analytical tools[12]. However, it should be noted that it is not necessary to build new systems, but to build on what is already in place.

There are a number of information management systems, which are used in various agencies. The transportation asset management guide, prepared by Cambridge Systematics for NCHRP, has classified information systems according to the following four functional systems:

1. Infrastructure Management Systems
3. Systems to Manage Agency Resources
4. Systems to Manage Programs and Projects

Information plays a pivotal role in establishing an information management system to support asset management. The type of information may change in different agencies and systems, but there are certain common system requirements. They are:

2. Asset Inventories, which should include extensive information on asset characteristics and classifications, including condition assessment, GASB financial reporting of infrastructure assets, reeds analysis and ranking. There can be separate inventories for different classes of assets. The asset rank determines the coverage and detail of inventory data related to that asset.

3. **Asset Condition and Performance**, which must be measures for each type of asset. In addition to technical measures, there should be measures to support policy making and to capture customer perspective. Condition measures should also be consistent with cost and deterioration models. The information systems objective should not be only to document current condition and performance data, but it should also be able to project asset condition and performance.

4. **Cost Estimation and Reporting** models should be incorporated in order to manage key infrastructure activities. Time series of costs need to be developed, so compilation of construction and maintenance costs is necessary.

5. **Needs Identification** with information should provide the capability to identify specific locations or individual facilities that do not meet one or more minimum standards. It should also provide the capability to estimate the costs of addressing the identified needs.

6. **Program Delivery** with overall summarization of information in terms of cost and time needs to be considered when establishing an information system.

The existing management systems can be applied to investigate the cost and implications of different asset management strategies. The infrastructure management systems can play a particularly important role in capital programming. There are a number of IT strategies that can be applied based on agency needs, including overall IT plans and objectives for asset management. Several key considerations should be addressed when developing an IT strategy. These considerations are:

- Define the architecture for databases and systems that support asset management.
- Develop an IT implementation plan addressing applications related to asset management. The plan should include GIS capabilities and requirements, data storage requirements and system integration priorities.

### 3.5 TAM around the world

In February 2002 PIARC\(^{13}\) presented the results of an extensive questionnaire-based survey of TAM among its member countries. The different parts of the questionnaire were answered by between 37 and 39 countries. It is evident that definitions, accounting principles, quality of response etc. differ from country to country and sometimes the responses are difficult to interpret. It is also difficult to make comparisons between the responses to some of the questions, and in this respect the material is not really clear. The summaries should therefore be regarded as indications of a development that in some respects appears not to be fully consistent. A few examples of the questions and responses from Part 1 of the PIARC questionnaire are given below.

*Has your organisation implemented an Asset Management Framework for your highway infrastructure?*

8% of the countries answered no. The others have in whole or in part implemented an Asset Management Framework for at least some components or are on the road to developing one.

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What assets are/will be included in this Framework? (eg roads, structures, human resources)

Over half of the countries states that they include/will include the roads (76% of the countries), fixtures such as lighting, traffic signals, road markings etc (54%) and bridges and similar structures (62%). With regard to other assets, the countries say that they include/will include Tunnels (22%), Ferries(8%), Human Resources (8%). Other, such as surface areas, parking areas, footpaths, bus-lanes, shopping centres, etc (30%), Under development, as yet unknown (5%). 16% of the countries did not answer the question.

How is the output of the Asset Management process utilised by different parts of your organisation?

19% of the countries did not answer the question. It is clear from the summary of the answers given that the output of the AM process primarily concerns such issues as; Planning/Operations Planning, Management, Follow-up and control, Review, Long-range strategies, Prioritize financing and taxation, Analyses, Updating the road database, Standard descriptions, Road network condition, Road network overview and construction projects, Budgeting maintenance, Maintenance, Improvements in standard, Interaction, regulations and specifications, Road safety, Identification of research needs, Maintenance, and Costs.

It can also be seen that countries use/intend to use the output of the AM process in regional and/or local administration for questions related to planning and control, and control and management under headings such as Planning, Review, Follow-up, Regional projects, Changes to assets, Long-range planning, Contracting, Strategy development, Development, Improvement analyses, Prioritising road maintenance, improvement projects and measures in maintenance programmes, Budgeting, Coordination, Maintenance information, Overview of policy changes, Input data for investment strategy, Data capture, Pre-qualification of operators, Input data for contracting, Transport policy negotiations, Policy/strategy, Monitoring/road network reporting, Programming development, Contracting, and Road network development.

By what means is information transferred from the Asset Management process to different parts of your organisation? (eg electronic transfer, hard copy, system integration)

19% of the countries did not answer the question. 65% use electronic transfer (including e-mail, CD etc) for all or some information while 62% also or exclusively transfer information on paper. 32% say that they make use of their integrated systems.

In another questionnaire (made up by this project) about aspects of asset management that are important the Main Roads Western Australia (MRWA) answered14 (the only answer so far) that Business aspects in connection with investments (acquisition costs) and road maintenance (maintenance costs) have the highest priority, followed by social aspects in the form of regional development and ‘road user aspects’ in the form of travelling time. Very high priority is also given to road users’ and society’s costs etc for road accidents and damage to vehicles, and freight transport costs. Great importance is also attached to welfare issues and questions related to the prerequisites of children, the elderly, the disabled, and cyclists in the traffic environment in the TAM process.

14 Julia Kelley, Main Roads Western Australia; Response to Questions about the importance of different aspects in the application of Asset Management, 9 Dec. 2004.
3.6 Development of the TAM process

The Cooperative National Highway Research Program (NCHRP) is sponsoring three ongoing research projects that will be of great importance for TAM in the USA.

1) In May 2003, the Chief Executive Officers of State DOTs held a meeting where it was decided to implement benchmarking for strategic performance measures for the authorities, for the authorities’ resource allocation tools, and for reporting to stakeholders. The NCHRP gives its support to these discussions in a project (20 – 24 (37), Strategic Performance Measures for State DOTs with the aim of defining a set of consistent strategic measures.

2) The lack of ability to share systems in service means that the authorities must put substantial resources into building interfaces with customers or maintaining duplicate databases and data processes. The aim of another NCHRP project (20 – 64 XML Schemas for Exchange of Transportation Data) is to develop schemas that allow the authorities to exchange information between different systems. The project will focus on four key areas – survey/roadway design, transportation construction/materials, highway bridge structures, and transportation safety.

3) It is important to continue to improve the quality of available data and analytical aids for TAM and to jointly invest in training and education for the authorities’ personnel so that they can use both the asset management concept and available decision support. Despite the fact that both the Bridge and Pavement Management Systems are available at all State DOTs, they are not used to any great extent to set performance goals for the road network or for decisions related to resource allocation. Education and training is therefore the third area for investment and development.

The Swedish Parliament is seeking development “that means that goals and results can be better related to the resources consumed...”15. The quality of the information affects the development of infrastructure, trade and industry, and society, and also the State’s finances, both directly and indirectly. The importance of the political system receiving sufficient information of good quality is emphasised in several government bills and reports16. Several documents indicate that the information needs to be improved for the Government’s monitoring and control, even if the Government and the authority have informal contact. It is also quite clear that improvement of public insight into the political decision-making process and information about the process and decisions taken is desirable.

- Are road maintenance appropriations sufficient and have they been used effectively?
- What measures have been taken in different parts of the road network and what results have been achieved in the form of changes in standard and condition and what effects have been observed?
- How have costs, productivity and efficiency in respect of road management developed and what are the road management costs for different types of roads?


What deficiencies in standard and condition remain in different parts of the road network and how great is the need to rectify bearing capacity and deficient frost-proofing in different parts of the country?

- What does it cost to transport freight ten kilometres by road in different parts of the country?

Compared to most reports and articles about the processes according to TAM, two articles provide a balanced discussion. In substance, however, they constitute continued support for the established TAM processes.

One of the articles\textsuperscript{17} questions the value of accounting according to GASB 34, when the objective is in practice to change ingrained work patterns and processes at road authorities. According to the responses received from a number of financial managers at local authorities who took part in a survey, a more reliable valuation of the road network according to GASB 34 is not a factor that affects the development of processes according to TAM. The general opinion is that it must be proved by means of good examples that TAM is a better method than the old one before any development can begin.

The second article\textsuperscript{18} discusses how a PMS in general use in the USA (The Metropolitan Transportation Commission Pavement Management System (MTC PMS)) can fulfill the accounting requirements in GASB 34 with some minor adjustments. MTC PMS has been used by cities and counties in their pavement operations for over fifteen years. Using existing management systems is a recurrent theme in several articles, where it is also stated unequivocally that:

“\textit{It is evident from the study that MTC PMS has the capability, to some extent, of supporting GASB 34 for reporting on a pavement network according to both the GASB 34 reporting methods: the depreciation method and the modified approach}”

and that

“\textit{Some modifications of MTC PMS software were proposed to make this management system more effective as a tool supporting an asset management system and overall GASB 34 requirements}”.

\textbf{3.7 Asset management in other sectors}

Asset Management has been used in practice in other sectors for a long time\textsuperscript{19}. The case studies from two railroads, two airlines, two energy companies, and one railcar leasing company, show that attention must be focused on communication, tools, education, and planning, if asset management is going to be successful. The case studies also reinforce the idea that the main objective of asset management in private industry is to enhance customer satisfaction. Performance measurement and proactive maintenance are critical aspects of the link between customer satisfaction and asset management.

\textsuperscript{17} Maze-TH; Smadi-O, GASB Statement 34: The On-Ramp to Transportation Asset Management or a Detour Leading to Business as Usual?, Conference Title: Mid-Continent Transportation Research Symposium. Ames, Iowa, 2003.


Property Asset Management (PAM) is a total management concept for property assets developed in the USA and some countries in Western Europe\textsuperscript{20}. This type of management is characterised by a team approach, where both owner-related functions and operative functions interact in a project for the administration of the property. Owner-related functions include strategic planning, property and business-related financial analyses, acquisitions and divestments, the controller function, procurement, and project management. Examples of operative functions are administration, letting and marketing, technical administration, and property maintenance.

An asset manager has the general operative responsibility for the properties and acts as the owner’s representative. The manager interacts with the functions listed above (owner-related and operative) and with the owner and the tenant, by means of two-way communication.

3.8 Action- and cash-related questions

Action-related questions should, in a very broad sense, be able to be summarised and clarified in some form of Profit and Loss Statement. The questions may concern how production and products take into account different effects for road users and society such as road safety, the environment, accessibility, trafficability, transport quality, equality, transport costs, and effects for households and trade and industry, data capture, accounting and internal control, and also operation, production and road management costs, productivity, efficiency, administration, organisation and various types of analyses.

Due to the focus of this licentiate thesis, a number of other action-related questions are taken up in Appendix 1. The questions, though, are connected to TAM and will be discussed in more detail in the doctoral thesis.

Cash-related questions should be able to be summarised and clarified in some form of Cash Flow Statement. Cash-related questions may concern control and how financing is taken into account, including questions of road-pricing, appropriations, taxes, tolls, borrowing, the mixture of private and public financing, road funds, cash management using financial instruments, questions to do with invoicing and payments, accounting, and internal control.

For the same reason as for action-related questions, other cash-related questions are described in Appendix 2. These questions are also connected to TAM and will be discussed together with action-related questions, as mentioned above.

4 Asset-Related Questions

Asset-related questions, primarily the transport system’s values, should in a very broad sense be able to be summarised and clarified in some form of Balance Sheet. Questions taken up in this chapter concern road installations; components’ standard, condition and deficiencies; investment in and maintenance of components; life cycle cost; cost distribution between generations; values of personnel, vehicles, transportation, freight, processes; data capture; accounting principles; and internal control, including valuation and recording changes in value.

Growing demands with regard to valuation and accounting

The increasing internationalisation of trade and capital ownership has accentuated the need for uniform, market-adjusted principles for the valuation\textsuperscript{21} and accounting of fixed assets\textsuperscript{22} in an international perspective. Valuation principles that are being discussed\textsuperscript{23} include principles for Fair Value, Market Value, Open Market Value, Depreciated Replacement Cost, Value to the Business, Value in Use, Existing Use Value and Historic Cost\textsuperscript{24} The consensus, according to Edgde, is coming down on the side of Fair Value:

“The amount for which an asset could be exchanged between two knowledgeable, willing parties in an arm’s length transaction” (International Accounting Standard 16, IAS 16).

In traditional external accounting in property management, development has been moving towards greater requirements being stipulated with regard to accounting from a valuation point of view\textsuperscript{25}. The idea is often to develop an accounting system more appropriate for control with fixed assets divided into components\textsuperscript{26}.

The scientific discussion also includes the question of freedom to make a clear division between maintenance and investment in the accounts, and how repair and maintenance costs are accounted in a Profit and Loss Account\textsuperscript{27}. The component question is considered to be significant in this context. Even though a property often consists of physically distinguishable entities (components), dividing it into these components in practice can lead to a lack of clarity on some points.

The rate and approval of the ongoing development in the field of accounting is in practice determined by the European Union’s approval mechanism (the IAS and the International Financial Reporting Standard, IFRS), with a certain amount of delay in individual countries’ rules and regulations.

Briefly, the situation regarding the rules is as follows\textsuperscript{28}:

briefly the situation regarding the rules is as follows\textsuperscript{28}:

RR 12 Component depreciation: is permitted/encouraged.


\textsuperscript{23} Hans Lind, Erik Persson, The quest for a market related value concept that is not current market value, Royal Institute of Technology, Building and Real Estate Economics, ISSN 1401-9175, Stockholm 1998.


\textsuperscript{29} Jorma Kyrö, Lena Ljungdahl och Gustav Nygren, En översikt av skillnader i redovisningsprinciper mellan Redovisningsrådet och IASBs norrgivning, Stockholm, 2004.
Component depreciation: is permitted/encouraged. The new standard (IAS 16, Property, Plant and Equipment) contains a stringent requirement regarding component depreciation and disposing of undepreciated residual values when replacing components.

"There are many questions that are both of interest and sometimes difficult to handle as regards component depreciation in respect of buildings and the changeover from Swedish accounting to IAS/IFRS. Examples of questions that may need to be answered in such cases include: How to handle situations where the sum of the physically audited remaining values per component is greater or less than the value in the Balance Sheet, and which in turn is based on Swedish accounting rules and historical acquisition costs."  

In cases where there is a large discrepancy between the book value in the external accounts and the actual value of a fixed asset, the Swedish governmental accounting rules recommend that the depreciation plan preferably be adjusted so as to reflect the real values as closely as possible.

The international cooperation organisations for road questions have given the need for benchmarking of road management in different countries a prominent position – a need that constitutes a very good reason for bringing uniformity to and improving the valuation and accounting of road capital in a road management perspective.

Asset management is increasingly becoming an integral part of any state transportation plan. This is the reason why institutionalisation of asset management is seen as an obvious step towards making it a part of the planning process (OECD, 13-Dec-2000). Measures are largely planned per component in road management.

4.1 Division of fixed assets into components

As far as roads are concerned, the question of components in the internal accounts has been taken up in the perspective of improving the basis for monitoring and control of road management activities. Depending on limits and definitions, a road component’s acquisition value can exceed the corresponding value for a whole piece of real estate.

A component’s original starting and/or ending points (limits) can change over time from the point of view of control and taking measures. Due to uneven wear, for example, or for geo-technical reasons, the condition of a part of the original installation may be maintained at the same time as a different installation instead of together with the rest of the original installation – a fact that gives further support to (the need for) a flexible view of components in road management. Components that have been maintained at the same time or that have a similar condition, do not therefore need to coincide in magnitude or location with the original components at the time of the investment, i.e. components’ limits may change over their life cycle. Figure 4 is a sketch based on recorded and actual data in the road database.

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30 Berth Jonsson et al., Draft final report on road capital with application examples (not officially published), SNRA, May 1993.
Figure 4 Summary of basic data and natural limits for components on a stretch

As can be seen from figure 4, the 7,007-metre middle stretch, opened to traffic in 1963, was most recently repaved in 1999. The new pavement, which can be regarded as a homogeneous component, extends some way into the unbuilt section and has a total length of 8,917 metres. In the same way, the 439-metre guardrail component erected in 1998 extends into the major part of the middle section. The original installation’s limits as regards the pavement and the guardrails have gradually been erased component by component.

4.2 Different valuation techniques

Table 1 lists the valuation techniques that are applicable to pavement and highways.²²

This research illustrates the modified integration framework of GASB, applying the cost approach for valuing pavements according to the recommendations of the AIREA (American Institute of Real Estate Appraisers)²³, and because it explicitly relates asset value to pavement value to performance and time. “With the cost approach, asset value can be determined from the pavement replacement costs and accrued depreciation. Accrued depreciation is estimated on the basis of physical deterioration and functional obsolescence.”

“The results demonstrate that the cost approach captures the relationship between pavement value, performance, and time and can be used to capture the added value of pavement maintenance activities. The results also show that the cost approach can be incorporated into various management systems and used as a common basis for evaluating investment trade-offs for different types of infrastructure in order to enhance the overall value of a mixed asset base.”

The results also indicate that the cost approach can provide a useful common basis and language for discussions among engineers, managers, and stakeholders and is a powerful concept for enhancing the planning and investment decision-making process. The results are potentially useful to agencies involved in upgrading their infrastructure management systems to incorporate asset valuation and to other researchers involved in developing and integrating useful approaches for infrastructure valuation in existing management systems\(^2\).

<table>
<thead>
<tr>
<th>Valuation Techniques</th>
<th>Features</th>
<th>Applications/Limitations</th>
</tr>
</thead>
</table>
| Cost                 | • Derives pavement value from replacement cost, physical deterioration, functional obsolescence and external obsolescence | • Useful for valuing assets which are not frequently sold in the market or where no market exists  
• Relates pavement value with its performance and time |
| Productivity Realized Value or Income Capitalization | • Based on the net present value of benefit stream of the pavement/highway for its remaining life | • Appropriate for toll highway by discounting its future cash flow  
• Possible to apply with public pavement/highway by studying current or future benefit of a pavement  
• Requires several assumptions |
| Option Value         | • Derives pavement value under certain circumstances, e.g., specified number of cumulative ESALs or minimum acceptable level of pavement roughness | • Can be applied as a decision making tool for maintenance or rehabilitation investments |
| Relative Value       | • Estimates pavement value by comparisons with other pavements based on common attributes such as traffic volume etc. | • Applicable to toll highway and public highway by estimating value based on traffic volume |
| Market Comparison    | • Based on market price by comparison with recent sales of pavement/highway | • Applicable to sales of highway pavement  
• Only few pavements/highways are sold in an open market |

Table 1 Valuation Techniques Applicable to Pavements and Highways (Herbat-P et al. 2002)

It is also said that the asset valuation is both an economic and an accounting concept that measures the value of an asset, but focuses more on accounting principles than on economic principles. Pavement valuation methods must extend to include economic principles as well.

In one article\(^3\), a team of researchers present different valuation approaches that support different purposes, and discuss the importance of selecting appropriate valuation methods to achieve different objectives.

“Valuation is a critical component of asset management for civil infrastructure because it provides a means for evaluating facilities whose value is to be preserved or enhanced. Although the basic concept of valuation is generic, there are various quantitative approaches for valuing assets. These approaches can be classified to provide guidance for selecting the right valuation approach to accomplish different asset management objectives. Various approaches are examined for valuing assets in transportation corridor, financial, and corporate real estate asset management from the viewpoint of the purpose of valuation”.

Table 2 shows some examples of measures or indicators of value for the transportation system from various stakeholder viewpoints.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Measures or Indicators of Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Users – General Public</td>
<td>Mobility/Accessibility, Safety, Durability, Environmental Quality, Functional Obsolescence</td>
</tr>
<tr>
<td>Financiers/Owners – General Public</td>
<td>Accountability and fiscal health of transportation agencies</td>
</tr>
<tr>
<td>Engineering and Construction Professionals</td>
<td>User Objectives, Infrastructure Improvement Opportunities</td>
</tr>
<tr>
<td>System Managers – Operation &amp; Maintenance</td>
<td>Economic Efficiency, User Objectives</td>
</tr>
<tr>
<td>Investment Decision/Policy-Makers</td>
<td>Overall condition and level of service of the system</td>
</tr>
<tr>
<td>Community – General Public</td>
<td>Physical functionality, economic impact, environmental impact, social impact</td>
</tr>
<tr>
<td>Marginal Populations, e.g. low income, racial minority and elderly communities</td>
<td>Equity in benefits and burdens of transportation improvements</td>
</tr>
</tbody>
</table>

Table 2 Value Measures for Transportation Facilities by Stakeholder Interests (Amekudzi-A et al. 2002)

There are four common dimensions specified “under which valuation methods can be classified for infrastructure valuation:

1. They may be either future based or historically based;
2. They may be either costs based or benefits based, or both;
3. They may have different sets of value indicators in the valuation function; and
4. They may or may not characterize the risks of investment.”

The article discusses multidimensional asset valuation as a function of the types of value parameters used. Figure 5 illustrates how valuation of fixed assets can be based on historical, known costs (book values in traditional Swedish praxis) or on indications of future benefits (Productivity Realized Value) or on current acquisition cost (replacement value). Information consisting of all types of valuations can improve control still further, since control is in itself future-oriented.

![Figure 5 Multidimensional valuation chart for civil infrastructure assets (Amekudzi-A et al. 2002)](image-url)
The following are the examples given in the article of important questions that must be addressed when a valuation approach is chosen.

1. When is it appropriate to treat past costs as sunked costs?
2. When is it relevant to use future based versus historical costs?
3. When does it make sense to use benefits instead of costs for valuing assets?
4. When does it make sense to use both costs and benefits to value assets?
5. What are the appropriate measures, attributes, or indicators for valuing an asset and why?
6. How can asset valuation approaches be integrated meaningfully within legacy management systems?

In table 3, the framework discussed is used to classify existing valuation approaches and illustrate the potential uses of different valuation methods.

<table>
<thead>
<tr>
<th>Category of Approach</th>
<th>Examples of Approaches</th>
<th>Uses</th>
<th>Data Availability/Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present Value of Past Costs</td>
<td>Book Value(^a) Equivalent Present Worth in Place(^b)</td>
<td>• Indicator of health of infrastructure agency • Public accountability Benchmark of relative condition level of assets</td>
<td>Data readily available/Relatively higher accuracy</td>
</tr>
<tr>
<td>Present Value of Future Benefits</td>
<td>Productivity Realized Value(^c) or Income Capitalized Value</td>
<td>• More easily applicable to income-generating facilities such as toll road</td>
<td>Little data available/Relatively lower accuracy level</td>
</tr>
<tr>
<td>Net Present Value of Past Costs and Benefits</td>
<td>--</td>
<td>• Benchmarking facilities by relative utility/obsolescence • Assessing agencies' investment efficiency</td>
<td>Data readily available/Relatively higher accuracy</td>
</tr>
<tr>
<td>Net Present Value of Future Costs and Benefits</td>
<td>Net Present Value</td>
<td>• Value-based asset management</td>
<td>Little data available/Relatively lower accuracy level</td>
</tr>
<tr>
<td>Market (Relative)</td>
<td>Written Down Replacement Costs(^d) Market Value(^e)</td>
<td>• Asset sales</td>
<td>Relatively little data available only where facilities have been traded on the market</td>
</tr>
<tr>
<td>Income Retrievable from Components</td>
<td>Net Liquidation Value(^f) Salvage Value(^g)</td>
<td>• Facility recycling or disposal</td>
<td>Data from similar facilities recycled/Relatively higher accuracy</td>
</tr>
<tr>
<td>Option Value(^h)</td>
<td>--</td>
<td>• Can be used as a decision-making tool for unusual circumstances; e.g. valuation of a highway being converted into a congestion pricing facility</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Present worth of capital and subsequent costs of asset depreciated to the present.
\(^b\) Represents worth “as is” based on historic costs adjusted for inflation, depreciation, depletion and wear.
\(^c\) Represents value of asset in use. Present worth of future benefits for the remaining service life of the facility.
\(^d\) Uses current market prices to determine costs to rebuild or replace facility in its current condition.
\(^e\) Price that buyer is willing to pay.
\(^f\) Present worth of amount obtainable from selling off the components of the asset over a reasonable period of time.
\(^g\) Present worth of the amount obtainable from disposing of or recycling facility.
\(^h\) Value of asset in specific circumstances.

Table 3 Example of Valuation Classification for Civil Infrastructure
It is concluded that this is an appropriate time to advance the scope of valuation tools to reflect multiple considerations in modern transportation planning, especially in the context of active research on sustainable transportation planning, strategic environmental assessment, equity evaluation for transportation system investments, and state and local activities driven by the GASB 34 requirements.

4.3 Accounting of depreciation

The principle of depreciation according to plan is deeply rooted among accountants. Tough discussions of principle are taking place around the world with those who defend the current principles of depreciation of the values of assets according to plan also in internal accounting. The introduction of an efficient TAM process, that will among other things handle the political directive to maintain the road capital in an appropriate manner, will generate a need for better quality information and, thus, also a need for new principles, primarily for the accounting of assets and costs.

In an article\textsuperscript{15}, Sherrie Koechling takes up various arguments that should persuade those responsible for results to abandon the method of depreciation according to plan. One argument deals with asset management’s focus on the value and effects of continuous maintenance on an asset over its whole life cycle, unlike the focus on depreciation according to plan, which is on the continuous deterioration of the same asset without considering the appreciation brought about by maintenance, with undervaluation as the result.

Many defend depreciation according to plan by claiming that the method is simple and cheap from an administrative point of view. If the political directive is to be reflected in the accounts, both the depreciations according to plan and the TAM registers must be continuously updated for collation reasons. To achieve the quality required in the accounts, improvements in capital must also be treated as increases in value (for example additional investments) and/or as a prolonged depreciation period. All together, the effort involved in maintaining good order in the accounts from the point of view of control is roughly the same as in a full "TAM accounting system". The quality of information, however, will still not be as good as in an accounting suited to TAM requirements.

In another argument, Koechling points out that the most primary objective of any accounting system is to supply the users with usable information, a fact also established in the Financial Accounting Standards Board Concept Statement No. 2, Qualitative Characteristics of Accounting Information (1980). It also says that usable information must have two primary characteristics: relevance (applicability/appropriateness) and reliability (trustworthiness).

The information is relevant if it is significant for the user’s decisions and it is reliable if it represents what it is intended to represent. Information about when to carry out maintenance in order to preserve the value of the asset is better information for the service of the asset than its book value (the historical acquisition value less accumulated depreciation). In addition, information about how an asset’s condition develops is more relevant to the user than the book value when road management’s problems and costs need to be described to citizens in general terms.

\textsuperscript{15} Sherrie Koechling, How to Convince Your Accountant That Asset Management Is the Correct Choice For Infrastructure Under GASB 34, Leadership and Management in Engineering, January 2004.
According to a third argument, infrastructure will be valued more highly as a financial asset than as a “cost already accounted”. When the value of the infrastructure is known and life cycle costs become more predictable, the value of these assets will play an important role in the budget process. Regardless of whether maintenance costs are calculated using depreciation or asset management data, the value of the asset must be known. The amount of the value, however, will be important when drawing up the budget. For example, it is considerably more difficult to argue for 30,000 SEK in annual maintenance costs for a car worth 90,000 SEK than for one worth 500,000.

In a fourth argument, Koechling highlights the responsibility for the physical and financial health of infrastructural assets, the obligation to maintain accounts, and the reporting of decisions, plans, and the use and control of public funds.

In the last argument that will be taken up in this context, Koechling claims that there is no better “music” to an economist’s ears than that something “saves money”. It has been repeatedly shown that preventive maintenance can reduce life cycle costs 6 to 10 times compared to a “take the worst first” strategy. The importance of and the increased efficiency in being able to change maintenance strategies are also taken up by other researchers and investigators.

The TAM process creates exceptionally good control tools needed for long-range planning, monitoring and control – tools that also lend credibility to the financial description when more funds are needed for the routine maintenance of existing assets necessitated as a result of under-financing of the investments.

Yet another reason is that the Government, with better accounting of assets, can get better terms in the financial markets, which will result in lower costs for capital. Having a value (high) both for the infrastructure and for its financial obligations creates a more balanced picture of the Government’s financial position.

### 4.4 Asset accounting around the world

Respondents’ answers to some of the questions in Part 2 of the PIARC survey are presented in summarised form below.

**Has your organisation ever attempted to place a monetary value on your highway infrastructure?**

8% of the countries answered no, 62% said yes. Others say that they do so to a certain extent or are developing procedures for valuation.

**What was/will be the basis of the valuation? (eg current replacement value, original construction cost, community value in terms of value of the efficient movement of people and goods, different for different elements of the network)**

The category “Other” contains answers like: Different for different elements on the road, Construction and improvement costs, Value to society of people’s mobility, Accounting regulations. Some answers have been included in more than one category in the summary below.

---

Replacement value: 25
Acquisition value: 9
Wear and condition (PMS is included): 4
Depreciated replacement value/cost: 2
Other: 6
Did not answer/have not decided: 4

What level of detail did/will you use? (eg typical cost per lane km, costs for different types of pavement construction, structures valued separately, elements of structures valued separately)

The category "Other" contains answers like: "Great flexibility in reporting", "Replacement value", "Average replacement value per square metre", "Condition", "Life cycle", "Percentage of deterioration" etc. Some answers have been included in more than one category in the summary below.

Average cost per lane km: 14
Costs of different types of structure: 11
Structures valued separately: 13
Elements of structures valued separately: 5
Other: 7
Did not answer: 6

Did/will you include the value of land, equipment, offices/depos etc?

8% of the countries did not answer, 38% answered no, 31% answered yes, and the remainder answered that they did/will do so to some extent.

Did/will you take depreciation into account?

21% of the countries did not answer, 18% answered no, 51% answered yes, and the remainder answered that they did/will do so to some extent.

If so, did/will you assume linear or non-linear depreciation? Or was depreciation based on current condition assessment?

The category "Other" contains answers based on: wear and decrease in value, statistics, in proportion to the production cost, restoration to condition at acquisition, experience, somewhat accepted accounting procedure. Some answers have been included in more than one category in the summary below.

Linear depreciation: 13
Non-linear depreciation: 4
Condition valuation: 7
Other: 6
No: 2
Did not answer: 12
At what level did/will you consider depreciation? (eg different for different types of road pavement construction, structures treated separately, elements of structures treated separately)

The most common answer in the category "Other" is based on useful life (4 of the answers). The others vary from great flexibility to how the information is reported in a new in-house breakdown model for controlling pavement work and measuring repair costs. Some answers have been included in more than one category in the summary below.

<table>
<thead>
<tr>
<th>No. of answers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Different for different types of pavement structures:</td>
<td>12</td>
</tr>
<tr>
<td>Structures valued separately:</td>
<td>9</td>
</tr>
<tr>
<td>Elements of structures valued separately:</td>
<td>5</td>
</tr>
<tr>
<td>Other:</td>
<td>9</td>
</tr>
<tr>
<td>No:</td>
<td>4</td>
</tr>
<tr>
<td>Did not answer/Not decided yet/being studied:</td>
<td>10</td>
</tr>
</tbody>
</table>

What were/will be your assumptions about the <<life>> of the network, or elements of it?

8% of the countries did not answer the question. The others’ answers vary from "Type of structure and material prerequisites over technically calculated life" to more detailed prerequisites over stated numbers of years. Some differentiate between, for example, pavement, structures, and fixed ground installations, while others merely state unlimited life or that the prerequisites are flexible.

Did/will you assume a <<salvage>> value? If so, how did/will you determine this?

13% of the countries did not answer the question. 31% answered yes and 33% no, while 23% chose one of the following alternatives: Not relevant, Not taken into account, Regarded as zero, Being studied or Flexible. Among the countries that answered yes, the following additional information was noted:

<table>
<thead>
<tr>
<th>No. of answers</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>This will be determined by</td>
<td></td>
</tr>
<tr>
<td>- wear</td>
<td>4</td>
</tr>
<tr>
<td>- experience</td>
<td>3</td>
</tr>
<tr>
<td>- a reasonable level</td>
<td>1</td>
</tr>
<tr>
<td>- gross value / replacement cost</td>
<td>1</td>
</tr>
<tr>
<td>- legal considerations</td>
<td>1</td>
</tr>
<tr>
<td>- detailed analyses</td>
<td>1</td>
</tr>
<tr>
<td>Did not answer</td>
<td>10</td>
</tr>
</tbody>
</table>

Have you considered whether and how the value of the network will be affected by <<renewal>> or structural maintenance works?

15% of the countries did not answer the question, 62% answered yes, 15% answered no and the remainder answered that they had done so to a certain extent.

Do you intend to regularly update your valuation of the network? If so, how? (eg by links to economic indicators)

74% of the countries answered yes, 3% answered yes, to a certain extent, 8% answered no, 15% did not answer at all or answered Planned, Not decided, or Still to be decided.
Answers to the question “How do you intend to update the valuation of the network regularly” vary. By far the most common answer is annual recalculation. The next most common answer is annual condition inspections, and annual checking against economic indicators. Some update their values on the basis of maintenance costs and new construction.

As an example, Main Roads Western Australia bases their valuation (in both internal and external accounting) on the real historical acquisition cost without considering, for example, standard estimated historical costs. The values are indexed to replacement values, which are only used as baselines for revaluations every 3 years. Condition-based replacement cost is straight-line depreciated over the interim period between revaluations.

The MRWA have systematic data about physical deficiencies of the components on the road network for Road body, Pavement, Bridges, Tunnels, Signal devices, Information equipment, Sign portals (answered on the basis that it refers to the whole sign), Railings, and Game preserves (answered as per roads in national parks, in which case MRWA maintains the MRWA roads passing through the park. The park is not maintained by MRWA. Rest areas etc are.). In the same way, systematic data on condition deficiencies also exists for Pavement, Bridges, Tunnels, Signal devices, Information equipment, Sign portals, Railings and Game preserves.

Table 4 lists the components for which specific information exists in the accounting system or some other system associated with it at the MWRA.

<table>
<thead>
<tr>
<th>Name of the component</th>
<th>Existing economic data about the value</th>
<th>maintenance</th>
<th>operation</th>
<th>See note number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drainage</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seal</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earthworks</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bridges</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tunnels</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Lines &amp; signs</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Signals</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Road side furniture</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intelligent Transport Systems</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Cycle paths</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise walls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note a. under investigation for valuation

Table 4 Components with economic information in the accounting (or associated) system

In Norway an official report will be given in 2005 on a major step towards implementing an AMS. The Norwegians’ ambition is to develop a system that permits full control of the road network’s capital value at any given time, although they are fully aware of the comprehensive, systematic effort required to achieve complete knowledge of the elements that exist on the roads and of their values.

They also consider that the basic prerequisites of a practicable AMS is detailed knowledge of the road network’s different components, established methods for calculating values, and well worked-out, simple procedures for updating data. Methods also need to be established for depreciating the value of different components.

In the conclusion, the Norwegian study emphasises that it is important to note that the depreciation methods do not necessarily need to correspond to maintenance needs, but that the methods applied together with the valuation principles must be accepted by the governing authorities (e.g. the Ministry of Transport and Communications and the Ministry of Finance).

The OECD points out (OECD, 13-Dec-2000) that no member country has yet achieved a complete AMS but that several countries are well on their way. Several member countries are carrying on significant, secured development of methods to capitalise fixed assets in roads and to implement a standardised form of accounting, but implementation is only its initial phases. The principal requirements in GASB recently introduced in the USA secure the development of standardised accounting and capitalisation methods for assets in the transportation infrastructure for the states and local authorities. These requirements must be fulfilled and functioning in the states and local authorities by 2006.

The OECD’s survey shows that Australia has advanced furthest as regards development and the USA is also in the forefront in this area (in Appendix 3 there are More on accounting according to GASB 34). The information available from Canada, Belgium, Finland and the United Kingdom shows that Government authorities are rapidly implementing standardised accounting and reporting with systematic surveys and valuations to handle depreciation. It is also quite clear that much work remains to be done. In Australia for example, with standardised accounting and capitalisation of assets in road installations already implemented, there are some differences between the different regions – differences that limit transparency and direct comparisons between the regions.

4.5 More theoretically oriented research

One article\textsuperscript{38} discusses a dynamic investment model for infrastructure in the form of a broadened Ramsey model for half-open economies. The basic theoretical framework for accounting infrastructure is described on the basis of its significance for economic growth. On the other hand, the article ignores the practical problems associated with designing the system itself.

In the model, the value of an asset is described according to the following accounting principles: 1) it is determined as a replacement value valued on the basis of a standardized quality level \( q \); and 2) the annual maintenance costs, \( R(q) \), that are necessary to maintain quality \( q \) permanently. Quantities and qualities are treated separately in the model, which also contains economic indicators. These are intended to facilitate drawing up an optimal control policy for an infrastructure of variable value.

Principal among the problems emphasised is the one of empirically determining the marginal efficiency of the infrastructure. There are details of the infrastructure’s established and accumulated productivity, but no information about the differences in the length of useful life of the capital tied up in the infrastructure and in private investment.

\textsuperscript{38} Muneta Tokomatsu, Kiyoshi Kobayashi, Ryo Ejiri, Infrastructure Management and Economic Accounting, Japan, SVF Konferens, Jönköping October 2004.
In order to be able to determine the marginal efficiency of investments in infrastructure, the model must be able to take these differences into account. It is therefore necessary to also develop methods to determine this marginal efficiency.

Secondly, a help function is needed to specify the optimal quality level. It would in this respect seem to be important to accumulate empirical information about willingness to pay for different levels of service in the infrastructure. There is also a need for some form of accounting of Profit/Loss indexes as regards the infrastructure’s value from the point of view of the taxpayer.

The third problem mentioned is that the study does not take into account monetary problems in the financing process, such as inflation, lack of capital, and budget restrictions. These have an extremely limiting effect on a practicable model.

The length of useful life of investments is a significant factor as regards management strategy. It is common for the life of investments to be mainly determined on the basis of assessed physical or technical durability, not economic life. One of the most efficient ways of handling an infrastructure project can be found in the internal accounting (Management accounting). This system does not however express sacrifices made by taxpayers or road users. The Government’s tight budget restrictions require clearer descriptions. Most of the infrastructure is used by several generations over a long useful life. The sacrifices made by different generations for the infrastructure and its benefit to them should therefore be clarified by generational accounting.

For management based on a long-range approach with repeated rebuilding of the infrastructure, the length of life chosen should be optimised either on the basis of each generation of the infrastructure or the length of time that gives the maximum economic value over a very long series of generations. This mathematical maximisation problem is studied in an article by Takayuki Ueda, Economically Optimal Lifetime of Infrastructure, Tokyo Institute of Technology, SVK Konferens, Jönköping, Sweden, Oct 2004.

The conclusion drawn is that, contrary to the results of conventional discussions, and primarily among designers, a very long life for a single generation of the infrastructure or for several generations does not necessarily need to be the optimum in a long-range perspective. It has also been shown that the optimum life for each generation when several replacements are made can vary, for example when traffic flows increase. In the same way, but in a scenario with decreasing needs, the infrastructure may need to be removed. If society is forced to maintain the infrastructure for a very long period, its useful life for each generation should be long in order to reduce the replacement costs.

At the present time, it is common to use asset management systems in civilian operations to minimise the discounted costs of repeated maintenance and rehabilitation measures by means of dynamic programming. One article by Kiyoshi Kobayashi, Kenneth Kuhn, The Temporal Distribution of Cost in Discounted Cost Minimizing Asset Management Policies, Kyoto, Berkeley, SVK Conference, Jönköping, Sweden, October 2004.
Using a simple decision model based on the principle of asset management different scenarios were studied with periodic, recurring rebuilding costs, partly with uniform maintenance costs, but also for cases with uncertain system dynamics. The article also discusses the weak points of the discounted cost minimisation technique. For example, it is shown that future generations’ costs are generally overemphasised. Minimising the discounted costs often leads irreversibly to a potential need for marked increases in authorities’ appropriations. It is shown that permanent cost minimisation can be achieved and problems avoided if the average cost is minimized instead.

The analyses described in the article are particularly important for illustrating the dangers involved in the method of minimising the discounted costs that is so popular and in common use in asset management. The article emphasises that it is important that the users are aware of the method’s weaknesses. In those cases where users’ costs and uncertain factors are judged to be less important, the average cost minimisation method can be regarded as an alternative to minimising the discounted cost.

Another article describes a combined accounting system for a hypothetical infrastructure project, where each generation’s net costs and the project’s total cost are shown. The conclusion drawn in the article is that insufficient financing of maintenance over a defined period causes an unfair cost burden between generations as an increased life-cycle cost and also leads to a project manager being assigned to draw up a maintenance plan that takes the results of generational accounting into consideration.

5 Analysis and Discussion

The aim of this review is to provide a well-supported view of the basic issues connected with an accounting model, based on the ideas behind Transport Asset Management.

- What are the requirements with regard to the accounting of road capital in road management?
- What reasons are given in the public debate for and against a new form of accounting as opposed to the traditional method?
- What accounting models exist, i.e. what road components, valuation methods, and accounting principles can be discerned, are applied, or are claimed to be under development?

It is quite clear from the evidence that there is increased pressure for efficiency in road management around the world – a pressure that has led to the development of or a demand for the development of ways of monitoring and controlling road management processes, financing, and opening up production to competition, including new forms of contracts with a redistribution of responsibilities and risks between client and contractor, with incentives built-in. The forms and techniques for reporting and maintaining a dialogue with governments, road users and taxpayers are currently under development.

Developments in technology have led to more efficient data capture. Interest in TAM and the principles for which it stands (for example the integration of engineering and financial skills and systems) is therefore great among road authorities and organisations around the world. Table 5 below summarizes the ambitions of 14 countries as regards the accounting of road capital according to the answers given in the PIARC-C 6 questionnaire in 2000. Ambitions and development in Norway and Finland show a similar picture.

41 Keiichi Kitazume, Combination of Management and Generational Accounting System for Infrastructure Projects, Kansai University, Osaka, Japan, SVF Conference, Jönköping, Sweden, October 2004.
<table>
<thead>
<tr>
<th>Country</th>
<th>Is AM used?</th>
<th>Is the road network valued in money?</th>
<th>Basis for the valuation?</th>
<th>How is the valuation made?</th>
<th>Is depreciation considered?</th>
<th>How is depreciation considered?</th>
<th>How often is the road network revalued?</th>
<th>Is the valuation influenced by maintenance measures?</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUS Road &amp; Traffic Authority</td>
<td>Yes</td>
<td>Yes</td>
<td>Depreciated value</td>
<td>Standard-estimated (cost per m²)</td>
<td>Yes</td>
<td>Linear depreciation</td>
<td>Annually</td>
<td>No</td>
</tr>
<tr>
<td>AUS Queensland</td>
<td>Yes</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Standard-estimated</td>
<td>Yes</td>
<td>Linear depreciation</td>
<td>Annually</td>
<td>Yes, periodic maintenance</td>
</tr>
<tr>
<td>AUS Victoria</td>
<td>Yes</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Standard-estimated</td>
<td>Yes</td>
<td>Linear depreciation</td>
<td>Annually</td>
<td>Yes, periodic maintenance</td>
</tr>
<tr>
<td>Holland</td>
<td>Yes, for maintenance. Under development for investments.</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Standard-estimated</td>
<td>Yes</td>
<td>Linear depreciation</td>
<td>When conditions change</td>
<td>No</td>
</tr>
<tr>
<td>South Africa</td>
<td>Yes</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Acquisition cost less depreciation</td>
<td>Yes</td>
<td>Linear depreciation</td>
<td>Annually</td>
<td>Yes</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Under development</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Varies</td>
<td>Yes</td>
<td>Linear depreciation</td>
<td>Annually</td>
<td>Yes</td>
</tr>
<tr>
<td>USA FHWA</td>
<td>Under development</td>
<td>Yes</td>
<td>Historic costs</td>
<td>Depending on?</td>
<td>Yes</td>
<td>GASB 34 rolling</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Japan</td>
<td>Under development</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Varies</td>
<td>Yes</td>
<td>Linear depreciation</td>
<td>Annually</td>
<td>Yes</td>
</tr>
<tr>
<td>Canada</td>
<td>Under development</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Yes</td>
<td>Annually</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sweden</td>
<td>Yes</td>
<td>Yes</td>
<td>Historic acquisition value</td>
<td>Actual cost of whole investment object</td>
<td>Yes</td>
<td>Linear over 40 yrs (in normal cases)</td>
<td>Every 6 months</td>
<td>No</td>
</tr>
<tr>
<td>Denmark</td>
<td>Under development</td>
<td>Yes</td>
<td>Varies</td>
<td>Linear</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium</td>
<td>Yes</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Standard-estimated</td>
<td>Yes</td>
<td>Study-based</td>
<td>Rolling</td>
<td>No</td>
</tr>
<tr>
<td>England</td>
<td>Under development</td>
<td>Yes</td>
<td>Replacement value</td>
<td>Standard-estimated</td>
<td>Yes</td>
<td>Study-based</td>
<td>Annually</td>
<td>Yes</td>
</tr>
<tr>
<td>Poland</td>
<td>No</td>
<td>Yes</td>
<td>Replacement value</td>
<td></td>
<td></td>
<td></td>
<td></td>
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Table 5 Summary of the situation regarding TAM in some countries (PIARC-C 6, Questionnaire 2000).

Countries’ values in infrastructure and its associated costs and benefits represent enormous sums of money. This is evident from several documents studied. Different ways of valuing publicly controlled road capital are discussed. Support can be found in the various discussions for several valuation techniques. Roads do not normally have any real market value in a free and open market. This means that valuation techniques based on earning capacity, surplus and similar, are of less interest at the present time when it comes to valuing road capital.
From the point of view of control, appropriate information can be found in a cost value based on factors such as replacement cost, physical deterioration and functional obsolescence, in an option value based on knowledge of for example a minimum acceptable level of pavement roughness, and in a relative value based on, for example, a comparison of other factors such as traffic volume, but also in some kind of income capitalisation based on the net present value of the benefit stream for its remaining life.

The review in table 5 shows that models and principles for accounting fixed assets in roads are being developed in many countries around the world. Several countries, American states, and writers, are of the opinion that road authorities should aim for condition-related valuation, to allow maintenance measures to affect the value of the installations. Different ways of accounting in this way can also been seen.

The clearest requirements with regard to the accounting is that it must be able to show in an easily intelligible way, how appropriations and taxes have been used, what the road management costs are, how the road installations’ values have changed and what deficiencies remain in the road network or, in other words, what funding will be needed in the future.

The only significant argument that can be found for keeping to traditional accounting is administrative simplicity. At the same time, all the articles state that the advantages of quality-related accounting outweigh the disadvantages. Authors are unanimous in their belief that the increased costs involved in a new form of accounting can give savings that exceed the costs. Some articles emphasise the possibilities to reduce the cost of data capture and data processing through the use of new technology and several examples of this have also been given.

One significant advantage mentioned in the literature in connection with describing the needs of the TAM process, is that condition-related accounting will increase efficiency in the road management processes and the dialogue with the taxpayers and other stakeholders, and thus also increase understanding for the problems in road management, planning (including resource allocation), budgeting, follow-ups, and accountability.

The total number of specific components taken up and accounted for separately in the different countries is estimated to be around twenty. Some of the components most frequently mentioned are pavement, bridges, tunnels, road structure, lateral reserves, drainage systems, road signs, traffic information facilities, and traffic signals.

Table 5 shows clearly that the development of valuation methods and accounting principles has advanced to different degrees in the different countries. The answers given to the questions on accounting, though, are probably of varying quality. The point of departure for the answers is not clearly evident. It is, for example, common for engineers and economists to do their work in different systems (technically based PMS, BMX etc and the external accounting system respectively – and these are not always integrated with each other). The table nonetheless provides a good picture of ongoing development, because it is in line with the discussion that is being carried on, and of the accounting needs with regard to road management.

Developments in technology are making data capture and data processing more efficient. In parallel, in the rest of society, the corresponding legal requirements with regard to valuation principles and accounting (IAS etc) are becoming more stringent – a development that can hardly be stopped, since accounting is so important to the monitoring, control, and reporting of very substantial capital values and its changes over time, and to international commerce.
In the more theoretically oriented research being done, advanced economic studies are being made of how a fair distribution between generations can be made with regard to these infrastructure initiatives, and of the effects on other regions outside the area where the initiatives are implemented. Life cycle costs are also being discussed in the light of the problem of securing sufficient financing for investments and maintenance. In the international arena, this is one of the problems mentioned most often in connection with the questions that TAM is intended to solve in an optimum fashion for society.

An important factor in this research is the changes in value of the road capital during the periods studied (the periods’ opening and closing values) and the costs and benefits that have existed during the periods. Analysis of the ripple effects of measures taken on roads require more information, for example about the changes in value of freight transported, population and mobility, the age distribution of the population, and about production and measures of prosperity in the regions studied.

The reports and articles that have been studied indicate considerable improvements in the road management process. The one single factor in the TAM process that leads to the greatest improvement is nonetheless probably the view of responsibility. In many countries, responsibility is explicitly expressed for the administration of the infrastructure’s values, costs, and benefits over the whole life cycle, including responsibility for an open, transparent accounting to politicians, road users, and taxpayers of what the taxes used have resulted in (cf. GASB, for example). Better accounting of road capital is a crucial factor for developing the responsibility for road management while maintaining political monitoring and control.

Asset Management has been applied in other sectors for a long time. In those sectors, the development of responsibility, roles, interaction, and processes are the characteristics that stand out most clearly. There is much to be learned from development there by the politicians and officials who are responsible for road management. Questions connected to responsibility, roles, and processes, and questions of monitoring, control, analyses, financing, results, and reporting will be treated in later articles, and these areas are therefore not discussed in greater detail in this paper.

6 Conclusions

The many reports and articles studied discuss road management’s need to develop control, monitoring, accounting, reporting, dialogue, responsibility, and financing. An emphasis on the advantages of the TAM concept is a common feature. The literature study shows quite clearly that traditional accounting is being developed to meet requirements with regard to depreciation by component and valuations of higher quality. There are convincing arguments that the quality improvements with regard to valuation and accounting of road capital need to be even more extensive. None of the articles puts forward any arguments for keeping the old principles governing the accounting of fixed assets in roads. As regards road management, without a properly functioning market for trading in road installations, in an international perspective it is most common today to develop cost-based valuation techniques. The ambition is also that maintenance and installations’ condition will have an impact on the values in road capital.
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Appendix 1

Action-related questions

Action-related questions should, in a very broad sense, be able to be summarised and clarified in some form of Profit and Loss Statement. The questions may concern how production and products take into account different effects for road users and society such as road safety, the environment, accessibility, trafficability, transport quality, equality, transport costs, and effects for households and trade and industry, data capture, accounting and internal control, and also operation, production and road management costs, productivity, efficiency, administration, organisation and various types of analyses.

Viewed in an international perspective, road management is undergoing extensive change. Different directions in development are quite evident in this respect. With the oral permission of the authors (Nils Bruzelius et al., 2002), material from their as yet unpublished report has been used, and sometimes quoted verbatim, in this thesis.

1. Autonomous operations are being exposed to competition and commercialized

The biggest change so far is that road construction is nowadays subject to procurement procedures and no longer the preserve of the road authority. Until a few years ago, all road management was in most countries carried on within the framework of a ministry (or a similar body at regional or local level). This organisation was then also responsible for road construction, principally for roads’ maintenance and operation. Roads have traditionally, but not always, been constructed by contractors who have won their contracts through free competitive procurement.

Just as in Sweden, authorities’ autonomous operations have in many countries now been separated out and transferred to separate units, which have sometimes been converted into independent subsidiaries and privatised. The change process has been connected to the introduction of rules for procurement that assume competition.

Similar development can be seen in a large part of planning, detailed planning, inspection, and administration of construction contracts – areas that have increasingly been taken over by consultants engaged through competitive procurement. Development in Sweden is fully in line with what is happening in other countries.

In summary, this development means that the pure construction tasks and the other parts of the supply side of road management that are open to competition, are being carried out more and more by suppliers (agents). In one of the notes, it is stated quite clearly that: It is a common conception that the introduction of competitive procurement has meant cost savings; cost reductions amounting to 15% and more are often claimed. It should, however, be mentioned that there are very few analyses that unequivocally bear out these efficiency gains.

In Sweden, all new projects and major maintenance, for example paving and surfacing work, have traditionally been procured through competition. Since the 1990s, the SNRA has also subcontracted all operations, and in recent years the contracts have covered increasingly longer periods (up to 5 years) and increasingly greater areas (road networks of up to 800 km). These more recent contracts have also taken the form of functional contracts (see below).
Several other countries, including Argentina, Australia, Canada, New Zealand and Great Britain, have come even further along the way towards delegating parts of road management to the private sector. Road managers in these countries have sometimes elected to procure the services of consultants to procure contractors for operation and maintenance.

In England, the process was begun in 1986 when the then Department of Transport (DOT) decided to open up the operation of the motorway network to competition in this way. For different parts of the network, the DOT selected responsible consultant companies who then took over day-to-day operations including the procurement of contractors and inspection. At the same time those DOT employees who had previously worked with procurement and contract administration were given the opportunity to move to the consultant companies. In one procured area comprising 336 kilometres of roadway, 305 bridges, 420 kilometres of drainage pipes, 950 road signs, and 3,400 lighting masts, costs were reduced by over 15%, at the same time as the quality of the operations improved.

In a global perspective it is New Zealand that has advanced farthest with regard to opening up the roads sector to competition, and by now almost all maintenance and operation of the state road network is handled in this way. The consultants are also responsible for the day-to-day operation of the ‘asset management system’ that is used partly to plan and control operation and maintenance, and partly by the road manager to monitor the entire road management process. Private consultants also carry out a large part of both the long-range planning and the planning of local roads.

2. Road management is being increasingly transferred to more independent organizations

As discussed earlier, road management’s supply side may lie inside the framework of a government ministry. In several countries, these operations are being transferred to more independent organisations – similar to the Swedish National Road Administration – that can in some respects act more freely than a government ministry normally can. An example of such an organisation is the Highways Agency (HA) in England. It is emphasised that this development only represents a limited change in the conditions that apply to road management. It is still the Government that orders and pays for road management while road management services, drafting policy, long-range planning, and the administration of road issues are generally done by another organisation. The purpose of making the change is for the Government to have road management activities divided into a client side and an execution side for reasons of efficiency.

In Great Britain, different ministries previously ran most activities in the public sector. The management of the country’s main roads was the responsibility of the Department of Transport (DOT). On 1 April 2004, the new organisation, HA, a so-called "Executive Agency" under the DOT, took over the responsibility for the management of main roads in England. Responsibility for the management of the main roads in Scotland and Wales was also later devolved to similar organisations.

The forms for managing, controlling and monitoring that apply at the HA are in many ways similar to those that apply at the SNRA. The HA must for example adhere to public procurement rules. Officials are recruited on terms similar to those in the private sector. The HA primarily deals with planning, procurement, monitoring and inspection with three-year appropriation frameworks. The client function remains with the government and its various bodies.
Originally, the HA functioned as an "asset manager" with the task of running road management on the basis of the infrastructure itself. Since 1998, the HA has had the task of acting as a "network operator", and also of controlling traffic in such a way that the road network is used in the best possible way. This new orientation has meant increased use of functional concepts in the planning of measures to be taken on roads and attitudes in the organization.

The HA therefore has a department called "Network and Customer Services" whose real job is to translate road users’ demands into functional demands. Another department, "Project Services", has the task of delivering new roads, operation, and maintenance that meet the demands stipulated. The HA is in the process of being split into a part that is responsible for formulating quality requirements and a part whose job it is to provide services that satisfy these demands. The organisation has no operations in its own right and therefore to a very great extent engages consultants for planning, detailed planning, and inspection.

3. Costs and effects for the transport system and data capture

Agencies need to develop strategies to decide on the types of actions and investments needed\(^{42}\). Asset management strategies can help agencies in this regard by providing trade-off analysis techniques to decide on a set of viable investments. Thus, asset management does not support the idea of a fixed set of strategies, and agencies needs to be flexible in their actions. Although actions can be tailored to particular situations, the following key elements should be included:

- Well defined measures of performance
- Effective distribution of roles and responsibilities
- Reliance on good information in all stages of infrastructure management
- Examining a range of options with effective trade-off analysis techniques
- A comprehensive decision making approach
- Management emphasis on customer service and accountability

The culture is changing, and the old ways of “worst first” project prioritizations have been and are continuing to be replaced by thinking in terms of system optimisation. As the data collection and management processes come on line and further linkages to the strategic plan are created, Michigan will realize additional benefits and will continue to be a model to other states looking to reap the substantial benefits of asset management.

The use of robust optimization\(^{43}\) has been introduced to deal with epistemic uncertainty. The Hurwicz criterion is employed to ensure management policies are never ‘too conservative’. An efficient solution algorithm is developed to solve robust counterparts of the asset management problem.


\(^{43}\) Kenneth D. Kuhn, Samer M. Madanat, Robust Maintenance Policies under Uncertainty in Asset Management, Department of Civil and Environmental Engineering, University of California Berkley, CA 94720, 2004.
A case study is used to demonstrate how the consideration of uncertainty alters optimal management policies and shows how the proposed approach may reduce maintenance and rehabilitation expenditures. It is quite clear that incorporating a robust optimization methodology will represent an important step forward for asset management systems.

In examples from England, it has been shown that it is the quality of the investments and maintenance rather than volumes that is important. Quality appears to ultimately depend on the contractor’s ability to identify, list, and plan urgent measures either as running maintenance or as improvements, and then carry out the work efficiently. This kind of maintenance has proved to work well on English roads, but less well on the railways. As regards the management of the railways, the potential savings resulting from more efficient maintenance are considered to be enormous (more than £266 million) without making any compromises as regards safety and transport quality.

The comparison between the two infrastructures has also shown that it is not the involvement of several contractors in itself that causes problems on the railways, but the lack of interaction between decision levels and of incentives to reduce asymmetries in the information. The final sentence is formulated as a question; are asymmetries in information related to the infrastructure’s quality to be allowed to remain?

4. Other values in the transportation system where effects occur and data capture

It has been determined (OEC, 13-Dec-2000) that there is no limit to which technology can be incorporated into an asset management system. With improved information technology, new avenues have opened to infrastructure management. Technology like GIS, GPS and interactive maintenance tools can be made a part of an asset management system. Intelligent transportation systems provide a new dimension to managing assets and enhance the management of new kinds of ITS assets.

New technology that allows trade and industry’s logistics systems to be further developed (including monitoring) is one of the less discussed questions in TAM. The question, however, is one that greatly interests trade and industry. In the USA alone transportation companies’ losses are said to amount to over $40 billion as a result of theft while goods are being transported. Further losses arise in connection with accidents, traffic jams, road closures, and other delays – costs that are additional to the enormous losses due to theft.

This article describes a mobile asset tracking device that combines Global Positioning Technology (GPS) with a Globalstar satellite simplex transmitter and advanced battery design. The device does not require external power sources or antennas, but instead, relies on a host processor that is powered by hybrid lithium thionyl chloride primary batteries.

The TAM process should make it possible to capture high quality data about the utilisation of the transportation system. Details of vehicles, freight, weights, the values of these assets, and routes, can be accessed in theory. The article is also an example of the current general level of ambition as regards asset management in trade and industry.

41 Roger Vickerman, Improving contracts for the provision and maintenance of transport infrastructure: the output measurement problem, Keynes College, University of Kent, Canterbury, CT2 7NP, UK, 2004.
In an efficient, integrated transportation system with combined transports and similar arrangements, knowledge of the transportation network in the form of roads, railways, shipways, including ports and air routes must be extremely good.

The article contains a discussion of “communications options, including cellular and satellite-based systems, as well as the data requirements of asset management systems. Operational challenges related to inventory management and real-time tracking are also discussed”.

GPS technology, voice-controlled software, and digital cameras have been used to inventory and collect “asset condition data” in Turnpike Enterprise Asset Management (TEAMS) – a tool designed to facilitate the handling of the 43-year-old integrated toll-road network in southern and central Florida. TEAMS allows Florida’s Turnpike Enterprise to administer all these roads and equipment with a “click of a mouse”. Using its number, an individual component can be viewed on video and detailed information, for example about the component’s condition, can be retrieved for further assessment.

Users of the TEAMS can for example “query by timeframe to determine which assets might need replacing within a set period, say over the next 6 months. This saves the Turnpike Enterprise time and money by purchasing equipment and supplies in bulk and planning ahead for traffic disruptions. Engineers can also bring much of their work indoors, reducing field visits and accelerating design cycle time.”

“As the TEAMS database grows year after year, asset conditions and repair costs can be compared and monitored to make maintenance scheduling and budget forecasting more accurate, allowing the turnpike to optimize capital spending. These innovative features require a robust, sophisticated system that immediately displays high-resolution photographs, calculates precise geo-positioning data, and allows users to drill down quickly to detailed information.

In addition, the web-based application must interface with nine legacy systems and eight existing databases. Integrating existing data presented one of the toughest challenges because information was stored over the course of many years of facility operations in a wide variety of formats”.

“Implementing an asset management system represents a major shift in philosophy, one that has evolved from traditional reactive, “fix-it-when-it-breaks” management to a pro-active, “fix-it-when-it’s-most-cost-effective” style”. This summary leads in a natural way to the next chapter about action-related questions.

5. Forms of contract - new forms of procurement

Contracts in the construction industry have previously normally been procured in the form of performance contracts. Characteristic of such contracts is that the client is responsible for engineering and that the agreement with the contractor is based on an agreement as to the different quantities to be delivered according to the engineering specification stated and the unit prices of these quantities. Performance contracts are also characterised by the fact that the procurement is based on a detailed plan drawn up by the client.

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In recent years a new form of contract based on functions has begun to be introduced in the roads sector. The client states the function or the results that are to be achieved and leaves it to the contractor to decide on engineering and materials. Functional contracts can be used for both operation and maintenance and road investments. The contracts normally need to be long-term, for example 10 years for maintenance contracts and 20-30 years for an investment. Another requirement with regard to this type of contract is that the contractor must take total responsibility for the road during the period of the contract. The advantage of this type of contract is that it stimulates innovation and development.

In functional contracts, as opposed to performance contracts, the contractor takes more and greater risks as a consequence of his total responsibility for the engineering solutions. Greater risk-taking is a driving force to seek better and more cost-efficient engineering solutions than the traditional ones. A functional contract opens up possibilities to act on the basis of different strategies in order to reduce costs related to the project-specific risk directly. A conventional construction contract does not contain the same incentive to achieve such a cost reduction since all the risk-related costs are borne directly by the taxpayer. This means that the costs of risks in functional contracts are shifted to the contractor, but not that they are any less in total for the client.

In Sweden, all-in contracts have also existed. In such contracts, the contractor is responsible for both planning and construction. The design of the actual contract in the case of all-in contracts has hitherto been characterised by the fact that the contractor is forced to adhere to the construction engineering form stipulated by the SNRA (the SNRA’s specifications), and is not responsible for maintenance once the road is completed.

Other countries have been using functional contracts for a few years. The best known examples are the DBFO (Design, Build, Finance, Operate) procurements that have been made in England. The contracts have also attracted interest because payment is made through shadow tolls. The central feature of this form of procurement is that it is intended to be based on functions, although for various reasons this is only partly the case.

Other countries that have begun using DBFO contracts or are about to introduce them are Finland, Holland, Portugal and Argentina. Payment may be independent of traffic, as is the case in a number of similar contract types in other countries. There are also good reasons why shadow tolls should not be used and that payment that is largely traffic-dependent is to be preferred47.

A concept known as PPP (Public, Private, Partnership) is also found in the roads sector. In a European Union context, this describes the private production of services supplied from the public sector. Normally, these are not only projects procured by means of ‘alternative financing’, but also those projects financed by means of charges (tolls) paid by users. The PPP concept is used in this way in a publication from the Swedish Agency for Administrative Development48.

Road authorities in a number of countries have also begun to use long term functional contracts that run over 5-10 years. There are also several examples of this form of contract in the USA, Finland, Holland, England, New Zealand, Australia, Argentina, Brazil, Chile, Peru, etc. New Zealand has begun to use this form of contract for the maintenance of road networks even on a large scale. Ten similar contracts have been entered into in Australia, covering a total of more than 20,000 kilometres of road.

No country in the world, however, has come as far as Argentina in this area. Since 1995, the country’s road authority has been signing five-year contracts for the maintenance of roads with little traffic in road networks of 200-300 kilometres. Characteristic of these contracts is that they are functional contracts and that they therefore also mean that the contractor must rebuild (rehabilitate) roads in order for the contracted functional requirements to be met. The contractor has total responsibility for the road over the whole contract period. So far, 61 contracts have been signed covering almost 12,000 kilometres of asphalt road (approximately 40% of the paved national road network). Another 20 contracts will be signed in the near future covering a total of 2,700 kilometres. An extension of the contract period to 7 or 10 years is being considered for these new contracts.

All functional requirements contained in the contracts are expressed in quantitative terms and cover such aspects as evenness (the IRI value must never exceed a given figure that varies depending on the type of pavement), rut depth (which must not exceed a given depth), cracking, the occurrence of potholes (which in principle must not be more than 2 cm deep), and friction. If the requirements are not met, deductions are made from the payments that are made once a month. Before any deductions that might be made, the payment is the same every month and totally independent of the work done by the contractor. The contracts assume that all contractors develop and apply their own quality assurance system.

In Argentina, the road manager has also entered into 11 road maintenance contracts covering 3,600 kilometres of paved road in good condition, and the contracts therefore only include maintenance and not rehabilitation. These contracts run for two years at a time, but can be renewed. Here, too, fixed payment is made and is totally independent of the work done by the contractor. It can also be mentioned that since 1990 Argentina has had tariff concessions on approximately 10,000 kilometres of paved road with normal amounts of traffic. The concession-holder has the right to charge tolls on condition that the road meets the requirements stipulated with regard to function, service, rescue services etc.

6. New forms of payment for construction contracts

In traditional construction contracts, the contractor is paid according to quantity and the unit price list in effect. The contractor is also paid – generally – as soon as the quantity stipulated has been delivered. With regard to road construction, a final settlement is made against the amount guaranteed after approval in a final inspection, which is normally made two years after completion of the road.

In recent years, new forms of payment have been introduced. There are two aspects that characterise the new forms of payment: payment to the contractor is not governed by the quantities delivered and payment is made at relatively regular intervals over the contract period. As mentioned earlier, the new types of contract normally run for at least 5 years. DBFO contracts in England run for up to 30 years.
Two forms of payment have been used so far. England has used a form of payment linked to the amount of traffic according to shadow tolls. The road manager pays the contractor for each vehicle that uses the road after it has been opened and for the remainder of the contract period. Thus, it is not the road user who pays the “shadow toll” but the road manager/government.

In other cases, the contractor is paid a fixed amount per month and year, possibly adjusted to the amount of traffic. The annual sums paid by the road manager to the contractor can be adjusted in both cases with both bonuses and deductions depending on whether the road provided by the contractor is of € higher or lower standard than that stipulated in the contract.
Appendix 2

Cash-related questions

Cash-related questions should be able to be summarised and clarified in some form of Cash Flow Statement. Cash-related questions may concern control and how financing is taken into account, including questions of road-pricing, appropriations, taxes, tolls, borrowing, the mixture of private and public financing, road funds, cash management using financial instruments, questions to do with invoicing and payments, accounting, and internal control.

Viewed in an international perspective, road management is going through a process of change. This appendix describes different development directions as regards financing, primarily supported by information contained in Bruzelius et al., 2002.

1. Financing through revenues – earmarked taxes

The roads sector has principally been financed through appropriations. Despite road traffic having been subjected to a series of selective taxes, these have not been earmarked for the roads sector. In recent years, a great many countries, principally developing countries, have begun to use selective taxation to secure financing. This method of financing, however, is only a complement to financing through appropriations. Some of the revenues from, for example, taxes on fuel go to a fund that is then used to finance specific road management activities, normally maintenance. The road funds are controlled by the Government, who normally decide both the levels of charges/taxes and thereby the revenues placed in the fund and the annual disbursements made from the fund.

Until the 1980/81 budget year, all petrol tax and part of the motor-vehicle (road) tax and the kilometre tax on vehicles that run on diesel was in Sweden paid into an automobile tax fund. This fund, which was used to finance road maintenance, was done away with as it was assumed that the government could best decide the balance between investment and maintenance. Decisions would therefore not be limited by the existence of a road fund.

After the Second World War, many countries financed their road maintenance partly by means of earmarked taxes. These have been abolished in most countries, the USA and Japan being two of the few exceptions. In the USA, the U.S. Federal Highway Trust Fund receives its revenues from a tax on fuel. The federal government receives contributions from the fund to finance investments in roads of national importance. The fund can nowadays also be used to finance measures aimed at public transport and road safety measures. In Japan, investment and maintenance have been financed by means of the Japan Road Improvement Special Account for a long time.

Above all, earmarked taxes and road funds are used to cover part of the cost of road management activities in countries in Africa, Latin America, and Eastern Europe. One reason for this is that the budget process in these countries does not work well. In countries that were formerly part of the Soviet Union, the reason may be that the country began to use a system of self-financing for roads during the 1980s – part of the glasnost policy of transferring power out of the Kremlin. Several countries, for example Latvia, have retained and developed this system following their independence.
The road fund that Latvia has today was established through a law governing vehicle taxation introduced in 1994. A national road fund and a number of municipal road funds were set up. The law states that 70% of the vehicle tax revenues will go to the national road fund and the remaining 30% to the local funds. In 1995 and 1996 the system was expanded by also earmarking some of the revenues from the tax on fuel. The revenues from the tax on fuel are divided between the different funds on the basis of the amount of traffic.

The law introduced in 1994 also created an advisory body for the road fund for state roads. This body’s task is to make recommendations to the government about the level of the taxes that generate the revenues and how the money in the funds is to be used. The members of the advisory body represent both the public sector and road traffic stakeholders. The road fund is administered by a secretariat at the Latvian road authority. The setting up of the fund has drastically increased the appropriations to road maintenance. The money in the road fund can be used to finance all elements of road management except new investments.

The International Monetary Fund (IMF) has for a long time maintained a wait-and-see attitude to the increasingly widespread policy of earmarking taxes in the roads sector. Traditionally, the IMF’s opinion has been that earmarking risks undermining the national budget process and making it difficult to enforce responsibility for the administration of public funds. The IMF recently made its view on this issue known in more detail by stipulating a number of requirements with regard to the motives for setting up a road fund and how such a fund should be organised.

These requirements first and foremost mean that it must be able to be shown that the introduction of a road fund can be expected to result in efficiency gains and that there are no alternatives to achieve such gains. Secondly, the money in the road fund must be used only for its intended purpose (financing maintenance). The third requirement is that the road fund will not only be a cashier but should also take on the role of client. Fourthly, the road fund must have sufficient competence in the areas of financial management and accounting, and fifthly it must have a board that stands free of any special interests. The board must be accountable for the results. New Zealand and Namibia are probably the only two countries in the world today that fulfil these requirements.

2. Financing through revenues – road tolls

A great many countries, including France, Spain, Italy, Hungary, Poland, China, Malaysia, Mexico, the USA and South Africa, have used and still use road tolls to finance, and also for a time service, motorways and other expensive road installations. Great Britain, just like Denmark and Sweden, has hitherto only used road tolls to finance major road projects in the form of tunnels and bridges. In a road toll, a concession-holder may levy a special charge for using a defined part of a road network. This charge is paid in addition to the other taxes and charges that burden road traffic.

In some cases, for example in Denmark, Sweden, the USA, France, Spain and Italy, state-owned companies hold the concession. Often, for example in China, Poland, Hungary, Thailand and South Africa, contracts are entered into with private companies by allowing companies to compete for the concession.

49 Barry H. Potter: Dedicated Road Funds: An IMF View, 1997
Financing by means of tolls normally require large traffic volumes. A concession entails uncertainty for the owner. It is often the subject of debate about the amounts charged and the effects.

There are two basic types of toll road. The first is characterised by the fact that different parts of a large road network (of motor ways) are built and operated by different concession-holders and that these parts of the network are relatively small. Usually, other parts of the motorway network are not operated as toll roads. This type can be found in developing countries and in Central and Eastern Europe. What characterises the second type is that one company alone is responsible for the construction and operation of the whole toll road network. In Japan, a state-owned company, Japan Highway Public Corporation, holds the concession for a total of 9,000 kilometres of road. Development towards a more uniform company structure with responsibility for a network of high-class roads is going on in several developed countries, including Italy, France, and Spain.

3. Financing through revenues – a self-financed roads sector

Further steps can be taken with regard to financing, ordering, and performing road management, where the government not only delegates the carrying out of road management but also sets up a self-financed client function based on revenues from road traffic charges. New Zealand has already taken this step but with only partial delegation as regards financing. This type of reform may require a new form of non-profit organisation to be created – a juridical person in its own right with a legal framework that resembles different forms of association in the private sector more than government agencies. An incisive way of describing New Zealand’s arrangement is that road management has been delegated to a ‘road association’ with responsibility for the state-owned road network. Road associations are common in Sweden for more or less privately owned roads, where the members are responsible for financing, often with municipal and/or government subsidies.

New Zealand is the best-known example of a reformed roads sector. Its distinguishing features are:
1. that the road manager, Transit New Zealand, that is mainly occupied with strategic questions is a small organization (approximately 220 employees),
2. that the client function belongs to a separate unit, Transfund New Zealand,
3. that the road network is financed through road charges.

Both Transit and Transfund are state-owned organizations with a great degree of independence. They are operated as non-profit organizations and are controlled by legislation that in many respects resembles legislation in the private sector. All day-to-day operations have been assigned to private companies through competitive procurement. The roads sector is financed by road charges that consist of a charge on petrol, an annual vehicle charge, and a special charge levied on diesel engines similar to the kilometre tax on vehicles that run on diesel that Sweden had previously. The Government sets the level of the charges, but all revenues go to the roads sector.

The independent road management system is an object of constant, extensive scrutiny. In the first place, stakeholders in the roads sector have a consultative role, and secondly, not only a financial audit but also an operative audit based on the agreements that the two organisations have entered into with the Minister of Transport are carried out once a year.
Appendix 3

More on accounting according to GASB 34

Various aspects of GASB 34 are discussed in a number of articles, for example the advantages and disadvantages of the two accounting alternatives that GASB permits.

Below follow some extracts from one of these articles50:

“GASB Statement No. 34, Basic Financial Statements—and Management’s Discussion and Analysis—for State and Local Governments (GASB 34), is a mandate of sorts that is not given to us by the federal government, but by the Federal Accounting Standards Board, which can hold the ‘clean audit’ over our heads if we do not comply. GASB 34 gives us two options for how to file the required annual reports: modified or straight-line depreciation methods. Both methods have benefits and drawbacks.

The benefit of straight-line depreciation is the ease of reporting and tracking. Once the initial information or database is developed, it is easily maintained. As time marches on, the asset depreciates at a rate that is established at the onset. The largest drawback to straight-line depreciation is that, for all the effort a department must put forth to develop the database, there is no required maintenance of the database so that it can be used in the end to help make maintenance-funding decisions to benefit the travelling public. The drawback to the modified approach is the continuous effort it takes to maintain the database. A well-maintained database can be used in return by a department to help make justifiable maintenance decisions that can be shown to be good, justifiable, and defendable expenditures of the taxpayers’ money.

Thus a significant benefit of the modified approach is that it reflects the actual state of the asset, taking into account actual wear and tear of the asset and the funds put back into its upkeep, as well as major improvements to the asset. Through discussions with a number of public works, street, or road and bridge officials throughout the Midwest, it appears that the most frequently chosen reporting method is the straight-line depreciation method, due to the ease of determining asset values after the initial report.

A number of initial questions had to be answered before beginning the data collection. Did we want all of the inventoried data to be tied to the county’s geographic information system (GIS)? What did we want to inventory? How did we want to segment the roads in the system? What type of rating system did we want to use? It was decided to create a rating system that could be easily replicated and understood by someone with a basic understanding of road maintenance. The university students and county staff traveled throughout the county to find a variety of conditions, from excellent (new) to failed. Pictures were taken and placed in the manual for future reference during the initial ratings, as well as future updates to the overall condition reviews. Roads were rated from 5 to 1, 5 being the best and 1 being the worst. Drainage structures, signs, and guardrails were rated 5, 3, and 1. Each of the initial data collection teams was given a simple handheld global positioning system (GPS) unit, 30- and 100-foot tape measures, a carerra, and a letter explaining what each of the teams was doing for the county to present to anyone who might stop them along the way.

The ratings for the paved roads took a number of items into consideration: widths, drainage, pavement edge condition, cross slope, potholes, pumping, and cracking (lateral, longitudinal, and alligator). The gravel roads were rated on width, cross slope, drainage, gravel condition, washboarding, and potholes”.

“Each rating (5 to1) is given a multiplication factor ranging from 0.95 to 0.225. The number then will indicate the asset’s value at this time in relation to its original value. It is possible that the values will change as a history is developed, and engineering judgment may be applied. The summary sheets provide an overall snapshot for each year showing a rating of every asset. The summary shows, for example, how many miles of asphalt roads are in excellent, good, fair, poor, or failed condition and the overall value of asphalt roads in the county.

One of the main goals of the county is to develop a five-year budget/rehabilitation program. The local government can determine a performance level at which the assets, on average, are to be maintained for the use of the public. By providing the department, the county commission, and the public an estimate of the funding needed to maintain the pavement at the required performance level, the agency could know how much it would cost to fix all the pavement to the acceptable desired condition, assuming a budget limitation with a five-year horizon.

This is a cost-effective way to maintain an agency’s assets. If the infrastructure assets can be maintained to the predetermined condition, the need for deferred maintenance will decrease, and thus the life-cycle cost for the whole network will decrease.

The condition matrix will take into account traffic volumes, worst sectional condition, and traffic loading. The cost-effectiveness will consider enhancements in comparison to cost of treatment. Finally, the maximum benefit will group projects by area to combine the cost-effectiveness for the budget year”.

The next article51 also discusses the two methods. An extract from this article also follows.

“The article also describes the Depreciation and the Modified Approaches, the two approaches permitted under GASB 34. While the depreciation approach involves estimating the current condition of the assets that are managed and depreciating the assets over the anticipated useful life, the modified approach involves first deciding what an acceptable overall condition for all assets is, then basing maintenance management strategies on a set index of quality. The article notes that the modified approach, while being the more difficult approach, provides greater accountability at a public works or a government entity level”.

The same question is also discussed in yet another article52.

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This paper illustrates how an agency’s pavement management database can be used to determine the replacement value of an agency’s pavement assets using both the depreciation and modified approaches. The depreciation approach offers several benefits since it follows a more traditional accounting approach and may be easier to implement. However, the modified approach, especially with the assistance of a pavement management system, also can be easy to use and has the advantage of showing the value of maintaining the roadway asset. In turn, the modified approach provides an additional use of the pavement management system, which can help justify the system’s expense. The modified approach also indicates the cost of actually using the asset in a given time frame, while the depreciation approach only provides the remaining cost of an asset, not reflecting the actual cost of using the asset”.

One article53 was found that questions the order in which TAM is normally introduced. An extract from this article follows.

“Public transportation officials I have come to know over 40 years in this industry are by and large dedicated, professional, serious, hard working, and honest and want nothing more than a first-quality transportation infrastructure in their jurisdiction. Yet some jurisdictions have good roads and some do not. Sure, money, climate, location, population, traffic, all have some bearing on the matter, but neighboring states (or towns) can have good roads in one place and bad roads in another, or we may have potholes, yet the city next door can be pothole free. Why?

Speaking as an engineer, I would submit that we are very good at the engineering aspects of our professional transportation decisions, and we are also pretty good at the smaller “e” economic decisions (steel versus concrete bridges, viaduct versus embankment, overlay versus reconstruction, and so forth). However, we as a group of transportation professionals have not often collected the information to understand our return on investment, and as a result we often find we are winning battles but losing the war. It is these bigger “E” economic decisions that we are not so good at.

This way of looking at the consequences of our infrastructure investment decisions is called asset management. What were the consequences of this policy of focusing the funds on the worst bridges first? Certainly we would have had many more deficient bridges without this program, but could we have had a lot fewer deficient bridges if we focused more of the NBRRP funds (maybe 15 to 30% or more) on keeping the good bridges good? What would be a reasonable distribution of funds, applied to a state’s entire bridge inventory, if the goal was to have fewer deficient bridges? “What if?” policy questions are an important part of asset management. Why then are we stalled in asset management implementation?

The problem is that deployment from the top down requires a significant investment in funds to get all the data systems interrelated; in human resources, to not only change over all these systems, but to keep them operating while changing them over; and in the energy the agency leadership needs to break down institutional barriers (“stove pipes”) and traditional practices. In my judgment we have three big hurdles to get over: (1) complexity is an excuse for inaction; (2) it costs too much to change, so we don’t; and (3) getting employee buy-in drains management’s energy.

Most top managers in asset management can easily accept the concepts we should accept: know what we have; know its condition/value; and be able to estimate its performance life. We would like them to evaluate various deployment options so as to make evidence-based decisions for our infrastructure investment, and do this in a way that is transparent to everybody, inside and outside the organization. However, we cannot seem to get past the philosophy stage for the reasons above. Perhaps we should start with concepts that are less complex, less expensive, and easier to understand. What I propose is “viral” implementation: Infect the organization with asset management. Why not build a system that would be very beneficial at the micro level(s) but could grow and migrate throughout the organization?"

“This is the approach I refer to as viral implementation: we infect the agency with asset management until it becomes an epidemic. It will start slow, but that is okay as long as all the steps that are taken are in the right direction”. “By approaching asset management in this manner it will prove not to be so complex and expensive, and the implementation energy will be manageable. It is then possible for the public works professionals—the top managers—to make evidence-based decisions considering both the smaller “e” and the larger “E” economic decisions. The concept of managing the return on investment should be as important to the transportation manager as the rest of the project development and implementation process. By implementing an asset management mindset, better investment decisions can be made”.

One article\cite{54} reports experience from Missouri:

“Asset management in the government sector had a limited focus until the Governmental Accounting Standards Board (GASB) issued its Statement 34: Basic Financial Statements—and Management’s Discussion and Analysis—for State and Local Governments (GASB 34). The impact of this statement on asset management is a great opportunity for governmental entities to improve the focus of their operations and enables them to apply many of the same management practices used by private-sector companies.

With the implementation of GASB 34 for fiscal year 2002, MoDOT has added infrastructure assets (roads, bridges, and rights-of-way) to its financial statements and accounts for depreciation of all depreciable assets on its annual and interim financial reports. Less than a year since MoDOT included the new data in its financial reports, the department’s controller is observing several benefits. These include a shift in the reaction to the financial statements by functional managers at all levels. The managers now understand how the financial reports show the impact of the year’s work on the roads and bridges and the amount of right-of-way owned or considered for disposition. When MoDOT spends large amounts of money on maintenance, the ending value of the roads and bridges goes down due to recognition of depreciation; on the other hand, when MoDOT spends large amounts of money on new construction or replaces roads and bridges, the ending value goes up.

MoDOT has a transportation management system (TMS) database to track roadway segments, interchanges, and bridges and their properties and condition. Data from this system have been used to help identify areas needing funding for improvement (projects to fund).

The ability to combine the financial picture of the infrastructure with the TMS picture of the road and bridge system has given management the tool to look at the current condition of the system and determine how available funds may be used to change or improve it. When funding limits do not allow improvements as requested or required by the legislature or the traveling public, data are ready to show what funding is needed to meet expectations.

They now have access to the book value of roads, bridges, rights-of-way, and excess or remnant rights-of-way to determine what disposition amounts are appropriate to consider along with current appraisals and public benefit information.

The engineering staff and accounting staff are making progress in coordinating dispositions of roads and bridges. The decentralization of the engineering staff and frequency of these events has made this coordination less intuitive. In addition to infrastructure disposition improvements, greater coordination is occurring when other fixed assets are disposed, transferred to different locations, traded in, or leased. In this time of reduced revenues for all governments, the public is requesting more information about the use of their tax dollars and demanding accountability from government officials. The public can see the use of their taxes by program in the statement of activities. The new management discussion and analysis section provides an understandable description of significant events during the fiscal year and items expected to have a significant affect on MoDOT in the upcoming year.

Review of MoDOT’s financial statements by the general public has not occurred to a great extent yet, but is becoming greater. MoDOT’s financial statements are available on its Internet site. The public can now see how funds were budgeted and how the money was spent.”
Essay 3
A model for quality-related valuation and accounting of road capital to the transport asset management process

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Stockholm 2005

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1 Method and Approach

1.1 Introduction

The paper presents a model for quality related valuation and accounting of the road capital and shows by full studies and discussions that the model is feasible. A further prerequisite of the full study is that control and monitoring must be able to be largely accomplished using the information that already exists in the SNRA's systems and databases.

1.1.1 The method and approach in this paper

In the *Quality-Related Valuation and Accounting of Road Capital: a Background and an Overview* the Swedish background and purpose of this paper is presented. The need for improved accounting of road capital is described and the paper is centred on a conceivable model for internal accounting of quality-related road capital. A chapter deals with the requirements and hypothesis for a Transport Asset Management (TAM) accounting model.

The article *Asset Management in the Transport Sector: a Review* describes the needs, the efforts, and how far the leading countries in the area of road management have come in their application of TAM, together with a summary of the most recent research findings in the area.

The essay *A Model for Quality-Related Valuation and Accounting of Road Capital to the Transport Asset Management Process* details a theoretical valuation and accounting model that is designed to meet the need to control, monitor and communicate road management in respect of the TAM-processes and the objectives in the national transport policy of Sweden, from the national political level down to the operative level. A model and principles for quality-related accounting is presented and the links to traditional external accounting are shown. The valuation technic in the model is described.

In chapter 3 the results in the form of examples from two case studies of the model are presented. The reference model is analysed and discussed in chapter 4. It is compared with the traditional model principle for valuation and accounting. There are discussions of the possibility of carry it into effect and three approaches for “value in”, about needs in road management processes and of indicators. Also e.g. the input questions and effective new technics therefor are dealt with.

On the basis of knowledge of needs and the international application of TAM, the reference model for valuation and accounting road capital is in chapter 5 tested against the presented hypotheses described and the objections that have been raised over the course of the work. The experiences from results of the application examples and analysis used leads to a conclusion.

A step-wise description of the approach and a diagrammatic outline of the process are given below.

*Step 1 – what is to be tested*

This paper focuses on the concrete improvements in the accounting system for the purposes of controlling and monitoring road management (from the political level down to the operative level) that the model is designed to accomplish. Hypothesis, application, research position, and other prerequisites are clarified.
The following groups of information users have been identified:

- the responsible government administrators/executive officials and the politicians involved in the national political processes,
- the responsible administrators/executive officials of the county administrative board and the politicians involved in the local political processes,
- users of the road network, the public / taxpayers and responsible officers in trade and industry,
- the SNRA’s management (including the board) and the responsible officers in the SNRA’s central processes,
- the SNRA’s regional management teams and the responsible officers in the regions’ governing subprocesses,
- the people responsible for operative processes, i.e. projects with contractors and consultants,
- the people responsible for the operators’ and consultants’ assignment-specific processes.

The introductory analysis leads into a general description of the empirical problem and the possibilities that are desired in an improved model for the control and monitoring of road management.

Step 2 – the accounting model for quality-related road capital
The model’s definitions, concepts, theoretical structure and principles, measurement methods, and quality requirements are sufficiently detailed to be able to be analysed on the basis of the concrete improvement needs.

A few limited case studies are made of the model in use, partly to show that the model can be used in practice with existing data and computer systems, and partly to illustrate how the data output from the model can be presented. An example is also given of how the concrete accounting can be designed.

Step 3 – analysis and discussion of the approach and the model in use
Analyses are made of whether the improvement needs have been satisfied for the different groups of users, what information can be obtained using existing systems and databases, what quality deficiencies were identified, and what possibilities exist to obtain the missing information.

Strengths and weaknesses, uncertainties in the conclusions, and the model’s contribution to closing empirical “knowledge gaps” are also described. From a user point of view, the model is built up based on the conviction that the most detailed information is needed at the lowest operative levels in Step 1, and that superior levels’ needs can be satisfied by accumulated data and analyses of more detailed information from lower levels.

The analysis from the points of view of the seven user levels is therefore made from the bottom up. It is, though, also important to consider the other direction, since some data may be meaningless in a limited context at a low operative level. In spite of this, the data may need to exist and be generated with high quality at this “lower level” in order to be able to be used in accumulated form at higher user levels.
In addition to the approach, the objections etc that were raised during the course of the work are also discussed here. The model’s possible impact on some of the more laborious of the road management processes is also considered.

Conclusions are drawn in a holistic perspective with regard to the model’s ability to satisfy the demands, as they are described in Chapter 1, but also from the point of view of the remaining empirical “knowledge gaps” and the need for continued research. In this paper we are focusing that kind of concept for a valuation and accounting model. The possibilities and the limitations of this model will be analysed in papers to come.

Figure 1 shows the approach in diagrammatic outline.

![Diagrammatic outline of the method and approach in this paper](image)

**Figure 1** Diagrammatic outline of the method and approach in this paper

This paper is part of a larger study and serves as the starting-point for the continuation of the research work. The work as a whole will highlight the possibilities to use the accounting of road capital and other values in the transport system to monitor and control road management. Therefore, this paper will be followed by a number of other papers dealing with related subjects.

### 1.1.2 About Transportation Asset Management and the explicit needs

There are many definitions of Transportation Asset Management (see A Background and an Overview, Appendix 1). The one most commonly used is that formulated by The Federal Highway Administration, which is part of the U.S. Department of Transportation.
When analyzing the TAM process it is normally appropriate to describe information needs in order from the top administrative level to the bottom, although a fairly good overview exists of different TAM objects and possibilities for higher levels of Swedish management. There is also a conviction that an efficient model of the TAM process is based on the principle that appropriate information for a superior administrative level should be based on accumulated information from the administrative levels immediately below (the accumulation principle). A theoretical, rational idea is that bad top-level decisions are generally a result of poor quality of information, and that unsatisfactory outcomes are often a result of bad or late decisions – or “no decisions at all” – with regard to difficulties generated or observed at an underlying or more operative level.

Road maintenance at the SNRA has political transport targets, in principle based on cost-benefit analysis for society and road users. Many calculations of this type are made at the SNRA, especially with regard to road investments. In these calculations there are many relationships between the physical standard and/or condition of a road and their effects for road users (such as costs for transportation time, vehicle use and ill-health) and for society (such as costs for traffic accidents and willingness to pay to reduce negative environmental impacts). Maintaining a comprehensive view throughout an AM analysis, while incorporating these targets and relationships, is therefore a major challenge.

Bearing this in mind, there is a need for management support from an accounting model with the focus of data for the TAM processes. The model’s starting point should be the financial information about ongoing road production (based on current data about road investment projects and road operations), the road capital (based on current data about the road’s physical standard, condition and deficiencies), and the need for financial support information in the relevant basic processes in operative road maintenance. Such basic processes affect planning, resource allocation, project management, follow-ups, benchmarking, other analyses, procurement, accounting, reporting, etc.

National transport policy and TAM dictate that control must as far as possible consider the values (positive and negative) that exist in and are generated by the transport system. The starting point for TAM from the point of view of the national economy means that it is relevant to define road capital in terms related to the national economy. Unfortunately, complex linkages exist with “most things” and with other activities in society, so such a definition would hardly be appropriate for control and monitoring based on a uniform, controllable, and credible value of road capital.

The valuation of road capital is therefore based on the physical (fixed) asset. The values related to the national economy influence the limit values in the model and as to the rest they are dealt with in each specific context. This will be analysed in detail in a later paper.
2 An Accounting Model for Road Capital

In the following, an attempt is made to describe an appropriate model for accounting road capital, which also can give correct road maintenance costs. The information that is accumulated from the model also is believed to meet the needs that exist with regard to TAM.

2.1 Road capital and valuation in general

There is no generally accepted definition of the concept of road capital\(^1\). However, this has not prevented the term from being used in many different contexts for more than twenty years. What the term was being used to refer to was generally clear from the context. If road capital data is to be used for monitoring and managing purposes or in construction contracts, the concept needs to be clearly defined.

A fixed asset according to Swedish accounting regulations is “an asset intended for permanent use or possession”. A general requirement is that a company’s fixed assets are accounted and valued individually in an asset register. A fixed asset at the SNRA has an acquisition value of SEK 10,000 or more and has an estimated life of three years or more. It must be owned for the whole period and must be used in some way in the Administration’s operations.

The SNRA’s final accounts today contain an item called Road infrastructure without any further division into subgroups. The item is the sum of the acquisition values of past road investments less the total accumulated depreciation on the assets. Depreciation according to plan is linear and all road installations have an assumed economic life of 40 years, which means that road installations are currently depreciated at 1.25% semi-annually.

Why the economic life is set at 40 years is not clear. Studies made by the Institute of Road Technique (VTI)\(^2\) have indicated that the economic life of road investments can vary widely, from twenty years around major conurbations up to a hundred years in sparsely populated areas. One explanation might be that 40 years is an assessed average life that is applied when dimensioning engineering investments (bridges, for example, are dimensioned for a life of at least 80 years and road surfacing in practice has a life of between 10 and 15 years).

When we study roads’ different components, their economic life varies from a few years for certain types of surfacing and road-sign gantries (on some roads) to over a hundred years for some bridges, tunnels and country roads. These variations are highly significant when describing the costs and finances of road maintenance and the life cycle costs of individual components.

Road investments are financed for the most part through appropriations that are settled with the Government annually. Investments are also partly financed by loans that are amortised over shorter periods than 40 years. This financing model means that the SNRA’s equity has a capital item called State capital (previously Road capital and Written-up capital).

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\(^1\) Ekdahl Peter, Deterioration Models and Road Capital as Tools in Performance Contracts for Pavement Maintenance (Nedbrytningsmodeller och vägkapital som verktyg i funktionsupphandling av vägunderhåll), Lund Institute of Technology, 2001

\(^2\) Jansson Jan Owen et al., an oral presentation in Borlänge 1994 on behalf of the SNRA department of planning.
A note to the Balance Sheet details the volume of investment (new and settled) in road infrastructure for the year and the reduction in State capital covering depreciation of road infrastructure for the year. The SNRA’s net profit according to the Profit and Loss Account (Change in capital for the year) is quite naturally negative with the accounting principle applied, since “Depreciation of road infrastructure financed through appropriations” is taken up there as not yet financed.

It would be educating for most readers of the SNRA’s Annual Report if the State issued a directive authorising the authority to "use" State capital as an income item in its accounts; ‘Income from State capital for depreciation according to plan’. The Profit and Loss Account would then be easier to understand and the reported profit would give a clearer reflection of the authority’s operations.

When politicians speak about maintaining road capital they are not, generally, referring to the values booked under Road infrastructure or State capital/Road capital/Written-up capital. This would have no practical importance, especially since the reported depreciations do not reflect the real change in value of the road investments. “Maintaining road capital” normally has a more practical meaning, i.e. that the SNRA ensures that the roads continue to fulfill their intended function through maintenance, preventive action etc. Sometimes, the term also includes increases in standard to keep pace with society’s changing needs and more stringent demands.

Roads represent not only technical values but also values related to the development of the national economy. The latter are difficult to estimate even at a general level. We could in principle, in order to put a figure on the value to society of the present road infrastructure, consider its entire historic value to the national economy, i.e. assess the total benefits and sacrifices resulting out of road connections, from the very first footpaths up until the roads we have today.

The values to the national economy that have developed out of the expansion of the transport infrastructure are enormous. In order to monitor and manage a road transport system at the service of society and financed through public funds, it is a reasonable demand that an appropriate definition of the concept of road capital also include this aspect. Whether this demand can be fulfilled is however still an open question.

The national transport policy demands that control as far as possible take into account the values, both positive and negative, that exist in and are created by the transport system. The basis, as regards the national economy, for a definition of road capital is relevant but due to complex linkages with "most things" in society will hardly lead to a uniform, controllable, and credible value of road capital appropriate to monitoring and management.

Sometimes politicians also use the term road capital to refer to marginal economic effects of the road network, ignoring cost of capital and the local effects of encroachments on the environment in connection with implementing investments – what’s done is done.

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3 Jansson Jan Owen, report dated 18 March 1993, VTI
A physical valuation of the road capital can be made froma number of starting points. A functional value might be based on the expected economy of the customers’ transports. Alternatively, the functional value could be based on the expected society’s direct costs in respect of personal injury and negative environmental impact, for example. The physical valuation could then be made on the basis of the following perspectives:

- The road user perspective, which would give a valuation based on transport economy covering the costs of travelling time, vehicles, freight, and ill health with regard to passenger and freight transport.
- The political perspective, which is fundamentally a holistic perspective. The political perspective is limited here to the direct effects for society of accidents involving personal injury, environmental damage, impact on regional economy, and other consequences related to public responsibility.
- The road manager perspective, here limited to a purely business-economic perspective with technical-economic aspects (a focus on quality, productivity, and life cycle).

The national transport policy covers all three perspectives together. A prerequisite to be able to make systematic, uniform valuations of road capital is that clear criteria for making assessments are established. The criteria for the quality-related valuation of road capital can be defined for the three different perspectives.

The criteria and quality requirements that govern the valuation can be based on parts of the road user and politician perspective. If, for example, it is stated that rut depth in the pavement of a road with a permitted speed of 110 km/h is not to exceed 15 mm as an average over 20 metres, this limit may have been set on the basis of what is known about how rut depth affects transport costs. It may also have come about as a result of the risk of accident. The 15 mm limit affects both the time and cost of taking corrective action and is one of the prerequisites for calculating the quality-related value of the pavement in question.

Studies have shown that up until 2001, different groups of road users were becoming increasingly dissatisfied with road maintenance, despite the continuous improvement in the measurable quality of road maintenance, according to the SNRA’s own criteria. Their dissatisfaction may be a result of anything from a lack of information about road maintenance and unfortunate attitudes in customer contact, to a perceived lack of safety and security on the roads, measures taken in the network that are difficult to understand, and shortcomings in the SNRA’s models for taking transport economy into consideration. It is therefore important to improve the situation as regards knowledge of the values of road users and politicians by systematically following up, checking, analysing, and reporting the criteria that should be central to the road user and politician perspectives.

The consequences of the criteria set need to be followed up and evaluated continuously as a basis for any adjustments in the endeavour to achieve as good a national economy and as high a degree of customer satisfaction as possible. A strict division into three perspectives (see above) with a systematic separate follow-up and monitoring of the road user and politician perspectives allows the road capital valuations to be based on a business-administration road manager perspective where control continuously takes the national transport policy into consideration.

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These starting-points in the valuation model mean that the valuation of the road capital is linked to the national transport policy in such a way that policy changes can be allowed to change the condition values of road capital in a controlled way.

The road manager perspective in such a valuation involves administering the road capital with the highest possible productivity within the “boundaries” set by the criteria “established” by the road user and politician perspectives (and which are also followed up and evaluated continuously). A systematic effort to develop productivity requires knowledge of activities cost drivers.

Maintaining (in respect of the installations that are to be officially “maintained”) productivity, quality, risk levels and efficiency aspects are central to the road manager perspective. An appropriate valuation of road capital and its deficiencies should therefore support control and monitoring of road management with regard to these aspects. For example, changes in value and in the values of deficiencies should be able to be related to details of costs, quality, productivity, risks, and effects for society and road users.

2.2 Fundamental views and financial concepts

The concept of road capital in this paper is defined as follows:

Road capital is a physical quality-related replacement value of a road installation. A capital value is assigned to components making up a road installation. The road capital for a complete road installation, a single section of road, sections of road through an area, roads, and road networks is equal to the sum of the capital values of all the components.

Deficiencies in a road installation’s standard, condition, or function is valued on the basis of knowledge of the economic effects for society, road users, and road managers, on the basis of knowledge of political opportunities and the cost of rectifying the deficiency. When the road capital value of an installation is being assessed, a deduction is made for wear, deterioration, and physical aging based on knowledge of the installation’s current condition in relation to the dimensioning requirements.

The valuation of a single component in a fixed asset is based on real factors (expenses and costs) related to the component without considering financial factors such as interest, alternative employment of capital, or returns. On the other hand, the interest expenses in the acquisition value of an individual component are taken into consideration and burden the contractor and the road manager during the construction phase. Other interest expenses are not linked to individual components in the accounts, but are grouped into general accounts for all fixed assets.

When accounting road capita, all valuations are made at the current price level. This means that the replacement value of an installation given in the accounts must be written up to the current price level in subsequent financial reports. For example, values could be written-up twice a year in connection with the half-yearly and annual financial statements by the index value for the previous six-month period (up to and including the December index and the July index). A write-up must result in an up-to-date acquisition value, approximately equivalent to the price in the open contractor’s market at the time the report is made. This type of incremental write-up can be handled practically by means of a price index.
In the State controlled road construction sector, three types of price index are conceivable consumer price index, factor price index, and construction price index. Which index is appropriate will depend on the purpose of the write-up.

A consumer price index is a compensatory index that expresses how large an increase in income is required to maintain one’s standard of consumption, despite any change in prices for the goods and services that are consumed on average. A factor price index measures the development of prices in the construction sector and reflects the price changes for construction materials and construction workers’ pay, but does not contain engineering or productivity changes.

A construction price index measures price developments for newly built housing according to figures from projects with state housing loans, and contains changes in both engineering and productivity. This type of index would best correspond to the needs of road maintenance with regard to writing up road capital etc. However, a construction price index would need to be adapted to the types of resources that exist in the production of components and services in the area of road maintenance.

With knowledge of different types of resources’ share of components’ prices and figures from Statistics Sweden in respect of the index values of the different types of resources, the SNRA would be able to calculate a price index for components and services using a system of fixed principles. The SNRA would be able to make regular checks (for example every five years) of the index-adjusted values of components and services against the actual prices paid over the period.

*Acquisition value* is either the historical (real) value if it is known or a calculated (standard-estimated) value if it is not. For roads that have been produced as a result of improvements (graveling, ditching, etc) over a long period and not through new construction, standard estimates are the only way of arriving at a true and fair value.

When investments are made, investment expenses and acquisition values are known in most cases. For practical reasons, most of these earlier made investments will also be valued using reference standards. In the IA’s proposal, the quality- and function-related accounting of road capital is based on an index-adjusted acquisition value at the actual price level for each year, the *Replacement value*.

On the basis of the Replacement value, a value can be adjusted for wear, deterioration, or improvement in the condition of a road’s component (e.g. road structure, pavement, bridge etc). An adjusted value of the current condition is called the *Condition value*.

An existing road may also have real and documented deficiencies as regards standard relative its target standard. On the basis of the Replacement value, a value can be adjusted for deficiencies in standard. A road with no deficiencies in standard keeps its physical target standard and then has an acquisition value equivalent to its *Target standard value*.

Existing roads often have deficiencies in both standard and condition. A deficiency in standard means a deviation from an established target standard, based on functional requirements motivated by the national economy or requirements set bearing in mind those risks that are acceptable.
The functional requirements include factors such as permitted vehicle weight, traffic flow, permitted speed, safety, and the environment. To the risks that a road’s function will be disrupted or its surroundings affected count for example, consequences affected by abnormal weather, natural disasters, geotechnical issues, design, or different kinds of accidents.

Deficiencies in standard are rectified through investment in the form of new construction or improvements. The action taken may be to permanently upgrade the de facto standard the road has and at which it is permitted for use.

This may take the form of raising a road’s bearing capacity from bearing capacity Load class 2 (10 ton axle load/16 ton twin load pressure/51.4 ton maximum gross weight) to bearing capacity Load class 1 (12/18/60 respectively) or increasing a road’s width, radius, or visible distance, improving road safety in adjoining areas or at intersections, building barriers to shut out traffic-related noise or protecting water catchments along the side of the road from pollution and spillage.

A deficiency in condition is a deviation in condition relative to the original condition of the component when it was new, or from the permitted function with no wear, deterioration or damage. A deviation (deficiency) from this ideal condition may result from natural ageing, wear, fatigue, rearrangement and breakdown of materials in the technical construction (e.g. bridges, pavement, road structure, geotechnical constructions etc).

Other examples of deficiencies in condition may be in respect of traffic direction (impaired reflection of road signs, worn road markings), drainage (silted-up ditches and culverts) and safety installations (damaged fences and guard rails).

An abnormal deficiency in condition must primarily be prevented or arrested through service in the form of maintenance and operation. When an abnormal or normal deficiency is rectified through maintenance, the purpose is to restore the function or condition to its original, expected, or acceptable state.

Sometimes the action taken may for financial reasons be combined with other measures to achieve an improvement in standard.

The definition of action used in this paper refers to both investment and management. In all essentials, the definitions used in this paper are in agreement with those used by the SNRA. The term management is based on the Swedish standard and is not used with the same meaning at the SNRA.

Investments are made in a financially justifiable manner and in such a way that the standard is permanently raised, in the form of a new road or improvements to an existing road. An existing installation may also be replaced, for example to allow land to be used for other purposes or to reduce road management costs. Investments are categorised as follows:

- **New construction**, i.e. a new road installation, which will normally give society and/or road users a permanent added value and/or lower total maintenance costs.
- **Improvement**, i.e. improvement of an existing road installation, in a way which will normally give society and/or road users a permanent added value and/or lower total maintenance costs.
Service aims to maintain the actual permitted and expected function and condition of an existing road installation in a financially justifiable manner through planned and/or emergency maintenance measures. Service is categorised as follows:

- **Maintenance**, which has a long-term effect with the aim of maintaining or restoring the existing road installation’s permitted function and/or its condition. The measure lasts for more than a year and is almost always plannable in time and/or scope. An abnormal event (storm, landslip etc) may make it considerably difficult to plan.

- **Operation**, the purpose of which is to maintain in the short term the road installation’s function for the road user, primarily as regards road safety, accessibility and trafficability and to rectify severe deficiencies that jeopardise the installation’s durability and or may have undesirable consequences for its surroundings.

  An operative measure has the nature of an inspection and fast corrective action to rectify a defect that has arisen suddenly. The measure lasts for less than a year and is often difficult to plan in time and/or scope.

In figure 2, the linkages between the different types of action have been outlined graphically. The figure also shows how action taken can affect the value of a component (road capital).

![Diagram](image)

**Figure 2** Linkages between type of action and road capital.

Established accounting principles govern to what extent expenses in respect of any of these types of action are to be accounted as costs or taken up as assets and periodised as annual costs.

The next section discusses the quality-related accounting method’s principles and definitions. The valuation is based on the standard, condition, and deficiencies in standard and condition of the components (road installations). Viewed from a user perspective, the accounting is based on the conviction that the most detailed information is needed at the lowest operative levels and that the information needed at higher levels can be obtained from accumulated data and from analyses of more detailed underlying information.
2.3 Road installations’ components

Successful financial control of road management requires extensive knowledge of the real costs of road management (change in the value of capital and the cost of management), about deficiencies in condition and standard with an accompanying need for maintenance and investment, and the effectiveness of road management (the relation between the benefit to customers and stakeholders and the productivity of the various activities).

The extensive knowledge that is needed is in respect of the transportation system as a whole but knowledge is also needed about the contributions from the system’s components, individual sections of roads, roads, road networks, contractors, types of contract, different groups of road users, society etc, and knowledge of road users’ and other stakeholders’ values and expectations, about cost drivers and quality of information.

Satisfactory accounting of fixed assets takes into account, the different acquisition values and economic life of components in so-called “depreciation of components”. A focus on components should lead to a total reduction in value that more correctly reflects the “consumption” of the fixed assets than is the case in today’s accounting.

If we would like to benchmark the effectiveness of road management or introduce models for road pricing, charges and tolls to finance investments, PPP solutions, or models to achieve neutrality of competition between transport modes, such accounting needs to be supplemented with more information. For example, information is required that makes it possible to analyse costs including the real expenditure of asset, real quality, and the effects from the point of view of society and road users (passenger and freight transport).

Details of components’ actual life, changes in value, and service costs are also important in order to describe the cost of road management (and components’ lifecycle costs) correctly. The real cost of a section of road for road signs (including the real expenditure of the road sign asset) can in theory exceed the corresponding cost of the road structure depending on differences in length of life, residual values and service.

For an item to be classified as a component in the SNRA’s accounts, the SNRA must have responsibility as owner, or a similar responsibility. A component owned by another party, but produced with contributions from the SNRA, must be accounted in some other way.

2.3.1 Division of road installations into components

The recommendations of the Swedish Institute of Authorized Public Accountants (FAR) with regard to questions of accounting and reporting support a breakdown of fixed assets into components\(^6\). “A breakdown that goes further than the law requires is often necessary.” Today this is satisfactory accounting of fixed assets (see chapter 2.3.2.1). Analyses made by the SNRA’s Internal Audit Department (IA) indicate that efficient control and monitoring of the State’s road management require a division of the road installation into components. For example, there is a need to monitor/follow-up the cost and quality development of each type of component.

\(^6\) In FAR’s recommendations as early as 1978
In order for components to be seen as natural cost units, they should be unambiguous, identifiable physical parts of buildings or units and last for at least three years. They should represent a significant value or require extensive maintenance and a substantial maintenance budget. Table 1 contains examples of further questions that should be answered for each component in question before any decision is made as to whether the component is to be a cost unit for accounting purposes. Explanations of the brief assessment criteria can be found as notes below the table, where three components serve as an example – fixed bridges, drainage systems, and road sign installations.

<table>
<thead>
<tr>
<th>Assessment criterion:</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Is the component or will it be...</strong></td>
<td><strong>-</strong> Fixed bridges</td>
</tr>
<tr>
<td>... the subject of development IV?</td>
<td>Yes</td>
</tr>
<tr>
<td>... the subject of benchmarking III?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Does the component contribute to better...</strong></td>
<td></td>
</tr>
<tr>
<td>... quality of information III?</td>
<td>Yes</td>
</tr>
<tr>
<td>... possibilities for analysis IV?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Does the component facilitate...</strong></td>
<td></td>
</tr>
<tr>
<td>... the procurement process IV?</td>
<td>Yes</td>
</tr>
<tr>
<td>... price analyses VIII?</td>
<td>Yes</td>
</tr>
<tr>
<td>... reporting of operations VIII?</td>
<td>Yes</td>
</tr>
<tr>
<td>... weighing investment – maintenance VIII?</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Does the component represent a...</strong></td>
<td></td>
</tr>
<tr>
<td>... significant acquisition value III?</td>
<td>Yes</td>
</tr>
<tr>
<td>... significant road management cost VIII?</td>
<td>Yes</td>
</tr>
<tr>
<td>... significant number of occurrences VIII?</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 1 Outline sketch of a decision matrix for individual components in the accounts

I) technically speaking to improve the effects for road users and society, but also to reduce the road managers’ costs for service or to increase the component’s technical life.

II) with regard to costs (including quality defect costs), road management productivity and the effects for road users and society.

III) with regard to the basic information (the indicators) for managing and monitoring road management, the overview, order, and confidence in the information about the effects and costs of road management, but also by representing a significant proportion of the road management costs.

IV) with regard to the road capital’s standard, condition, deficiencies and changes to the deficiencies in standard and condition and with regard to the important knowledge about road management’s cost-drivers.

V) with regard to flexibility in procurement, the quality of tender documents, detailed performance descriptions, follow-ups and checks of contracted functional requirements and the handover procedures at the beginning and end of construction.

VI) in connection with the evaluation of tenders, of how the construction market works, any suspicions regarding cooperation between contractors, cartels etc.

VII) refers for example to reporting results relative to transport policy targets.

VIII) – a comparison that requires production costs to be accounted continuously for each component, either as standard costs, where the action taken has concerned several components or as actual costs, when measures have been applied only to the component in question.

IX) refers to a significant proportion of a road or proportion of the total volume of investments/improvements.

X) refers to a significant annual road management cost for service and/or as reduction in value within a limited area/a road/a road network/in total for a region/in total for the whole country.

XI) refers to a significant number of occurrences within a limited area/a road/a road network/in total for a region/in total for the whole country.
The SNRA’s road database (RDB) and other databases of road-related information contain a quantity of current and historical data about the road network and traffic, and about condition, deficiencies and accidents, for example. The data about components (called phenomena in the RDB) is extensive. A substantial amount of the information in these databases will not be used in the model for controlling and monitoring road management that is presented in this paper.

There is a widespread belief at the SNRA that the quality of the data in the RDB has markedly deteriorated since the mid-1990s and that the quality varies substantially between different road management regions (VX). Important data for the model for control and monitoring that the paper deals with, such as the dates the components were commissioned, may be missing.

The component review and experience gained from practical work with the model have led the author to conclude that among the parts in RDB bridge edge girders, gates in deer fences, interchanges, crawler lanes and roundabouts are not suitable as individual components.

Two borderline cases that on the contrary were judged to belong to the group of components worth accounting separately are road markings and large road sign installations, for example gantries. These meet most of the requirements in the analysis. The costs related to road markings and road sign installations can constitute a major part of the annual cost of road management for a section of road.

Table 2 contains a gross list of the components in the model divided into eight main groups and a total of 43 sub-groups, of which seven sub-groups (named Other...etc) exist for unforeseen components.

For land and buildings, the legal aspects of ownership, responsibility and use should be clarified. Different laws may govern different types of land, for example for right of way, freehold property, and land covered by a local area detailed development plan. In the same way, Buildings and premises can be supplemented with more details, for example freehold building, owned or rented road user service premises, office premises, and other types of buildings or premises.

<table>
<thead>
<tr>
<th>Real estate for roads and traffic</th>
<th>Road constructions</th>
<th>Traffic safety structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground</td>
<td>Road structures</td>
<td>Structures for canalisation and separation</td>
</tr>
<tr>
<td>Buildings, premises and physical planning</td>
<td>Retaining walls</td>
<td>Adjacent areas</td>
</tr>
<tr>
<td>Off-road facilities</td>
<td>Erosion barriers and side slope reinforcements</td>
<td>Fences</td>
</tr>
<tr>
<td>Rest and parking areas</td>
<td>Ground insulations</td>
<td>Guard rails</td>
</tr>
<tr>
<td>Rest and parking area equipments</td>
<td>Geotechnical constructions</td>
<td>Anti-glare shields</td>
</tr>
<tr>
<td>Other off-road facilities</td>
<td>Drainage system arrangements</td>
<td>Shelters against land- and snowslide</td>
</tr>
<tr>
<td>Environmental structures</td>
<td>Other road constructions</td>
<td>Lighting appliances</td>
</tr>
<tr>
<td>Cultural, floral and floral protection structures</td>
<td>Constructional work for roads</td>
<td>Other safety structures</td>
</tr>
<tr>
<td>Water protection structures</td>
<td>Fixed bridges</td>
<td>Facilities for traffic routing</td>
</tr>
<tr>
<td>Noise barriers</td>
<td>Tubular bridges</td>
<td>Road sign facilities</td>
</tr>
<tr>
<td>Aesthetic arrangements</td>
<td>Drawbridges</td>
<td>Traffic signal installations</td>
</tr>
<tr>
<td>Other environmental structures</td>
<td>Tunnels</td>
<td>Facilities for traffic information</td>
</tr>
<tr>
<td>Special installations</td>
<td>Ferry berths</td>
<td>Other facilities for traffic information</td>
</tr>
<tr>
<td>Special arrangements for accessibility</td>
<td>Public signs</td>
<td>Road markings</td>
</tr>
<tr>
<td>Special arrangements for sex equality</td>
<td>Other constructional works</td>
<td>Other facilities for traffic routing</td>
</tr>
</tbody>
</table>

Table 2 A gross list of road installation components
The National Rail Administration’s financial reports contain financial information linked to installation types divided into seven main groups and 62 sub-groups. At the beginning of the 1990s, the two state-owned public utilities the Swedish Telecommunications Administration and the State Power Board, which now operate as companies, both had seven main groups and 33 and 64 sub-groups respectively in their installation registers.

Project management staff at the SNRA focus their financial interest on controlling contracts’ adjustable quantities and the quality of the work, not on “procuring” and managing components. An experienced project manager may be responsible for ten or more projects, and thus approximately two thousand separate adjustable items.

The current Bill of Quantities, 2004dif, contains considerably more than a thousand different adjustable quantities, which from the project managers’ point of view can be compared in several respects to the full list of the 43 component sub-groups. Important issues to look at are the advantages and disadvantages of the rough component structure compared to today’s financial structure based on the contracts’ bills of quantities.

The need for good quality information for controlling and monitoring road management will require a review of the quality of existing information in the RDB and other road-related databases. Such a review should include the need to supplement the data.

Existing programs and applications in the RDB and other road-related databases can be used as they are, with a few minor updates and adjustments, to realise the improved reporting as regards monitoring and management according to the model described here.

Definitions of the components in Table 2 as they apply to this paper can be found in Appendix 1. These correspond for the most part with those used by the SNRA.

2.4 General principles for a quality-related valuation and accounting

2.4.1 Overview

Function-, condition- or quality-related concepts that will be described in more detail in this section are Target standard value, Replacement value, Condition value, Standard deficiencies and Condition deficiencies.

Common to all these values and deficiencies is that they are registered in such a way as to link them to phenomena in the road network through the RDB’s reference system, in exactly the same way as today’s phenomena terms. Values and deficiencies must be able to be totalled for roads, road networks and areas of roads in the same way that other phenomena terms can be totalled today. Comparisons will then be possible, for example of how values and deficiencies change over time for selected roads and geographical areas.

Condition description and condition valuation are critical activities both in the model and for determining quality-related values. These activities must be carried out systematically and according to fixed principles, and satisfy the requirements that are generally stipulated with regard to good internal control. The results must be able to be checked in independent audits without any great assistance from engineering specialists.

7 The National Rail Administration’s installation types from 1 January 2001 show great similarity with the components in the reference model.
In order to satisfy stringent quality requirements, a series of studies must be made of the principles, values, rules, and procedures that are to be applied. Values must be documented in clear, easy-to-understand tables. The principles, rules and procedures must be described clearly in the documentation.

As time passes, values etc will quite naturally need to be revised as knowledge grows and prerequisites change. Principles and rules, on the other hand, should remain unchanged. Revisions and continuously entered data must be able to be scrutinised by independent auditors, and it must also be possible to detail the impact of changes on earlier accounting and reports. This requires the clear structure described above, with well-defined tables for the data used for valuation and accounting.

Figure 3 is a sketch of the systematic work assumed necessary in the described model.

Figure 3 A sketch of the systematic activities assumed in the described model

The accounting model presented here can be either a complement to the existing external accounting, as regards the valuation of road installations or a new internal financial report. The aim is that the model will generate basic information of adequate quality for control, monitoring the road management processes, and reporting results. The model must be based on clearly defined principles, be controllable and stable, and meet the requirements stipulated for component reporting. The model’s fundamental principles have been summarised and explained in five points, see below.
1. The basis of the valuation is the component’s real acquisition value according to the external accounting, or when this value is not known a well substantiated standard acquisition value.

2. Acquisition values are adjusted continuously to current price levels (Replacement values) by write-up against an external resource price index (from Statistics Sweden) for each component type. The component types’ indexed prices are checked against actual prices regularly (for example every five years). Previous years’ reference values (for example from the Annual Report) are adjusted afterwards according to established principles. A road installation’s Replacement value expresses a current value for the installation "as new" with its actual design and standard, as it is permitted to be used and is expected to function.

3. Quality-related values of components are based on costs for rectifying identified deficiencies in standard and condition relative to "as new", as expressed by the Replacement value.

4. "As new" in respect of a road installation can be compared to the standard the road installation should have according to existing rules and regulations and which is based on economic analyses, official decisions, and/or accepted traffic engineering knowledge. A Standard deficiency is an indication that the installation should have another standard than the one it in fact has and is permitted to be used for.

Standard deficiencies are classified (grouped) in a communicable way using the terminology used in planning and in dialogues with politicians and the public. Standard deficiencies also include the physical defects a component may be found to have in a risk analysis. Information about an assessed risk is documented as a phenomena term. The cost of rectifying an identified standard deficiency can be largely determined using reference standards but can also be calculated accurately, for example in connection with the physical planning.

The Target standard value, a desired function value (including risk reduction), is obtained by adding to the Replacement value the cost of action or the size of the investment, at the same year’s price level, that is judged to be necessary to achieve the target standard on an existing road (i.e. the zero alternative). A road installation’s Target standard value is realised primarily through investment.

5. “As new” in respect of a road installation can also be compared to the installation’s current worn, deteriorated, and damaged condition. The cost of rectifying identified deficiencies with regard to condition (Condition deficiencies) can be determined using standard estimates and accurate calculations, for example when corrective action is planned.

A condition description is based on the results of a listing (for example made visually using a scale), of the measured values of an installation’s condition (e.g. BÅRUND, bridge inspections, laser measurement) or according to established depreciation principles based on documented experience (cf. “Depreciation according to plan”). The condition description is drawn up according to established principles and models for each component type.
The current condition is described in relation to best condition (“as new”) and the lowest acceptable condition limit. A component’s Condition value is calculated from data on relative usage (current relative condition), the cost of the measure applied (standard cost) to achieve best condition (“as new”) for the lowest acceptable condition, and its Replacement value. The Condition value (function value) is obtained by reducing the Replacement value at the same price level by a proportionate share (current relative usage) of the cost of the measure applied.

The condition of a road installation is restored to or close to “as new” primarily through maintenance. The cost of repair or maintenance, which is judged to last for more than a year, increases the Balance Sheet value of the component.

Standard and condition deficiencies (phenomena terms) as regards a component (phenomenon), section of road, road, road network and geographical area can be individually specified by type of deficiency and presented in a table or on a map in any combination, using existing computer support.

Road sections’, roads’ and areas’ values of deficiencies in bearing capacity, road safety and condition, for example, that fall short of accepted limits, and/or of for example a wearing course that has passed any defined limit and/or lies in an interval of limits, can thus be selected, totalled, and presented using a computer. In the same way, different types of road management costs can be selected, listed, and presented using the model.

2.4.1 Road installations’ target standard value

According to the above, the replacement value of a component is equivalent to its current acquisition value, as new with no condition deficiencies, as it is permitted to be used with its standard deficiencies relative to the standard as expressed in the target standard. To calculate the replacement value, the acquisition value, the year of acquisition (\(A\)), and the price indexes for years \(A\) and \(X\) must be known. For year \(X\), the calculated replacement value is:

\[
\text{Replacement value } X = \text{Acquisition value } A \times \left( \frac{\text{Price index } X}{\text{Price index } A} \right)
\]

The component’s target standard value is obtained by adding the assessed cost of rectifying the documented standard deficiencies to the components’ replacement value. A standard deficiency exists when a component does not fulfil either the standard that the SNRA’s regulations stipulate or the standard determined by an official decision, as a result of a special investigation or through accepted expert knowledge of a component or the physical risk level established in separate risk analyses.

For regional-economic reasons, a component may be assigned both a higher and a lower target standard than the SNRA’s official norm by formal decision (by a county administrative board or by the SNRA). An example of a standard deficiency that can be drawn from the RDB is that a road installation with a certain traffic load should be upgraded from a 9-metre road with a permitted speed of 70 km/h to a 9-metre road with a permitted speed of 90 km/h. A deficiency can be determined by computerised comparison between the existing standard and the SNRA’s standard for 9-metre roads. In the early stages, reference standards are used to assess the cost of increasing the width etc of an existing road to upgrade it from 7-metre to 9-metre standard. The replacement value of a 7-metre road, with the cost of rectifying the standard deficiencies added, gives the target standard value for the road in question.
Quality requirements and internal controls include descriptions of deficiencies and any risks. It must be possible to check this information and it must be documented continuously and systematically with details of possible action, the cost of the action at the time, the effects for road users and society, and any risk valuation. In the early stages, the cost of action can be based on a reference standard. For a calculated value of some form of action to be accepted, it should be the result of a formally approved analysis and calculation in connection with a preliminary study, a road investigation, a work plan/construction document, or a price tender.

References can be used to locate descriptive videos and/or digital images, previous studies, names of contacts, and cost, risk and benefit calculations regarding the effects on transportation, road users, and the national economy. An example of a form that can be used to document an identified deficiency at an early stage can be found in Appendix 2. The form is similar to the one used by the SNRA’s central region during 1996 and 1997.

The road capital reference standards are generally higher for a higher road standard than for a lower standard. The reference standards can be adjusted to some extent to reflect the real situation as far as possible. They can for instance be adjusted for differences in geotechnics, hydrology, cold content, road structure, and the quality of the materials used in the road. They can also be adjusted for price differences in mountain areas, along the coast, in river valleys, forests and plains, sparsely and densely populated areas etc.

Standard deficiencies are structured in such a way as to correspond to the terms used with regard to actions and measures in discussions with politicians and the public and in internal control and planning. Terms such as Road safety measures, Environmental measures, Bearing capacity measures, Frost-proofing measures and Redesigning measures are often used, but concepts such as Risk object should also be used.

Most of the terms also have subdivisions. Road safety measures, for example, can include measures applied to Intersections, Roadside areas, Visible distances, Road profile adjustments etc. Measures at intersections can also be subdivided, for example into Roundabouts, Canalisation, Interchanges, Spanish U-turns etc. Environmental measures can be grouped in the same way into Noise reduction measures, Water protection measures, Upgrading of road environments etc. Reconstruction measures can be divided into measures applied to Bridges and Roads. Risk objects are subdivided into Risk level 1, Risk level 2 etc. The terminology structure for standard deficiencies should be uniform and clear to everyone.

The target standard value for each component is calculated according to the outline sketch in Figure 4 by adding the cost of rectifying the deficiency to the component’s replacement value. The measure is normally applied within the component’s existing design/route corresponding to the principles in the physical planning of rectifying within the “zero alternative area” if possible with measures least of all.

In the physical planning, economic analyses may later show it to be profitable to rectify the deficiency by abandoning the “zero alternative area” and building a new road along another route. When a measure has been decided, the target standard value must be adjusted accordingly, regardless of the route. The model described here presupposes that the valuation of a standard deviation is based on the best knowledge available on rectifying a deficiency, when the target standard value is calculated.
Figure 4 shows the replacement value at a certain point in time, A, of a component, a road installation or a road network, the target standard value, and the total cost of rectifying identified, registered standard deficiencies.

![Graph showing value, standard target value, costs for standard deficiencies, and replacement cost over the years.]

**Figure 4** Replacement value, Standard target value and cost of rectifying Standard deficiencies

### 2.4.2 Road installations’ condition value

Road installations gradually become worn over time and deteriorate relative to the condition at the time of acquisition. It is especially important in connection with the financial control of road management to have control of the changes in condition of the most valuable components, e.g. road structures, bridges and wearing courses, tunnels and drainage systems.

Condition deficiencies are valued according to established controllable principles. A component’s condition value is calculated as its replacement value adjusted with the “calculated cost” (expense) of rectifying the condition deficiency. Figure 5 shows an outline sketch of replacement value, condition value, and the cost of rectifying deficiencies in condition.

At a certain point in time, A, figure 5 shows the replacement value of a component, a road installation or a road network, the condition value, and the theoretical cost of rectifying identified, documented condition deficiencies.
In traditional accounting, where taxation aspects are not taken into account, the condition valuation is often based on the forecast life of the fixed asset. The valuation is made in such a way as to ensure that the asset is not overvalued in the Balance Sheet in relation to its actual value (the prudence principle). A similar valuation principle as the traditional can be used to determine a condition value for most components, especially those that will not be surveyed regularly and that do not represent substantial values.

Development of valuation theory for special properties is moving in the direction of putting more emphasis on valuing the properties’ components and in accordance with market valuation. In the case of machinery, industrial, rental and commercial premises, and other fixed assets for business activities, valuation can be based on the assets’ earning capacity, which in principle is equivalent to a sound market valuation.

In the model, the value of a component is based on its actual physical condition. The change in condition over a period is expressed financially as the difference between the component’s value at the beginning and end of the period. In order to determine a component’s condition-related value in an accounting context, the physical condition must be described in an unambiguous and systematic fashion according to established principles, so that the valuation permits independent checking.

In condition-related accounting, the prime concern is objective measurement data about condition. Since this is not possible in practice for the majority of components, other approaches are necessary. Condition descriptions, for example, can be based on samples, visual inspec-
tions, forecasts, or a combination of these. A number of different models for describing components’ physical condition are presented below.

2.4.2.1 Models for describing components’ condition

High values and a need for extensive care and maintenance of a component may have led to interest in developing technical equipment for measuring condition. For some components, therefore, there exist a number of more or less fairly advanced measuring methods for describing condition.

Nonetheless, only one piece of equipment has been put to any practical use on a large scale, and that is equipment for measuring the component wearing course (primarily bound with bitumen).

For most components, there are no technical measurement methods for determining condition objectively. Extensive, systematic visual inspections have been developed for those cases where a type of component represents a high value, requires extensive care and maintenance, or is of practical importance for safety in the transport system.

Current condition can be assessed using the available technical knowledge about these components. Forecasts of how condition will develop can also often be made of such quality that the information can be used for condition descriptions and valuations.

A certain type of component may occur a great many times in the road network (and in the RDB) but may still only represent a relatively low value. With documented experience of how a component’s condition develops, it may be rational and acceptable in these cases to use a simple model to describe condition – one based on condition forecasts similar to those used in traditional accounting.

There are also other reasons for drawing up a structured, generally accepted condition description of the road capital’s different components. For example, the condition description is important when dealing with road management’s function-related and condition-related construction contracts, following-up the contracts and paying the contractors.

Six models for describing condition

Models for describing condition can be viewed from two dimensions. One is whether a model is based on a forecast of whether condition will develop or not, and the other is whether the condition is measured/inspected regularly and objectively or not. In practice, descriptions can be drawn up using a combination of measurements, inspections, and forecasts.

The condition descriptions that the SNRA uses are based on visual inspections, samples, measurements, and forecasts. The condition forecasts are based on technical experience. In the following, the different approaches have been structured into six description models.

Figure 6 shows how the models (I-VI) in principle have been assessed with regard to their degree of objectivity and forecast content (without or with regularly reconciliations).
The terms used below in the different models and formulas are as follows:

- $n_{\text{max}}$ = The total number of parameters and measurement and assessment methods for describing deficiencies of a component (that are used when carrying out an inspection, measurement, and assessment of a component’s condition and condition deficiency).

- $B_n$ = The measurement and assessment value for best possible condition (“as new”) according to the method of measurement or assessment used.

- $S_n$ = The measurement and assessment value for lowest acceptable condition (“shame level”) according to the method of measurement or assessment used. The regulations in force stipulate that corrective action must be taken immediately.

- $U_n$ = The actual value measured according to the method of measurement or assessment used.

- $R_n$ = Relative usage for deficiency $n$: $R_n = \frac{U_n - B_n}{S_n - B_n}$ For $R_n > 1$ the limit for lowest acceptable condition has been exceeded (§ different from $B$).

- $K_n$ = The assessed cost of rectifying deficiency $n$ (at current price levels) at condition $= S_n$, in order to achieve condition $= B_n$. (In situations where $R_n > 1$, $K_n$ often needs to be adjusted with a factor $> 1$.)

Total depreciation year $X$ at current prices: $V_X = \max_{n=1}^{n_{\text{max}}} R_n \cdot K_n$
Model I
Model I is used when there is no change in the condition of the component that affects its value. For land (right-of-way), no deduction is made for depreciation. The acquisition value is the basis or writing up against index. Owned land should in principle be valued according to market prices. Figure 7 shows the change in the condition value (adjustment to index) over the period.

![Graph showing change in value over time](image)

**Figure 7** Outline sketch of the change in condition values over time according to model I.

Roads that are transferred to private road management very often need to be improved and if the right-of-way land is to be returned to the land-owner, it is not unusual for it to be restored first. A central allocation for these and other similar types of future costs in respect of land might be justified. This would strengthen the principle of not making any depreciation on land value.

Model II
No change in condition affecting value is considered to have taken place until a deficiency has been identified (and documented), which means that no depreciation is accounted until a deficiency has been identified. Checks can be made in respect of a number of measurement and assessment parameters. For any depreciation to be made, at least one of the checks must return a value below what is acceptable. The depreciation is calculated using the parameter of these that has the highest cost to rectify.

When a deficiency that needs to be rectified and the cost of rectifying it have been documented, there are two ways of dealing with the reduction in value.

a. Where the deficiency, when detected, is in principle a total deficiency and cannot grow substantially worse, a one-off reduction in value is made equivalent to the total cost of rectifying the deficiency.

b. Where the deficiency is such that it will gradually develop to such an extent that it needs to be rectified later (within a certain number of years assessed by experience), deductions for reduction in value are made annually until that year so that the sum of all the deductions is equivalent to the total indexed cost to rectify the deficiency.)
In practice, the ambition is often to rectify all deficiencies of a component at the same time. The contractor’s fixed costs (for start-up and removal) and the costs to road users are normally relatively high, so it is not generally justifiable to rectify each deficiency as it is detected. The real cost of rectification must be calculated separately when several deficiencies are to be rectified at the same time. Figure 8 shows the change in condition values over time for models IIa and IIb.

![Diagram showing change in condition values over time](image)

**Figure 8** Outline sketch of the change in condition values over time according to models IIa and IIb.

**Model III**
A change in condition that affects the value is considered to have occurred when a deficiency is identified according to the same principles as in model II. No depreciation is therefore made until a deficiency has been identified. When a deficiency that needs to be rectified and the cost of rectifying it have been documented, there are in principle two ways of dealing with the reduction in value (cf. II a and II b). In model III, a strategic approach is devised, with a maintenance plan covering a specified period. Alternative b (according to II b) is therefore clearly the predominant method in model III.

If the deficiency is not rectified in time, according to maintenance strategy 1, the consequence may be that the deficiency or damage will become worse and require more expensive maintenance measures. A new maintenance strategy must then be drawn up in respect of the more expensive maintenance measures. When the strategy switch has been decided, reductions in value are accounted in relation to the new cost of the measures to be applied and for the number of years upon which strategy 2 is based.

If this new maintenance strategy is not implemented either, the deficiency may become even worse and a new maintenance strategy, 3, may be needed with a new schedule and new costs. These changes the prerequisites for calculating any further depreciation (see table 5). Maintenance strategy 3 can be drawn up before the year action to be taken according to strategy 2 arrives, if it is known that the limit for deficiency according to strategy 2 has been exceeded or if strategy 2 will not be followed. Figure 9 shows the change in condition values (adjustment to index) over time.
Model IV

The SNRA’s PMS system contains objective condition values measured using laser-equipped vehicles for the component wearing course. The values are calculated as mean values for 20-metre and 200-metre sections and homogeneous sections. Measurements of 10 cm sections are already stored today in order to be able to calculate a measure for vibrations of the whole road user body and a measure of the pavement’s bearing capacity will be introduced shortly based on data of the development of rut depth over a number of years.

In PMS, values are calculated per December 31 for all homogeneous sections in the road network (lengths between 1 and approx. 10 km each). The latest values are used in the calculation/forecast, together with all earlier measurements from the wearing course in question. Where, for example, a pavement’s rut depth on 5 October 2004 was found to be 8.2 mm on average for a specified homogeneous section, the rate of development for the rut depth (the derivative of the curve of measured rut depth over time) from earlier measurements until the latest measurements will be the basis for the assessed rut depth on 31 December 2004 (for example 8.6 mm). The calculation is made with three levels of quality depending on the number of measurements made. The important thing in this context is that, using the best knowledge available, there is a dimensioning measurement (for determining any action to be taken) for each homogenous section on 31 December of the accounting year.

If a visual inspection is needed and perhaps some samples taken, in addition to the objective measurements, in order to determine the quality of an asphalt pavement, the extra inspection data can be built up according to a scale (for example from 1 to 5), similar to the principle for the values obtained using the measuring vehicle. The new values can be included in the same calculation as for the measured values.

Since measures can not be varied for short sections, a number of 20-metre sections will in practice also often be rectified, on the basis of knowledge of the mean values of the actual condition for 20-metre sections. The measurement parameter with the lowest relative condition will serve as guidance as to the type of deficiency that will trigger a maintenance measure first (time-wise).
The type of maintenance measure that will be applied first in practice, however, depends on the total need for action on a longer section (a number of 200-metre sections). Often, a course of action will be chosen that rectifies all types of deficiency along this longer section. The real cost is therefore equivalent to price per 20-metre section, that can be calculated separately.

Figure 10 shows the change in condition values over time.

![Graph showing change in condition values over time]

**Figure 10** Outline sketch of the change in condition values over time according to model IV.

**Model V**
A scale of step-wise change in condition can be used, especially where components are inspected visually. The evaluation is based on clear descriptions, pictures, photographs and/or films, and the condition are graded according to a scale.

1. A component “as new”. No reduction in value is made here.

2. A worn component with an acceptable condition from the point of view of function. The component is about half-used. A reduction in value is made equivalent to 50% of the assessed cost to rectify.

3. An installation deteriorated to a functional condition corresponding to lowest acceptable condition. A reduction in value is made equivalent to 100% of the assessed cost to rectify. If the worn component is to be exchanged for a new one, the whole value of the existing component is written off; otherwise a residual value will remain.

4. A component has passed its lowest acceptable condition and must be rectified immediately (possibly at a higher cost). A higher cost to rectify must result in a corresponding increase in depreciation unless the component has not already been fully written off.

Figure 11 shows the change in condition values over time.
**Model VI**
For a component whose condition or change in condition is not identified *in situ* or where adequate knowledge of its technical life exists, a reduction in value according to plan can be applied, (see table 8). The reduction in value may be either in full or down to an assessed residual value.

Figure 12 shows the change in condition value over time. The upper, upward portion of the curve shows a residual value written-up to the current price level.
Combinations of models
Sometimes, components’ condition can best be described in practice using a combination of the models. Such an example might be a combination of models IV and VI, when a component for example has two types of deficiency, where one can be maintained without detriment to the user while the other deficiency leads in the long term to a replacement (fatigue or ageing of the material so that it no longer possess its original properties and falls below its lowest acceptable value).

Some other times a deficiency such as ageing or fatigue is detected suddenly and unexpectedly and a whole component has to be replaced within in a certain time (e.g. 10 years) of the inspection, despite regular maintenance being carried out according to all requirements stipulated on the basis of condition descriptions.

The way in which the condition value is accounted in the example follows model IV down to the lowest acceptable value, which in the most difficult case from the point of view of accounting, also has a residual value. When deficiency number two, which will ultimately lead to replacement, is detected, a reduction in value of the residual value (depreciation) down to zero is begun according to model VI, that continues over the assessed period until the replacement itself (10 years in this case). The component is then replaced as planned.

In the example above, the maintenance measures applied to rectify the deficiency, and that follow model IV, are adapted to the replacement in time and scope (after the ten years have gone by). The ideal case and the challenge when planning is, that the whole component is worn out and in the accounts has its lowest possible value (preferably equal to zero), when the time comes for it to be replaced. If this is successful, no cost will arise for scrapping the component for the year the replacement is made.

If the maintenance cost for the deficiency, following model IV, increases due to the deficiency that follows model VI, it may be appropriate to adapt the time to scrap the component to the first time, when deficiency one (according to model IV) is deemed to reach its lowest possible value (= its residual value). Instead of ten years as in the above example, deficiency two (according to model VI) may perhaps need to be written down to zero over a period, say, of four years, when the replacement should be in view of the total cost. Only calculations can show, in a situation with two mutually dependent deficiencies, what is the best course from an economic point of view.

2.4.2.2 Summary of issues related to condition valuation

For pavements and bridges there exist financial data (acquisition and maintenance) and data about conditions linked to the road network in the RDB reference system.

The condition of wearing courses (but not gravel wearing courses) is measured systematically and regularly using laser technology. The results are measurements of a number of the pavement’s physical properties (rut, roughness, crossfalls, texture etc). The condition description is represented by model IV.

Bridges are inspected systematically and regularly (visually, using X-ray equipment, by means of samples, stress calculations, test loadings etc) and maintenance strategies are drawn up as needed. The condition description is represented by model III. A corresponding inspection programme exists for the component tunnels.
For these three components, the condition values are based on documented measurements, inspections, and/or analyses.

Objective investigations are also carried out to a certain extent of the condition of road structures, in respect of bearing capacity using the measurement techniques georadar, deflectometry and sample measurement (BÅRUND). The condition description is systematic and is drawn up when bearing capacity problems have been identified. The procedure is represented primarily by model II (normally IIb).

Some components have detailed requirements in construction contracts as regards lowest acceptable condition and about service – requirements that are followed up more or less systematically and regularly. Several of these components are already inspected visually today according to the principles in models II and V.

There is no question that the number of types of components that are systematically inspected will increase as the number of construction contracts containing function requirements grows. This means that systematically described conditions will come more and more to govern maintenance needs and maintenance costs related in road management irrespective of whether they are included in the internal accounts. The data will exist whether or not it is included in the accounts (here and there on paper or in more less computerised systems).

The annual cost of inspection, documentation and registration in the case of some components may be judged to be expensive in relation to the benefit, because a certain type of component may account for a small proportion of the total value and cost of a road section. This aspect may justify considering whether the component’s condition value is to be recorded systematically or not. If not, both condition and valuation can follow model VI and be done on computer.

The condition value for year X is calculated for all components and description models using the formula:

\[
\text{Condition value}_X = \text{Replacement value}_X - V_X
\]

The value of all right-of-way land, all road structures, bridges, tunnels, and pavements may, at a guess, be equivalent to at least ¼ of all the road capital. In a test of the model on four sections of road, these components accounted for 80% of the sections’ value. For a large proportion of the roads’ capital value, condition can therefore be expressed, technically speaking, according to one of the mode’s I - V. The prerequisites thus exist for performing a condition-related valuation for a large part of the road capital. What remains to be done is to improve procedures, system, and aids and to establish the principles, indexes and reference standards that are to apply with regard to accounting.

The prerequisites for achieving good quality in a condition-related method of accounting quickly should therefore be very good. System and smart computer-assisted solutions are the first things to be solved in order to be able to link financial data to each component. For the components that account for the remaining proportion (at a rough estimate less than ¼ of the total value of the road capital the quality of a condition-related valuation may vary. It will, however, gradually improve. If the condition of all the remaining 35 components were described according to model VI, this would lead to a considerable improvement in quality compared to today’s accounting.
An index-adjusted valuation according to the six main models for describing components’ condition is illustrated graphically in Figure 14. Each of the models may both have and lack a residual value, which is determined for each type of component with regard to its different deficiencies. Pavement, for example, has residual values for the deficiencies rutting and unevenness, but generally not for instability and insufficient bearing capacity. The six models in Figure 13 can not be compared with each other.

Image: Outline sketch of six different models for quality-related valuation of components

It would seem to be appropriate, at least to begin with, to allow the possibility of using several of the models presented to describe the condition of a type of component. Eventually, it may become necessary to restrict the number of models permitted and perhaps even prescribe only one description model for each type of component. The word recommended may therefore at a later stage need to be replaced by the word decided.

Quality-related accounting must be able to be checked against similar requirements that apply for traditional external accounting.
Above all, an overview may be needed of the models that are recommended (or permitted) to be used for the condition description of each component. Such a list might be drawn up as shown in table 3.

<table>
<thead>
<tr>
<th>Component Name</th>
<th>Models recommended for describing condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>first choice</td>
</tr>
<tr>
<td>Real estate for roads and traffic</td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>1</td>
</tr>
<tr>
<td>Road constructions</td>
<td>5</td>
</tr>
<tr>
<td>Road structures</td>
<td>5.1</td>
</tr>
<tr>
<td>Wearing course</td>
<td>5.2</td>
</tr>
<tr>
<td>Constructional work for roads</td>
<td>6</td>
</tr>
<tr>
<td>Fixed bridges</td>
<td>6.1</td>
</tr>
<tr>
<td>Facilities for traffic routing</td>
<td>8</td>
</tr>
<tr>
<td>Road sign facilitess</td>
<td>8.1</td>
</tr>
</tbody>
</table>

**Table 3** Example of a list of recommended models for describing condition

At their lowest possible condition, components may have a residual value. Maintenance measures in such cases take the form of repairing damage and wear to a condition that as closely as possible restores the condition to “as new”. In other cases the residual value may be zero. To determine relative usage and condition value, both best condition and lowest acceptable condition and residual value must be defined.

2.4.2.3  **Limit values for condition**

The limit values for condition that govern the valuation of road capital can be set on the basis of a number of criteria but are not influenced by factors such as financing (lack of capital) and interest. The valuation of the road capital is done at component level, which means that the limit values for “as new” and lowest acceptable condition are specified for each component. A component may also have several types of condition deficiency (wear, deterioration, ageing, damage etc).

A component’s “best condition” is determined as the best values, as regards the types of deficiency that occur, that can be attained when manufacturing the component in question using the best technology under the best possible conditions and that are acceptable as having deficiency equal to zero.

“Lowest possible condition” must be clarified for each type of deficiency and description parameter. When a component has reached its lowest possible condition, it may be completely worn out and in need of replacement. It may also have a substantial residual value and be the object of some form of repair.
Residual value and cost to rectify must be specified for each type of deficiency and description parameter for at least four separate categories of aspects that are to be considered when determining the limit value for “lowest acceptable condition”.

1. Aspects concerning effects for road users – road users’ sacrifices and benefits

The effects referred to here are the costs to road users (both passenger and freight traffic) in respect of travelling time, freight, vehicles, comfort, and ill health. Typical components that can influence these effects are bridges, tunnels, ferry berths, road structures, and wearing courses. As regards asphalt pavements, there are known linkages between the transportation costs for different types of vehicles and condition in the form of unevenness in the longitudinal direction of the road expressed using a measure called International Roughness Index, IRI (see figure 14).

The outline sketch about linkages in figure 14 up to and including IRI = 5 are similar to the ones used in the investment calculation while the extrapolated linkages that lie between IRI values 5 to 7 are symbolic and should be investigated. Corresponding linkages exist for trucks both with and without trailers. For these, the linkages are especially uncertain for IRI > 3.

![Additional transportation cost for passenger cars caused by unevenness](image)

**Figure 14** The linkage between passenger car transportation costs and IRI values

In the analysis the highest acceptable increase in different road users’ costs should be specified – an increase caused by the road surface’s deficient condition. The condition that gives this limit for the unacceptable road user cost corresponds to the “lowest acceptable condition” from the point of view of the road user with regard to the IRI value. In practice, the IRI limit value may be dependent of the traffic flow (cf. section 4. Aspects with regard to political considerations).
2. Aspects concerning effects for society as a whole

The effects of primary concern in this section are emissions, pollution of water resources, noise, injuries, and fatalities. It is also possible in this respect to begin with demands that emanate from groups of individuals, for example children, the elderly, disabled people, or people who live alongside a road.

Examples of components where condition may be linked to this type of effects are wearing course, safe adjacent areas, fences, guard rails and safety equipment, anti-glare shields, rockslide and snowslide barriers, lighting, traffic signal and road information installations, protection against pollution of water catchments, and noise barriers.

Emissions of CO₂ are proportional to fuel consumption and there are known linkages between different vehicles’ fuel consumption and the design of a road, above all with regard to its height profile. Linkages also exist between fuel consumption and vehicles’ speed, the IRI of the wearing course and different types of wearing course. Road design, speed, and type of wearing course are principally issues related to roads’ standard while IRI has to do with condition.

In the case of noise, objective linkages exist with the condition of the road. Society’s costs (willingness to pay for reduced noise levels) can be assessed and can guide decisions as to “lowest acceptable condition” and can also be used to determine the deficiency scale for condition in the form of “noise leaks” in noise barriers. In practice however, hardly any damage to a noise barrier can be permitted before action is needed.

Similar linkages exist in principle for fences, guard rails and safety installations, anti-glare shields, rockslide and snowslide barriers, lighting, traffic signal and road information installations, and protection against pollution of water catchments. Because the consequences of deficiencies may be very extensive, in most cases no damage at all is permitted. Here, however, it is risk analyses that constitute the basis for the deficiency scale. In principle, the scale may have a binary design based on the limit value for highest acceptable exposure to risk but expressed as a “lowest acceptable value” for condition.

Objective linkages exist between pavement condition and the risk that people will be killed or injured. However, a limit value must be established for society’s costs and the asphalt pavement’s “lowest acceptable condition”. As regards the component safe side areas, subjective measures apply for “lowest acceptable condition” and the risk of injury to people (cf. the components in the previous section).

3. Aspects concerning effects for the road maintenance

‘Effect for the road maintenance’ means that a component’s condition deteriorates to such an extent that the cost of restoration is “unreasonably” high from an economic point of view or that the risk that the road’s intended function will be jeopardised is too great. For example, the consequence of “too” serious a component’s deficiency may be that other components are also damaged. On the other hand, it is not economically justifiable to take action as soon as a deficiency is detected, because the contractor’s start-up costs and road users’ disruption costs are relatively high.
The road maintenance perspective is a way of viewing things in terms of business administration (including the risk of, for example, claims for damages), that can be applied to all components and deficiencies. In principle, it is a cost minimisation issue, where linkages between condition and the cost of action are known.

4. Aspects concerning political considerations

'Political considerations' means a holistic perspective based partly on national economy and partly on general political "reasonableness and fairness" in a social perspective. The economic holistic perspective here means an overarching total appraisal of all considerations based on a total economic perspective. For example, the effects of taxation can be eliminated for aspects 1-3 above. It is, for example, not acceptable for the cost increase per vehicle kilometre according to figure 11 to be as high for large traffic flows as for small flows (see the outline sketch in figure 15).

Social perspectives, "reasonableness and fairness", may be a question of political "limits of shame" – the lowest politically defensible limits for what is an acceptable condition for a public road in Sweden or in one region compared to other regions.

Figure 15 Outline sketch of acceptable increase in transportation costs and traffic flow.

Lowest acceptable condition concerning all aspects

When all limit values for lowest acceptable condition for each type of deficiency have been systematically determined for each component and type of deficiency with regard to the four aspects, the information can be compiled (see table 4) to find the lowest acceptable limit value that will apply. This value will in principle satisfy the requirements of all the criteria.
Table 4 An example of a compilation of limit values per type of deficiency and component

<table>
<thead>
<tr>
<th>Component and type of deficiency</th>
<th>Aspects of lowest acceptable limit value</th>
<th>Value that applies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Road users</td>
<td>Society</td>
</tr>
<tr>
<td>Wearing course, pavement</td>
<td>pass.</td>
<td>freight</td>
</tr>
<tr>
<td>IRI</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Rut depth</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Crossfall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration measure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drainage systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draining function of ditches</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Safe adjacent areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspection form for adjacent areas</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

2.5 Further comments concerning things like data used and data needed

The International Roughness Index (IRI) is an international measure of comfort used to express the road surface’s condition as regards unevenness in the road’s longitudinal direction. The rut depth and IRI values can be determined by means of measurement with a laser camera fitted to a vehicle with measurement equipment. These values are today very important for PMS and for planning pavement maintenance.

A new measure of whole-body vibration has been developed in Sweden. The measure is based on laser measurement with values for every 10 cm along the road and is currently being tested. It is hoped that it will be possible to link the vibration measure to European work environment legislation that will set maximum values of whole-body vibration that an employee may be exposed to during an 8-hour period for example.

However, it is claimed that certain types of pavement damage can not be described correctly using laser measurement. In such cases, a complementary visual inspection may be required and perhaps also samples for laboratory analysis. These cases will be documented entirely manually, but based on the results of analyses.

In its economic analyses and calculations, the SNRA uses more or less scientifically devised linkages between IRI values and the transportation costs (for travelling time, vehicle, comfort, and ill-health) of different types of vehicles (passenger cars and trucks with and without trailers). There are also linkages between these different types of vehicles’ fuel consumption and exhaust emissions that are applied in the SNRA’s calculations.

Linkages also exist between risks of accident on the one hand and IRI and rut depth values on the other\(^5\). Requirements and limit values in respect of the lowest acceptable pavement condi-

\(^5\) Reports from the SNRA, VTI and Gunnar Lennér, Chalmers University of Technology
tion for different types of roads expressed primarily in terms of IRI and rut depth can there
fore also be defined for the national economy.

The road construction may gradually be worn down by traffic and its bearing capacity will
then deteriorate; there are a number of investigative methods for determining this. The
SNRA’s central region performs measurements of the road structure and grade materials us-
ing dual-frequency mobile georadar and laser cameras. The radar’s measurement values reach
different depths and give different accuracy of data.

On sections where measurements indicate unsatisfactory bearing capacity, deflectometric
measurement and materials analyses are performed on untouched core samples of the road
superstructure and grade materials. Sometimes samples of material dug up are also analysed.

Much of the evaluation is done manually by trained engineers on the basis of measurement
data and analyses of samples. The manual evaluation has become increasingly automated. The
investigation that goes by the name of BÅRUND provides a basis, which can be used to as-
sess appropriate reinforcement measures and cost calculations.

Requirements will increase with regard to documenting and inspecting components, quality of
checking, and objective technical aids. One technical aid, previously under development at the
SNRA’s associated company RST, was intended to interpret more or less automatically the
video images recorded while driving the laser-equipped measurement vehicle. Another exam-
ple is optical measurement of the reflective capacity of road signs and road markings.

GPS technology is of great value in automatic measurement to be able to link inspection data
to a specific component along the road.

The condition value of a section of road is the sum of all components’ condition values along
the section. The difference between the total condition value and the total target standard
value calculated in the same way constitutes the assessed costs for rectifying all standard and
condition differences on the section of road in question deficiency by deficiency. However, it
is common for an investment, in order to reach target standard, to rectify one or more of the
condition deficiencies at the same time. It is therefore not possible to total the deficiencies
without checking that the same things are not being counted twice.

If several measures are co-ordinated and carried out in the same construction contract, the
total cost will often be lower. When the model is used, there exists a basis for also analysing
the value of co-ordinated planning and assessing different types of synergies.

Condition descriptions of gravel roads’ wearing course (gravel wearing course) are in Sweden
an important issue, because the component exists on approximately 21% (21,247 km)9 of the
total state-owned road network. 31% (6,664 km) of Sweden’s gravel roads are in the SNRA’s
Northern region while only approximately 3% (717 km) of them are in the southernmost re-
region and only 0.3% (68 km) in the Stockholm region.

When rainfall is heavy and the amount of traffic relatively high, it is very common for un-
evenness to occur of the “washboard” type. Potholes, dust, and camber problems are other

9 SNRA’s Sector Report 2003, Publication 004:29, ISSN 1401-9612, Borlänge, 2004
examples of deficiencies that may be of a temporary nature. The camber is also often planed off before the frost season to make it easy to clear snow. After planing, the road surface may be smooth in good weather for a long time. The time a specific condition persists can thus vary widely.

To determine a condition value for a gravel wearing course, it is important to find those deficiencies that have greater permanence than those that visibly vary “from day to day”. When traffic has used the gravel road for a long time, a large part of the finest particles disappear in dust and as result of spreading hygroscopic road salt, CaCl₂.

The traffic degrades the stone and gravel fractions into sand and coarse mo-clay. The end result is that it becomes difficult for the wearing course to bind. This shows itself in less resistance to the effects of traffic and weather and as a grading curve with a pronounced “sand hump” and low fines content. An important factor in understanding the long-term quality and resistibility of the gravel road may therefore be connected to the grade curve of the wearing course in relation to that of “ideal gravel”.

Examples of measures that have a permanence of at least a couple of years and that should affect the value of wearing course component in the accounts are matrix, gravelling and gravel recycling (several methods are used to restore material from shoulders and ditches) followed by planing. The measures ultimately aim to recreate a grade curve for the gravel wearing course component similar to that of “ideal gravel”.

With reference to the quality inspections it would therefore be necessary to investigate whether condition in the case of the component gravel wearing course can, among other ways, be described on the basis of the grade curve’s deviation from “ideal gravel’s”. During the period of contract should the contractor, according to FSB¹⁰ uphold or improve the opening composition quality of the gravel wearing course (see Appendix 4).

Other components on and along a gravel road can be administered and valued in the same way as corresponding components on other roads.

Maintenance of a road that is classified as being of cultural or historical importance, a tourist route with old-fashioned components, or with several species of flora in the shoulder, protected fauna in the immediate vicinity, a picnic area, or a demand for clearing the view, are governed by special instructions. The road management often means higher costs.

The sections of road and their components are special cases from the point of view of valuation. For sections of road or components subject to protection or preservation orders the valuation principles must be adapted to acquisition, replacement, and condition values. The principles for describing deficiencies also need to be investigated separately.

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¹⁰ Function and Standard Descriptions, SNRA/FSB 04-08-04, 83.16 Quality of the gravel wearing course, page 23, Borlänge 2004.
2.6 A road installation’s values according to two principles

In the following, it will be shown how quality-related accounting is connected to traditional (external) accounting and how one principle can be explained in theory on the basis of the other. Figure 16 shows the fundamental linkages between book values and quality-related values – all at current price levels (index-adjusted) based on the acquisition value.

The value of a road installation in quality-related accounting is the condition value (the red curve in figure 16). The figure illustrates and example where improvements in condition are achieved through repeated maintenance measures. That it is maintenance is clear from the fact that no investments were made during the period (cf. the continuously falling purple curve for booked values in fixed prices).

The standard deficiencies (the green curve) represent an identified need for standard-improving measures, to increase the benefit to society, reduce transportation costs, and/or reduce the cost of road management. The curve for the target standard value shows an installation’s or a connection’s desired value “as new” and executed according to target standard.

The standard-improving measures may include a great many measures the results of which may be better road safety, greater bearing capacity, shorter travelling time, greater accessibility, less noise from traffic, less risk of pollution of water catchments etc. They may also lead to sacrifices and negative effects. The net effect, however, should be positive.

In continued application of quality-related accounting according to the model, a component’s actual acquisition value should be used. The replacement value (the blue curve) represents the acquisition value adjusted to current price level by means of a price index appropriate to the component. The green, blue and the red curves represent all values in current prices.

![Figure 16 Outline sketch of a component’s book and quality-related values](image)

Figure 16 Outline sketch of a component’s book and quality-related values
Sometimes a condition value may be lower than the book value for a time. In such cases, according to sound accounting principles, writing down the book value should be considered. Where the condition is assessed to be poor during a short change-over period (action is planned and perhaps financed), it may in traditional accounting be reasonable not to make any accelerated depreciation. If the poor condition is judged to be permanent, a one-time depreciation should be made.

At a certain point in time, A, there will be a difference between the book value and the condition value, due to the differences between the accounting principles. In the corresponding way, there will normally be a difference between a property’s book value and its market value, unless the latter is the book value. The condition-related valuation is essentially based on the asset’s actual condition and the condition is regularly and systematically described according to established principles (models I – VI).

The basic principle in modern accounting is to apply depreciation according to plan on installations’ acquisition values. The rules and regulations, however, also permit other financial considerations to be made in valuation – a possibility that is seldom exploited. Bases for other considerations are not obtained automatically.

The sections above have described measures that are taken to rectify either a standard deficiency or a condition deficiency. There are often situations when it is economically defensible to rectify two types of deficiency at one and the same time. Quality-related accounting can still be done using the same approach as detailed earlier.
3 Examples and Application

3.1 The E4 European highway, Järna – Södertälje South interchange

Over the period from 1 July 2003 (opening balance) until 30 June 2004, with a half-year bal-
ancing on 31 December 2003 (closing balances) the model has been studied on four trial sec-
tions. The example described here is taken from one of the sections – the E4 European highway
from the Järna interchange to the Södertälje South interchange.

The section comprises a four-lane motorway with approximately 27,000 vehicles a day. The
section was opened to traffic in 1968. In the test, the different components’ acquisition values
were determined according to actual data. Most of the object’s components are from 1968, while
some, for example pavements and rockslide barriers are investments that were made later.

The replacement values were determined according to accepted calculation principles for
price indexes. The consumer price index (CPI), base year 1914 with forecast CPI = 4,050 on 1
July 2003, 4,080 on 31 December 2003, and 4,120 on 31 June 2003, was used for lack of a
good construction price index for the different components. The quotient replacement value
divided by acquisition value may vary for the different components, since they may have been
acquired at different times.

The lowest acceptable condition value was calculated as the acquisition value less the actual
cost of the measures to improve the condition from lowest acceptable condition to a condition
equivalent to “as new”.

In summary, the following (see table 5) are the values for the section of the E4 between the
Järna and Södertälje South interchanges. Maintenance for almost 5.5 million SEK has been
carried out over the period. The total condition value has increased by approximately 3 mil-
lion SEK net at current prices.

| Component | Acquisition value (SEK) | Replacement value (SEK) on Condition value (SEK) on Service over the period | Description model |
|-----------|-------------------------|-----------------------------|------------------------|----------------|----------------|
| E4, Järna - Södertälje South interchange | | | | | | | | | | | | | | | | | | | |

Table 5 The section’s component values etc at three points in time.

The Fixed bridges item is a total figure from seven different bridges of which two were as-
signed explicit maintenance strategies during the inspections carried out in 2002. The defici-
cies in these should be rectified before the end of 2003 and 2012 at an estimated cost if
702,000 SEK and 163,000 SEK respectively. No action was carried out on the bridges during
the period and a new maintenance strategy will therefore need to be drawn up for the first
bridge.
No deficiency has been identified as regards road structure, geotechnical constructions, drainage system installations, adjacent areas, fences, shelters against landslide (rocks) or guard rails.

The basis for calculating the condition values is shown here for wearing course and lighting installations, where models IV and VI respectively have been used to describe condition. The lowest acceptable condition value was calculated as each component’s replacement value less actual cost to rectify, in order to improve the condition from lowest acceptable condition to a condition equivalent to “as new”.

Experience from the SNRA’s Stockholm Region indicates that the lighting appliances, that date from 1998 (BV = 1998), have a useful life of 20 years (LAV = 1998 + 20 = 2018). In order to detect a difference during the test period, the years were set at 2003, 2003.5 and 2004, to indicate a reduction in value every 6 months (see table 13). The road sign facilities were put up in 1995 and their useful life is set at 15 years.

Analysis of the laser measurement vehicle’s data 20-metre sections showed that the rut depth in the pavement was the parameter with the highest relative usage. In the Stockholm area, with a maximum permitted speed on motorways of 110 km/h, the lowest acceptable value (LAV) is 15 mm rut depth and the best value (BV) is 2 mm.

Table 6 shows the measured and totalled 20-metre values on three occasions, partly normal spring measurements (1 July 2003 and 30 June 2004), and partly an extra autumn measurement (31 December 2003) and the relative usage.

<table>
<thead>
<tr>
<th>Component / Homogeneous part of component</th>
<th>BV value</th>
<th>LAV value</th>
<th>Measured / recorded values on 1/7 31/12 30/6 1/7 31/12 30/6</th>
<th>Used relative share on 1/7 31/12 30/6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wearing course</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7,554 m of K1</td>
<td>2</td>
<td>15</td>
<td>9.68   3.76 4.25</td>
<td>0.59 0.14 0.17</td>
</tr>
<tr>
<td>750 m of k1 - 8,304 m of K2 (1995)</td>
<td>2</td>
<td>15</td>
<td>5.63   6.08 6.88</td>
<td>0.28 0.31 0.38</td>
</tr>
<tr>
<td>Lighting appliances</td>
<td>1998</td>
<td>2018</td>
<td>2003   2003.5 2004</td>
<td>0.25 0.28 0.30</td>
</tr>
</tbody>
</table>

Table 6 Dimensioning measurement data for wearing courses and lighting appliances.

On a 7,554 metre section of the right-hand lane (K1), it is found that the condition over the period has improved from measurement value 9.68 to 3.76 and 4.25 respectively. The reason for the improvement is the pavement maintenance carried out in autumn 2003. The autumn measurement was made immediately after the work was finished. No maintenance was carried out along a 750 m stretch of K1 or in the left-hand lane. There, the condition deteriorated from 5.63 to 6.08 and 6.88 respectively.

The pavement maintenance carried out on K1 during the autumn cost 5,282,000 SEK. The old pavement was milled out (using box-milling) and transported away to be stored and reused later on some other road with less traffic. A new pavement was then laid in the milled-out “box”. The value of the stored pavement is in this case assumed to result in a lower pavement price on the road or in the location where it will later be used. The quality of the pavement there will be somewhat lower than would be the case with completely new paving. Another assumption might be that the agreement with the contractor includes the sale of the old milled-out pavement. In that case, 5,282,000 SEK would be the net price.
The condition value falls to zero when the old pavement is removed – a reduction in value that burdens net profit (equivalent to a one-time depreciation). Lane K1 is then given a completely new pavement at a total cost of 5,282,000 SEK, which is the new replacement value for the stretch of lane K1 in question. The change in value over two periods (half 03 and half 04) is shown in the sketch in figure 17.

![Figure 17 Changes in the condition value between 1 July 2003 and 30 June 2004.](image)

### 3.2 Road 71, section between Nås and Björbo

An attempt to apply the reference model was made in 2001 on a section of road 71 between the intersections with road 525 at Nås (junction 1342A009.00) and road 568 at Björbo (1342A027.00). The section, which is 15.088 km long, was chosen because it is made up of three approximately identical stretches of different ages. The traffic flow is approximately 4,000 vehicles a day.

The westernmost stretch is “unbuilt”, which means that no real road investment has been made. The standard of this stretch has been achieved through a number of small improvements, mainly financed through appropriations. The acquisition date in the accounts is set to the date it was incorporated into the state road network in 1944. For lack of data on actual acquisition values and adapted construction price indexes for the different components, the replacement values have been calculated using reference standards and the consumer price index (CPI).

The middle stretch was built and opened to traffic in 1963. The eastern part constitutes about half of the whole stretch of the Björbo bypass investment object, which was opened to traffic in 1998. In the example here, these two objects have also been valued according to the reference standards method in the same way as the “unbuilt” stretch.

---

The main purpose of the exercise was a quick evaluation of the model with the quality of basic data that can be retrieved directly from technical systems. This was one of the reasons why a relatively large volume of data was tested on all stretches and according to the reference standard method. It would have taken longer to retrieve the components’ actual values from archives and accounts.

This example shows how the road capital values are accounted in the model, including the values of standard deficiencies over a longish period (10-year and 5-year forecasts) for a section of road that is not homogeneous (three different standards of road). The quality of the data in the SNRA's databases in respect of this section will be illustrated. The calculation model itself will not be touched upon, since it is the same as in the example of the E4 south of Södertälje.

All data about components, including the components’ condition were taken from the RDB, Road and maintenance data, PMS, BMS, and Stänga. Only details of the dates the components guard rails, road sign installations, and other installations along the section were put into operation have been ascertained by interviewing the operating personnel responsible. The components, types, quantities etc. that were taken from the SNRA's registers are shown in figure 18.

In the figure, the components have been “stacked” along the Y axis. Along the X axis, they are placed proportionally along the section of road. It can then be seen that components of different ages can overlap, which is one of the reasons why it is important to work with each individual component in a quality-related accounting model. The arrows are showing the components’ location on the road section (and even the right/left hand side).

Figure 18 Summary of the basic data in SNRA’s registers for each component on road 71 between intersections at Näs and Björbo
The condition descriptions were drawn up using model IV for pavements and model VI for the other components. Measurement data from the PMS system was used for rut depth and IRI. PMS contained data for the whole period including forecasts for years 2001 to 2005.

The reference standards used were provided by an experienced project manager for investment objects. The reference standards are set at year 2000 price levels and correspond to an acquisition of the type of components found on the section of road in question.

The data for standard deficiencies has been assessed on the basis of the best available knowledge of the road standard needed on road 71, according to an earlier study and a road audit. Deficiencies have also been identified, partly in respect of the unsatisfactory bearing capacity, that was assumed to be documented, according to the BÅRUND model, and partly shortcomings with regard to road safety, that were assumed to be documented, according to the established procedure using the template in Appendix 2.

In the example, the valuation according to description model VI was made using individual principles for the different components. No consideration has been paid here to the rules that apply in governmental accounting, for example in respect of economic life. Progressive depreciation has been used for the components with the longest lives. The principles applied are shown in table 7.

In order to get an idea of the quality of the basic data, measurements were taken along the whole section in connection with an inspection. Errors in both length and area were detected with regard to the road construction. Some information was also non-existent.

The deficiencies in the basic data and the consequences for the quality-related accounting are shown in figure 19. The principles under the heading Component errors in table 7 were used to assess the consequences of the missing information.

<table>
<thead>
<tr>
<th>Component</th>
<th>Reduction in value principle</th>
<th>Life length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridges</td>
<td>Progressive depreciation (2% annuity)</td>
<td>80 years</td>
</tr>
<tr>
<td>Road structure</td>
<td>Progressive depreciation (2% annuity)</td>
<td>60 years</td>
</tr>
<tr>
<td>Guard rails</td>
<td>Linear depreciation</td>
<td>30 years</td>
</tr>
<tr>
<td>Road sign installations</td>
<td>Linear depreciation</td>
<td>6 years</td>
</tr>
<tr>
<td>Bus-bays</td>
<td>Linear depreciation</td>
<td>20 years</td>
</tr>
<tr>
<td>Lay-bys</td>
<td>Linear depreciation</td>
<td>40 years</td>
</tr>
<tr>
<td><strong>Component errors</strong></td>
<td><strong>Linear depreciation</strong></td>
<td><strong>40 years</strong></td>
</tr>
<tr>
<td>VVIS equipment</td>
<td>Linear depreciation</td>
<td>40 years</td>
</tr>
<tr>
<td>Floodlighting</td>
<td>Linear depreciation</td>
<td>30 years</td>
</tr>
<tr>
<td>Tubular bridges</td>
<td>Linear depreciation</td>
<td>30 years</td>
</tr>
<tr>
<td>Elevated refuges</td>
<td>Linear depreciation</td>
<td>40 years</td>
</tr>
</tbody>
</table>

**Table 7** Principles applied for reduction in value for the different components (according to model VI)
Figure 19 Deficiencies in the example’s basic data with their causes and the consequences for the accounting

The reference model’s results in the example (totalled for the whole section) are presented graphically in figure 20. The figure also shows the index-adjusted road capital values for different types of deficiencies. The book values according to traditional accounting are not index-adjusted but were calculated for each component and using the same depreciation principles as in the rest of the example. No adjustment was made in view of the shortcomings detailed above with regard to the basic data.

Figure 20 Values and deficiencies in the road capital on the Näs – Björbo section of road 71.
3.3 The financial accounting

The external accounting may use the same division into components as in the internal accounting but do not need to. According to the model, however, both are based on the acquisition value. This is an important prerequisite for the internal accounting to be perceived as stable and possible to collate with the external accounting. This provides stability that in the long term should affect the credibility of different information with regard to the road capital.

As regards the external accounting, no write-up against index to current price levels may be made and the basic principle is that depreciations according to plan must be made – preferably at component level. The internal accounting can be done at current levels, i.e. written up against index. Instead of depreciations, deductions are made here for reductions in value, which according to the model are calculated using data about the actual and forecast condition of the component, using one of the six condition description models.

The application example in section 3.1 *The E4 European highway, Järna – Södertälje South interchange*, contained a description of pavement maintenance. The same example (for the period 1/7 – 31/12 2003 and the “½” in figure 17) is presented in the tables 8 and 9 below at T-account level with totals for the section. To make the presentations flexible, the component’s values in the accounting are transmitted as unit values to RDB (as a section phenomenon – a RDB term). The value for a section can then be calculated on any length of the component in a selection of sections or roads (here 7,554 m).

With the prerequisites of the accounting example, that investments are financed by appropriations that are added to the capital, and that changes in value are deducted against the capital, the Balance Sheet and Profit and Loss Account can be summarised as shown in table 8.

<table>
<thead>
<tr>
<th>Balance sheet</th>
<th>1/7/2003</th>
<th>31/12/2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installations</td>
<td>5,289,648.00</td>
<td>5,282,000.00</td>
</tr>
<tr>
<td>Installations, index</td>
<td>136,204.53</td>
<td>0</td>
</tr>
<tr>
<td>Depreciation, Installations</td>
<td>-2,679,696.11</td>
<td>-657,020.59</td>
</tr>
<tr>
<td>Depreciation, Installations, index</td>
<td>-74,161.05</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2,472,006.37</td>
<td>4,624,979.41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liabilities and stockholders’ equity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
<td>2,409,961.89</td>
<td>4,624,979.41</td>
</tr>
<tr>
<td>Capital, index</td>
<td>62,004.48</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2,472,006.37</td>
<td>4,624,979.41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profit and Loss Account</th>
<th>1/7 – 31/12</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating costs / set up as an asset</td>
<td>5,282,000.00</td>
<td></td>
</tr>
<tr>
<td>Change in value (the new pavement)</td>
<td>657,020.59</td>
<td></td>
</tr>
<tr>
<td>Change in value (the old pavement)</td>
<td>2,472,006.37</td>
<td></td>
</tr>
<tr>
<td>Costs for the period (consumed)</td>
<td>3,129,626.97</td>
<td></td>
</tr>
<tr>
<td>To be written off against appropriations</td>
<td>5,282,000.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Values and deficiencies</th>
<th>1/7/2003</th>
<th>31/12/2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacement value</td>
<td>5,425,852.53</td>
<td>5,282,000.00</td>
</tr>
<tr>
<td>Condition value</td>
<td>2,472,006.37</td>
<td>4,624,979.41</td>
</tr>
<tr>
<td>Condition deficiency</td>
<td>2,963,846.15</td>
<td>657,020.59</td>
</tr>
<tr>
<td>Change in value for the period (rise)</td>
<td>2,152,973.03</td>
<td></td>
</tr>
</tbody>
</table>

Table 8 Pavement economic values in the year-end closing accountancy for the E4 section

The underlying transactions at T-account level, with numbered explanations, are shown in table 9.
<table>
<thead>
<tr>
<th>OB</th>
<th>5 289 648</th>
<th>5 289 648</th>
<th>(1)</th>
<th>(3)</th>
<th>2 679 696</th>
<th>2 679 696</th>
<th>(10)</th>
<th>(12)</th>
<th>2 409 952</th>
<th>2 409 952</th>
</tr>
</thead>
<tbody>
<tr>
<td>(6)</td>
<td>5 282 000</td>
<td>5 282 000</td>
<td>(11)</td>
<td>(11)</td>
<td>657 021</td>
<td>657 021</td>
<td>(11)</td>
<td>(11)</td>
<td>657 021</td>
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Table 8 T-account for the economical events during 1/7 – 31/12 2003 on the E4 pavement

In the accounting example, the expense in respect of pavement maintenance is regarded as a cost. The change in value (increase) achieved as a result of the action taken is accounted as an asset (with the index accounted separately). The costs are credited to the amount accounted as an asset, which means that the cost, replacement value, condition value and condition deficiency for the year are the same as in section 3.1.

3.4 Indicators

3.4.1 Road capital values as combinations, differences, and quotients

The different values of the road capital as they are presented above can be use as indicators by using them to form different combinations, differences, and quotients. Unit prices (for example cost per vehicle kilometre or metre of road, time series and lengths of time for components’ values can be compared for more or less comparable roads and traffic flows. The different values illustrate different things, such as standard and standard deficiencies, condition and condition deficiencies, and changes over time.

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When road management costs, prices, and changes in value are known, the performance of the contractors involved in road management can be measured. Life cycle costs for the most valuable components from an economic point of view can be used as indicators of the organisation’s competence, and for those components that need a more thorough analysis.

Indicators can be used to highlight differences on roads in different parts of the country, for comparisons between components and the whole network or differences in road management between different areas. For example, the objectives of the national transport policy with regard to regional development can be analysed in respect of differences in roads’ physical differences.

Indicators and key ratios are important instruments in monitoring and managing road management. They will therefore be analysed in more detail in a separate paper.

3.4.2 Maintenance backlog

The SNRA uses the term Maintenance backlog (eUh). The exact meaning and definition of the term are not completely clear. In this paper, “Maintenance backlog” is taken to be an expression of the volume of appropriations that would be needed today to carry out all the accumulated maintenance measures that have not been carried out to a sufficient extent due to too insufficient appropriations. The historical effects of the maintenance backlog for society and road users can not be recovered.

As pointed out in Chapter 1, decision-makers have insufficient information about operation and maintenance costs, linkages between investment costs, maintenance costs and operating costs, and the effects for society and road users, the development of condition, quality, productivity and efficiency in road management as a whole and in respect of different roads and components. Any statements about the size of the maintenance backlog are therefore bound to be uncertain, despite the fact that may be based on experience and surveys.

Figure 21 is a diagram used by the SNRA in recent years to illustrate the different values of road capital. It contains both a limit line, “value at lowest acceptable condition”, and three alternative measures (a, b, and c) for point in time A.

The lowest acceptable condition or “shame limit” should be able to be expressed in the measurement parameters used (for example laser measurements and BÅRUND values). The limit value should thus be able to be shown in the graphs presented.

The limit values can be determined on the basis of several aspects (see section 2.4.2.3 Limit values for condition). Indicators of eUh must be discussed in the perspective of quality-related accounting at component level.
Figure 21 Three alternative contents (a, b, and c) in an indicator of “maintenance backlog”

At point in time A, the component described in figure 21 has an unacceptable condition. Assume the SNRA has tried to do everything possible to rectify the condition deficiency even before point in time A. If the unacceptable condition is a consequence of insufficient financing, the need for maintenance is included in the maintenance backlog, $eU_h$. There is thus also a period when $eU_h$ has existed.

Where a component’s condition is lower than “lowest acceptable”, maintenance has been insufficient. It is clear that there are several sections of road where the condition of some component is lower than the lowest acceptable condition (“maintenance neglect”). All “maintenance neglect”, however, does not need to be a consequence of financial problems.

For example, a decision may have been made to delay the maintenance of a component due to some unclear points in the physical planning or because extensive changes may already have been decided with regard to the road in question and maintenance would thus be pointless or because the maintenance, for economic reasons, is to be coordinated and procured together with other measures planned for a later date. Or it may be so that prices in the construction market are unacceptably high at the point in time in question. It is also possible that maintenance is not carried out on a component because the action may for some reason be difficult to justify in an economic perspective.

Long periods of insufficient appropriations lead to an increasingly deteriorating condition for components with more or less serious consequences. One consequence might be cost increases for transportation and for society. The cost of maintenance may be higher or lower than the combined increase in cost for transportation and society.
Theoretically, the transportation costs of companies with small margins might increase so much that they lose market share or are forced out of the market, with unemployment and a smaller tax base as a result. The probability of this type of scenario occurring is greatest in sparsely populated areas, where distance to the markets is already a handicap.

Even in cases where condition would not fall below the lowest acceptable, it can be assumed that appropriations are insufficient, if increased appropriations would lead to maintenance being carried out that would reduce the total cost for transportation and to society to a degree equivalent to the increase in appropriations. Most components however, lack such clear linkages.

Both ways of viewing the shortfall in appropriations presuppose that the available appropriations for maintenance have been used in an efficient manner. They also assume that the maintenance backlog is calculated for the components individually, since components have different:
- useful lives
- residual values
- lowest acceptable values determined on the basis of different aspects (social, transportation, road management, and purely political aspects/effects/criteria with different effect linkages).

“Optimum” road management is theoretically the sum of each component’s optimum values for the different variants of the component that there can be (the limit values / useful life that apply to European highways, for example, are not the same as those that apply to gravel roads in the north of Sweden). The question of how eUh is to be valued on the basis of the accounting in the model will be taken up in a separate paper. Here, the issue is confined to how eUh for different components and in total can be indicated in the model automatically.

Components that in the accounts have a poorer condition at a certain point in time than the lowest acceptable condition can be identified, listed, and presented (for example, by marking them on a road map). The difference in value between such a component’s condition value and the lowest acceptable condition value can be calculated by computer. The totalled values for components having “unacceptable condition” can thus be determined by computer.

Value a in figure 21 is an indicator showing the difference in value between an individual component’s actual condition value and its lowest acceptable value, when the condition value falls below the acceptable value. If the period with eUh is short (for example, less than two years) it is hardly possible, generally speaking, to claim that the component is part of the volume of eUh. “Temporary” poor condition can, according to the examples above, be a result of it being impracticable for a relatively short period to carry out the necessary maintenance measures.

If, on the other hand, the period with eUh is relatively long, it is then more probable that insufficient appropriations have been available to rectify the deficiency. In times of financial hardship, action on the component may have had to be delayed in favour of more urgent measures on any number of occasions due to lack of funding. Henceforth it is assumed that the component is still part of the volume of eUh after repeated attempts to finance the measures.
Which of the values b and c best indicate the actual appropriations needed to eliminate the "maintenance backlog" with maintenance measures and the long-term adjustment to appropriations that is needed to prevent new components appearing for which maintenance has been postponed?

Value c represents the financing that is needed to carry out maintenance on a component to raise it from unsatisfactory condition to "as new". If c is used as an indicator of eUh the totalled value will be greater than the actual value. By totalling all the c values of the components in question as an indicator, there is a risk that the credibility problems will remain.

If amount b in figure 21 only refers to one component and a lump sum, the figure could be interpreted as indicating that it would be "optimum" or appropriate to "only nearly" restore the component’s condition. For example, it would in that case be "optimum" to procure a pavement that already has a pronounced rut when it is procured, to replace a worn-out road sign with a slightly defective one, or to rectify insufficient bearing capacity but only to the extent that "a few" bearing capacity problems remain.

Regardess of whether appropriations are insufficient or not or whether effects for the road user and society are considered or not, it is probably uncommon for aiming to "only nearly" restore the condition of a component to be "optimum". Fixed costs represent a large proportion of the total cost of action to rectify a deficiency.

It may be suitable to use value b as an indicator of the appropriations needed if figure 21 reflects the sum of several components with unsatisfactory condition. Value b could also be used to indicate annual appropriations over a period. The measures would then not be carried out the same year, but spread over more than one year. As a rough estimate, b could be a predetermined proportion of value c.

Taken all together, there is much in favour of not quantifying the volume of eUh today. It may nonetheless still be useful to use measure a as an indicator of the volume of components having the lowest condition and of how a changes over time, despite the fact that a also contains components whose condition is unsatisfactory for more or less "natural reasons".

A follow-up of eUh should focus not only on the volume of all a changes, but also on changes to the condition values of different types of components. A more correct value of eUh should, as stated earlier, be analysed in respect of both efficient use of available funds and the effects for society and road users. These aspects will be analysed in a separate paper.
4 Analysis and Implementation

4.1 The two principles for accounting road capital

The main purpose of accounting is (Financial Accounting Standards Board Concept Statement No. 2) to provide a recipient with financial information with two essential characteristics: relevance and reliability. The information is relevant if it is significant for the user’s decisions and it is reliable if it represents what it is intended to represent.

The person responsible for the service of a pavement according to the requirements stipulated in the national transport policy is one example of a recipient of information. Information from the two accounting methods discussed is outlined together in figure 23. Traditional accounting is shown in fixed prices and accounting according to the model in current prices.

Examples of relevant and reliable information that this particular recipient needs may be the costs for “actual annual usage of a pavement”, quality defects in the physical pavement and for decisions about the maintenance of the pavement, and when maintenance will need to be carried out next in order to maintain the pavement’s function effectively.

The model’s accounting satisfies this need for information at current prices while the traditional method does not provide any useful information at all about these issues.

The traditional accounting method provides information about maintenance costs for the years maintenance can be financed and no information about other years. The accounting also gives information about the pavement’s original, no longer existent, depreciation cost and its book value.

If no maintenance can be financed at all, the cost of maintenance using the traditional accounting method would fall to almost zero. The costs that would be reported are depreciations on old pavements, where most pavements have not been in use for a long time since they have been replaced a couple of times with new layers.

4.1.1 Comparison of information from the two accounting models

Questions of relevance, reliability and prudence can be discussed on the basis of the example in chapter 3.1 The E4 European highway, Järna – Södertälje South section partly in respect of how the pavement is accounted in the SNRA’s traditional accounting (see figure 22) and partly in respect of the model’s accounting principles.

In today’s accounting system, the road’s original pavement, that had probably come to the end of its useful life as a wearing course over 15 years ago, will continue to generate an annual cost until 2010, according to the traditional principle of depreciation according to plan for the whole project. The accounts also indicate that a new pavement will not be needed until 2010.

Traditional accounting does not contain any specific details of the pavement in the example; these are included in the acquisition value for the whole object. The values for the pavement have therefore been ascertained from information about the whole object, the values being drawn from project data from 1969.
The real values have then been dealt with according to the current accounting principles that apply to them, as they are accounted when they are included in the figures for the total object.

Figure 22 Diagram showing how the pavement in the example would be accounted in the SNRA’s external accounting

The roughly 10-kilometre long section of pavement of the right-hand lane of the motorway cost 5.4 million SEK (a maintenance cost of 5.282 + a depreciation cost of 0.132) over the period in question (from 1 July 2003 to 30 June 2004). According to the accounts, the value of the pavement has fallen by 0.1 million SEK from 0.9 million SEK to 0.8 million SEK (the depreciation cost). The accounts have indicated that a new pavement would need to be laid in 2010 for the past 33 years.

The general opinion at the SNRA is that financial accounting can not be used to control pavement operations, for example. This is a clear example that supports that opinion. Tradition accounting is in reality also misleading as regards management and monitoring.

The experts’ data gathered from PMS are the best basis for management. The figures used in respect of the pavement component in the model’s financial accounting have also been taken from PMS as the stored real reassessment test results (the laser values). In the pavement example, the SNRA’s accounting can hardly be regarded as meeting reasonable requirements as regards relevance and reliability. This should become quite clear if figure 23 is compared to the more reality-based figure 18 (see figure 24).

According to the accounting in the model, the lane cost 3.3 million SEK (2.5 + 5.3 – 4.5). The existing pavement was scrapped early at a cost of 2.5 million SEK. The depreciation of the new pavement is 0.8 million SEK (5.3 – 4.5), of which 0.6 million SEK represents the cost of quality defects. The value of the section of pavement, however, has increased by 2.0 million SEK from 2.5 million SEK to 4.5 million SEK.
The measurements (rut depth 3.76 mm for the whole section) are dated 8 October 2003. Since the PMS values per 31 December are now routinely calculated every year for the entire paved network, these values should be used instead when the reference model is implemented. A calculated PMS value might possibly have been somewhat different to that used in the example. The value would probably, but not necessarily, have been a little higher. For example, a calculated PMS value of 3.96 mm would have increased the cost for the year by 74.7 SEK Thd.

![Diagram showing values and costs according to the two accounting principles](image)

**Figure 23** Diagram showing values and costs according to the two accounting principles

Since measurements were made immediately after maintenance was completed, the model shows that quality defects in the work cost about 0.6 million SEK (5,282 – 4,625). The new pavement’s real quality development will quickly become evident in an intelligible fashion in the accounts. It will be possible to predict a suitable time for new measures very quickly and fairly accurately at the same time as it will be possible to see its real life cycle cost.

The differences in the information provided by the two accounting principles are enormous. The deprecations in the SNRA’s traditional accounting emphasise the negative deterioration despite the concurrent high maintenance cost, while the accounting in the model shows quality defects, wear, and positive appreciation in respect of maintenance. Quality defects include both the decision to scrap the old pavement at a cost of 2.5 million SEK (of which 41% remains to be used) and the acquisition of a new pavement of low quality, where 14% (0.6 million SEK) had already been spent by the time it was handed over (see figure 23).
The results of the specialist’s analysis would probably never have come to the attention of the decision-maker responsible, because decisions and product quality were to a great extent influenced by the specialist’s assessments. PMS contains the technical-economic data that is needed to make clear what the accounting in the model illustrates in economic terms.

Similar differences between the information from the two accounting principles are also obtained for the components bridges, tunnels, and road structure, i.e. for approximately 75% of the value of state-owned road installations. The accounting information from the two principles for the remaining 25% of the installation value shows a smaller yet still significant difference in quality.

The accounting of computers during the 1980s can serve as a comparison. Depreciation times could nonetheless be anything up to 18 years, despite the fact that the computers were often replaced or needed to be replaced every five years. The deficiencies in the accounting also had consequences for financial computer systems. Nonetheless, it still took a long time to change the accounting rules. A similar discussion with more serious consequences has been going on for some time with regard to road installations’ components and their multi-billion values.

In the case of the computers, the deficiencies in the accounting meant that investments in new computers were delayed, resulting in soaring costs for computer support and low productivity. The consequence of deficiencies in the accounting of road capital may be considerably more extensive, where the total annual cost of efficiency losses in the road traffic system may be several billion SEK.

Is the accounting in accumulated form, as it is presented for the entire road management, more correct if we study its component parts (according to the “Law of Large Numbers”)? This can hardly be the case, since the accounting does not reflect the road installations’ real usage. If the new road capital that is added through new investment is compared with what is subtracted in the form of depreciation, the difference is nothing but a measure of political ability to finance new road investments in relation to an expected life of 40 years. No one has any better knowledge of road capital than just that.

For external auditors, the traditional accounting satisfies the good accounting practices requirement, which is why the SNRA is given a “clean auditor’s report” on this point every year.

The “clean auditor’s report” is a strong incentive not to make any changes – an incentive also supported by obstacles in the rules and regulations in force. The SNRA therefore continues to pay a substantial amount of money in for systems, procedures, staff etc every year to produce accounts that contain directly misleading information about road management.

For anyone using the financial reports, the information in respect of the development of the road installations’ condition is more relevant than the book value when trying to describe the problems and costs associated with road management in a comprehensible manner for politicians and tax payers. The actual value of the road installations is of significance for understanding the needs of road management. For tax payers and politicians, it should for example be easier to accept a need for 7 billion SEK in annual maintenance of installations worth 1,000 billion SEK in replacecerent value than for the same installations with a book value of 90 billion SEK.
Parliament, and primarily the Government, is under an obligation to render account of plans
decided upon and actual tax revenue used, and of the control exercised over activities and
decisions. The model provides a good foundation for such confidence-inspiring reporting by
the SNRA to the Government and by the Government to Parliament and tax payers. The ac-
counting in the model clearly shows the consequences both of the use of appropriations and of
insufficient appropriations. It also provides a basis for discussing at least some of the quality
defects in its use.

The values presented above in respect of road capital and the dedicated cost content can be
used in analyses of components, roads in total and different areas with roads in a way that is
not possible today. Dedicated indicators and key ratios, which are essentially missing from
today’s accounting of road maintenance, can be used in order to illustrate differences in the
road network in different parts of the country. These instruments are extremely important for
control and monitoring.

The accounting in the model also ascertaining components’ real life cycle costs (quality-
related values and changes in value over the whole life cycle). Traditional accounting with
depreciation according to plan focuses on an asset’s forecast and current deterioration over a
fixed useful life, that in practice is not in agreement with its real deterioration. Increases in
value that arise as a result of maintenance are not taken into consideration. In today’s tradi-
tional accounting, the asset is thus usually undervalued and the costs are periodically too high.

The efficiency requirement in the transport policy objectives means that road installations are
to be maintained in a cost-effective manner. In order to maintain a usable quality of control in
respect of this efficiency requirement (cost-effective maintenance of capital) in traditional
accounting (and according to generally accepted accounting principles with regard to rele-
vance, reliability and prudence), improvements in capital must be continuously updated either
as appreciations or prolonged depreciation periods.

4.2 Discussion of the facts

The pavement example

The reasons why the condition value of the pavement on section K1 is not higher after carry-
ning out the measures, that the first year’s depreciation is substantial, and to the high annual
cost might also be traceable to one or more of the following factors:

- The reference standard price of the measure to improve the condition from the lowest
  acceptable condition to “as new” (replacement value) is incorrect.

- There may have been other condition parameters than those measured and used in the
  valuation – parameters that in reality were crucial to the decision about the measure
  and which would have shown a greater relative usage than 59%\textsuperscript{12}.

\textsuperscript{12} One reason given is bearing capacity problems in the lane’s pavement. This is borne out in a later study by
Johan Granlund of the SNRA’s Consulting Division. Measurement data shows that bearing capacity problems
may have existed on a short section (= 300 m) of the right-hand lane. In view of this, a bearing capacity measure
is currently being developed in respect of rut depth growth. The measure is based on the derivative of historical
laser measurement rut depth data.
Measures taken deliberately when relative usage was still low, because there are other factors besides the condition of the road that can both justify (and recommend against) the decision to take the action. Such deviant factors (relative to “normal”) might include transport costs, disruptions during the construction period, the expected effect of the measure on accidents, pure business considerations, (e.g. coordination with other measures) etc.

- The write-up of the component pavement against CPI is grossly misleading.

- The index for writing up acquisition/replacement values may in certain cases be grossly misleading, due to a number of factors, including local/regional variations in the construction market and the world market price of bitumen. Variations over time may not be captured sufficiently well by the index for a short period of time.

- Original acquisition/replacement values may in certain cases be too low where components have been built to less stringent quality requirements. Prerequisites may have changed quickly shortly after the acquisition. The replacement value would have been higher if construction had been subject to the later prerequisites.

It should be mentioned in this context that prerequisites that can change quickly include traffic volumes and the proportion of heavy traffic, especially in places where a shopping centre might be built or an industry established. These prerequisites can change radically over a very short period, for example only 5 years.

- The condition curve may turn down immediately following the measure. A pavement on which a measure has been carried out may have a relatively high used-up proportion immediately after hand-over. Figures of between 10 and 30% have been quoted in this context for different types of pavements, in the form of initial ruts and roughness. The model would then clearly show the cost of quality defects.

On the K1 section in question, it is claimed that there was a different condition parameter (bearing capacity, see footnote 12) than those measured, which was crucial to the decision on when to take action. How many decisions are based on parameters other than measurement data? What quality problems are caused in the accounting by the fact that there are parameters other than the measurement data used in the accounting in the model?

To begin with, it is quite clear that measurement data in respect of a road’s pavement covaries well with the effects for road users and how they experience using it. It is also clear that, as a preventive measure so that road users are spared annoying experiences and costs or to prevent the road manager from being hit by abnormally high maintenance costs, it is important that the best possible knowledge and prediction of pavement deterioration be brought to bear on any decision with regard to measures.

According to information given orally by one of the SNRA’s pavement experts, 60% of all decisions with regard to measures follow the measurement data that exists in a rational manner. The rest (40%) are based on other factors. Generally speaking, it is important that these other factors as far as possible be based on facts and expressed in objective terms. When the assessments are written objectively, they can be dealt with in the same way as measurement data, which will lead to more correct accounting. The objective description is an important credibility issue for the pavement engineers to avoid any discussion about arbitrariness. Accounting according to the model will emphasise the demand for objectivity, because those responsible will be able to see the figures in respect of pavement activities.
The limit value for “lowest acceptable condition” is of decisive importance for when a particular course of action is to be taken. If the limit is set incorrectly, there is a risk that the action will not be “optimum”. A study should therefore be undertaken to clarify the limit values to apply for each component and whether limit values should be set/monitored at a central level. In the limit values that are set, both national-economic aspects and road users and transportation will be considered, as described earlier.

It is also assumed that the limit value “lowest acceptable condition” will be generally acceptable. The limit value must thus be set at a level where politicians, after reading the study or visiting physical reference installations, can also accept it.

Further examples

The example from road 71 shows the values and information structure that the internal accounting can provide according to the model. Corresponding information can be obtained for any component, section of road, road, road network, and area with roads. The extent of the quality deficiencies in the RDB’s data in respect of the section in question is also quite evident.

The quality of the information in the accounting is primarily dependent on the quality of the data in the RDB and the quality of the inspections carried out of the components’ condition according to description models I-VI. It is known that there are great differences in quality between different regions in Sweden. For the model to function as intended, the quality of the data must therefore be improved and made uniform for the whole country – as is currently being done in Norway and Finland for example.

A realistic estimate is that the initial work will take a few years to accomplish. Data must then be collected and updated continuously as an established procedure with the help of the staff involved in operative road management. Smart procedures can then be introduced to render follow-ups, analyses, and administrative tasks with regard to operative production more effective, with substantial savings as a result. This important issue will be discussed in more detail in the separate papers on analyses and on monitoring and controlling road maintenance.

A review of the quality of the RDB data requires that mandatory organisation-wide definitions, systems, and procedures be put in place and that the quality assurance systems be updated. As regards the procedures, it is important to work on the basis of the new technical prerequisites that exist and enlist the support of external resources. Contractors are paid for inspection trips and should also be required to provide information about their observations in an orderly fashion. The documentation of observations and the quality assurance systems should be integrated where the information is especially important.

The accounting example shows that write-ups against index can be handled in the internal accounting in such a way that the external and the internal accounting can be collated. This is possible if the index values are stated separately in the accounting. RDB, on the other hand, uses total indexed values calculated as values per metre.

By entering the index values on the asset side against State capital on the liability side in the Balance Sheet, and introducing an income item in the Profit and Loss Account called “Income from State Capital” equivalent to the whole of the cost item Depreciation on Road Capital, the index values have no effect on the bottom line.
The consequence of this is that the Profit and Loss Account is easier to understand. Today’s inescapable and misleading losses in the Profit and Loss Account are eliminated – losses caused by the fact that accounting regulations require depreciations to be regarded as not yet financed. Financing is not booked until later, when the negative result is written off against State capital (Equity).

Giving the SNRA the authority to use State capital to finance depreciation on existing installations and installations added during the year, up to a predetermined figure, in the letter of appropriations, would allow corresponding income item to be booked, with an intelligible Profit and Loss Account as a result.

Corresponding neutral effects of the index adjustment would also be seen in the SNRA’s appropriation settlements.

The actual indexing (calculation of index values) and accounting are somewhat complicated. From the point of view of internal control, it is therefore important that index write-up and accounting be done by computer. Index tables can then be linked to each component individually and specific output data generated automatically for manual checking and collating.

If manual accounting of index values is nonetheless preferred, the procedure must have built-in controls to minimise the risk of incorrect accounting.

4.3 Opportunities and threats in the model and the accounting

The model provides important information for several of the road management processes, such as long and short-term planning (deficiencies, risks, resource allocation, life cycle costs, productivity, efficiency, cost drivers etc), financial control / budgeting (resource requirements, resource consumption, resource usage, economic results, reporting etc), procurement (status, function- and quality-focused requirements and contracts, measures, etc), follow-ups, management and monitoring of production (computer-aided analyses of unit price-, quantity- and time-dependent deviations, internal and external benchmarking, costing etc).

The model’s application in the road management processes and in steering road management towards the transport policy objectives will be presented in a separate paper. Not only values and costs from the accounting but also data in respect of the effects of road management will be documented systematically there.

It is important to emphasise that the cost of measures to rectify deficiencies cannot be totalled without checking that the same figures are not being counted twice or checking for any significant synergies.

The total cost of the measure taken on a certain installation is often reduced if, for example, an investment to attain target standard rectifies one or several of the condition deficiencies at the same time, or if several measures are co-ordinated and carried out under the same contract. On the other hand, the model contains a certain amount of basic data for analysing the value of coordinated measures and assessing different kinds of synergies.
Condition descriptions of gravel road’s wearing course (gravel wearing course) are an important issue, because the component exists on approximately 21% (21,247 km) of the total state-owned road network. In the same way, it is vital to study how risk management and accounting are to be arranged with regard to roads open for use as ice roads in winter. Operating and maintenance costs are normally booked against the component on which the measure is taken. A wearing course named “ice on ice road” may possibly be needed.

The service of a road with a special classification (for example roads of cultural interest) is subject to special instructions. Such roads, their components and their deficiencies require a dedicated description of the road capital – principles and values that also need to be investigated separately.

_The valuation principle and quality_

A condition value is determined either from an acquisition value based on real figures or on standard-estimated figures, and this affects the quality of the analyses that are done. If reference standards are used consistently in valuations of investments, the difference between the real prices paid and the standard-estimated or recommended basic prices will have a direct impact on the Profit and Loss Account. The net profit/loss is thus automatically corrected for “good/bad business”.

A problem with reference standards is that they can hardly take differences in quality into full consideration. In reality, a higher price often is accepted for reasons of quality. Higher quality can result in a longer useful life, which means lower annual depreciation and hence lower annual costs (lower life cycle cost). Reference standards make it difficult to benchmark quality, changes in value, and costs in the road transportation system. In a longer perspective, it may also prove difficult to get at “the true facts” with regard to road management costs and the real linkages between the measure carried out and the effects for road users and society.

Price changes and cost indexes should be analysed routinely and regularly (for example every five years) collated against actual price development. Experience from the SNRA tells against using standard-estimated valuations without collating against actual figures. Comparisons over time are an important element in management and control, so it is important that the principles underlying valuations are stable. If actual price is the basis for valuation of condition, the model principles are stable and the annual depreciations will be based on actual values.

Quality factors of long-term significance manifest themselves correctly in annual “deprecia-
tions” when real (actual) values are used. According to the theory behind quality-related accounting, depreciations must reflect changes in components’ condition as well as possible. Quality defects in production will be able to clearly shown in the results as quality defect costs already during year 1 in connection with the closing of the accounts and in life cycle cost analyses.

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13 This refers to the SNRA’s experience in its operations of problems with standard prices for machinery in the so-called MCF (Central Machinery Resources) system and the regularly updated prices of friction materials in the stores system (Lagermodellen) which both systems were indirectly linked to the settlement of appropriations. The principles of the five-year plan of operations were based on similar ideas about standard as regards resource allocation etc. The examples described were solutions devised in the 1970s (according to typical economic planning principles) in the authority’s autonomous Operations division. The authority lost touch with the real costs in all cases within ten years of introduction. Competence and effort were focused on developed models, data and computer support and continued development instead of on analyses of actual cost, productivity etc.
If depreciation can be identified in connection with taking over some measure, this will have an immediate impact on the year’s results. Where the quality of a component is low, this also gives a higher annual cost than “normal” for both the component and road maintenance. This is detected in an analysis by type of component.

The model must be able to account real changes in standard and condition in a stable, uniform, and controllable fashion using intelligible values of road capital. As stated in chapter 2, An accounting model for road capital, efforts have been made to construct a model that fulfils stringent requirements with regard to stability and uniformity. However, stability must not compromise the model’s flexibility and continued development to keep pace with new knowledge. If only the principles for the condition valuation itself (which are the core of the model), are fixed, most changes connected with, for example, a new condition parameter (measurement value), alterations to a component’s condition description (a new description model), a new standard-estimated cost, a new component, or a change in index value, can easily be handled without causing any problems about the stability or continuity in the accounting.

The limited computer support that is needed must be designed wisely with tables that can be updated easily. It should be possible to see the consequences of new prerequisites on the basis of previous valuations etc. This is made possible by storing basic data for a number of years. As regards changes in indexes, adjustments for previous years can be spread evenly over a number of years, for example all five years of the comparison.

Controllability is facilitated by basing the model on established, uniform principles. As a basis for the valuation, reference standards exist for costs to rectify different identified and documented deficiencies. The valuation of a component can thus be checked in situ, supported by documented basic data and fixed accounting principles. Acquisition values and replacement values, standard target values and condition values are valued in Swedish kronor (or euros), which in itself is easy to understand. Changes are calculated as the difference between values at two different points in time, which are calculated according to the same principle.

It is important to understand that the real cost of the measure taken will in all probability not be the same as the reference standard, because in the real world there are many factors that influence when the measure is taken. Examples of such factors are the prices in the construction market, the possibility to co-ordinate the measure with other measures, the cost of the measure in relation to fixed costs, and geographical, geological, and environmental conditions.

4.4 Implementation of the model

4.4.1 The model and the processes

The reference model’s importance for road management’s subprocesses

The reference model should make it possible to increase efficiency in several processes at the SNRA, primarily in respect of activity planning – follow-up – activity analysis, purchasing – procurement – project management, financial accounting and reporting – accounts closure – annual report and long-range planning. A general description is given of how the model concerns the processes purchasing – procurement – project management, activity planning – follow-up – activity analysis and long-range planning. The model’s application in road management will be analysed in more detail in a separate paper.
An attempt has been made to raise the quality of financial control in projects using today’s accounting principles. It proved to be an extremely time-consuming task to follow up all the adjustable quantities with unit prices – the level at which a project’s cost deviations are generated.

It is therefore not often that managing, monitoring, and forecasting are done on the basis of today’s detailed level, which leads among other things to uncertain forecasts. And because many people are involved in forecasting, where each has his or her own personal view of accrual accounting and budget adjustment items, the quality of the forecasts is generally quite low and variable.

Expressed in other words, the problem is that there is good reason to assume that financial control and monitoring are hardly completely satisfactory. The individuals involved in producing forecasts have varying levels of ambition as regards the financial work, and many of them may feel a degree of disinclination when faced with the pressure from superior requirements regarding financial control in a system that may be too laborious to work.

The knowledge and discipline needed to achieve quality-assured control and monitoring of over two thousand adjustable quantities per project manager, and simultaneously for all project managers, is difficult to accomplish. It is made even more difficult when a customer focus primarily leads to the project manager’s involvement today being directed at following up and controlling the project’s physical qualities, which in a longer perspective is probably the right way to go. In the short term, however, this can be a major management problem (see Financial control in road management below).

Computer support will be used in the project manager’s financial follow-up with forecasts and analyses, as described above. A prerequisite is that the contractor’s schedules are documented by type of component in the follow-up system.

This will make it possible for all projects to specify cost deviations with computer support and also make computerised analyses with regard to the quantities, unit prices and time-dependencies according to uniform principles and with a constant high level of quality.

For the “investment project manager” the reference model will mean that the operative focus can switch from discussions about a large number of adjustable quantities to the quality and function of products or components. The basic principle is also that it must be possible to measure adjustable items afterwards. There are a few exceptions from this general principle of controllability, for example for road structures and geotechnical constructions.

Knowledge of components’ unit prices is important for checks in connection with purchasing and procurement. This knowledge will build up gradually if the reference model is used. Knowledge of the causes of price differences is also needed.

IA developed an analysis method to assess the cost of lack of competition in the pavement area\textsuperscript{4}. The method can be used to analyse the reasonableness of the prices offered for components and also to show road management’s “cost drivers” more clearly.

\textsuperscript{4} The method was developed by IA in 1990 and was called “Index analysis”. Using this analysis model, IA was able to show that lack of competition in the pavement area in one part of Sweden had led to a price that was at least 20\% too high.
Offers in connection with investments can be evaluated when the "normal prices" for components and the proportions that individual types of resources represent, for example machinery, wages, gravel, bitumen, are known. Knowledge is also needed of the price development of each type of resource according to figures in the construction price index from Statistics Sweden. Checks must also be made regularly to identify any changes in the proportions of the prices that the types of resources represent caused by price development.

According to experienced purchasers, quality in procurement can be achieved by means of careful analysis of risk factors and uncertainties in the offer documents to see how they can affect prices. The examples in this section deal with how information about road capital might be used in drawing up the procurement documents for road operation contracts. For purely business reasons, it may be appropriate to regulate factors and conditions that are difficult to assess, in order to avoid receiving offers containing unnecessary mark-ups for risk or gambles. Separate prices can be requested by component for major (plannable) measures.

The components on each section of road can be shown in a map with links to digital images of critical components with details of quantities, ages, condition development, and current condition. Other components on the section of road can be organised into tables with the same details, supplemented with condition requirements, traffic data and other significant data for the road’s management. Different colours can be used for different types of data.

The age and condition data in the offer documents can give an indication of a need for the tenderer to investigate the component’s condition separately. It may be necessary to request a separate offer or offer some sort of regulation where a component’s condition is unclear. Good quality in tender documents reduces the risk of mark-ups in the offer and the likelihood of problems/disputes occurring at a later stage.

Maximum levels can be set for annual changes in value and/or lowest condition value for the component/section at handover when the work is complete. Inspection procedures can also be specified. The tender documents should also state whether any bonus will be paid or if any deductions will be made for significant deviations from the condition values when the work has been completed.

According to the reference model, procurements are made according to the following principles:

- In the case of investments, components are purchased at agreed unit prices. The number of adjustable quantities varies greatly depending upon the component but are normally strictly limited to kronor/unit (for example kronor / metre of guard rail), where the number of metres can be adjusted over the course of the project.

- Component maintenance is purchased at agreed unit prices. The number of adjustable quantities varies greatly also in this case, but should be restricted. Maintenance is normally paid for in kronor / unit (for example kronor / metre of bridge) for the number of metres that are found by inspection to have reached a certain condition level according to one of the condition description models. Different unit prices may apply for different lengths, for example 0 – 10 metres, 11 – 50 metres, 51 – 200 metres and over 200 metres.
Component service can be purchased for example to maintain function round the clock, every day of the year, and in all kinds of weather, for the benefit of passenger and freight transport and anyone else concerned. The number of possible adjustments should be strictly limited also in this case. For example, the price of keeping roads clear of snow and ice prevention can be expressed in kronor/kilometre of road occasion and type of road. The cost can be entered against the wearing course component. The measure can be controlled according to principles similar to those of today.

Limitation of the number of adjustable factors in the contracts, as detailed above, should be based on analyses of business risks and a sound distribution of any risks between client and contactor. Where operations are analysed according to the “index analysis” principle, this will provide a basis for a structured risk analysis of the economy of the entire road management. A number of questions of importance for strategic control will be able to be analysed. Below follow some examples of questions that should be put and also answered or at least illuminated in a qualified manner:

- Which types of resources are the biggest “cost drivers” in road management?
- How can the different types of resources be expected to develop economically in the short term and in a longer perspective?
- What types of resources can be expected to be most critical for cost development in road management?
- What types of resources account for the greatest risks and opportunities in road management in financial terms?
- What can be done to hold back cost development in the most effective way?
- What development should be encouraged or counteracted to stimulate positive development of productivity in the most effective way and what risks are involved in different courses of action?
- What are the financial consequences from the point of view of road management of different results of contract negotiations for the current year and for the whole period covered by the plan?

It is important in financial control in road management and risk management to maintain control of projects’ costs and expected effects. Current contracts with contractors, as stated earlier, contain a great many adjustable quantities that change and are discussed within the projects. The adjustable quantities can be exploited economically by contractors with knowledge of the details. Every adjustable quantity can act as a “volume knob” to increase the total tender amount, which might mean that the more knobs the greater the risk of cost increases.

The overarching financial control requires knowledge of the causes of deviations in the different projects and in total for all projects. What is the result of a deviating unit price, deviating quantities and deviating production rate, and what financial problems do the deviations cause in the short term and in a longer perspective? Early, accurate information about the causes of the deviations means that fast decisions on possible measures will have a greater chance of success.

Knowledge of the cost drivers is also important to sound long-term financial control – knowledge that is insufficient at the SNRA. This deficiency is a serious one, since the SNRA is the single most dominating player in the industry and has a responsibility to counteract unfavourable price development. The reference model is well suited as one base for this type of analyses.
Most contractors use project network techniques to plan their assignments. This fact opens up a possibility that is not fully exploited in the SNRA’s project control and cost follow-ups. One attempt to computerise analysis of cost deviations was mentioned earlier. The analysis model worked in the experiment but was judged to be too administratively heavy to be used with the current level of detail. In the reference model, components can be purchased by the metre, unit, and ton etc with only a few adjustable quantities. Computerised deviation analyses can then be made against plans, budgets, and contracts.

If long-range plans based on available knowledge of the included projects are drawn up using project network techniques with quantities and unit prices at a level that is judged to be meaningful, the proposed analysis model should then be applied in parallel with the follow-up of the long-range plan and the activity plan. Details of projects in long-range plans can in principle vary from the total number of metres of road and an estimated unit price per metre of road to the quantities of different components and assessed unit prices.

The cause of any deviation from budget and plans should be analysed in rolling follow-ups. A regular check needs to be made of the economic prerequisites for realising commitments and of the consequences of different deviations for the project. The analyses are needed as input to the control of risks such as punctuality, costs, additions/changes, functions, effects, problems, and opportunities, and to specify what measures to take, decisions, and the need for deeper analyses in support of learning in the organisation and efforts to improve the road management processes.

The orderer / the SNRA has details of the latest agreed unit price and approved change and addition orders. To make a “computerised” analysis the SNRA needs to ensure in its contracts that the contractor, in addition to an overall network plan, also provides (for example in invoices) monthly details of actual quantity processed or produced of each component.

The project manager is responsible for the project and should have the best available knowledge of the likelihood of new unit prices and quantities and additional orders based on the discussions held with the contractor. It is therefore important for the project manager to personally check, adjust, and ultimately approve “computer-devised” forecasts before they proceed to the reporting system.

For long-range planning, the proposed model contains the following data for any road:

- Condition value, target standard value, replacement value, book value, annual depreciation according to plan, a list of the different kinds of condition and standard deficiencies with the estimated cost to rectify per type of component and in total.
- Forecasts of how the condition value and depreciation are expected to develop.
- Historical cost data for road management (operation, maintenance and depreciation) for example expressed as SEK / vehicle kilometre and forecasts of future operation and maintenance costs per component and in total for any section of road.
- Traffic, vehicle mileage, the composition of the traffic (passenger cars, trucks with and without trailers etc) and forecasts of how the traffic is expected to develop.

A later paper will take up other important aspects of long-range planning, i.e. the effects for society and road users. Effects will be able to be presented for any road section in a similar way to the figures for road capital and road management costs. All data in the model and also the effects must be controllable and documented and follow uniform established principles and procedures.
It is important when planning to be able to compare and select information objectively from similar roads in different parts of Sweden, which can be done in the reference model using existing data-processing tools. This makes it possible to use a computer to indicate or list the following information for any road, road network or area of roads:

- The "worst” and best sections from a physical and/or economic point of view.
- Road sections where road management costs are highest due to contracts or less successful investments.
- Components, road sections or points in the road network with the greatest and/or most advantageous improvement potential if standard deficiencies are rectified.
- Road sections with unacceptable physical deficiencies relative to rules and regulations in force or "fairness aspects" as regards the demands for regional development.
- Road sections with unacceptable costs for transportation and to society – an opportunity that will be analysed later in a separate paper.

The road sections and points in the road network indicated can be analysed further in the traditional way (separate studies and EVA calculations) according to applicable planning process criteria. It is also important to analyse the value of different synergies, if different measures are coordinated and co-planned; this can be illustrated using the reference model. A number of expert systems for planning will be able to be developed alongside the model. The planning process can be made more efficient, transparent, and communicable.

4.4.2 The model and indicators

The model must be able to generate useful indicators and show changes by road network component and different parts of the road network in a flexible manner.

The following groups of information users have been identified:
- the responsible government administrators/executive officials and the politicians involved in the national policy processes,
- the responsible administrators/executive officials of the county administrative board and the politicians involved in the local policy processes,
- users of the road network, the public / taxpayers and responsible officers in trade and industry’s process,
- the SNRA’s management (including the board) and the responsible officers in the SNRA’s central processes,
- the SNRA’s regional management teams and the responsible officers in the regions’ governing subprocesses,
- the people responsible for operative processes, i.e. projects with contractors and consultants,
- the people responsible for the operators’ and consultants’ assignment-specific processes.

To analyse the model’s usefulness and the indicators it is important to state who is the user of the information. The model is based on the principle that superior user levels mainly use accumulated information from the levels immediately below and that it is possible to perform detailed analyses using the information from the lower levels. It is therefore appropriate to begin the review with the lowest user level in the list above.
The people responsible for the operators’ and consultants’ assignments work in their processes to maintain control of deviations from agreements entered into. Financial deviations are principally a result of changes in prerequisites which in some way affect agreed unit prices, quantities or schedules. Contracts today contain a great many adjustable quantities arranged so as to achieve a shared responsibility that will reduce the contractor’s risk. Viewed over the whole process chain, the financial consequences and resource consumption are substantial, since project control, monitoring and accounting become extremely detailed.

The model puts project control at a less detailed level. It became clear from discussions with experienced project managers for investment objects that this less detailed level works very well for project control. The assignment of responsibilities between client and contractor would change a little – an issue that will be dealt with in a separate paper.

With the same arrangement as today, the operative level would link unit prices, quantities, and schedules to the components. As regards investments, all checks would be possible at later stages, with the exception of those components that are located underground, i.e. ground insulation, geotechnical constructions, protection installations for water catchments and any regulating elements in the road structure. Investment projects also provide the accounting with details of components that are part of the acquisition.

In the same way, unit prices and quantities related to the service of the components would be linked to the components concerned and for which service and condition requirements have been specified in contracts. Follow-ups and reporting of service and condition (according to the description models decided) for those components judged to be suitable can be done at invoicing time. The information might even be the figures needed for the invoice itself.

It is not always possible to report service by component, as it is carried out at the same time on a number of components along a section or loop. There should therefore be a template for each such type of measure for distributing costs and quantities between the components concerned. The template can often be the relative quantity of a component, for example its length in metres, according to the RDB, of the total number of metres for all components serviced. At other times, service is carried out on a specific component, and in such cases costs and quantities are booked directly to the component in question (unique component number).

Maintenance and service can be booked to components in the same way, and together with details of changes in value can form a basis for different types of analyses, comparisons of life cycle costs, benchmarking etc. The indicators that the model can generate at project level are computerised analyses of costs, deviations divided according to unit price, quantity and time-dependency. This information, based on work related to the schedule per type of component, changes to orders, additional orders, and invoicing provide a good basis for forecasts of actual costs compared to annual and total budgets.

The principles for this type of deviation analysis and reporting mean that “everyone” responsible for forecasts uses the same basis for their accrual accounting. Indicators will be examined in more detail in a separate paper on analyses.

Other indicators at operative level in the service area are the condition descriptions per component (where they exist) and the changes in condition value per type of component that the model provides. Results can be viewed against the requirements stipulated in the works contracts. This can also be done by computer.
Condition values can be totalled and compared with different kinds of costs, lengths, areas and other dimensions, and e.g. vehicle mileage and can be used as a basis for benchmarking and improvement efforts. However, the effects of road management should be included as important parts of the analysis here. A separate paper will illustrate how effects for road users and society can be used together with condition data.

In connection with procurement, price analyses can be made using the same method (called index analysis), that was developed by IA in 1990, to identify markets with unhealthy competition and price development in the pavement sector. The method is based on knowledge of “normal” prices and the proportion of the total price that the types of resources included represent, and these resource types’ price development according to Statistics Sweden’s construction price index.

In the index analysis attempts are made to justify markedly deviating prices by identifying, for each type of resource, prerequisites that justify a higher price. A type of resource that for example accounted for 10% of the total price could be assessed to be 30% more expensive in a special situation. This fact would then be used to justify an approximately 3% higher total price than usual. Any substantial deviations that remained after totalling the justified price increases at resource type level can be a sign of unhealthy competition and price development.

It is simpler to systematically perform automated price analyses based on type of resource, using components as the starting-point rather than adjustable quantities. Using components as the starting-point provides stability, since component prices are included in the continuous data collection. Information about the resource types’ proportion of different prices of components and measures must be obtained through special follow-ups or purchased from contractors or of reasons of knowledge by officially managed production (with subcontract to a certain degree).

The operative level will work at component level. However, in the model presented, totalling the components into larger groups is no problem. On the contrary, the model is completely independent of the number of components. In discussions about a less detailed division, however, other aspects are concerned that have to do with analyses, checks, how contracts are designed and how work in the project is done.

It should also be emphasised that the extra cost of registering financial information for components whose technical content is already handled in the RDB, will probably not be very great, because the registration must be accomplished using smart computerised solutions and be connected with the invoicing. The components that do not exist in the RDB are relatively few, so the cost of entering the data will generally speaking not be so very great either.

No one knows today the magnitude of the values that each component represents in the book value of road installation or of a replacement value in the road network, or how high the components’ service costs are. If this information had been available, it would have been possible to discuss the importance of the component’s values, the cost of changes and service, and the cost of handling the information.
Some components can reliably be said to represent relatively small values, since there are relatively few of them. These include machinery and fixtures for roads/traffic, other installations over roads, all five components in the group of environmental installations necessitated by a road, other ground installations, ferry berths, public piers, other constructional works, anti-glare shields, rockslide and snowslide barriers, other safety installation, other road informatics equipment, and other traffic direction installations. This leaves the 24 most important components, of which land, buildings and premises can be ignored from the point of view of accounting. Some of the components, however, may represent especially important road management items and work at the locations where they occur. Other components may represent only values and require no work. If the components and their economic data are not properly organised, it may be difficult to perform analyses and general benchmarking for example.

The remaining 24 components can be subjected to the same type of discussion, which will eventually result in the elimination of all but the seven components road structure, wearing course, drainage installations, fixed bridges, tubular bridges, adjacent areas, and road markings, of which road structure, wearing course, and fixed bridges together represent the highest values. In summary, it is clear that no component type that occurs seldom and only “here and there” causes any administrative problem at the locations and in road management where they do not occur. Where they do occur, on the other hand, they may have great economic significance.

The quality of the external accounting would be considerably higher if the components were divided into the three most important components and a group containing all the others. For users at all levels from the SNRA’s executive management (including the board) and the people responsible for the SNRA’s central processes through users of the road network, the public, taxpayers and the people responsible in trade and industry’s processes to the responsible offices in the county administration and the politicians involved in the local and national political processes, a road capital consisting of four items would undoubtedly be sufficient. Analyses to answer questions from these users might, however, require more details.

And with such a general level of only four items, the people with the operative responsibility would in any case need their own system to follow up contracts and to support their own learning and improvement processes.

4.4.3 Different starting-points for how information is viewed

Road management engineers can be divided into two groups. One group, often at operative level and sometimes without any direct responsibility for data capture works actively to gain access to detailed information about their tasks. The other group, normally consisting of engineers at higher levels in the administration, can actively and successfully discuss in general terms and also against the importance of detailed information. They are successful as long as the detailed knowledge available does not say the opposite.

Many in the second group feel that a great deal of data (components) is an administrative burden – an attitude that easily gains acceptance in the organisation. This group of engineers are often under pressure to reduce administration costs. Sometimes they put forward a more acceptable argument, i.e. that it is important to capture good quality information about “sizeable, significant items” and that rough estimates and “general knowledge” should be sufficient for the “less significant” ones.
This “general knowledge”, however, is often based on detailed historical information. In slow processes, the prerequisites may gradually change unnoticed. Without detailed information, it can be difficult to detect such changes in time. The result may be financial losses or credibility problems, for example, a not infrequent occurrence in the public sector. The world around realises that the authority “does not know what it is talking about”. There are many examples of successful companies in markets subject to tough competition that suddenly collapsed because they did not see the changes in prerequisites in time. The companies had been run on the basis of “general knowledge” and an antiquated attitude to the market.

As regards components’ condition (with the exception of bridges and pavements) questions are often answered by one person or a group of people making assessments and estimates on the basis of some kind of “general knowledge” about the road network and road management. This answer is more often than not sufficient in the context, but in some cases it is not.

One and the same question can be answered by several different people, with markedly divergent answers. The question may return again when general checks are made. The answer then may be quite a different one. At the SNRA, there are examples that indicate that the problem is a very real one. It is also clear that the authority’s credibility is being eroded.

Knowledge of road management costs is insufficient at the SNRA today, despite the fact that the authority works at a very detailed and resource-consuming level. The operative accounting contains figures at the level of priced quantities – quantities that in most cases are connected to producing a component or parts of a component in for example an investment object. The need for figures on which to base calculations is a legacy from the time the authority operated in its own right that still controls the detailed accounting but that lacks any foundation in how risks are apportioned between client and contractor.

How is this detailed knowledge used for control purposes? What are the cost drivers in road management and what is done about them? Which 20 roads have the lowest and highest road management cost per vehicle kilometre in each region? Which 20 roads have the lowest and highest road passenger and freight costs and cost to society per vehicle kilometre in each region? How does the SNRA work in order to be as efficient as in the available best practice examples in all areas? What measures can be taken, which are taken, and what are the results? How can we know that general knowledge of cost-efficiency is sufficient for good results from the improvement effort?

Well-defined and systematically accumulated information leads in the long run to the greatest efficiency and best quality in underlying information for decisions, reports, and development. In a large organisation, the prerequisite for achieving a real improvement in efficiency may be goal-oriented work according to the “every little helps” principle (finding and dealing with small costs). In such an approach it is especially important to have adequate control of small changes in cost, benefit, and quality in a continuous improvement effort covering processes, procedures, and products.

Since IA proposed its road capital model in 1992, the development of information in operation and maintenance has been in that direction. The operative division has developed an application named Stänga, which contains input routines, for example for quality data in respect of phenomena. In the same way, Bridge data system has been further developed so that it is now largely in agreement with the reference model and IA’s proposal.
The reference model presented in this paper deals with the aspect of different requirements for the “large, significant items” and the “less significant items”, in such a way that the condition description is more sophisticated and objective for the “major items” (laser measurement, bridge and tunnel inspections, BARUND etc, according to description models II, III, IV, and V). For the “less significant” items can the depreciations be done according to a forecast over a predetermined period (description model VI), in a computer-based accounting system.

It is important that the issue of how detailed the division into components should be is based on a holistic perspective and takes into consideration the fact that road management may in future need hitherto unused information.

Popular assertions about the need to reduce administration costs have an enormous “blast effect”. In reality, such utterances have proved to be rather pointless. The improvement effort has often not included the fundamental problems. The present systems (with their thousands of cost drivers) have had to become a permanent prerequisite, despite their being very unwieldy and laborious. The system has for example proved to have difficulty when modern EDI solutions are implemented on a large scale. Efforts have been made in very extensive projects running over several years.

The system is the cause of substantial quality defect costs – that must be handled and borne without being looked at closely. It has been the case on occasion that information supplied that is of defective quality “has had” to be cut out at a later stage by means of awkward and expensive administrative “clarifications”.

Some ten different levels may be involved in supplying information to produce a forecast. In principle it is possible for “all levels” to have their own perception of budget adjustment items and accrual accounting. Examples exist where administration costs of anything up to 100 million SEK below budget have suddenly come to light between the November forecast (which is drawn up in the middle of December) and the closing of the accounts in December the same year. This is yet another example of a quality defect cost. Investigations with meetings and dialogues around large budget deviations are expensive and consume important production resources.

Analyses at the end of the 1980s showed how a detailed division of price-affecting factors in the annual price negotiations in connection with central haulage contracts resulted in disastrously spiralling prices. The haulage industry’s negotiators, with their detailed knowledge, had a very broad base in all the discussions about details and succeeded in fuelling price development. The SNRA’s negotiators found it difficult to put forward their arguments at the detail level. During the final years of the 1980s, prices in the central contracts had reached such a level that several of the authority’s divisions did not keep to them. Local prices were considerably lower and the central agreements were eventually discontinued.

In the same way, adjustable quantities can be exploited by contractors with detailed knowledge. Every adjustable quantity is the equivalent of a “volume knob” for a contractor, with which the total tender price can be increased. The more “volume knobs” the greater the likelihood of higher project costs. Switching to component structure would reduce such price increases – an aspect that should be considered when evaluating today’s way of working in projects (detailed contracts and resource-consuming financial control).
The administrative work done today to handle technical input data for the phenomenon is extensive. The reference model will probably prepare the way for increasing efficiency in capturing both technical and financial data.

### 4.4.4 Comparison between components, RDB-phenomena and rail installation types

One prevalent complaint is that it is impossible to keep track of all the data needed in the reference model and that the number of components is far too high. A general comparison has therefore been made between the reference model’s components, the RDB’s phenomena, and the Swedish Rail Administration’s installation types.

Wholesalers and other companies that hold large stocks are forced to devote man-months every year to stocktaking millions of units of goods over the course of a few days, despite a total value that may be less than 50 million SEK. Stocktaking at the SNRA involves physical fixed assets or components that together may be worth 10,000 times that figure.

It might also be considered a natural ambition for a responsible road authority to keep track of its fixed assets’ physically controllable independent components, especially as their service is in the hands of external contractors and that each one represents substantial values and all have different useful lives and different changes in condition.

The road authorities in Finland and Norway have been working to raise the quality of data in the road databases for some time. As in many countries, a purposeful effort is being made to make control of road management more efficient according to Asset Management principles (see other paper in the thesis).

Comparisons have been made between the model’s division into components, the Swedish Rail Administration’s installation types and former (1992) Swedish Telecom’s and State Power Board’s division into installations. The model has eight main groups and 43 subgroups while the others all have seven groups, and 62, 33, and 64 subgroups respectively. The SNRA has since the beginning (in 1994) had one group containing complete investment projects.

The reference model is principally based on existing data in databases and applications in the SNRA’s systems. One important source is the RDB, as it contains a great many phenomena connected to roads. There is administrative and technical data, but financial information is almost non-existent. Exceptions are the systems for bridges, tunnels, and pavements, which in principle contain all the information the reference model requires.

Allowing for misinterpretation of content etc, RDB data is available for 35 of the reference model’s 43 components (of which seven are miscellaneous items) in the form of a phenomenon in its own right (see Appendix 3, and compare also with the Swedish Rail Administration’s installation types). If the quality of RDB data in the seven road management regions is as varied as it is claimed, it is nonetheless still not clear how useful the RDB is in practice.

### 4.4.5 More views on components and reporting requirements

When the reference model has been presented, objections have been raised with regard to some details in the proposal. The division into components is one, as can be seen from the discussions earlier in this chapter. Another recurring objection is discussed below.
When business economists debate the division into components, a comment often heard is that it is not necessary. On several occasions, a comparison has been drawn with the accounting of an investment in a house. Detractors point out that the roof, paint, oil-fired boiler, and balcony, for example, are not accounted separately. The whole investment is depreciated over the same length of time. Expenses for a new boiler and repainting the house, for example, are regarded as maintenance costs.

Many economists see the handling of component data as a manual burden. Not too far in the future, it will be possible to transfer contractors’ reporting of investment details etc to the SNRA electronically via EDI once the possibility is asked for. The consequences brought about by EDI should be considered when discussing the level of ambition in the improvement effort. SNRA staff already handles most of the proposed component data in the RDB and other systems today, but almost never financial data.

It is engineers’ need for information to monitor physical assets, functions and phenomena that lies behind the existence of the RDB. The technical ambition in respect of control has steered the work with basic data and data capture. It is crucial to acceptance of the model that the levels of ambition with regard to basic technical and financial information be reconciled. Data and data capture need to be coordinated, made more efficient, and given a structure based on a holistic view.

Quality-related accounting of road capital emphasises the quality aspect of the financial information in order to improve the control and monitoring of road management. The idea is to coordinate different ambitions and structures and different ways of handling input data. The starting-point is the SNRA’s role as road manager and the needs of the road management processes.

Economists have compared the needs covered by the reference model with the needs and accounting of property investments. The comparison is both good and misleading at the same time. It is good because most people can understand it. It is misleading because it contains significant differences with respect to the information that the two items compared need for control and because the development of external accounting has now come past that stage for property. It is today regarded as an accepted accounting standard to account per component¹. The issue now is at what level of detail and according to what principles.

According to the “Fair value model” in International Accounting Standard (IAS 40) the accounted value of each building in the Balance Sheet that is not continuously valued at market-value is divided into its main components. Depreciation is accounted on the basis of the depreciable amount and useful life is to be assessed for each component. The requirements, the aim of which is uniform, accurate accounting, place great demands on the procedures and on the installation register.

¹ Stellan Lundström, Bo Nordlund. Komponentavskrivning på byggnader – företag som redovisar enligt IAS/IFRS, (Depreciation of buildings using components – companies accounting using IAS/IFRS), Tidskriften Balans nr 3 s. 16-18, FAR, Stockholm, 2004

- The Swedish Financial Accounting Standards Council, Accounting Recommendations RR 12, Tangible fixed assets

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IAS 16, Property, Plant and Equipment, has been established by the IASB and approved by the EU. The requirement for depreciation by component is made already there. The SNRA’s asset accounting of road installations, which is done for whole projects with the same averaged economic life for all the project’s components applied country-wide is in conflict with the revised IAS 16.

4.5 Practical implementation of the model

The model can be implemented in practice, and essentially based on existing information and existing data processing application, systems and procedures.

4.5.1 Quality, data capture and basic data in road management

Issues to discuss from the point of view of quality have to do with investments, database handling, use, and basic data, and collation between actual values, valuations, indexes, and keeping the information up to date.

Surveys

Certain components or data about components can be overlooked when surveys are made either by error or due to lack of competence. Components and quantities can be entered in the wrong way. Information can be reported incorrectly or not reported at all due to deficiencies in documentation, general order, communication, or resources.

Where data is retrieved from revised construction documents there is a risk that the quality will be insufficient; the documents may contain shortcomings and inaccuracies, they may not be suitable for the needs of the reference model, can be misunderstood, or difficult to interpret for people who are not sufficiently competent to do so.

In the case of condition surveys and measurements, the quality problems are related to system, procedures and calculations. The reference model contains a structure made up of six formalised models for drawing up condition descriptions. Using these models as the starting-point, dedicated and uniform procedures should be drawn up for each type of component, with built-in checks and output data for collation purposes. This should be done together with the contractors, because the procedures and bases for valuation may be included in the contracts entered into for different types of construction projects. The contractor can for example be obliged to make reports in connection with invoicing, with data to support the valuation procedure.

Measurements of pavements are made systematically using vehicles equipped with laser-cameras. There are differences between different makes but these can be considered and adjustments made if they are known. Quality development here is ongoing and positive, and can be traced to method, approach and equipment.

System- and procedure-related problems also exist with regard to surveys of standard and descriptions of deficiencies and development efforts are being made in this area. The reference model should be adapted to the development efforts, to ensure that it is not divergent in some significant aspect.
The basic principles of the model are that it must be based on "best available knowledge" and that data is captured using rational solutions and methods without the need for any specific data and data capture requirements of its own. The model must be "open" in the sense that it must be able to receive and use the information that is nonetheless needed to be able to monitor and steer road management in the direction of the objectives of the national transport policy in a businesslike and acceptable manner.

Database management

There may be problems with the quality of the information in the databases, that may for example be related to shortage of resources. These may include obsolete information as a result of updating problems, and incorrect or incomplete registration of data. There may also be shortcomings with regard to the applications, the systems, the user handbooks, the instructions given, and the competence of the people who manage the databases.

Use

A person using the reference model or who contributes information from databases and other sources may have insufficient knowledge and competence regarding the reference model – a deficiency that may make it difficult to understand the importance of data, its use, and of making plausibility checks of data.

Inaccurate or misleading reports can be made if the users do not have sufficient competence.

Basic data and the RDB

In the RDB, phenomena are normally linked to the road network as sections (section phenomenon), between a starting-point and an end-point. They can also be linked to the road network as points (point phenomenon). A phenomenon in the RDB is often assigned details of properties for example in what are called phenomena terms. A component is an example of a phenomenon while a component’s acquisition value per metre of length would be an example of a phenomena term.

The reference model assumes that quality-assured procedures are in place to systematically identify deficiencies in the road network. Examples of such procedures are when information about a deficiency is to be retrieved from physical planning, from computer searches, inspections or measurements according to one of the condition description models or when the information is to be approved and registered. Quality assured deficiencies must be documented uniformly for the whole country and registered as a term against the phenomenon in question in the RDB.

In the reference model, financial data is linked to the road network as RDB terms or exist in a separate system integrated with the RDB. Acquisition values, for example, must exist by component also in the case of historical road investments. In the following, the work and effort that may be involved to adapt the existing basic information in the SNRA's systems are analysed and discussed. The descriptions are based on the components in table 2 and the fact that there already exist several functioning programs, phenomena and terms in the RDB.
A condition deficiency in respect of for example the component pavement according to the annual RST measurement, is registered and linked to the reference system by computer in the same way as today, but with a standard-estimated deficiency cost (calculated using the cost of the measure and the lowest acceptable limit value for the measure). A bearing capacity deficiency in relation to permitted vehicle weight is for example detected according to the BÅRUND model by means of georadar, laser measurement, deflectometry, or analyses, including analyses of different types of materials samples. The bearing capacity deficiency and the calculated cost of the measure are located in the road network and linked to the Road construction element as a phenomena term.

Procedures exist to systematically identify and document condition deficiencies for bridges and tunnels. For other components, simple, dedicated procedures for capturing condition deficiencies may be developed together with committed contractors. Good technical aids exist that should be able to be used, for example GPS equipment and digital photography. There are also excellent possibilities to transfer information digitally.

A standard deficiency (for example in respect of road width, visible distance, intersection design, a road sign, an adjacent area, lighting mast, or bearing capacity) is to be registered as a deficiency in the component (phenomenon) that the deficiency concerns according to the definition. It is crucial to the quality of monitoring and control to use the best available knowledge and that this is registered continuously and available to the reference model. “Approved deficiencies, deficiency costs and effects” may have been identified and standard-estimated (or calculated) in one of the following ways:

- A computerised comparison is made in the RDB between standard and established target standard road by road. In the early stages, the effects on transportation, society and road manager are standard-estimated or calculated using the linkages used in the EVA model.
- A systematic survey (e.g. a road audit), a dedicated analysis, external complaints or a professional observation results in information about deficiencies being documented and approved according to a uniform, established procedure. Documentation and registration can be done here with the help of a form similar to the one in Appendix 2.
- The formal physical planning results in an approved preliminary study, investigation or work plan. Quality assured information about deficiencies can be obtained from these documents.
- An approved counter-calculation based on a construction document can be done before procurement. The calculation of the cost of the measure can sometimes be used as a deficiency cost.

The model should be able to interact with different needs in road management. For this reason clear references and cross-references are needed to and between all the different types of appendices, video films, digital images, calculations of the costs of measures, road management, transportation, and social considerations that can be linked to the model for the benefit of those who use the model.

Appendix 3 contains a list of the phenomena defined in the RDB (from 30 March 2000). During spring 2000, the number of occurrences of these phenomena varied greatly in the SNRA's regions. On 31 March 2000, registered data existed for 21 mandatory phenomena with 39 terms, 133 voluntary phenomena (with 566 terms) and 12 region-specific voluntary phenomena with 17 terms. A total of 166 different phenomena have thus been used, with a total of 622 terms.
In the regions registration is proceeding with some speed. On 30 March 2000 Region Central had registered data in respect of 19 mandatory phenomena with a total of 37 terms, 29 voluntary phenomena (with 159 terms) and three region-specific voluntary phenomena (with four terms), i.e. a total of 51 phenomena with 100 terms in all.

The number of registered occurrences of mandatory, voluntary, and region-specific phenomena in all regions totalled almost 3.5 million on 30 March 2000. Of these 2,022,164 were maintained centrally, of which 1,827,421 were to be found in the mandatory phenomena group.

For each phenomenon, a defined number (between 1 and 22) of terms are registered. In the case of mandatory phenomena, the average number of terms registered per phenomenon is 2.25. A rough average for the other phenomena is just over four terms per phenomenon.

This would mean that on 30 March 2000, there were 4.1 million mandatory and 6.7 million voluntary terms or a total of almost 11 million terms registered in the RDB. Data can also be accessed about the road network’s reference system and about approximately twenty years’ historical data about the road network and changes in it. There is thus a very great deal of data available about the road network.

In addition to the information in the RDB, there are a number of separate systems (but linked to the RDB) that contain considerably more current and historical data. These systems contain data about bridges (BMS), pavements and pavement condition (PMS with RST data, Operating and management data, Stanga), traffic (TDS) and road accidents (VITS and STRADA).

The accident data system contains considerably more road-network-related data than the RDB and also has most users (including external users). In total, there is thus a great deal of road network-related information in the RDB. The slightest need for any change in the RDB, for example to meet the reference model’s needs, must therefore be carefully analysed with regard to the consequences for other systems that may be affected.

A general review of the phenomena in the RDB and other systems shows that data on properties is held in separate registers without any links to the road network. However, it may be possible to link these registers using the National Land Survey’s property register.

Pavements’ condition exists in the form of measurement data (10 cm and/or 20 and 200 metre means), that are linked to the road network in the RDB. A relatively unsophisticated computer program needs to be developed to transfer measurement data to condition values for the pavement.

At the same point in time, the Brodata system contained among other things data on 10,741 fixed bridges (with a total area of 3,176,957 m²), 2,385 tubular bridges (with a total area of 196,413 m²), 56 moving bridges (with a total area of 30,223 m²). All the information needed in respect of bridges according to the reference model was available.

A continued comparison between the contents of the existing systems and data contained in the Brodata system that the model needs in respect of components shows the following:

- Tunnel constructions (data exists for 17, with a total length of 8,901 metres, but no data exists for approximately 10 others).
Ferry berths (no data exists for any of the 38 State owned ferry routes or approximately 80 ferry berths).
- Public piers (data exists for 13 piers but is lacking for others).
- Retaining walls exist for example in bridge drawings and are registered to a small extent (there are 11 for the whole country in the bridge data system). They also occur in other places in addition to on bridges.
- Erosion barriers (4,001 bridge supports with erosion barriers were in the register). No details are registered about the erosion supports, which exist among other things to protect road embankments from erosion caused by flowing water and that are not in the immediate vicinity of a bridge.

Essentially, data (but not financial data) has been registered in the RDB system for the following phenomena:

- Rest and parking areas
- Equipment in rest and parking areas
- Machinery and equipment for roads / traffic
- Other off-road facilities
- Protection installations for water catchments
- Noise barriers
- Drainage installations
- Canalisation and separation installations
- Adjacent areas
- Fences
- Guard rails
- Glare shields
- Rock and snowslide barriers
- Lighting installations
- Other safety installations
- Road sign installations
- Traffic signal installations
- Traffic information installations
- Other installations for traffic informatics
- Road markings
- Other installations for traffic routing.

No data is available for traffic information installations except for VVIS stations, which have been mandatory phenomena since 2002. The RDB also lacks road network-related data for:

- Ground
- Buildings, premises and physical planning
- Special arrangements for accessibility
- Special arrangements for sex equality
- Ground insulation
- Geotechnical constructions

During the investigation made in 1992, geotechnicians/soil engineers at the SNRA’s Head Office felt that it was a matter of some urgency to create some form of orderly documentation of information about geotechnical constructions (ground insulation and geotechnical land reinforcement) linked to the road network.
It would also make marking out easier, to avoid destructive excavation and cracking piles and pile foundations. Examples exist of errors and “disorder” leading to costly restoration. A comparison can be made here with the order that municipalities and telephone and power companies maintain with regard to underground lines. The SNRA, for example, demands that lines be marked out before beginning any excavations in connection with road projects. As regards uniformity and data quality, a great deal of checking and supplementing of data will be needed in certain regions. And in all probability there is a substantial backlog in reporting and registering information that will need to be dealt with.

With the reference model, the number of phenomena in the RDB will increase. Some of the content of some phenomena may also change. Correspondingly, the number of terms will also increase. Generally speaking, the number may increase by about ten, depending on the computerised solution adopted. How the new terms can be transferred electronically from other systems is described in section Setting values on existing assets. The reason for the new terms is the need to create appropriate possibilities and bases for analyses and benchmarking of valuations, deficiencies, risks, prices, costs etc. These needs will be taken up in more detail in a separate paper.

4.5.2 Setting values on existing assets (“value in”)

At the end of 1999, SNRA’s Region Central had 1,754 investment objects in the road installation register, of which 1,708 had a book value in the asset accounts. This book value was approximately 13.2 billion SEK. In figure 24, the investment objects are shown ordered and accumulated by descending book value, so the highest asset values (normally also the newest objects) are accumulated first and the lowest values (normally the oldest objects) last. 70 roads (approximately 4%) together account for 50% (6.6 billion SEK) of the total asset item. 10% (171) of the objects account for approximately 65% of the asset item.

The Björbo bypass on road 71, where approximately half the investment object is the eastern section as described in example 2 (3.2 Road 71, section between Näs and Björbo), opened to traffic in 1998. The object has the 53rd largest book value in figure 24 and is therefore included among the objects that make up the first half of Central Region’s Balance Sheet item.

![Figure 24](image-url)

Figure 24 Ranked, accumulated book values of road installations in the Central Region.
An important issue to do with introducing the model is the data that is needed for road structure (terms). The wearing course is separated from the road structure in the reference model. The reason for this is that they each represent high values, have different useful lives and condition changes, and that maintenance is procured separately (pavement laying contracts). PMS today contains all the information about pavements that the reference model assumes, but how does the picture look in the case of road structure. This question needs to be investigated separately.

What accuracy requirements and what level of ambition should apply when the existing road network is integrated into the reference model?

The most important investment objects from the point of view of accounting are those with the highest book values (and usually the youngest). It should be possible to determine a volume limit based on the most valuable objects, for example those that account for half the Balance Sheet item in the accounts. The accuracy requirement might be to demand the highest quality of data for the values at component level.

Provided that Region Central’s accounting is also representative of other regions this would be equivalent to approximately 300 objects over the whole country according to the final accounts for 1999. By setting a limit of 500 objects for the SNRA, it should also be possible to capture other especially important roads (e.g. good examples for benchmarking) in the improved accounting.

Analysis purposes are an operative motive for having a certain volume of real values in the quality-related accounting. Another might be the linkage to the traditional accounting.

Three different approaches for creating the reference model's “historical” information (“value in”) are presented briefly below. One way is to find the real values of the components (approach 1), another to create component values based on reference standards but adjusted so that the total cost of the object is in agreement with the real situation (approach 2). The third approach is to make a “blind” standard-estimated valuation of components (approach 3).

According to a survey conducted in the computer department in 1992, it would take about 10 man-days to adapt the existing RDB system and programs to the model's needs. The locations, positions and ages of as many investment objects as possible should, if they do not already exist in the RDB, if possible be registered with the help of people who were involved in them. The objects' numbers should be registered in the RDB together with details of location and year of acquisition.

In the following it is assumed that the RDB’s systems and programs are adjusted to make it possible to work with the reference system and that the new phenomena (the components) according to the reference model have been registered as phenomena in the RDB. It is further assumed that the RDB’s term directory has been expanded with those terms that are assessed will be linked to roads to allow fast selection and presentation or for other reasons.

The new term data, that will be transferred electronically from other systems, may be data about components (or in certain cases the homogeneous section’s) acquisition value, book value, replacement value, target standard value, condition description model, condition value, least acceptable condition, year of acquisition, quantity/size, annual operating costs, and accumulated maintenance costs.
As a suggestion, the date the investment object was opened to traffic can be entered as a temporary road section phenomenon and after checking be transferred electronically to terms linked to the components on that section. Since some phenomena (components), for example bridges and pavements already have data registered about their time of acquisition etc, the checking can be done by computer.

**Approach 1**

Obtaining real data about the acquisition of the components in an investment object requires a review of the object’s documentation. Since this is very detailed, any shared data must be apportioned to the expense items concerned, and then the various items combined so that they are reduced to a total acquisition expense per component. The physical properties required (type length, area, volume, soil type, rock, earth removal, excavation, superstructure, materials, surface treatment etc) must be obtained for each component.

How much work is involved to obtain the real data per component in an investment object? A trial was carried out on a section road 1053 where it runs past Sälenstugan in Dalarna. The object comprises both a combined foot and cycle path and geotechnical constructions. An experienced project leader has assessed the level of detail in the accounting as “normal” for objects in sparsely populated areas.

In the trial on the newly completed 40 million SEK object in a sparsely populated area, it took two working days to collect all the information desired (components and terms) without the support of data from the RDE. All the data was obtained from the detailed accounting for this particular object.

Assuming that it would take on average twice as long as in the trial, i.e. four working days per object, to collect the same information, it totally would take approximately 10 man-years or two people per region for fully a half-year to achieve very high quality in the accounting according to the model for a volume equivalent to half the Balance Sheet item (the 500 most valuable investment objects in the SNRA’s external accounting).

In those cases where the expense for a component can not be derived from the object documentation without considerable effort, simplifications (reference standards) might be permissible. Since the total cost of the object must agree with the actual cost, some of the reference standards for components can be proportionally adapted to the actual values without serious loss of quality with the aid of a computer (cf Approach 2).

**Approach 2**

For known investment objects without any changes in road network, it should be possible to value all components using reference standards and proportionally adapt the values obtained to actual acquisition values with the use of a computer. Each object’s location, position, and age (the year it was opened to traffic) must be registered in the RDB together with its acquisition value. Using the extraction programs that exist, is should be possible to retrieve the object’s phenomena from the RDB.
The standard estimated acquisition value of all the object’s components (with the exception of the unknown below the ground) where no changes in the road network have occurred should be able to be calculated using a computer. This requires that a table of reference standards (acquisition values) exists, together with a table containing construction price indexes for all types of components.

Changes in the road network since the object opened to traffic must be investigated and dealt with separately. A change in the road network often means a new investment object, and the old object is judged to have been written off on the section concerned by the new one.

Sometimes changes and additions are made to a section that is part of an object. These changes may have been registered in a version of the road network that is of later date than the completion of the object. A comparison between versions with the aid of a computer should make clear any differences. Significant differences are dealt with separately (cf Changes in the road network).

By adding together the indexed reference values for all components’ acquisition values up to the year of acquisition and then comparing the total with the object’s actual acquisition value, the total deviation can be calculated. The standard-estimated values of all components can then be adjusted proportionally to eliminate the deviation. The total of the adjusted standard-estimated values and the actual acquisition value of the object will then agree.

How much work is involved in determining adjusted standard-estimated values per object? This has not been tried. Estimating the time needed to determine a reference value to calculate the acquisition value per component in respect of relevant factors at one man-month, it would take four man-years or eight people six months, to draw up a complete table of reference values for all components.

These eight people could also be assigned the task of determining the “normal” proportions of the price those types of resources represent of the total acquisition expense per component – a task that may take as long to accomplish as determining the acquisition value (six months).

The construction price index per component based on the types of resources that each component’s acquisition value is based on, should be able to be obtained from Statistics Sweden. This should not take longer than six months to do. At a rough estimate, two people will be fully occupied with the task over that period. If the price development per type of resource is known, it is possible to make appropriate general analyses of road management activities. This will be studied more closely in a separate paper.

Suppose that it takes an hour to locate and position an old investment object with a good degree of accuracy, it would take approximately eight man-years to position all known investment objects, i.e. on average approximately two people per region for six months. There are indications that most of this work has already been done.

With the information about an investment object’s position and acquisition value, the reference values of the types of components, and the construction price index, it is theoretically possible to list, value, and adjust all an object’s components by computer so that they agree with their actual acquisition value.
Approach 3

For the remainder of the road network, which for the most part consists of “unbuilt roads” or “not built roads”, a “blind” standard-estimated valuation of the components in the RDB can be made without manual effort as long as the RDB data is of sufficiently good quality.

For “unbuilt roads” the road structure is standard-estimated using a replacement value reference standard at an index-adjusted acquisition value. Year of requisition can be the year the roads were taken over by the State, i.e. 1944. Other component (except bridges and bound wearing courses, for example) are assigned a year of acquisition and thus standard-estimated values best one can. Some state-owned sections exist that were previously private roads.

When the road network’s components have been assigned details of year of utilisation, acquisition value, replacement value, and book value, the information can be listed and checked, and adjusted to as current and acceptable values as possible.

Changes to the road network can be handled continuously in the accounting system, much of the work being done automatically. Computer support might consist of listing the components on a particular section of road that need to be adjusted in the RDB. It is even possible that the system might be able to suggest whether and with what values an adjustment should be made in the accounting system. Gross figures can be presented, for example in a note to the final accounts, so that scrapping, phasing out, and new additions can be clearly seen (listed by municipality, for example).

Component data should be able to retrieve largely automatically from the accounting system, digital audit drawings, and various digital reports from contractors, consultants, etc. New objects, regardless of the form of financing or contract, should, as stated above, be subject to the same requirements as regards information. Registration in the RDB and the accounting system should have been completed by the time comes for final inspection or opening to traffic. A reasonable demand is that the accounting be correct in the first periodic statement or final accounts when the section of road has been opened to traffic.

4.5.3 Continuous updating

4.5.3.1 Input from contractors

The requirement regarding what financial information contractors must provide is an important issue from the point of view of quality. The discussion should be given high priority, since the forms that functional contracts take develop rapidly and are later put to practical use.

One objection heard is that there is no fundamental reason why a contractor to the SNRA should provide any figures about investments in different components. It is claimed that it may very well be so that these figures should be regarded as confidential information for business reasons.

According to the reference model, the SNRA does not need to request more information about a contractor’s costs than the contractor’s price per component, with separate specification of the price of maintenance and service of the component during the construction period.

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It is important that the SNRA can both show a correct, comparable road management cost according to the same principles for the whole road network and perform efficient benchmarking. What are the accepted accounting principles in respect of accounting assets in the form of road installations, for example in PPP projects? How can the authority’s price consciousness and business professionalism be maintained and developed in the long term and the procurement process be made more efficient without knowledge about prices?

The accounting can be done in two different ways. One is based on access to actual prices with regard to acquisition and service, and the other on reference standards where values are assessed from case to case by the client. The advantages and disadvantages of each method are discussed below.

It is difficult to predict how the construction market will develop. Today it is very sensitive to swings in business cycles. Competition has local variations and deficiencies, factors that may be difficult to reflect with reference standards. There are also differences within and between different types of construction activities. Only a few major contractors in Sweden have the capacity to take on large contracts. The proportion of foreign contractors is small and it may prove difficult to implement international benchmarking at a sufficient level of detail using reference standards.

There are few medium-size contractors and their number appears to be growing smaller all the time. Small contractors, who largely work as subcontractors to the major contractors, may have an unhealthy dependency on them.

In connection with tenders, deadlocks may arise that prevent competition. This can happen when major procurements get caught up in forms of their own, in fixed constructions, and a fixed content without good analyses. Therefore, it is important to ensure variation and an accounting with opportunities for price follow-ups and appropriate analyses.

The SNRA needs to develop its business strategies even more. It may be necessary to stimulate the establishment of specialised contractors. What might happen to technical development for instance if the SNRA changed direction and instead began procuring “supervision/service” of fences, guard rails, and adjacent areas and the erection of game fences and guard rails by call-off” on for example 10,000 km of roads with heavy traffic in the north of Sweden over a ten-year period?

When these tasks are included in areas with 500 km of road, the small local contractors who do the work will be put under great pressure from the major contractor who has the assignment. All technical development would cease. Dependencies, economic prerequisites and incentives all work to break technical development – phenomena that may be difficult to detect when analysing standard references.

In the same way, investments and the service of other components such as road signs, elements to do with the road’s construction (including bearing capacity, drainage, culverts), pavement, road markings etc can be procured individually. All work along a section of road can be co-planned in a joint planning process, where one contractor is assigned responsibility for coordination through well-considered incentives based on minimal disruption to traffic and efficient production.
How would such an arrangement affect the “cost drivers” and what new risks/opportunities would arise? Reference standards make it difficult to get a picture of what the development of road management’s cost drivers really looks like.

If development continues to move in the direction of more and more specialised functional construction contracts, the client is going to need adequate, clear information, for example about each physical unit/component. Pavements, the painting of lane markings and certain type of bridge repairs are already procured per component.

Today, the SNRA to a large extent trusts to its own calculations when it comes to assessing prices. Lack of knowledge can lead to uncertainty and an aversion to thinking in new ways and trying new strategies. The reference model simplifies the work of analysis and evaluation. It is flexible in the sense that it functions in the same way independently of how procurements are made.

There are a number of conceivable models when it comes to paying for investments in functional contracts. Here are a few examples.

A. The contractor is responsible for the financing of the investment and “writes it off” over the life of the function and receives:

- An annual payment equivalent to depreciation cost according to plan based on the price that the SNRA says for the investment, plus interest and a remuneration upon completion of the contract equivalent to the actual condition at the time according to an approved inspection report.

- The same as above without adjustment for actual condition (cf New Zealand’s model). This assumes that the condition meets a certain specified minimum level on handover.

B. The contractor is responsible for the financing of the investment and “writes it off” over the life of the function and receives:

- An annual payment equivalent to depreciation cost according to plan based on the SNRA’s acquisition price, the assessed economic life of the different components, plus interest and remuneration upon completion of the contract equivalent to the SNRA’s book value adjusted for current conditions that deviate from the predeter-

- The same as above without adjustment for actual condition (cf the second point under A).

C. The contractor is responsible for the financing and receives

- a payment based on the price of the investment and a fixed payment plan, payment as components are completed and preliminarily approved, payment when the entire objec

- t is opened to traffic, or payment according to a payment plan over a number of years that do not coincide with A or B above, plus interest and a remuneration upon completion of the contract that is adapted to the components’ actual condition on handover.
- The same as above without adjustment for actual condition (cf the second point under A).

D. The contractor is responsible for the financing of the investment and receives

- a fixed annual payment divided into investment, maintenance, and service as agreed. A certain adjustment may be made for service in respect of the weather for example and for the price of the investment in respect of real condition at the end of the contract.

- the same as above but without any adjustment (cf the second point under A).

E. The contractor is responsible for the financing of the investment and receives

- a payment for every vehicle using the investment (a toll charge or payment from the road manager based on traffic counts). A certain adjustment may be made in respect of the actual condition of the road installation or component at the end of the contract.

Should the SNRA’s accounting principles vary with the type of contract and payment chosen? If so, how can benchmarking be done between the different models when prices are based on the SNRA’s own reference standards? How can totals be made for roads with sections that are serviced according to different forms of contract and payment if the financial data is based on different accounting principles?

A general attitude to this question is that the information is so valuable that the client’s needs must go first. The SNRA in its role of client should also be able to steer the development of the accounting requirements vis-à-vis the contractors. The reference model functions perfectly well without any complications with reference standards and in all five alternatives A – E. Here it is more a question of the desired quality of the analyses and of the improvement process in road management.

4.5.3.2 Rational methods for continuous data maintenance

The quality of the follow-up can be improved with GPS equipment (Global Positioning System) and various sensors (for example for quantities of salt) in construction vehicles. Third Generation (3G) mobile telephone networks enable enormous quantities of data and images (both digital and video) to be transferred to and from vehicles in real time.

Together with weather and road information from the SNRA’s VVIS equipment, both follow-ups of operation and maintenance work and cost accounting, invoices and payments can be made more efficient and automated (see figure 25\(^{16}\)). This is a model of which parts are currently being tested by the SNRA’s Production division. The client’s and the contractor’s processes will thus move towards closer integration, something that the client needs to consider right from the start when implementing the model.

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\(^{16}\) Berth Jonsson and Gordon Larsson, Datasäkerhet och internkontroll i framtiden (Data security and internal control in the future), Norddata 87, Congress in Trondheim, 1987. An updated picture of Berth Jonsson’s lecture on new prerequisites for internal control.

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The value of technical data about the components etc would increase significantly if other financial data were registered for a selection of phenomena (components), which would be perfectly possible to arrange with relatively small changes in existing systems and procedures. It is important that solutions for the model are far-sighted and based on a holistic perspective of the road management task.

One important issue concerns the difficulty of keeping all the data in order. The task to handle data input and data maintenance in a satisfactory manner must be prioritized. It is important to introduce new, more efficient technology for data capture (GPS, digital photography) more generally. The operative responsibility for input data can be assigned to consultants and contractors. The physical planning is largely done by consultants. They could also be required to report all identified standard deficiencies in digital form according to an established procedure. Operations contractors, who are paid for continuous supervision of the roads in a particular area, could also be required to report what they observe during their inspections. In the beginning they could also help with the measurement of all occurrences of components in their respective areas.

In the contractors’ quality systems, modern technology could be used to document components’ condition. The systems would need to be built up in a way that harmonises with the reference model and its needs. In a corresponding fashion, contractors of new constructions could be required to draw up audit drawings digitally, and accurately indicate the positions of all the object’s components.
By procuring new constructions and/or service of one or a limited number of components in large geographical areas, the client can push the development of engineering and productivity. In this type of contract, the contractors may be small specialised units with a minimum of administration and relatively little need of financial resources.

New contracts can stipulate continuous systematic reporting of the contractor’s supervision and production, in way that renders the client’s data capture and the contractor’s financial administration more effective and improves the contractor’s liquid prerequisites (cf the concept in figure 25). For example, reporting can include coordinates determined with GPS for the component concerned, either in the form of a point close to the component, where it is registered in the RDB and supervision is carried out while moving, or in the form of start and end points for a new component, the component’s current condition (if it deviates from the registered condition) and measures taken (documented digitally in photographs or on film).

The problem of maintaining order can thus be solved by stepping up the demands on the contractors and their quality systems. Or the work can be done by independent consultants as in many other countries. The SNRA’s work with regard to input data and data maintenance can thus be reduced to a minimum. How much external services may cost needs to be investigated.

The client’s focus can be directed towards the control and monitoring of road management, with follow-ups, costing, price analyses, benchmarking, analyses of condition, standard, and effect and analyses of a financial nature (for instance land improvement, co-financing of investments etc). The reference model, on the other hand, will help make a number of laborious processes at the SNRA more efficient. This topic will be discussed in a separate paper on management and monitoring.
5  Concluding Discussion

A certain condition of a component will "only" give one condition value provided that standard costs for measures applied and limit values are used.

Conversely, a certain condition value can correspond to several inventoried conditions. For example, in the case of the component pavement, the relative deficiency with regard to ruts depth value multiplied by the cost of repair and the relative deficiency with regard to the road’s longitudinal evenness (its IRI value) multiplied by the cost of rectifying the unevenness may give the same condition value.

The target standard value and information about standard deficiencies can be handled in several different ways. Standard deficiencies can for example be handled:

1. As a liability item in the Balance Sheet.
2. In a separate road-linked system, together with effects, to provide information as notes in the Balance Sheet and as input data to the investment process.
3. The same as 1 and 2 as a basis for regional equalisation compensation.

These questions will be discussed in greater depth in a later paper on monitoring and control.

How does the model’s accounting meet the requirements stipulated in chapter 1.3 Requirements regarding an accounting model for Asset Management? These requirements are:

- that data and accounting information be systematic, adhere to simple, fixed principles, and not be devised in a "black box" and that they can be checked by external, independent personnel without extensive help from technical experts,
- that changes in the accounting model do not lead to historical data being rendered unusable,
- that procedures and accounting model live up to the intentions of good internal control and accepted accounting principles

The prerequisites for the model state that information about deficiencies in the road network are to be registered and valued systematically according to simple, fixed principles. A valuation of locatable components in the road network can be checked manually and calculated according to the model’s simple principles without extensive help from technical experts. Measurement data of a pavement’s physical condition comes from personnel independent of the SNRA and is presented in easily accessible form.

Since the model is based on acquisition values, data, and the condition of the road network’s physical components, changes in index and reference standards (tables in the system) will be able to be applied to old facts to a much greater extent. The physical components in the road network are in this context a robust starting-point also in the case of changes in the accounting model itself.

Current procedures for the accounting should be improved so that new technology is introduced for data capture. Electronically transferred, appropriate and smartly designed data from the contractors involved in road management and electronic commerce should be able to be used to a greater extent directly in the accounting while still maintaining adequate internal control. It should be clear from the discussion of the example above that the principles for the model’s accounting meet the demands for relevance and reliability, two of the prerequisites of accepted accounting principles.
The third prerequisite, prudence as regards valuation, is met primarily through using reference standards that are low enough so as not to cause overvaluations. The prudence principle is therefore no problem in this context. It should be added that the prudence principle is more relevant in private industries, where the valuation can for example affect a company’s value and share prices more than in non-commercial road management. Any borrowing by the State on the international money markets may have a small but very marginal significance.

The reference model has a stable structure, with (for the various components) the general principles of

- determining the acquisition value according to the best available knowledge of cost development in respect of replacing the component (for example in the form of an adapted construction price index),

- determining the relative usage based on the best available knowledge of the component’s current condition in relation to “as new” and “lowest acceptable condition” according to a condition description model (scale) appropriate to the component, in those cases where the component is surveyed regularly,

- determining the forecast break-down of the component (linear, progressive, degressive etc) based on the best available knowledge, when the component is not surveyed regularly or for periods between surveys,

- determining the standard cost of restoring the ”lowest acceptable condition” to ”as new” condition, and the residual value for the ”lowest acceptable condition” based on the best available knowledge,

- calculating the current condition value by means of a simple calculation model based on the best available knowledge as described above.

Best available knowledge, on the other hand, means that indexes, “as new”, “lowest acceptable condition”, standard costs and residual values will change. New components may be added and old ones removed. Such improvements in knowledge and adaptations to reality do not necessarily need to involve any change in the model and its principles. In this sense, the model can be considered stable and simple.

In the introduction it is assumed that a developed accounting of the road capital should result in a number of improvements. These assumptions will be discussed further in forthcoming papers. Each point taken up in the introduction will be commented upon briefly here.

- better documentation of the road network’s condition and standard deficiencies (including assessment of risk and maintenance and investment needs) among other things to prepare for financing discussions.

The model is based on systematic documentation of condition and standard deficiencies linked to the digital image of the road network in the road database (the RDB), where the components’ properties (phenomena terms) are registered as today. Condition, standard and assessed risks are information synonymous with properties. If the deficiencies are not registered the model will not be able to take them into consideration in connection with valuations, calculations of maintenance and investment needs, analyses etc.

- better valuation of components’/roads’/road networks’ deficiencies, standard, and condition and of the effect of maintenance and investment both carried out and not carried out.
How this expectation is fulfilled is described in the pavement example.

- better opportunities for analysing the road network’s geographical differences with regard to condition, standard, risks, and transporation prerequisites.

Current data is uniformly linked to the road network over the whole country. Differences between sections in different parts of the country can thus be studied in respect of a great many factors. The selection programs etc needed already exist in the RDB.

- better monitoring and control of risks in road management, of planning and production in road management, of the various players involved in road management, and of production results.

These expectations will be discussed in a separate paper dealing with control and monitoring of road management processes. It is quite clear, however, that the new accounting improves control and monitoring.

- better resource allocation.

Information on deficiencies and various needs can be detailed and accumulated or general, and is built up systematically. The prerequisites for more efficient resource allocation have thus improved.

- Simple, systematic, transparent, controllable, and credible accounting and reporting in comprehensible economic terms that can be discussed and are also easily understood by people who are not specialist engineers.

The accounting is built up systematically in a series of simple steps, where each step can be understood and checked individually. Transitions between steps can be checked manually. Valuable basic data in respect of condition can very often be checked by means of independent measurement or inspection. The plausibility of financial data can be assessed by most people.

- better interaction and a better dialogue with road users, trade and industry, authorities and political decision-makers.

Deficiencies in condition and standard, deterioration, improvement, quality and measures can all be described in economic terms. It should be easy for most people to carry on dialogues of a financial character, so the prerequisites for better interaction should arise out of the model’s accounting. Technical knowledge of the various concepts in road management need then no longer be an absolute necessity.

- a basis for planning preventive maintenance that serves its purpose.

Since the accounting and the information about values, deficiencies, and changes are also linked to the road network, this creates a proper basis for planning preventive maintenance.

Unexpected deficiencies are fewer and the costly maintenance principle of “take the worst first” should be able to be abandoned.

- better opportunities for analyses of deviations from budget with regard to unit price, quantity and time-dependent causes.
In construction contracts, financial control is essentially focused on quantities, the unit prices of quantities, and on times such as the time the measure is taken or completed. The number of adjustable quantities is often very high. Because it is to a large extent these quantities that cause the deviations, financial control in projects must necessarily focus on these details. All the details provide the contractor with a number of "potential volume knobs" that can be used to increase the project’s costs.

With the focus on components, the level of detail is considerably lower. Deviations can be analysed by computer, since the basis of the analyses is the normal information in an invoice. In today’s systems, it is not even possible to make analyses, since the degree of detail is so great the work necessary to collect the information cannot be justified. How this can be done in the model presented will be shown in a separate paper on the possibilities for making analyses.

- better accounting of costs, which with regard to road management can facilitate
- follow-ups and costing of measures taken,
- analyses of component’s life cycle costs,
- analyses of how components’ and services’ quality and price develop,
- analyses of road management’s cost drivers,
- analyses of how road management’s productivity and efficiency develop,
- opportunities to perform internal and external benchmarking (against Best Practice),
- opportunities to assess investment against continued maintenance,
- opportunities to make replacement calculations.

The focus in the accounting is on the individual components, their acquisition dates and acquisition values, their standard, condition, deficiencies and changes in standard and condition, and their operation and maintenance costs over their entire useful life.

An appropriate cost concept, independent of the financing, time of financing and annual appropriations, provides excellent prerequisites for carrying out all the points listed above with very high quality. The value of better analyses is substantial. How the analyses can be made using the model presented will be shown in a separate paper on the various possibilities available for making analyses.

Another separate paper, on control and monitoring, will discuss ways of making the road management processes and organisation more efficient. The potential savings are judged to be considerable but ultimately depend on the political will to change and increase efficiency. It has repeatedly been shown, to give just one example of the consequences of an increase in efficiency, that preventive maintenance can reduce life cycle cost 6 to 10 times compared to a "take the worst first" strategy.

Considerable savings are thus possible with appropriate information as the basis for planning preventive maintenance, supported for example by analyses of the consequences of lack of financing and of how road management’s productivity and efficiency develop.

Compared to GASB 34, the reference model in principle contains both accounting methods. It corresponds in all essentials to the content of the modified approach, but allows both reductions and increases in road capital based on actual changes in standard and condition. One important reason for constructing a valuation and accounting model that deviates from the modified method is that a state-controlled road authority does not often have financing instruments at its disposal and can not therefore in its own right express a commitment to adhere to established maintenance plans.
Once implemented, the reference model will provide new prerequisites for developing road management. The development opportunities are not described in this paper but will be discussed in more detail in a separate paper on the monitoring and control of road management. It is, however, quite clear that the reference model’s overall merits together with models like the modified approach are of such magnitude that the question arises of whether their introduction does not constitute a paradigm shift in the field of road management.

It should also be said that the reference model has also attracted attention for use in several other areas. These include rail transport, coastal shipping, physical installations for electricity and telephony, optical fibre networks, wireless networks for information transfer, municipal water and sewage networks, streets, cycleways, footpaths, and parks, and also for describing and valuing ancient trade routes. A common feature of all of these is the need for information and descriptions of the assets’ physical standard, condition, different kinds of physical deficiencies and risks, and the financial values, changes in standard, condition and values, and costs associated with future maintenance. There is a need of further research how to apply the model on other areas mentioned and how to use the new platform of knowledge to improve the management and the TAM processes by using key ratios, benchmarking, and other analyses.

Continued research should also focus on the linkages between components’ standard and condition on one hand, and the effects for society, road users, politicians, and road managers on the other.
References


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SNRA, *Quality of the gravel wearing course*, Funcion and Standard Descriptions, SNRA/FSB 04-08-04, 83.16, Borlänge 2004, page 23


The Council of Civil engineering (Väg- och vattenbyggnadsstyrelsen), Swedish Statute Book (Svensk Författningssamling, SFS) 1943 Nr 681 – 685, Sollden 30 August 1943, Stockholm, 13 September 1943

### Description of deficiency and proposed measure for component

<table>
<thead>
<tr>
<th>Object number:</th>
<th>Road number:</th>
<th>Component:</th>
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<table>
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<th>Junction:</th>
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</table>

**Description of Problem/Deficiency:**

---

**Continued ☐ in attachm.:** Video ☐ Ref no.: Digital ☐ Ref no.: Film ___________

**Objective of measure:**

---

**Proposed measure:**

---

**Previous records etc.:** ☐ Ref no.: Detailed plan ☐ Ref no.: Cultural protection ☐ Ref no.: Environm. Study ☐ Ref no.: Other

**Remarks etc.:**

---

**Urgency/coordinated with contact with:**

---

**Standard deficiencies:**

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<tr>
<th>Bear.</th>
<th>Frost prof.</th>
<th>Road width</th>
<th>Disability</th>
<th>Public transport</th>
<th>Control place</th>
<th>Parking</th>
<th>Rebuilding</th>
<th>Special measure</th>
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<tr>
<td>cap.</td>
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<table>
<thead>
<tr>
<th>Intersection</th>
<th>Visible distance</th>
<th>Adjacent area</th>
<th>GC road</th>
<th>Lane</th>
<th>Guardrail</th>
<th>Fencing</th>
<th>Lighting</th>
<th>Traffic env.</th>
<th>Traffic routing</th>
<th>Special measure</th>
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<td></td>
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</table>

**Condition deficiency:**

---

**Estimated cost of measure:** SEK Thd ± SEK Thd at year 20.... price level

**Standard cost:** SEK Thd at year 20.... price level

**Estimated net present value ratio:**

---

**Issued by:**

**In consultation with:**

**Decision at:**

**By (signature):**

**Name in block letters:**

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---
## Phenomena in Road Data Bank (30 March 2000)

<table>
<thead>
<tr>
<th>Name of Phenomenon</th>
<th>Mandatory, Voluntary, Own, Other</th>
<th>No. of terms in phenomenon</th>
<th>Hitherto registered no. of occurrences in whole country</th>
<th>Hitherto registered no. of occurrences in region studied</th>
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<tr>
<td>Avenue</td>
<td>Voluntary</td>
<td>3</td>
<td>?</td>
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<td>Connecting road</td>
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<td>3</td>
<td>?</td>
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<tr>
<td>Connecting leg</td>
<td>Voluntary</td>
<td>7</td>
<td>?</td>
<td>156</td>
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<tr>
<td>Road works</td>
<td>Voluntary</td>
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<td>?</td>
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<td>Road entrances and exits</td>
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<td>1</td>
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<tr>
<td>Buildings around road</td>
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<td>?</td>
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<td>Voluntary</td>
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<td>Pavement</td>
<td>Other</td>
<td>See PMS</td>
<td>See PMS</td>
<td>See PMS</td>
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<tr>
<td>Cut</td>
<td>Voluntary</td>
<td>2</td>
<td>?</td>
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<td>?</td>
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</tr>
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<td>11</td>
<td>?</td>
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<td>Fire hydrant</td>
<td>Own</td>
<td>3</td>
<td>5</td>
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</tr>
<tr>
<td>Wide lanes</td>
<td>Voluntary</td>
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<td>?</td>
<td>157</td>
</tr>
<tr>
<td>Bridge</td>
<td>Other</td>
<td>See BMS</td>
<td>See BMS</td>
<td>See BMS</td>
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<td>Well</td>
<td>Voluntary</td>
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<td>?</td>
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<td>Pier</td>
<td>Voluntary</td>
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<td>Noise barrier</td>
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<td>?</td>
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<tr>
<td>Property subject to noise pollution</td>
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<td>Bearing capacity class</td>
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<td>3</td>
<td>?</td>
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<tr>
<td>Surface standard, gravel road</td>
<td>Voluntary</td>
<td>1</td>
<td>?</td>
<td>0</td>
</tr>
<tr>
<td>Opened to traffic</td>
<td>Voluntary</td>
<td>3</td>
<td>?</td>
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</tr>
<tr>
<td>Section opened to traffic</td>
<td>Voluntary</td>
<td>1</td>
<td>?</td>
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<tr>
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<td>HO phenom.</td>
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<td>All</td>
<td>?</td>
<td>621,040</td>
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</table>
Appendix 3

Example of a road management process

Checks of existing components can for example be made in connection with taking inventory as shown in SNRA’s figure 1 (example 1). Condition descriptions can be made systematically according to the SNRA’s instructions for process maps, in this example for the process Manage the Road Environment. The figure contains the components Wearing course (paved road and gravel road), Road markings (comprising gantries according to the accounting in the model), Guard rails, Rest and parking areas (comprising Rest and parking area installations and equipment, and other off-road installations according to the accounting in the model) and Adjacent areas.

This is what a (relatively complex) process map according to the instructions might look like.

Figure 1 Outline of the Manage the Road Environment process (SNRA process descriptions)