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TRANSPORTATION ASSET MANAGEMENT

Quality-Related Accounting, Measurements

And Use In Road Management's Processes

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FOREWORD

The commission given to the Swedish National Road Administration's (SNRA) Internal Auditing department (IA), to clarify the 1989 proposed model for accounting of road capital was drawn up in late summer 1992 by the authority's Director-General at that time, D. Econ. Per Anders Örtendahl. In his directive and in discussions, the Director-General described the problems associated with overall monitoring and control of state-administered road management and communicating the results to the authority's political principal. First and foremost, he emphasised the needs of process control, continuous learning and the problems involved in describing road management's status and funding needs in a credible manner.

The decision to expose all operational activities to competition was accompanied by new needs regarding operative monitoring and control of road management, the development of the road capital and push, for example, the industry's productivity development forward in the client's organisation. The model that was requested should correspond to the requirements stipulated in the transport policy, be transparent and verifiable, and provide relevant information to road management's sub-processes. The assignment was carried out during autumn 1992 and a final report submitted in December the same year. In May 2003, the internal accounting of road capital was described in a draft report together with some examples of its possible application.

Officials responsible at the Swedish National Audit Office (SNAO) for governmental accounting's regulatory framework and external audits of the SNRA expressed their support for IA's proposed model at a very early stage. In his review of the proposed model, Professor Roland Artle of the University of Berkeley in the USA emphasised the fact that the road capital should be more clearly linked to the needs and expectations of road users and other stakeholders. D. Econ. Per Anders Örtendahl, and D. Econ. Nils Bruzelius, acting Director of Finance at the Swedish National Rail Administration B. Econ. Leif Hansson, Professor Rune Wigren and Director of Communications Bengt-Göran Jönsson have made valuable comments on the model. Discussions with LicTech Sven-Erik Delsenius, and M. Eng. Per Westberg have served to deepen knowledge of the processes.

Highly stimulating discussions on the model have been carried on repeated occasions with Professor Hans Lind, Professor Börje Johansson and Professor Åke E Andersson and the Directors of the Centre for Operations and Maintenance (CDU) M. Eng. Håkan Westerlund and M. Eng. Hans Cedermark. The model has thus been given a clearer linkage to the transport policy's requirements regarding socioeconomic effectiveness and better systematic. Significant opinions and comments have been put forward at the meetings of the research project's steering committee by Director-General B. Econ. Lena Erixon and Directors M. Eng. Jan-Erik Reyier, M. Eng. Håkan Wilhelmson and M. Eng. Lennart Lindblad. The SNRA, that commissioned and financed the research project, has requested that the thesis will be published in both a Swedish and an English version. It has therefore been written in Swedish and competently translated by Ian Hutchinson B. Arts. Many people have contributed information to the tests of the model that has been carried out and others have checked the model in detail on the basis of the SNRA's practical prerequisites within the authority's implementation project. The discussions that have arisen have served to further advance work on the model. Professor Lind's committed support as principal supervisor in the research project has been invaluable, as has his involvement in the text of the thesis. The entire research project has been well administered by the CDU.

I would like to express my sincere thanks to all the people mentioned above and to everyone else who has made valuable comments and contributed in other ways to the work. Finally, my beloved wife Ingela and our children Ylva, Petra and Jonas must be recognised for their patience and active support. We have lived together with questions concerning road management processes, road capital and effects for road users, society and taxpayers for more than 35 years. Without their support and patience the work would not have been possible. I give them my heartfelt thanks.

Falun, February 2010

Berth Jonsson

ABSTRACT

Today there are shortcomings in monitoring, control, analyses, learning and reporting of the results of activities and operations in the road management processes. There are also shortcomings in transparency and verifiability, in knowledge of road management's costs and life cycle costs, of the road capital's standard and condition and in measures of quality deficiency costs, productivity and maintenance backlog.

The starting points for different applications of the model are taken from experience of the sub-processes in practical road management, independent analyses of activities, operations and results, presence at directors' meetings (in an independent co-opted capacity) and literature reviews. It is my belief that the problems can largely be solved with transparent, verifiable information that is relevant to the sub-processes. A model has been designed with the transport policy's requirements at the focus for all sub-processes' applications without repeating errors as regards internal control, use of standard values and index adjustments. For each component, the model provides quality-related information about its current condition and condition value, acquisition value, replacement value and standard target value with the effects of measures carried out. Changes in standard and condition of new construction, improvements, maintenance and consumption can be shown in the model. Information can also be found on a component's consumption cost, index adjustment and successively accumulated life cycle costs. Quality deficiency costs, inefficiencies, maintenance backlog, cost drivers, productivity and, for example, expected funding needs can be calculated by computer. The model has been tested and this document also describes the model's implementation project at the SNRA.

Most of the road network's components have been registered for a long time in the SNRA's road and traffic data bank as compulsory or optional phenomena. The remaining components will to a large extent be entered automatically. Some will require inventorying. In theory, the quality-related accounting will thus have access to information about every individual component in the entire state-administered road network. For at least 75% (80% in the implementation project) of the total value of the road capital, current condition information will exist for each individual component in the road network. The information, that constitutes "best available knowledge" of the components' current functional condition, is administered in dedicated administration systems and comes from different kinds of inventories. The values of the remaining components can be appraised systematically on the basis of individually assessed technical length of life and, for example, planned maintenance. The model shows that decisions to carry out measures can also be based on "best available knowledge" of socioeconomic effectiveness, consideration of the environment, climate and energy in a life cycle perspective, customers' (society's and road-users') expectations and political demands for fairness. These requirements are systematically worked into the limit values for "as constructed" and "worst acceptable condition". The condition interval between the limit values shows the component's functional consumption margin provided that the transport policy's requirements are taken into consideration.

The information makes it possible to consider and stipulate requirements regarding the development of components' accumulated life cycle costs in procurements. Contractors will have a natural focus on increased productivity and cost increases in projects should be smaller. The model makes the long-term planning process more efficient and shortens lead times. Prices, costs, accumulated life cycle costs and various types of deviations can be analysed continuously to achieve systematic learning from good examples and failures. In the project follow-up, deviations are automatically divided within the system into causes dependent on time, quantity, and unit price. Control and monitoring with analyses and learning can be made more effective through automatic monitoring against control limits. The concept of quality-related accounting of road capital should be a part of the international discussion around models for Transportation Asset Management (TAM).

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1 OVERVIEW AND INTRODUCTION

1.1 A short summary

At the same time as Vägverket Produktion began to be exposed to competition and the Government's decision [1] on its conversion into an independent subsidiary company came into effect in 1996, development of road management began to take a new direction. The decision also meant that the SNRA would be converted into a client organisation with new prerequisites, for example to gather knowledge of practical road management and actual prices and costs. New points of departure would also apply, for example for driving the development of production technologies. The problem set was discussed in depth by the authority's management team prior to its being exposed to competition (in 1993). Management also took an already identified need [2] for more relevant accounting into consideration, a need that became even more important as the authority became a client organisation.

The political objectives for road management had over time become increasingly complex and affected many aspects of the authority's activities and operations. It became natural to think in terms of processes and quality assurance systems in order to be able to handle parallel issues with internal effects more reliably and to be able to strike necessary balances and make tradeoffs. During this period of sweeping change a consultant was engaged to document and describe the road management process's sub-processes together with personnel [3] from the Director-General's staff.

Challenges in improved monitoring and control and communication included ensuring process control with a focus on socioeconomic effectiveness and customer satisfaction and the ability to continuously analyse prices, costs and life cycle costs. The proposed development would also secure benchmarking and for example quality assurance with systematic learning along Japanese lines [4]. The quality-related accounting of road capital would deliver information to support process control and learning. The concept of quality-related accounting of road capital should be a natural part of the international discussion around supporting models for the "Transportation Asset Management" (TAM) process.

In 2007 the Director-General at the time [5] decided that the model would be implemented. A project, here referred to as the implementation project, was initiated. Experiences from the project are described in more detail in Chapter 8.

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[1] Decision in Government Bill 1993/94:180.

[2] IA analyses of operations in 1987 by Berth Jonsson, Olle Kamlén, Alf Lundgren and Rolf Norberg,
IA's contribution to discussion on 20 June 1989, d nr AL 60 A 89:1450 by Berth Jonsson and other internal auditors.
Financing of the Infrastructure, K 1990:04, led by Tony Hagström, Director-General of Televerket, the former national telephone utility.

[3] Hans Wahlström (formerly Johansson) worked together with Jonas Fried at Interpares between 1991 and 1993 on documenting road management's processes. All necessary decisions, including a study of roles and responsibilities (1993 – 1994) to implement more effective road management were to hand in February 1995.

[4] [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.

[5] Ingemar Skogö, BSc (Econ.)

In Chapter 1 the road management's problems are described together with the research assignment's aims and hypotheses. Appendix 1 gives a more detailed background, detailing with some experiences and cultural issues of significance for important questions concerning the quality-related accounting.

The method applied in the research assignment is described in Chapter 2. There is also a discussion about the position of research in the field (i.e. the state of the art), which was a chapter in the licentiate thesis [6]. Chapter 3 contains the review of Transportation Asset Management as it was presented in the licentiate thesis.

The quality-related internal accounting model is described in Chapter 4. The quality information is based on "best available knowledge" of components' socioeconomic effectiveness, customers' (society's and road-users') expectations, fairness, and consideration for the environment, climate and energy. The accounting is also based on "best available knowledge" of the actual current function of the road network's respective physical components. Bridges, bound wearing courses, footpaths and cycleways, and guardrails are examples of component types while an individual occurrence of for example a bridge, e.g. the High Coast Bridge, is a component. The quality-related accounting delivers information in current prices but naturally also contains historical data about acquisition value and expenditure for measures for example. Price levels are adjusted using construction price indexes compiled from resource price indexes in those proportions that the resource prices represent of the total acquisition price of each specific component type.

Knowledge of the component types' resource price proportions [7] can be used in analyses of each respective type's consequences for energy, climate and the environment in a life cycle perspective, to detect effects that should result in requirements regarding component types and components' condition. Socioeconomic calculations are made for a few component types with known correlations between condition and effects for road-users and society in order to determine "optimum condition" for measures. Effects for society include, for example, road accidents, noise and emissions, and for road-users costs in respect of journey time, vehicle and comfort. Limit values for "optimum condition" for carrying out a measure are defined in "circumstance algorithms" that may contain one or more circumstances. Circumstances that can affect a component's "optimum condition value" include, for example, type of road, permitted speed, and traffic flow.

The analyses described above of consequences for energy, climate, the environment, safety and costs to road-users should be implemented by the road manager in order to fulfil the requirements of the transport policy. In order for the analyses to maintain an acceptable level of quality and lead to monitoring and control, they will probably need to be made for each component type. In these analyses it is not inconceivable that requirements will come to light that must be taken into consideration in procurements, contracts, and upkeep and inspection instructions. The quality-related accounting has a high degree of transparency and verifiability. This means that the analyses must be structured, documented and transparent. Their scope will probably vary between the different component types.

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[6] Berth Jonsson, A model for quality-related valuation and accounting of road capital ISBN 91-975358-3-4, Royal Institute of Technology, Stockholm 2005

[7] Knowledge of component types' resource price proportions is also used to determine reasonable variations in acquisition prices for example.

Customer satisfaction can be determined in respect of component types' condition as a "worst acceptable condition" by means of surveys (e.g. EFA methods [8]). Similar analyses should be made to establish what in political terms can be judged to be a reasonable "worst acceptable condition" taking fairness and similar aspects into consideration. There are only a few component types for which such analyses would be meaningful in practice. All component types are analysed in respect of dimensioning technical life and other consequences for road management.

Every component type is analysed for every measure of quality used. In the case of bound wearing courses, for example, limit values are determined for both rut depth in mm and roughness along its length in mm/m (IRI [9]) in respect of "circumstances" such as type of road, traffic flow and permitted speed. Other types of quality measures can be provided by laser measurements, as carried out on paved roads. On all paved, state-administered roads the administration system has provided calculated values of rut depth and roughness at a certain given time for many years. The figures that are calculated (interpolated or extrapolated according to consumption models) on the basis of existing measurement values are for example obtained for every 20-metre, 200-metre and/or homogenous section of road.

All requirements, expectations and considerations are thus identified systematically for every component type before any decision is made as regards limit values for condition. The decision, based on "best available knowledge", applies for both "condition as constructed" (according to the lowest requirements stipulated for the contractor's delivery) and "worst acceptable condition". Some component types may have values that vary according to "circumstance algorithms" and for one or two, "worst acceptable condition" may be the same as "optimum condition".

The condition intervals set between "as constructed" and "worst acceptable condition" shows the component's functional consumption margin. Through the analysis, the margin satisfies society's and road-users' expectations, the requirements regarding socioeconomic effectiveness, political demands (for example for fairness) and road engineering requirements using the approach described. The limit values also take into account society's requirements regarding consideration of energy, climate and the environment in a life cycle perspective according to "best available knowledge".

Most of the road network's components have been registered for a long time in the SNRA's road and traffic data bank as mandatory or optional phenomena. The remaining components will to a large extent be entered automatically while some will require inventorying (cf. the implementation project). The retroactive "valuing in" of all existing components can be accomplished in a number of different ways with varying quality as a result. In the SNRA's implementation project, standard values are used. For new investments and new maintenance, the actual expenditures given by the accounting system are used. The quality-related accounting will thus have access to all necessary information about every individual component in the entire state-administered road network. The information, however, needs to be obtained from different systems.

For at least 75% (80% in the SNRA's implementation project) of the total value of the road capital, current condition information will exist for each individual component in the road network. The information, which comes from different kinds of inventories, constitutes the

[8] Thurstone, Vectors of Mind, 1935 has led to Explorative Factor Analysis (EFA) according to Jens Grafarend

[9] International Roughness Index, IRI

"best available knowledge" of the components' current condition. The information required can be found in the SNRA's administration systems [10] and can be transferred automatically to the quality-related accounting.

The value appraisals of most of the road capital's remaining components (fewer than 25% of the value of the road capital) will be based on "best available knowledge" of the components' technical life and preventive maintenance. For these components, whose replacement value is judged to be between 150 and 200 billion SEK, value reduction follows the principle of depreciation according to plan adapted to each component type. The estimated length of life is given as "worst acceptable condition", which means that all component types can be treated according to the same principle in the model.

The primary information that exists in the model for each component is acquisition value, replacement value, target standard value and current actual functional condition, condition value and changes in standard and condition over the year. Figures also exist on price indexes, the year's consumption costs, successively accumulated life cycle costs, costs for value adding measures, and remaining consumption margin. The figures can be totalled, for example, for component types, road sections, and roads, areas of roads, road networks and for the entire country. It is therefore possible to for instance analyse differences between comparable roads in different parts of the country.

Quality deficiency costs, inefficiencies, maintenance backlog, cost drivers, productivity and, for example, expected funding needs can be calculated and followed up for each component, component type etc automatically within the system. The information makes it possible to consider and stipulate requirements regarding the development of components' accumulated life cycle costs in procurements.

The model should lead to less arbitrariness when deciding on measures. Every component can be followed automatically on the basis of specific information about the component type. This greater transparency and verifiability, where every component can be located and inspected, improves the processes' internal control.

Through the application of control limits and automatic monitoring of various types of deviations, bases for effective control, verification and follow-up of the processes can be produced continuously. Control limits can be set for prices, price trends (for example for cost drivers), the year's consumption costs and successively accumulated life cycle costs. Process control is described in more detail in Chapter 5 and Chapter 6 describes how maintenance backlog can be calculated automatically within the system.

In response to a special request made at the licentiate seminar, road management's sub-processes and learning are treated in greater depth than was originally planned. In the implementation project it proved to be difficult to identify operative users of the information in the present organisation. At the same time, the information was considered to be important for making the processes more efficient. To facilitate the improvement effort, the application of the model in road management's sub-processes for long-term planning, operational planning and follow-up, procurement, project control are described in Chapter 7 along with some brief sections on accounting and reporting.

[10] Pavement Management System (PMS), Bridge and Tunnel Management system (BaTMan) and Väg och Underhållsdata (VUH) [Road and Maintenance data].

For deviations in road projects, computerised analyses can be made of causes that are dependent on time, quantity and unit price. Project managers can be given forecast suggestions for approval and underlying information for comments. Components with deviating development can be identified and analysed at an early stage to provide lessons that can be disseminated quickly throughout the organisation and to the contractors.

Learning can focused on automatically identified failures and good examples per component type. Information and deviations can be selected by, for example, supplier, region, road network, municipality, etc. Statistics and, for example, life cycle costs, cost and effect analyses, can be produced per component type for each supplier – information that can be used in tender evaluations and when detailing specifications in contracts.

The quality of the information in the technical systems varies widely between the regions today and is overall too low. In many situations, fast responses to requests for various kinds of basic information for central or political decisions have been more important than quality. This has been excused and accepted by classifying the provision of the information as “quick and dirty”. Since the figures have on many occasions been the only ones available, they have been used as the basis for the decision in question. They have also come to represent the true picture, despite their being based on vague definitions and rough estimates.

When it was decided that the quality-related accounting would be introduced in 1994, a decision had been taken to improve the quality of the input data to the various technical systems. For example, laser measurements of the entire paved road network were carried out every year for a number of years. A corresponding directive was issued for an increase in the quality of the information in the road and traffic data bank at the same time as the Director-General gave the go ahead for the implementation project in 2007 (see Chapter 8).

The internal accounting model in the thesis has been tested on the road and railway infrastructures. The deficiency in standard section of the model description has only been partly tested by the SNRA, and on a small scale and in one region, and is not included in the present implementation project. The generalisation that is made with reference to other physical infrastructures has led to a need to use less precise choices of words such as infrastructure capital and infrastructure management – concepts that are intended to have their equivalents in road capital and road management.

Chapter 9 analyses and discusses the model and its application among other things on the basis of the experiences presented in Appendix 1. Shortly before this document went to print, the Swedish National Audit Office (SNAO) published a report [11] that primarily concerns pavement maintenance at the SNRA. Among other things, the auditors write:

> “Knowledge of road standard tends to remain with individual people at the authority. One consequence of this is that the SNRA lacks aggregated knowledge of maintenance needs in the state-administered network and the costs of measures. This in turn affects the quality of the underlying information provided to Parliament and the Government.
>
> *The SNRA thus submits imperfect underlying information about the cost of normal maintenance and maintenance backlog to the Government. The Ministry of Enterprise,*

[11] Maintenance of Paved Roads, Swedish Nation Audit Office, RiR 2009:16, ISBN 978 91 7086 189 5, Riksdagstryckeriet, Stockholm 2009.

> *Employment and Communications has realised this and has said that it does not trust the SNRA's information."*
>
> "All in all, it is the opinion of the SNAO that there are significant shortcomings in the basic planning documents that the SNRA uses in its own organisation and submits to the Government. This concerns assessment of condition, need for maintenance and details of the measures' costs.
>
> *The SNAO's opinion is therefore that the SNRA lacks sufficient and reliable information on which to base the maintenance of the road network. Road maintenance therefore risks being carried out at random and not according to need. The SNRA does not ensure that maintenance appropriations are invested where they are best needed. The consequence of this is that knowledge is lacking of goal attainment and of whether the goals could be attained at a lower cost."*
>
> "Neither the SNRA's accounting systems nor its maintenance-specific management systems provides reliable data about the cost of comparable maintenance measures. The SNRA's cost information is instead based on the replies from the regions to questionnaires. The SNAO's opinion is therefore that the SNRA's basic information has significant shortcomings and does not give a reliable picture of the total cost of maintaining the condition of the road network."

Regarding maintenance backlog the auditors draw roughly the same conclusion as VTI in its report [12] to the Government.

> *"On the basis of the information available it is not possible to either corroborate or reject the SNRA's statement that the cost of the maintenance backlog is 20 billion SEK."*

Our analysis supports these conclusions.

This thesis deals with a quality-related system of accounting that gives more efficient monitoring and control with measurement, rapid detection of good and bad examples, analyses and learning. Analyses in the pavement area may concern issues such as time chosen, pavement measure and price, but also type of binder, mineral aggregate, voids, temperatures and a number of production engineering prerequisites. What is good and what is bad? The culture must include transparency and verifiability without making people "afraid to make mistakes". People must be allowed to make mistakes – but not repeat them. Good examples must be able to be copied throughout the organisation while repetitions of mistakes must be avoided. In our opinion, competent people would be even more competent with better prerequisites in the form of relevant information and thereby improve road management's socioeconomic effectiveness.

The model's application in long-term planning means that "best available knowledge" of deficiencies, measures, and effects are reported openly. Therefore all society's players have access to the same information. Regional and local responsibility should be strengthened in the planning process. With other starting points for the process it should be able to be simplified without the requirements regarding legal security and socioeconomic effectiveness being lowered. For example, one starting point might be that every identified need for

[12] Gudrun Öberg, Mats Wiklund, Jan-Eric Nilsson, Review of the SNRA's and the National Rail Administration's proposed operation and maintenance strategies, VTI report 492-2003, Linköping, August 2003

measures in the transport infrastructure is potentially good for at least one of the factors energy, climate, environment, accidents and the logistical prerequisites of trade and industry and road-users.

With such starting points as the foundation, it should be possible to begin a planning process for an individual measure at any time. In the process, the measure would be examined in a wider perspective for all transport infrastructures in a similar way as in a building permit process. In a building permit process, all general plans, specific local regulations and local plans drawn up in parallel, "separate" processes are considered continuously. Today, in the ordinary planning processes, trade and industry may be forced to wait through up to fifteen years of uncertainty before an urgent measure materialises. These are not conditions that suit a flexible trade and industry sector that has to act when opportunities arise with the best prerequisites possible. The State's funding responsibility – linked to a net present value ratio for a stipulated number of effects – should broadly speaking also be the same in the normal planning process. The regional public authorities, who among other things should be responsible for the calculations, must together with the private stakeholders be responsible for the costs in excess of those covered by the State on the basis of the value of the net present value ratio set.

The model's application in the procurement process will change the contractors' incentives and creativity from increasing quantities to reducing components' life cycle costs.

Today the contractor has an advantage as regards internal information and the client has inappropriate incentives in the very many negotiations/agreements. With the model's contract concept this will not have any financial significance. It means that the project's cost increases should decrease overall. The model should make it easier to control and follow-up projects and lead to better internal control and capital utilisation.

In all essentials the external auditors support the problems and weaknesses in road management described in this thesis. The model with quality-related accounting has been devised to eliminate, among other things, the problems taken up by the auditors, to increase efficiency in all road management's sub-processes and the learning. The problems have been known since the end of the 1980s and the Government's dismantling of the SNRA and the formation of a new traffic agency provides new prerequisites that should facilitate the much needed improvements in this area.

The model for quality-related accounting of road capital should in principle be able to be applied for all physical infrastructure for the transportation of people and freight (road, rail, marine and air transportation). Researchers at KTH have judged the model to be of interest for application in electricity distribution grids. It should then also be able to be applied for fixed and mobile telephony and data networks, and all physical infrastructures in the local government sector. In Norway, interest has been shown in its application in coastal shipping. Other areas of application might be found in organisations with property stock in buildings, premises and other installations. The starting point for applying the model to buildings would, with a quality-related accounting, be the real standard (for instance for energy and function), replacement cost, and real condition on the components of the building (roof, windows, facades, water and sewage systems etc). On the other hand the property's component type land should be evaluated according to more marked-related principles.

If applied to all physical transport infrastructures in the new Traffic Agency, the accounting system would lead to greater efficiency in the Government's and Parliament's monitoring, control and resource allocation. Correctly applied, the model can be developed to take into account consequences for energy, climate and the environment in a life cycle perspective. The demand for socioeconomic effectiveness and customer satisfaction and the need to able to analyse non-conformities in prices, costs and life cycle costs are also satisfied. This development would secure systematic learning and ensure that "best available knowledge" can be used in decisions on measures. It is also important to create a new and better platform for the continuing improvement effort and for research into linkages between measures and effects.

Knowledge of the condition value of infrastructure capital, changes in value, deficiencies in standard and condition, and costs create new possibilities for conducting analyses. The various transport infrastructures' condition-related values, changes in value as a result of new construction, improvements, maintenance and actual consumption would for example be able to be detailed in the new Traffic Agency's annual report. The total effects for society, road-users and trade and industry of the changes in value would be able to be assessed. Distributed over the respective types of transportation, actual consumption costs and price trends will be able to be reported together with infrastructure management's maintenance backlog. It will also be possible, for example, to report infrastructure management's quality deficiency costs, cost drivers and productivity development.

1.2 Background

The management of road maintenance in Sweden followed till the 1990s the principles of planned economy with a low real interest of expectations of the customers and in follow-up. The analyses that were made were based on statistics of low quality from operations activities and on standard prices. The inevitable result was low productivity and a decline in confidence in road management (see Appendix 1 for details).

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 70s and 80s [13].

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 [14] requested permission to find a better way of following up the real changes in the road network's standard and condition and of obtaining objective information to support the implementation of improvements. There was a need for consistent, controllable, reliable, and comprehensible reporting of the road maintenance and construction, the roads'

[13] Some people who should be mentioned in this context are the earlier Directors of Finance Karl-Jan Walck and Dan Näsman, 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.

[14] Doctor of Economics, Director-General Per Anders Örtendahl (1982 – 1995).

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 condition-related road capital [15], which would be able to be used for reporting and monitoring and control purposes.

IA's model was examined by external experts [16], who made several valuable comments. Professor Artle, for example, in his review, emphasised the fact that a condition-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 accounting a condition-related 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 [17], 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 control cards.

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.

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

Anyhow, in 1995, a report was presented about this alignment at the PIARC-congress in Montreal, Canada [18]. The ideas were in all essentials in harmony with the development of Transportation Asset Management (TAM) around the world.

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 (see Figure 1.1). Internationally, in the road management context, this type of monitoring and control is known as Asset Management (AM).

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[15] Published with application examples as Draft final report on road capital in May 1993 by Berth Jonsson et al.

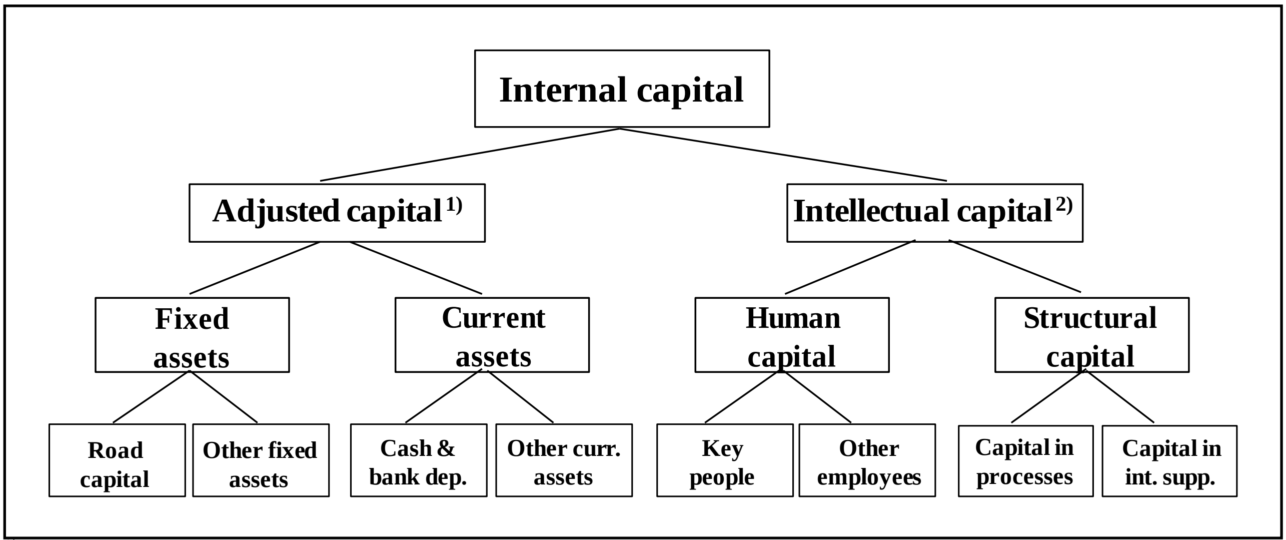
[16] The people responsible at the National Audit Office for the regulations for governmental accounting, Dir. Claes-Göran Gustavsson, Dir. Lennart Mårding and the National Audit Office's Audit Director Filip Cassel and Professor Roland Artle (University of Berkeley, USA).

[17] Japansk företagsledning. Vad kan vi lära?, [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.

[18] Berth Jonsson, Performance management of road administration in Sweden – We are committed to serving our customers, PIARC XXth World Road Congress, Question 1 (20.21.E), Montreal, September 3-9 1995.

The model for accounting road capital in this paper can be used as a reference model in the continued research. Differences in the accounting of infrastructure can be elucidated with regard to countries where requirements similar to GASB 34 [19] 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 (IT-systems) and report generators and 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.



1) Adjusted capital in the SNRA's accounts
2) Unadjusted capital in the SNRA's accounts

Figure 1.1 Outline structure of Swedish road manager's internal asset values (capital items)

1.3 Problems

Many problems still remain to be solved in order to realise the ambitions outlined above. Maybe the most serious and fundamental problem that the SNRA needs to solve has to do with the accounting of the road capital.

Every year the SNRA, e.g. declares the size of the road maintenance backlog, a figure that is growing year by year. The politicians, themselves often urban living, can see that the condition of the road network is not so very bad. Though, it sometimes is obvious that there are needs of standard improvements. If they travel in the rural area they may find roads that are in fairly bad condition, but can on the other hand see that the traffic loads are obviously lower there. It is thus not hard to understand that politicians may believe that the SNRA is exaggerating the problems with the roads.

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

[19] Statement 34, published in June 1999 by the Governmental Accounting Standards Board (GASB).

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 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 produced roads not financed through investment appropriations during the last 40 years 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. As regards monitoring and control of road management, however, the results of the accounting are misleading.

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.

Instead, the organisation uses information from technical management systems, for example the Pavement Management System (PMS) with regard to pavements and the Bridge and Tunnel Management System (BaTMan) for bridges and tunnels. These systems also contain financial information, which is mainly interpreted and compared against established regulations without the help of any specialist engineers. The specialists sometimes 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 would 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 would 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, risk 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. Other motives are 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.

1.4 Aim and hypothesis

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.

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.

There is a clear political expectation that road management should change from a focus on budget control to a focus on the general political goals of customer and efficiency, accompanied by an increase in transparency.

The aim of this paper is to describe a model for valuation and accounting of road infrastructure, which satisfy the political requirements in social effectiveness and needs in the process of road maintenance. The study is based on experiences from road maintenance in practice, literature studies, tests and real work with implementation of the model. This thesis will also illustrate the strength and weakness and the possibilities and difficulties of implementing the "quality-related road capital" model in practice.

The purpose is also to show how an accounting system based on a quality-related value of road capital can be used to increase efficiency in the different processes in road management.

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 throughout the organisation at the same time, and some parts of the organisation have fallen behind.

One example of this is the area of accounting, where the rules and regulations for the external accounting have been in focus, while development of the internal accounting has been neglected.

The hypothesis for internal accounting suited to its purpose of physical road installations according to the requirements of the transport policy are:

- that there exists a possible verifiable value appraisal in accordance with good principles, where "experts' best available knowledge" about every installation's functional condition can be used to advantage,

- that the functional value appraisals can be based on "experts' best available knowledge" regarding socioeconomic effectiveness and society's and/or road users' expectations,

- that the financial value appraisals can be made in current prices on the basis of actual expenditures and costs,

- that efficiency in the road management process can be sufficiently improved to a level corresponding to the extra costs that the model may cause,

- that political monitoring and control can be sufficiently improved by a value equivalent to the extra costs that the model may cause.

2 METHOD AND APPROACH

2.1 The engineering tradition

This thesis is written in what can be called an engineering tradition where the aim is to construct more efficient "machines", in this case an information system for making better decision about road investment and maintenance. Central statements concern what "can" be done and what "will be" the effects of implementing a certain system. But how can such statement be substantiated?

"Can"-statements

The best way to show that something can be done is of course to do it. This is the role of tests in the engineering tradition, and through series of tests new and better products are developed. In Jonsson (2005) examples of how road capital can be measured for a specific road was presented in order to convince the reader that the method is possible to use.

A variant of this is to show that someone else already has done it. After the licentiate thesis were finalised, part of the plan was to look at other countries that have been working with Transport Asset Management models, in order to see how they had solved various problems. This part of the plan was however changed for two reasons.

The first reason was that an overview of the international experiences was made by WSP Consulting [20]. This study of the most outstanding countries showed that no one had come very far in their development. The expected marginal utility of spending more resources on collecting information about other countries was believed to be rather low.

The second reason was that the SNRA had decided to start the implementation of the TAM-concept's quality-related accounting. It was judged to be given more interesting information to follow this implementation project in order to get more detailed information about whether such an accounting really can be implemented. In the licentiate thesis information was presented about the situation in other countries but this information is not repeated in this thesis as it is not developed further.

If something has not been done and when it is not possible for the researcher to do a test, what remains to do in order to show that something can be done is to present convincing arguments. Many parts of this work consist of this type of text. It is probably not possible to give some general characteristic of what is a convincing argument. This research is (see below) partly based on many years experience of the road management processes in SNRA, a great deal of activity analysis in independent positions, and many discussions about different possibilities to improve the factual foundation for decision making and about the TAM-concept itself.

During these discussions a number of arguments have come up saying that the accounting model is problematic and impossible to implement, and in this thesis several such arguments

[20] WSP Analys & Strategi, Report Road Asset Management, State of the Art, Benchmarking Study, 2008-09-01, Stockholm. In the study they compared Sweden, U.S.A. – General description, U.S.A. - Washington State (WS), Canada, Australia, Japan, England, France, New Zeeland and South Africa

are analysed and the hypothesis is of course that if these arguments can be questioned then it indicated that the TAM-model can work. The result of such an analysis can never be final, as new problems might be found later. For the moment it is not possible to do more than analyse the arguments actually put forward and arguments that we today think can be put forward against the model. In this way convincing arguments can be presented, but there is no guarantees that what are convincing today will be seen as convincing tomorrow when new arguments might be presented.

The implementation of a TAM-concept's quality-related accounting is now on its way in Sweden and a conventional evaluation can be done maybe within 5 years or so. The arguments presented in this thesis can then be tested in a more standard scientific way. By clearly presenting the arguments today it will be easier in the future to see what the strong and the weak arguments were and if there were some missing aspects.

"Will be"-statements

The "can" statements are the most central in this theses and the focus is on designing a model than can work according to the TAM-concept. In the thesis it is also argued that introducing such a quality-related accounting will have certain positive effects for road management, given the goals of SRNA. In the instructions for the research, and during the research work, there have been expressed clear demands to show how the output data can be used in the road management sub-processes. These examples, presented in Chapter 7, are an important part of the argumentation about the possible positive effects.

On this point there are also methodological problems of a similar kind as those with can-statements. If a certain model already is implemented it is possible to show that there are certain effects by a standard evaluation. If it is not implemented yet it is once again a matter of presenting convincing arguments about the possibility to obtain the specific effects. More general theories are however important for understanding e.g. how the Road Administration's organization work and what the introduction of a new information system will lead to. The theoretical framework primarily used in these discussions is transaction cost theories and theories relating to monitoring and control in the public sector.

2.2 Participatory observation and action research

Many of the observations and arguments presented are based on practical experience and analyses of operations in state-administered road management over a long period of time, and also to a limited extent in the Swedish manufacturing industry. The author has been working in several of the sub-processes analysed in Chapter 7. He has also experience of in-depth analyses of real world control and action. The analysis is based on theoretical training in issues relating to internal control, operation monitoring and control in public administration. During the last years the author has also been involved in the practical implementation of the quality-related accounting restricted to components' condition.

From a more general research method perspective this work can be seen as a combination of *participatory observation* and *action research*.

Participatory observation has been described in the following way: [21]

> "Ostensibly, participant observation is a straightforward technique: by immersing him- or herself in the subject being studied, usually over a long period of time, the researcher is presumed to gain understanding, perhaps more deeply than could be obtained, for example, by questionnaire items. Arguments in favor of this method include reliance on first-hand information, high face validity of data, and reliance on relatively simple and inexpensive methods. The downside of participant observation as a data-gathering technique is increased threat to the objectivity of the researcher, unsystematic gathering of data, reliance on subjective measurement, and possible observer effects (observation may distort the observed behavior). Participant observation is particularly appropriate to studies of interpersonal group processes."

The statements presented in the following chapters concerning how organizations function are however not only based on the author´s own experience, but it also based on a number of reports and studies presented in the respective chapters. Still, the statements in the thesis must of course be seen as preliminary and in need for further research. The focus in this work is however on presenting a model of quality related accounting of road capital but the sections on how especially the SNRA has worked historically is important as a background to this model and as a way of showing the need for this new model.

Action research is described as: [22]

> "Action research is a subset of participant observation, where the participants (typically practitioners, such as teachers in a school setting) in some focused change effort (ex., to improve some organizational function) self-reflect on their experiences in order to improve practice for themselves or the organization. Action can be undertaken by one individual, by a group of individuals, or as part of a collegial team approach. If the latter, it may be termed "collaborative inquiry."

The author has during several periods been involved in developments of the model presented in Jonsson (2005) and further developed in this thesis. Experience has been gathered not only from passive observations of the organisation and how different systems work, but also from involvement in projects aiming at changing the current system in directions that will be described in detail in coming chapters.

As mentioned in the first quotation above there is of course problem related to objectivity in these research methods, but the difference between these and other methods should not be exaggerated, as all methods involve considerations and decisions made by the researcher. As McCloskey underlines in the famous article "The rhetoric of economics", in the end it is about presenting arguments that convince others.[22]

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[21] This quotation is from http://faculty.chass.ncsu.edu/garson/PA765/particip.htm

[22] McCloskey, D.N. (1983) The Rhetoric of Economics, Journal of Economic Literature, vol XXI, pp 481-517.

2.3 Further comments about the specific chapters

Chapter 3

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. It also comes 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, USA, Canada and England are regarded as having advanced furthest as regards TAM. Other distinguished countries are Japan, France, New Zeeland, South Africa and Norway but also Sweden. Both research and application have been studied. The basis for the work in this chapter therefore 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 international conferences, seminars and workshops,
- national and international discussions with responsible officers at road authorities and with researchers [23],
- rules and regulations governing authorities,
- documentation concerning application in property management and management in the manufacturing industry.

Chapter 4

In this chapter the fundamental model for quality-related accounting of road capital is presented based on the approach described in Chapter 3. The arguments are more deductive, starting from the demands for a better factual foundation and furthermore based on the general ideas behind the TAM-concept and the literature and experiences described above (Chapter 3).

Chapter 5

The principle presented for control and monitoring is in itself a general one based on experiences from the manufacturing industry. Here the principle is related to road management but should, for example, be applicable for all physical infrastructure management. First, a theoretical model is described for quality control, followed by a model for process control. Control and monitoring are then concretised for some of road management's critical indicators. This exposition is based on practical experience and analyses of operations in state-administered road management over a long period of time, and also to a limited extent in the Swedish manufacturing industry, and in studies of literature.

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[23] E.g. SVF Conferens, Jönköping October 2004 documented in: Charlie Karlsson, William P. Andersen, Börje Johansson, Kiyoshi Kobayashi, The Management and Measurement of Infrastructure – Performance, Efficiency and Innovation, ISBN 978 1 84542 643 9, Edward Elgar Publishing Ltd, Sheltenham, UK, Northampton, MA, USA, 2007.

Chapter 6

The point of departure for this chapter is the background presented above, a literature review of definitions and a model for valuation and accounting of road capital (the TAM concept) [24] including the chapter on efficiency and quality control and learning in the control of the process. The literature search also included terms and expressions like “neglected maintenance”, “maintenance backlog”, ”maintenance debt”, “maintenance mountain”, and “overhaul need”. All the terms and expressions essentially have the same sense as “maintenance backlog” (Mbl).

The method is primarily deductive, pointing out different possible interpretations of the Mbl-concept as used in the general debates. Here is shown how Mbl mechanically can be measured and estimated within a quality-related accounting in the TAM-concept.

Chapter 7

The problems and the need for improvement described in this chapter are based on

- external independent inspection results and ideas
- own experience of working in the sub-processes,
- own experience of in-depth analyses of control and action in reality,
- theoretical training in issues relating to monitoring and control in public administration,
- theoretical studies in connection with this research project.
- literature reviews of other organisations’ analyses, both national and international.

The arguments concerning the possibilities of the TAM-concept described is based on the characteristics of the TAM-model and knowledge about the different sub-processes based on the sources above.

Chapter 8

In the implementation stage the perspective of the researcher has been that of an expert in the project. The expert’s role was to support the project manager, take part in working groups, be a member of the project manager’s so-called presiding committee of three, and a member of the steering committee. Of particular importance was participation in the working group whose task it was to develop the concrete IT model Condition-related accounting of road capital (in Swedish, "Tillståndsrelaterad Redovisning Av Vägkapital" TRAV)).

The arguments are based on interpretations of meetings and discussions in the different constellations and of the project manager’s notes and minutes from formal meetings (over 100 in all [25]). Discussions with the project manager have been very important to my interpretation of the implementation project.

[24] Berth Jonsson, A model for quality-related valuation and accounting of road capital, Licentiate Thesis, Royal Institute of Technology (KTH), ISBN 91-975358-3-4, Stockholm, Sweden 2005
[25] According to the list in document VaegkapitalStatus080623.doc

3 TRANSPORTATION ASSET MANAGEMENT

This chapter aims to illuminate in an international perspective and in a properly documented fashion, the meaning and thoughts behind the Transportation Asset Management (TAM) framework.

3.1 Definition of TAM

Definition of Transportation 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" [26] 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 [27], viz:

> **"**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 3.1 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 thesis, Transportation 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.

[26] Asset Management Primer, U.S. Department of Transportation, Federal Highway Administration Office of Asset Management, Washington, DC 20590, December 1999, page 7.
[27] OECD Asset Management Working Group, Asset Management for the Roads Sector, Head of Publications Service, Paris, 2001, page 12.

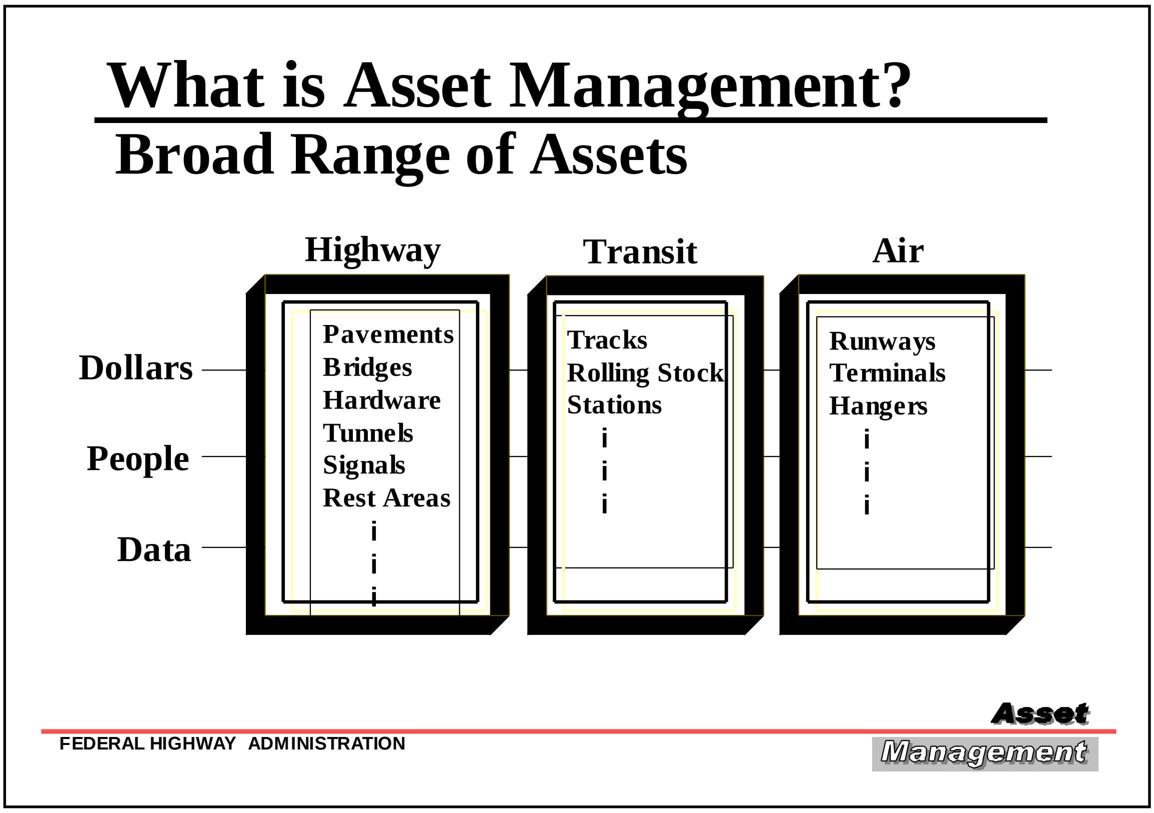

Figure 3.1 A broad range of assets in the focus of Asset Management (FHWA, 2003)

This study of the state of the art is structured around four issues. The primary, overarching issue is the holistic perspective in Transportation 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 Cash Flow Statements (financial analyses). Figure 3.2 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. The figure also shows what was covered in the licentiate thesis (Jonsson 2005).

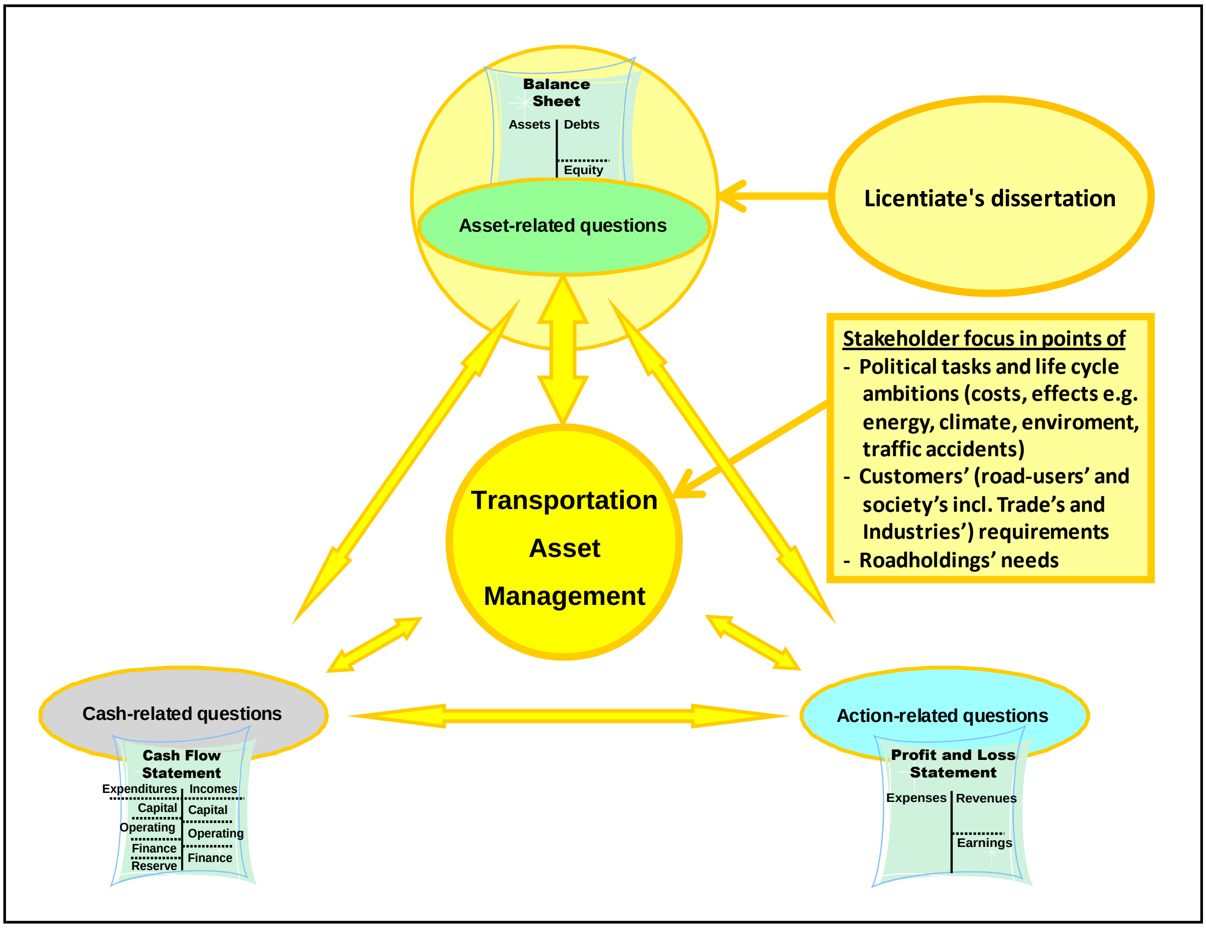

Figure 3.2 Outline sketch of interactions between different aspects of Transport Asset Management

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).

3.2 Why transportation asset management?

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 [28]. 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.

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 the TAM concept during the latter half of the 1990s. International interest has therefore been extensive and no fundamental questions have been raised about the process that TAM represents as a whole. 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 [29]. Why is asset management important? Why is it more important than it has ever been before?

Kane 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?

[28] - Jason Bittner, Howard Rosen, Transportation Asset Management Overwiew, Public Works Management & Policy, Vol 8 No. 3. January 2004, 151 – 155.
- Lance A. Neumann, Michael J. Markow, Performance-Based Planning and Asset Management, Public Works Management & Policy, Vol 8 No. 3. January 2004, 156 – 161.
- Lynne Cowe Falls, Susan Tighe, Analyzing Longitudinal Data to Demonstrate the Costs and Benefits of Pavement Management, Public Works Management & Policy, Vol 8 No. 3. January 2004, 176 – 191.
- Mohammad A. Hassanain, Thomas M. Froese, Dana J. Vanier, Framework Model for Asset Maintenance Management, Journal of Performance of Constructed Facilities, February, 2003, 51 – 64.
- Nils Bruzelius, Dick Jonsson och en vägverksintern arbetsgrupp bestående av erfarna chefer, Idépromemoria om Upphandling, Finansiering och Organisation – UFO 2000 (ej publicerad), Borlänge, 2002.
[29] Anthony R. Kane, Why Asset Management Is More Critically Important Than Ever Before, A speech to the Asset Management Peer Exchange, sponsored by the American Association of State Highway and Transportation Officials and the Federal Highway Administration, in Scottsdale, Ariz., Dec. 1 through 3, 1999.

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.
- 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.

3.3 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 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 [30].

What, then, are the typical characteristics of an AMS? [31] 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. 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,[32] and a TAM system that provides a strategic approach to maximising transportation investments.[33]

3.4 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-

[30] Transportation Association of Canada, Highway Asset Management Systems – A Primer, Ottawa, 1999.
[31] - Anthony M. Pagano, Sue McNeil, Alicia Morreale, Shaumik Pal, Jon Schermann, Jane Berner, Best Practices for Linking Strategic Goals to Resource Allocation and Implementation Decisions Using Elements of a Transportation Asset Management, Management Project 02 – 05, University of Illinois-Chicago, June 2004.
- United States General Accounting Office, Report to Congressional Committees, Highway Infrastructure FHWA's Model for Estimating Highway Needs Is Generally Reasonable, Despite Limitations, GAO/RCED-00-133, Washington, D.C. 20548, June 2000.
[32] Lance A. Neumann, Joseph A. Guerre, William E. Robert, Transportation Asset Management in the United States – Current Practice and Future Directions, Cambridge, 2004.
[33] Geiger-D, Asset Management: Resources for Maximizing Your Transportation Investment, APWA Reporter. 2003/07, 2003.

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[34]. 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 installations' 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 [35] 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.

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.

[34] New York State Departement of Transportation, Blueprint for Developing and Implementing an Asset Management System, New York, 1998.
[35] Expert Group on Asset Management Systems (IM1), OECD Division of Transport, DSTI, Asset Management for the Roads Sector, DSTI/DOT/RTR/IM1(2000)1, 13-Dec-2000.

- 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 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 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 an article [36].

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. That facilitates the communication among the different stakeholder groups in TAM programmes.

The Web site 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).

[36] 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.

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

There is in the OECD-report a recommendation that road administrations should consider the following points when implementing an asset management system:

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 3.3.

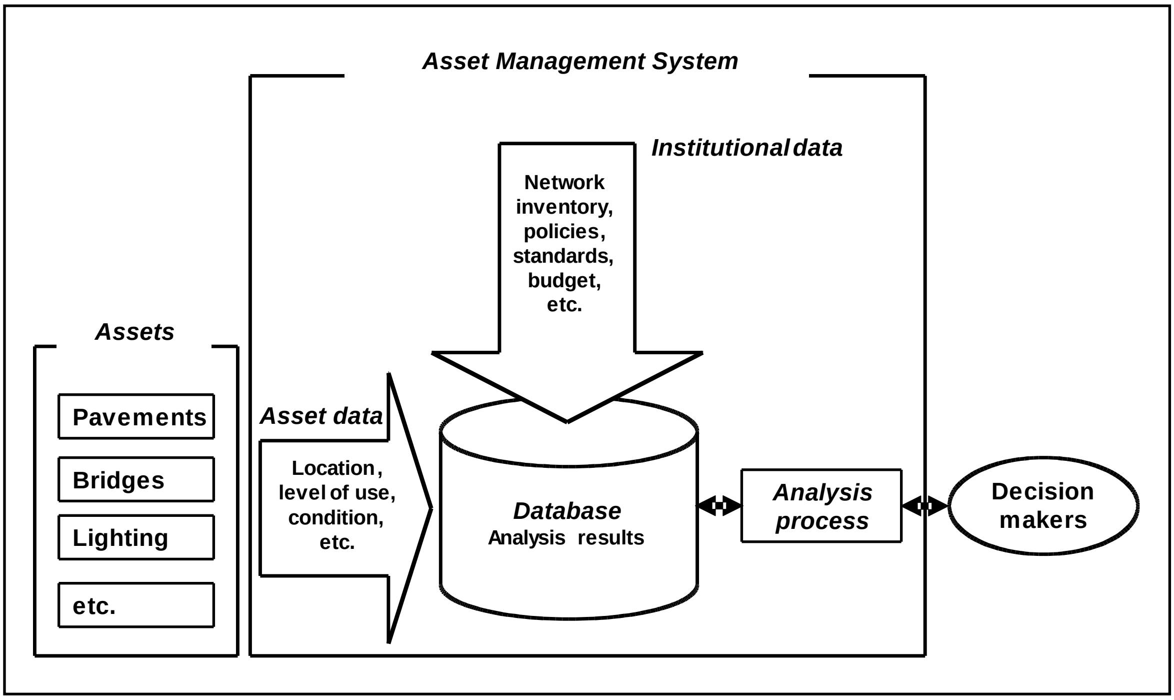

Figure 3.3 Typical flow into and out of a generic road asset management system (OECD 2000).

The key to an effective TAM system is quality information (Anthony M. Pagano et al, Best Practices etc., March 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 [37]. 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
2. Management Systems in Transportation, Operations, Safety and Customer Service
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:

1. *Asset Inventories*, which should include extensive information on asset characteristics and classifications, including condition assessment, GASB financial reporting of infrastructure assets, needs 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.
2. *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.
3. *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.
4. *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.
5. *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

[37] Derocher, Robert J, Information Technology Comes of Age – Finally, Progressive Railroads, May 1998.

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.

3.6 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.

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.

3.7 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 [38] and accounting of fixed assets [39] in an international perspective. Valuation principles that are being discussed [40] include principles for Fair Value, Market Value, Open Market Value, Depreciated Replacement Cost, Value to

[38] John D. Dorchester, Jr., Joseph J. Vella, MAI, Valuation and the Appraisal Institute in a Global Economy: The European Initiative, The Appraisal Journal, January 2000.
[39] Clare McParland, Alastair Adair, Stanley McGreal, Academic Papers, Valuation standards, A comparison of four European countries, Journal of Property Investment & Finance, Vol. 20 No. 2. 2002, pp. 127-141.
[40] Hans Lind, Erik Persson, The qest 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.

the Business, Value in Use, Existing Use Value and Historic Cost [41] 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 [42]. The idea is often to develop an accounting system more appropriate for control with fixed assets divided into components [43].

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 [44]. The component question is considered to be significant in this context. Even though a property is often a physically distinguishable entity, dividing it into 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 [45]:

RR 12	Component depreciation: is permitted/encouraged.
IAS 16	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” [46]. ”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

[41] John A. Edge, FRICS, The Globalization of Real Estate Appraisal: A European Perspective, The Appraisal Journal, January 2001
[42] Hans Lind, Stellan Lundström, Lokalens rätta värde – Fastighetsvärde och kapitaltjänstkostnader i offentlig sektor, ISBN: 91-7099-466-8, Katarina Tryck AB, Stockholm, 1995.
[43] Hans Lind, Håkan Bejrum, Nya principer för avskrivning – En strategi för "rätt" bokfört värde på offentliga fastigheter, ISBN: 91-7289-074-6, U.F.O.S. och Svenska Kommunförbundet, Repro8, Nacka, 2002.
- Statlig förordning (2000:606) om myndigheters bokföring, Ekonomistyrningsverkets föreskrifter och allmänna råd (http://apps.esv.se/ea/kapitel4.html,), 2004-11-19, Stockholm, 2004 (och muntlig tolkning av Kristina Lundqvist, ESV, 2003).
[44] Bo Nordlund, Essays in property valuation and accounting, Report 5:62, Building & Real Estate Economics, Departement of Infrastructure, Royal Institute of Technology, Licentiate Thesis, Stockholm, 2004.
[45] Jorma Kyrö, Lena Ljungdahl och Gustav Nygren, En översikt av skillnader i redovisningsprinciper mellan Redovisningsrådet och IASBs normgivning, Stockholm, 2004.
[46] Bo Nordlund, Komponentavskrivning på byggnader – företag som redovisar enligt IAS/IFRS, Balans 3/2004, pp16-18.

> 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.

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 [47]. Depending on limits and definitions, a road component's acquisition value can exceed the corresponding value for a whole piece of real estate.

Different valuation techniques

Table 3.1 lists the valuation techniques that are applicable to pavement and highways [48].

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) [49], 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,

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[47] Berth Jonsson et al., Draft final report on road capital with application examples (not officially published), SNRA, May 1993.

[48] Herabat-P, Amekudzi-AA, Sirirangsi-P, Application of Cost Approach for Pavement Valuation and Asset Management, Transportation Research, Record, 2002, (1812) pp219-227.

[49] The Appraisal of Real Estate, 9th ed. American Institute of Real Estate Appraisers, III., 1987.

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".

Valuation Techniques	**Features**	**Applications/Limitations**
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 Realised Value or Income Capitalisation	• Based on the net present value of the benefit stream of the pavement/highway for its remaining life	• Appropriate for toll highway by discounting its future cash flow • Possible to apply to public pavement/highway by studying the 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 3.1 Valuation Techniques Applicable to Pavements and Highways (Herbat-P et al. [48])

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

In one article [50] published, 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

[50] Amekudzi-A, Herabat-P, Wang-S, Lancaster-C, Multipurpose Asset Valuation for Civil Infrastructure: Aligning Valuation Approaches with Asset Management Objectives and Stakeholder Interests, Transportation Research Record, 2002, (1812) pp211-218.

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

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

Table 3.2 Value Measures for Transportation Facilities by Stakeholder Interests (Amekudzi-A et al. [50])

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 3.5 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.

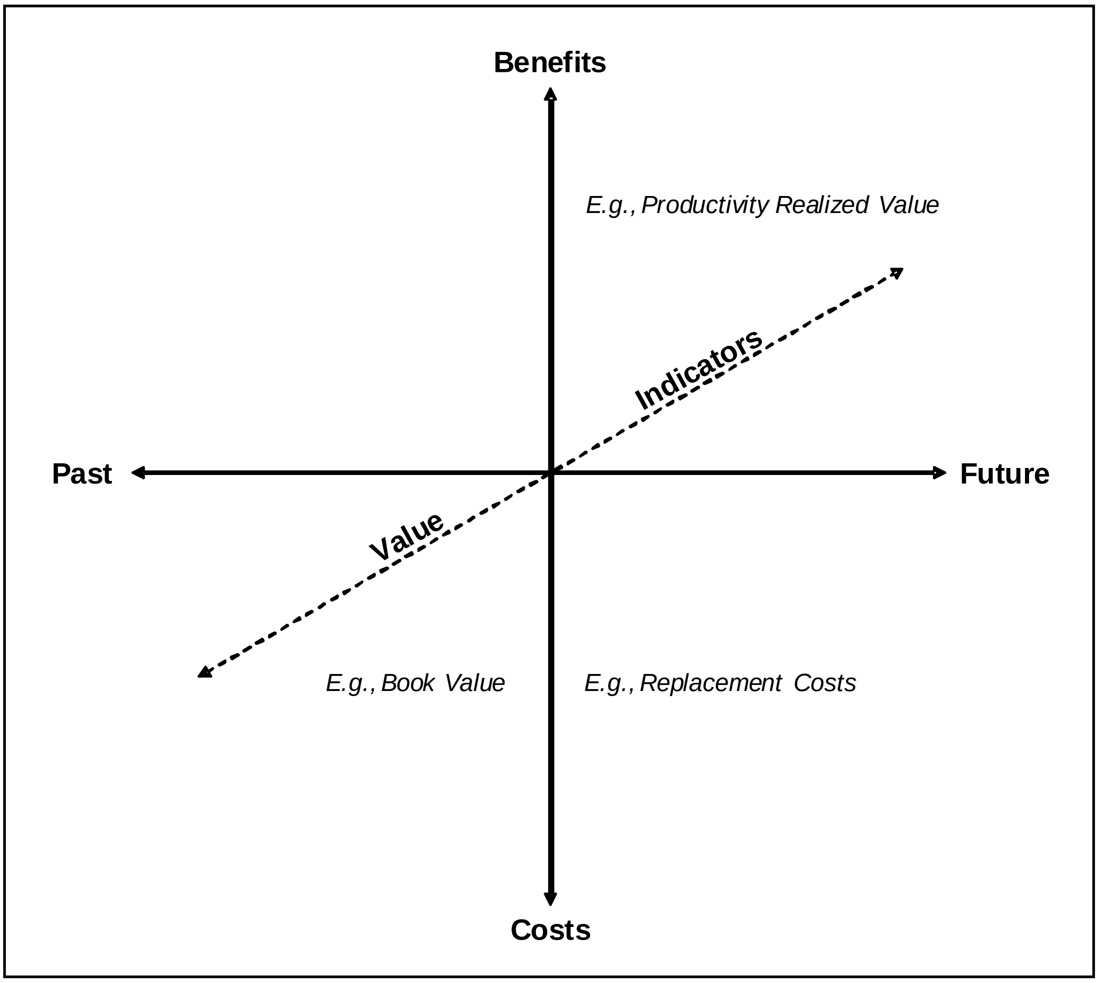

Figure 3.5 Multidimensional valuation chart for civil infrastructure assets (Amekudzi-A et al. [50])

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 sunken 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 3.3, the framework discussed is used to classify existing valuation approaches and illustrate the potential uses of different valuation methods.

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

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 3.3 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.

Accounting of depreciation

The principle of depreciation according to plan is deeply rooted among economists. Tough discussions of principle are taking place around the world with economists 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 [51], 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 in 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 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.

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

[51] 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.

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 [52] 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.

3.8 More theoretically oriented research

One article [53] 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.

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[52] - Ekdahl Peter, Deterioration Models and Road Capitals as Tools in Performance Contracts for Pavement Maintenance, Lund Institute of Technology, 2001.
- R. J. Gerke, Road network maintenance – the big issues, The Institution of Engineers, Australia, 1993 (ISBN 0858255758)

[53] Muneta Tokomatsu, Kiyoshi Kobayashi, Ryo Ejiri, Infrastructure Management and Economic Accounting, Japan, SVF Conference, Jönköping October 2004.

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. 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 [54] both from the point of view of the generation concept, and on the basis of different economic prerequisites.

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.

[54] Takayuki Ueda, Economically Optimal Lifetime of Infrastrukture, Tokyo Institute of Technology, SVF Conference, Jönköping, Sweden, Oct 2004.

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 [55] analyses the effects of the discount rate.

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 over-emphasised. 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 [56] 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.

In Jonsson (2005) a more detailed overview of the literature is presented, but the focus in the additional parts presented below is how the TAM-model can be used and implemented.

3.9 Discussion and conclusion

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 Transportation 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

[55] Kiyoshi Kobayashi, Kenneth Kuhn, The Temporal Distribution of Cost in Discounted Cost Minimizing Asset Management Policies, Kyoto, Berkley, SVF Conference, Jönköping, Sweden, October 2004.
[56] Keiichi Kitazume, Combination of Management and Generational Accounting System for Infrastructure Projects, Kansai University, Osaka, Japan, SVF Conference, Jönköping, Sweden, October 2004.

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.

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 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 (see Appendix 8).

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.

4 AN ACCOUNTING MODEL FOR ROAD CAPITAL

4.1 Introduction

In the following, an attempt is made to describe an appropriate model for accounting road capital. There is no generally accepted definition of the concept of road capital [57]. 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 estimate life of three years. 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 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. VTI studies[58] 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 a an assessed average life that is applied when dimensioning engineering investments (bridges, are for example, 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 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.

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 gains a capital item called State capital (previously Road capital and Written-up capital).

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

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[57] 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

[58] Jansson Jan Owen m fl, Publication around 1994

applied, since "Depreciation of road infrastructure financed through appropriations" is taken up there as not yet financed.

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 fulfil 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.

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.

A physical valuation of the road capital can be made from a number of starting-points. A functional value might be based on the expected economic effects on 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 for 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 with demands on efficiency 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 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 follow-up and monitoring of the road user and politician perspectives allows the valuations to be based on a road manager perspective where control continuously takes the national transport policy into consideration. 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 extensive knowledge of activities costs, and the developments of costs, prices and cost drivers.

Maintaining (in respect of the installations that are to be officially "maintained") productivity, quality, risk 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 the values of deficiencies should be able to be related to details of costs, quality, productivity, risks, and effects for society and road users.

4.2 Basic approach and concepts

4.2.1 About the models in general

One basic idea behind scientific model construction is to establish congruencies between logical systems and external "natural" systems [59]. The infrastructure capital has been created over a long period of time and with great variations in quality and is still being created through investment and long-term maintenance. The aim is to depict the actual quality, consumption and economy of the road network by means of a theoretical accounting model for infrastructure capital. The picture in the quality-related accounting will be drawn such that values and costs are also based on transport policy requirements regarding socioeconomic effectiveness and customers' expectations.

At the same time, traditional external accounting is also carried on, arranged according to the regulatory framework of the Swedish Bookkeeping Ordinance. In content, the two systems will complement each other. The quality-related accounting will for example comprise acquisition and maintenance values and consumption and quality deficiency costs for the entire state-administered road network. The external accounting comprises acquisition values added over the last 40-year period and depreciation costs for them but also the maintenance costs for the entire road network. The external accounting also contains all the road network's operating costs. One requirement is that differences in the models' accounting of one and the same road installation must be able to be explained.

Descartes' principle of "arranging one's thoughts to analyse the complex by dissecting it into its simple elements" should apply to the quality-related accounting. *The physical quality and economic reality of the road installations' individual components will form the basis of the accounting.* The reason for this can be exemplified by the fact that a lighting installation's changes in condition, price and value do not have the same causes as for other components or for the road network as a whole. Knowledge of a lighting installation cannot explain all bound wearing courses' wear or economic price or value trends. The extension of the original paving will e.g. change over time through maintenance measures. The components in the original investment project will have prices that develop in different ways. In other words, the different components do not follow the same dynamic laws. The total values of all the road network's components make up the total quality-related road capital – a complex concept.

[59] På tvärs i vetenskapen (Across the scientific field),

This fact is the main reason why it is the elements (the components) that constitute the foundation for the structure of the quality-related accounting model.

Value appraisals of components and of the measures carried out on components will be adapted to the requirements stipulated in the transport policy and customers' expectations as far as is practicable. Corresponding totals added to road capital and for entire road projects are also assumed to be adapted in a similar manner in practice.

4.2.2 Road capital and other concepts

Road capital is defined in this thesis on the basis of road management's needs in respect of resource allocation, control, monitoring, analysis and reporting as follows:

> Road capital is a condition-related value of physical road infrastructure at current prices. The value appraisal is based on actual expenditure for acquisitions and measures and systematic technical assessments of how far the functional quality meets the requirements stipulated in the transport policy regarding socioeconomic effectiveness and customers' expectations.

The value of road capital is determined for every component in road installations on the basis of actual expenditure or by means of retroactively "valuing in" installations using for instance standard values. Road capital for a road installation, single section of road, sections of road in an area, roads and networks is made up the sum of the values of all the components concerned.

A deficiency in a road installation's standard, condition or function is valued on the basis of "best available knowledge" of technical deficiencies and costs of applying measures. In the case of deficiencies in standard, the cost of the measures and the financial effects for society and road-users are documented according to "best available knowledge". When the current condition value (road capital) of an installation is determined, the replacement value is reduced by an amount corresponding to actual wear, degradation or ageing according to "best available knowledge". The amount is based on the cost of applying the measures. The quality scale is determined using "best available knowledge" of socioeconomic calculations and road-users' expectations. All information is verifiable and quality-assured in transparent routines that involve everyone responsible in the organisation.

"Best available knowledge" means that the most qualified specialists in each technical and specialist area has been responsible for the deficiency assessment, analyses, calculations and information in question on the basis of the best knowledge that is available. In quality-related accounting the specialists' documented information is used in a systematic and structured manner according to principles that in all essentials correspond to good accounting practice.

The appraised value of an individual component will be based on actual expenditure or standard figures. The cost of applying measures in relation to a component's maintenance is assessed on the basis of efficiency, disregarding financial factors such as interest, alternative use of capital, return, or lack of capital. On the other hand, the interest cost in the acquisition value of an individual component that burdens the contractor and the road manager during the construction phases is taken into consideration.

In the internal accounting of road capital all valuation is done at current price levels, which means that the acquisition value of an installation in the accounts is adjusted to the actual price level at the time of accounting. The adjustment results in a replacement value, theoretically equivalent to the expenditure at the time of accounting for a new acquisition of an installation in an open construction market. This type of successive upward adjustment will be handled by means of price indexes.

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 (gravelling, ditching, etc) over a long period and not through new construction, standard estimates are the only way of arriving at a correct value.

When investments are made, investment expenses and acquisition values are known in most cases. For practical reasons, most of these 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. 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 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. The risk that a road’s function will be disrupted or its surroundings affected may for example be 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 Class 2 to bearing capacity Class 1 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.

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 maintenance. In all essentials, the definitions used in this paper are in agreement with those used by the SNRA. The term *maintenance* 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 possible to plan 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 4.1, 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).

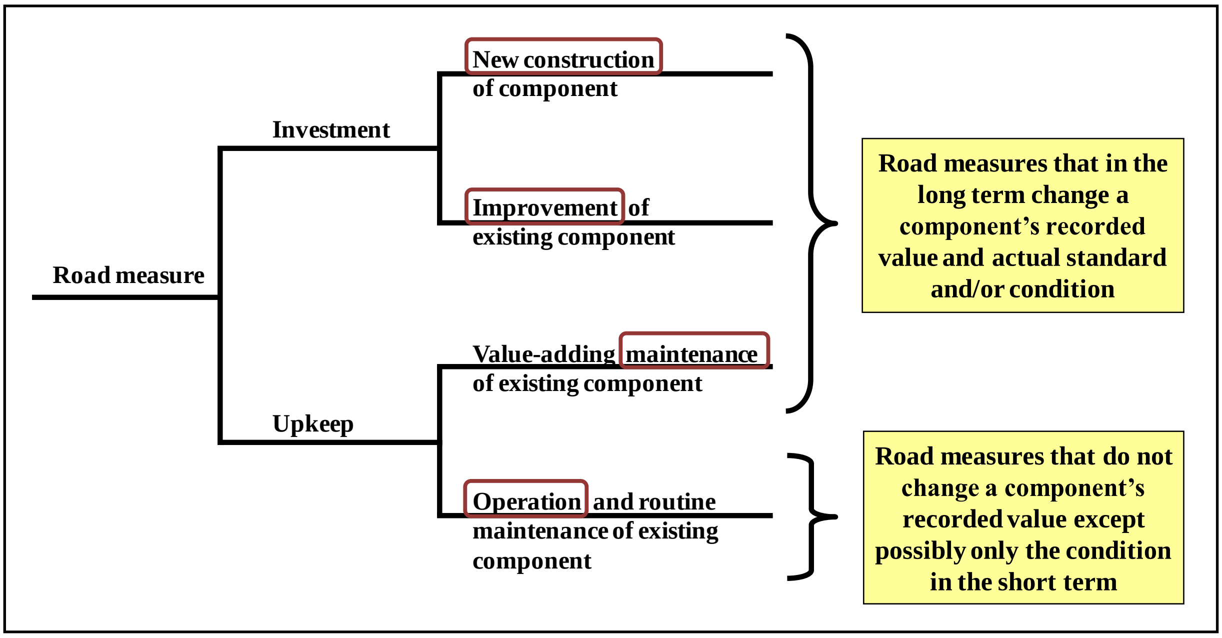

Figure 4.1 Relationship between the concepts used for road measure and the value of the road capital.

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.

4.2.3 Valuation of components

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. These conceptions will be applied to the different components of the road. Why this is done on the component level is discussed in section 4.3.

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. BÄRUND, 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 “worst 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 “worst 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 that is judged to last for more than a year, raises the internal 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* off 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.

A summary is presented in figure 4.2.

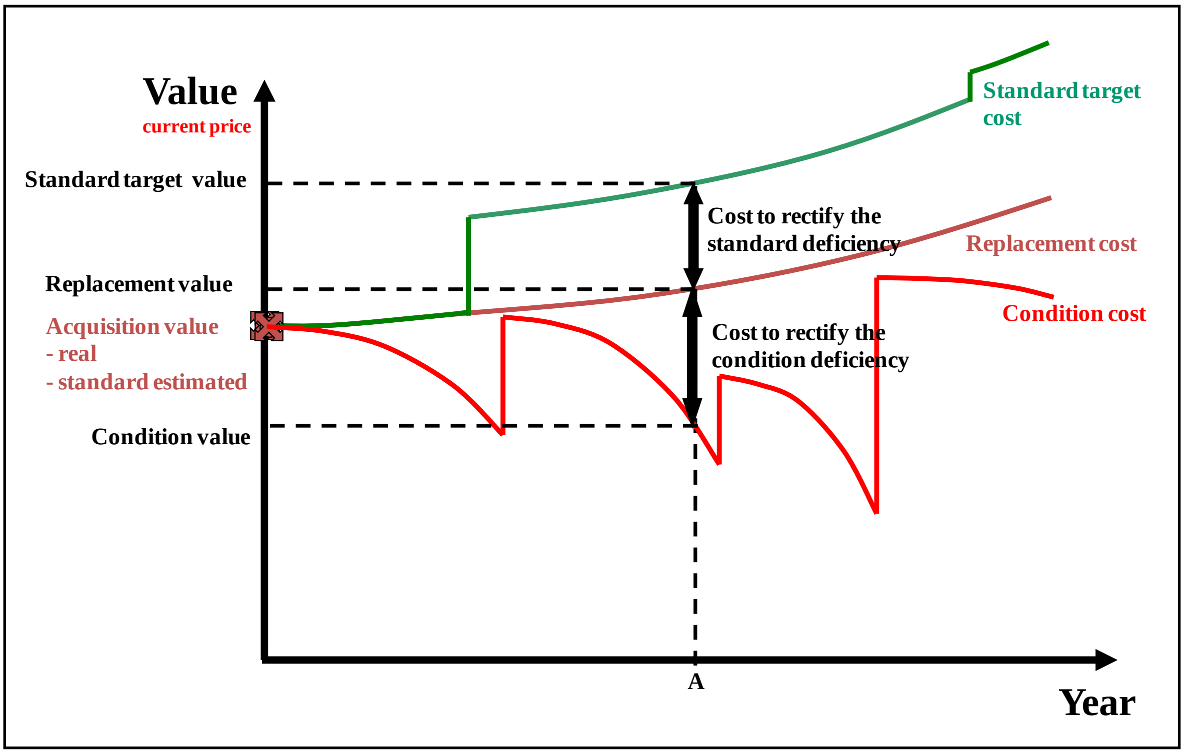

Figure 4.2 Values and costs of rectifying standard and condition deficiencies

4.3 Road installations' components

4.3.1 Introduction

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). 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, cost drivers and quality of information.

It is necessary that a 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.

Examples of important questions to discuss when choosing a depreciation principle and function are:

1. Which devaluation principle is most similar to the asset's actual consumption?
2. What effect does the depreciation principle have on the incentives for the people responsible for results when choosing between a short or a long term perspective as regards, for example, continued maintenance and investment?
3. How do uncertainties concerning long term road investments' actual life and future utility affect the choice of depreciation principle?
4. What significance does the depreciation principle have as regards costs over an object's life, expressed in kronor per vehicle kilometre (kronor/vkm) for example, and when the consumption costs must be as uniform as possible in respect of forecasts of purchasing power and changes in traffic?

Where uncertainty exists as to future utility or if it is feared that utility may be drastically reduced, such that an unanticipated one-off depreciation is required, a case may be made for degressive depreciation. The depreciation is then higher at the beginning and falls gradually as time passes.

The road's total maintenance cost increases over time since the materials in the road's construction wear, age and degrade structurally and are rearranged at an accelerating rate. This indicates degressive depreciation, especially since the aspect of uniform cost weighs heavily. Productivity improvements and increases in traffic on the other hand are factors that lessen the need for a degressive depreciation model if the purpose is for example to achieve a uniform road management cost per vehicle kilometre over time.

With a short-term result-oriented approach, linear depreciation may be less advantageous as regards new investments than annuity depreciation. A linear depreciation principle can thus hinder well motivated investments. Instead, existing ones may perhaps be "tolerably maintained" for far too long. The shorter the economic life the more appropriate linear depreciation appears to be.

The depreciation model should also be analysed externally on the basis of the design of PPP [60] solutions, traffic-related charges and whether any requirement has been stipulated as regards some simple form of accounting-supported benchmarking.

[60] Public-Private Partnership, PPP, P3 or P^3 involves a contract between a public sector authority and a private business company, which regulate financial, technical and operational risks in a long-term society project.

Benchmarking and learning are important reasons in favour of privately funded road investments with a concession for a limited period to levy road charges or similar being booked as assets, depreciated and booked in the SNRA's installation register in the same way as other road installations. For example, the results of studies made in other countries as to the contractors' better understanding of life cycle costs' significance for road management's costs than authorities' [61] could also be demonstrated for Swedish conditions. It is also important to include details of concession agreements in the annual accounts.

The concession could also be booked as a liability in the same amount as the components' total acquisition values booked as assets. The total liability would then be able to be "amortised" over the concession period through successive transfer to Administrative capital.

When choosing between investment and continued maintenance, the socioeconomic aspects are normally the decisive factors. There is often a considerable delay between a decision to carry out a measure and noticeable socioeconomic effects, and sacrifices and utility should therefore be discounted to a fixed point in time. The first point above (1) highlights the importance of describing component's consumption costs correctly.

In order to encourage wise long-term decisions from the point of view of socioeconomics, it is important to consider the whole life cycle perspective in an appropriate way. A road project's total reduction in value should therefore resemble the total of all its components' real consumption in as good a way as possible in analyses and bases for decisions before decisions are made.

To describe the component's value and the cost of road management (and components' life cycle costs) correctly it is important to pay regard to real consumption or changes in user's benefit, service costs, business, and other socioeconomic aspects. The real cost of a section of road can in theory exceed the corresponding cost of the road structure depending on differences in length of life/change in value, residual values and service.

4.3.2 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 [62]: "A breakdown that goes further than the law requires is often necessary." Analyses made by IA indicate that efficient control and monitoring of the State's road management require a division of the road installation into components.

Several factors support the focus in control and monitoring of road management being based on components' costs, cost trends, and effects. In road management it is known that

- the road investment's expenditures can be assigned to the road network's components,
- maintenance and operation are in all essentials carried out on the roads' physical components,
- from a purely technical point of view maintenance and operation are adapted to the different types of components,
- technical life and different kinds of costs vary between component types,

[61] The English study quoted by Håkan Westerlund showing 40% lower costs
[62] In FAR's recommendations as early as 1978

- technical development takes place for each individual component type and its upkeep,
- life cycle costs can also vary widely between components of the same type.

It is obvious that components have great significance for road management's operative control and monitoring and, among other things, for analyses that need to be made continuously. For these reasons it is important to also define the level of detail that the component types should have for control and monitoring to be relevant, efficient and operative.

In the SNRA's road and traffic data bank (RDB), all phenomena are determined by their position and distribution in the road network as section phenomena or point phenomena. *Component* is an example of a phenomenon. The system contains both compulsory and optional phenomena with additional information about characteristics (attributes). The road and traffic data bank has functioning applications for input and output of information about components. Functioning routines also exist for handling changes in condition of component occurrences' data for the *Bound wearing courses* type in the Pavement Management System (PMS). Information about individual occurrences of bridges and tunnels is handled in the Bridge and Tunnel Management system (BaTMan). In the Road and Maintenance data system it is possible to handle information about other component types' occurrences, condition and costs.

4.3.3 Criteria for component types

A case can be made both for and against a detailed component structure in the internal accounting model. The component types included in the accounting structure must be able to be justified on the basis of purposes such as better resource allocation, financial control, control, follow-ups, analyses and reporting of road management. Six main criteria have been drawn up to aid the classification and assessment of what should characterise a road installation's component types. A component type should represent individual components that:

1. are physically identifiable with distinct quantities and/or deficiencies in function or quality,
2. have a critical function in the road transport system with significant effects for customers and quality requirements regarding upkeep, condition and/or monitoring laid down in construction contracts,
3. have a homogeneous life or characteristic consumption or value reduction (depreciation) plan,
4. require specialised technical knowledge to be inspected and maintained effectively,
5. have a substantial value, at least in total for all occurrences of the component type,
6. together require significant resources for day-to-day upkeep.

In addition to the six main criteria there are a number of other factors that may support the inclusion of a certain component type. The component occurrences may

- have upkeep costs that can vary widely between different parts of the country,
- have a clear need of product development and/or substantial significance for improvement potential and benchmarking, LCC and cost driver analyses,
- already exist as easily accessible phenomena in the road and traffic data bank.

4.3.4 Component structure according to a gross list and the SNRA

The component types proposed below have been analysed and discussed in respect of the above criteria and factors etc in the SNRA's implementation project. A number of attributes that can be associated with the respective component types have also been proposed. Table 4.1 is a gross list and compilation of the results from this review (with a marginal deviation [**B**-marked in Appendix 3] from the list established in the implementation project).

The classification in table 4.1 comprises *six component type groups* and a total of *37 component types*, of which 10 have been specified into 39 different attributes that all give unique economic characteristics. The total number of component types is consequently 66. In the implementation project 11 of these are excluded (see Appendix 3).

Groups of component types and Component types		
***Prerequisite items* C)**	***Road constructions***	***Road equipments***
Road zones	Geotechnical constructions [63]	Road markings
Physical plannings	Terracing, surface run-offs, road-side areas	Guard rails
Archaeological surveys	Superstructures excl. wearing courses	Central safety barriers
Preparatory works	Wearing courses [63]	Wildlife fences
Traffic control devices	***Special installations***	Slide barriers [63]
Construction administration	Protection for water catchments [63]	Road lighting
***Structures* D)**	Noise barriers [63]	High mast lighting
Bridges [63]	Other special installations [63]	Traffic signals
Large culverts	Foot and cycle path installations	Road information structures [63]
Tunnels excl. installations	Machinery and installations [63]	Other road equipment [63]
Pile foundations	***Roadside areas***	
Troughs	Rest areas	
Support structures	Traffic control and information areas	
Ferry berths	Park-and-ride car parks	
Jetties and quays	Buildings [63]	

C) In the implementation project this component type group is called Real Estate
D) In the implementation project this component type group is called Constructional Works

Table 4.1 Six component type groups and 66 component types including the specified [63]

The component review and experience from case studies have for example resulted in bridges' edge beams, game fence gates, intersections, climbing lanes and roundabouts' traffic lanes not being considered suitable to have as component types. Three borderline cases that on the other hand were judged to belong to those component types that are worth accounting separately are road markings, large sign installations and portals. These satisfy several of the criteria in the analysis. If we consider road management's annual costs for a section of road, the costs of the road markings and sign installations may constitute a significant portion.

The expenditure for the *Prerequisite items* (real estate) according to the principles applied earlier could be spread over other component types. In order to increase the benefits of the accounting, it is of value to record them separately.

[63] Generic term for a number of component types (see Appendix 3).

As comparison can be mentioned that The National Rail Administration's financial reports contain financial information linked installation types divided into seven main groups and 62 sub-groups [64]. At the beginning of the 1990s, the two state-owned public utilities Televerket and Vattenfall, which now operate as companies, both had seven main groups and 33 and 64 sub-groups respectively in their installation registers.

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.

4.4 Components' 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, and the price annual indexes.

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.

Many standard deficiencies can be drawn from the RDB. A deficiency can for instance be determined by computerised comparison between the existing standard of 7 metre 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 initial 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. 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.

[64] The National Rail Administration's installation types from 1 January 2001 show great similarity with the components in the reference model.

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. The terminology structure for standard deficiencies should be uniform and clear to everyone.

In the physical planning, economic analyses may later show it to be profitable to rectify the deficiency by 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 4.3 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.

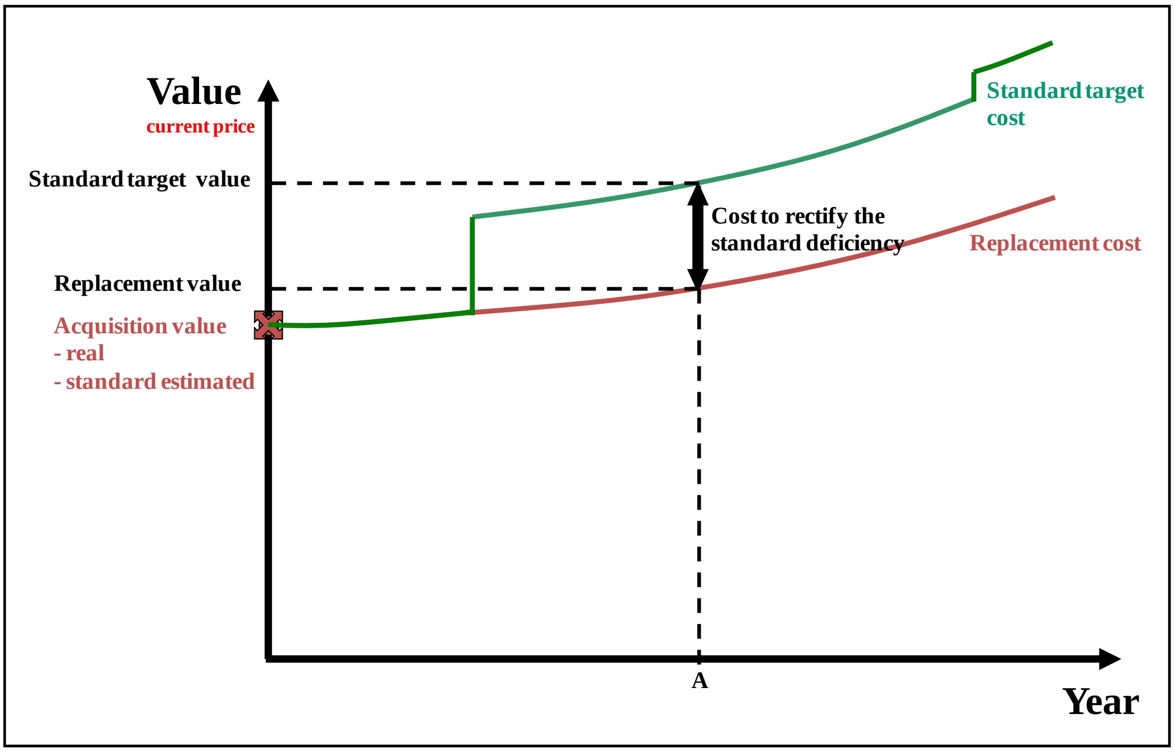

Figure 4.3 Replacement and Target standard value, and values for Standard deficiencies

4.5 Components' condition value

4.5.1 General

Road installations gradually become worn over time and deteriorate relative to the condition at the time of acquisition. It is 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 4.4 shows an outline sketch of replacement value, condition value, and the value of deficiencies in condition.

Figure 4.4 shows the replacement value at a certain point in time, A, of a component, a road installation or a road network, the condition value, and the theoretical cost of rectifying identified, documented condition deficiencies.

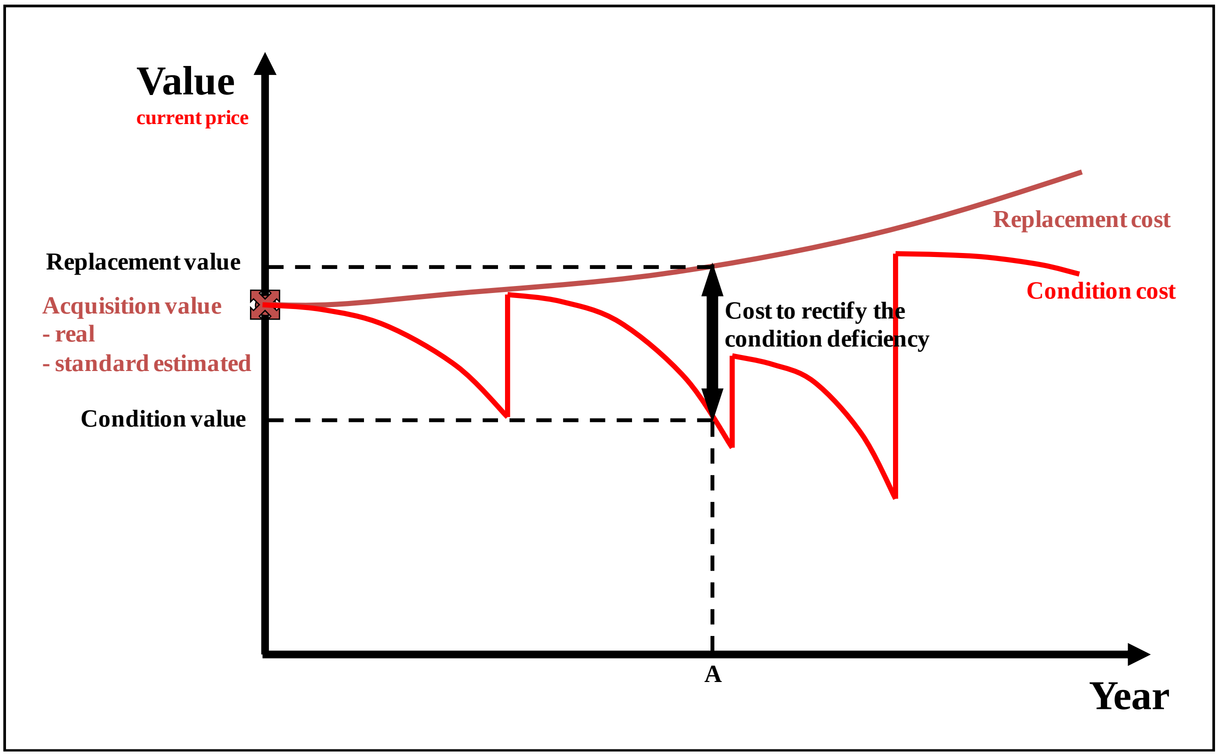

Figure 4.4 Replacement value, condition value, and cost of condition deficiencies

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 can be used to determine a condition value for most components, especially those that will not be surveyed regularly and that 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 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 inspections, forecasts, or a combination of these. A number of different models for describing components' physical condition are presented below.

4.5.2 Comments relating to the prudence principle

In good accounting practice in Sweden the prudence principle applies, which means that the financial position in the external accounting must be cautiously realistic and not overvalued. Costs must therefore be valued high and booked as early as possible while revenues on the other hand must be valued low and not booked until they have been realised. Allocations must be made for certain expected costs.

For the TAM concept the same basic principle applies of using prudence relative to the purposes for which the accounting is used. When a component's condition is described with several parameters or aspects, according to the prudence principle the parameter to describe condition would be chosen that corresponds to the greatest depreciation. In "normal" cases this is the same parameter that controls when a road measure must be undertaken, i.e. has the greatest relative consumption value.

For the few exceptions that may exist for inventoried component types, the question may be brought to its head. If a cheaper, identified deficiency should need to be rectified first, the consequences as regards value are probably either minor or negligible, since the actual action taken will also comprise measures to rectify more expensive deficiencies. This is usually a consequence of the fact that fixed costs' portion of the total price of a measure is "normally" high and/or that the cost of traffic disruptions is taken into consideration. Should the measure nonetheless only comprise the cheaper deficiency, this may still apply. Condition is determined again during the final inspection after the measure or measures have been carried out, and any errors in previous condition values will therefore be able to be corrected afterwards.

Component types whose condition development is based on a forecast do not have the same assessment problems regarding identified actual deficiencies as the inventoried components. Instead, either the forecast value reduction rule must take into consideration the fact that a component's various elements may wear at different rates or the components must have planned preventive maintenance that takes this into consideration. Hereafter the term "composite component types" will be used when referring to these component types (see Appendix 5).

Too short a forecast life relative to actual life satisfies the traditional prudence principle but at the same time sends a somewhat premature signal to the politicians that funding is needed for replacement or rebuilding. Assessed life must be as long as possible but nonetheless realistic. In reality, components can continue to function without any great problems and without measurable costs to road-users and society for some time after their ideal life has expired. From the point of view of control and credibility, the computerised value appraisal should therefore be based on the components' greatest relative consumption with the costs of measures that the component specialists specify. This could then be called quality-related accounting's "reversed prudence principle" or prudence principle.

4.5.3 Component types' consumption models and determination of condition

Substantial values and system risks with a need for extensive inspection, upkeep and resource allocation analyses have in the case of some component types led to measurement techniques or systematic routines being developed to monitor and/or describe condition. For some components, therefore, there exist a number of more or less advanced measurement methods or routines for determining condition. One such piece of equipment that is used in practice on a large scale is the laser equipment for condition measurement of the *Bound wearing course* component type (see Appendix 2). Systematic inspection procedures that require specialised technical knowledge exist for the types *Bridges* and *Tunnels*.

For most types of components, however, there exist no technical measurement methods or systematic inspection routines to objectively determine their condition. It may often be rational and acceptable to use a simple condition description model. The description might for example take the form of condition forecasts based on documented experience of how the component type's condition develops, similar to depreciation according to plan in traditional accounting.

A certain component type may occur a great many times in the road network (and in the RDB). Nonetheless, they may relatively speaking represent only a small value. Other component types may constitute a large proportion of the total road capital but have only a relatively few occurrences. Consumption rate and maintenance costs vary widely between different component types and need not be a consequence of values. Systematic condition descriptions are not always the result of rational decisions but have sometimes arisen out of individuals' strong

There are further reasons for drawing up a structured and generally accepted condition description of the road capital's different components. The condition description has significance for the follow-up of road management's functional contracts with contractors and for the payments they receive. Structured, systematic and uniform routines throughout the country will make life simpler for the contractors. This should result in greater competence and lower risk costs for uncertainty and arbitrariness.

4.5.4 Six models for condition description and value reduction

Accounting models for describing condition and value reduction can be viewed in two dimensions. One concerns how far a description model is based on a forecast or actual determined development of condition. The other concerns to what extent condition can be measured objectively or assessed subjectively. The condition descriptions that the SNRA uses are based on visual inspections, samples, measurements and forecasts.

The condition descriptions made by the SNRA are based on visual inspection, samples, measurements and forecasts. Condition forecasts are based on experience of the component's function over its life cycle for example. Components' functional condition is described according to one of six approaches called Condition Description Models I – VI. Hereafter the designations Value Reduction Model, Consumption Model or simply Model are also used.

Forecasts without reconciliations in Figure 4.5 nonetheless contain a certain amount of computerised checking against control limits (see Chapter 5). For example, the deviations are brought out and analysed. Index adjustments are also made using component-specific price indexes. Indexes are checked against the actual price trends for acquired components. This check may lead to adjustment of, for example, the "resource basket" that makes up the price index. Figure 4.5 illustrates how the models (I – VI) can be considered to be based on objectivity and forecasts with or without regular reconciliations.

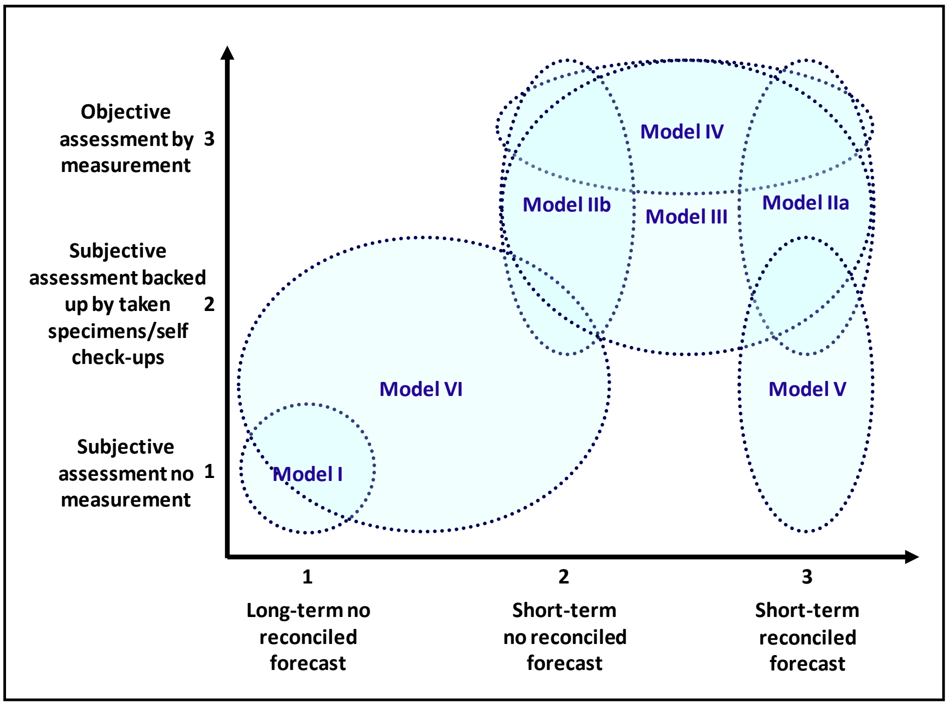

Figure 4.5 The condition description models' objectivity and forecast content

In Appendix 3 components are listed per model according to the principles that are applied in the SNRA's implementation project. The tables in the appendix contain the assessed degrees of objectivity and forecast content.

4.5.5 Model I - constant real value

Condition description model I is for example used for all component types belonging to the *Prerequisite items* group. It is an accepted accounting principle in Sweden not to make any depreciation for land. When “normal” land is valued, condition and change in condition are not considered at all. The replacement value is the same as the condition value with an index adjustment of the acquisition value. Figure 4.6 illustrates the change in the condition value over time.

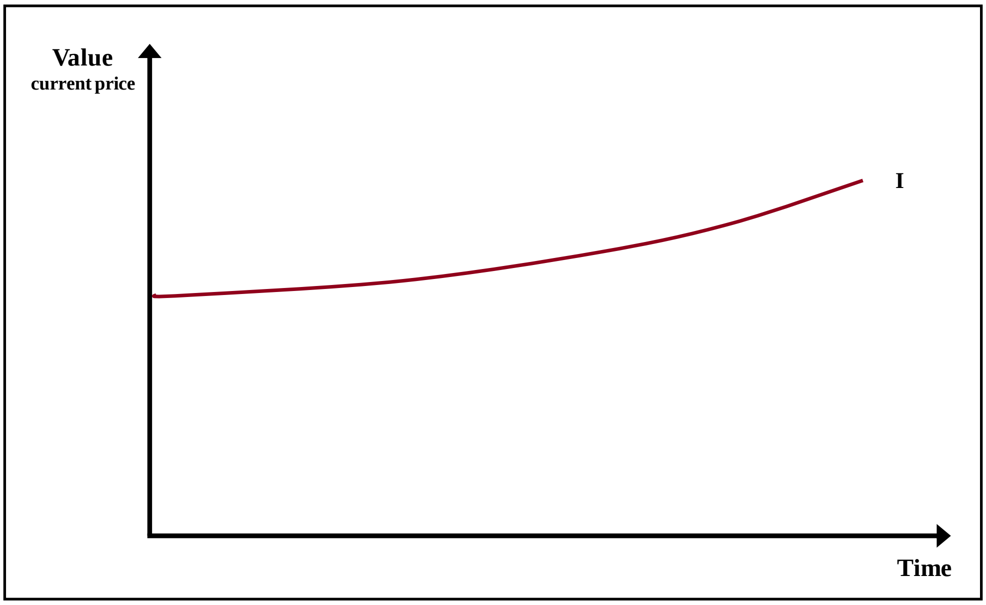

Figure 4.6 Outline sketch of the change in condition value over time according to Model I.

Roads that are transferred to private road management very often first need to be improved. If the land is to be returned to the land-owner, it may need to be restored first. A central allocation for these and other similar types of future costs in respect of land might be justified. Stricter environmental demands may lead to extensive work and remediation with an increased need for contingency allocations. This does not contradict the principle of not making any depreciation on land value

4.5.6 Model II - constant real value until deficiency observed, then according to a plan

No change in condition affecting value is considered to have taken place until a condition deficiency has been identified and documented. Checks can be made in respect of a number of measurement and assessment parameters on one and the same occasion, of which at least one of the checks must be assessed as a deficiency for a reduction in value to be booked.

When a deficiency that needs to be rectified and the cost of rectifying it has been documented, there are two ways (a and b) of booking the reduction in value.

a. When the deficiency in all essentials is judged to be total and immediate corrective action is deemed necessary in order to prevent risks or circumstances for road-users and society becoming unacceptable. The reduction in value is of a one-off nature and corresponds to the total cost of rectifying the deficiency.

b. When the deficiency develops into a need for action within a number of years assessed on the basis of prior experience (time before measure). Annual reductions in value are made up to this year in such a way that all reductions in value are equivalent to the total cost of applying the measure (index-adjusted).

In practice, the ambition is often to rectify all deficiencies at the same time. The contractor's fixed costs (for example 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 one by one on closely recurring occasions. Alternative a can be regarded as a special case of b (time before measure = 0).

When several deficiencies are rectified at the same time, the actual cost of carrying out the measures should be calculated separately. Figure 4.7 shows the change in value over time for alternatives a and b in model II.

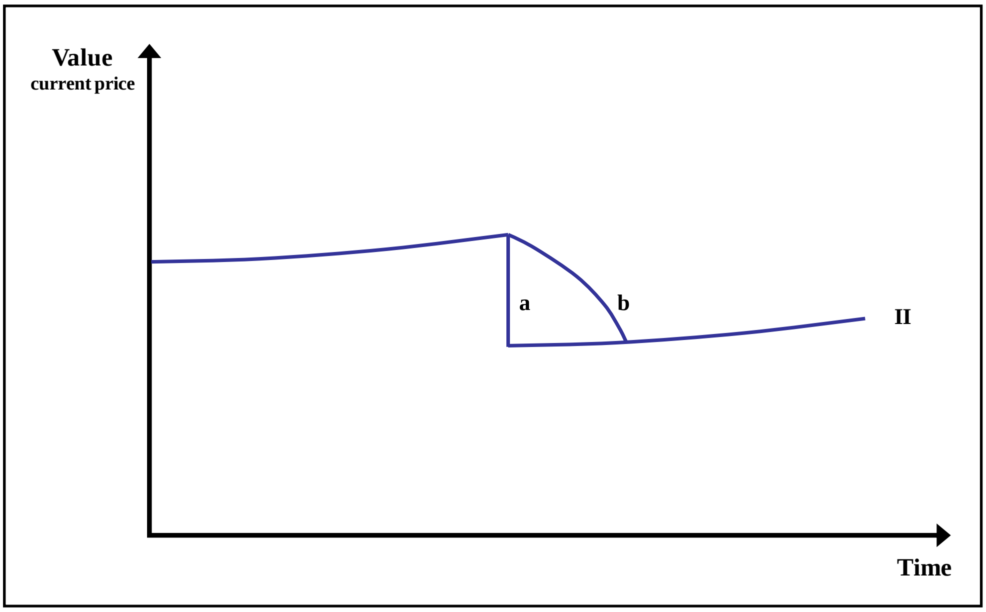

Figure 4.7 Outline sketch of the change in condition values over time according to models IIa and IIb.

4.5.7 Model III - constant real value until deficiency observed, then according to a strategy

A change in condition that affects the value is not considered to have occurred until a deficiency is identified and documented with a need for measures and costs of carrying out measures according to the same principles as in model II. When the deficiency has been analysed, the specialist devises a strategic approach in the form of a maintenance plan up until a defined period of time. This corresponds in principle to alternative II b. The difference is that strategies also exist for the case where the primary strategy (strategy 1) is not implemented.

If the deficiency is not rectified in time, according to maintenance strategy 1, the consequence may be that that the deficiency or damage will become worse and require a more expensive maintenance measure maybe at a later point of time. A new maintenance strategy 2 in respect of the more expensive maintenance measures then applies. When the strategy switch has been decided, the continued reductions in value are accounted in relation to the new cost of the measures to be applied, and for the new period (number of years) upon which strategy 2 is based.

If this new maintenance strategy 2 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. This changes the prerequisites for calculating the continued reduction in value. 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 the deficiency according to strategy 2 has been exceeded or if strategy 2 will not be followed.

Another strategy might be maintenance consisting of planned measures in a number of steps. This is either described by the bridge engineer with only one value reduction rate that adequately reflects the actual consumption, or handled in the system in a similar way to preventive maintenance in composite component types (see model VI c). The total cost of applying measures to rectify an identified deficiency or the total planned preventive maintenance is then the point of departure for calculating value reductions. Figure 4.8 illustrates the change in value of a component over time according to model III.

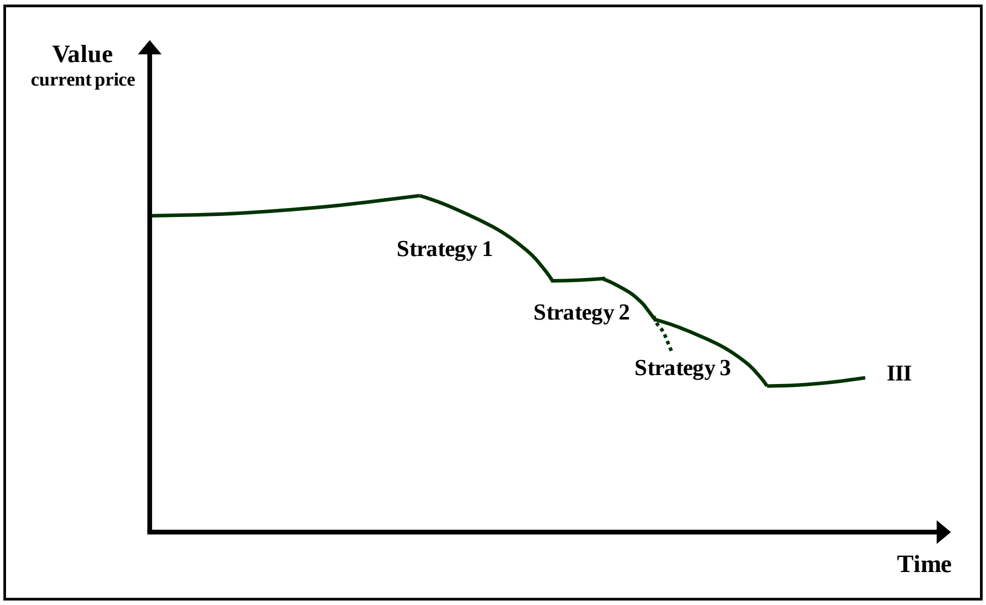

Figure 4.8 Outline sketch of the change in condition values over time according to model III.

4.5.8 Model IV - continuous consumption and value change

The SNRA's administration system PMS contains objective condition values measured using laser-equipped vehicles for the *Bound wearing course* component type. Today, measurement values are stored from a total of 19 lasers, of which two are mounted on the rear of the vehicle, length gauges, and inertia instruments for measuring the vehicle's own movements in the mobile computer (at least 20,000 pieces of data per metre of 3.2-metre wide road at normal traffic rhythm). At least one scan is performed every two millimetres in the road's longitudinal direction in order to calculate several different measures (parameters) such as rut depth, texture, holes and slopes along and across the road, horizontal and cross-section alignment, super elevation, IRI (International Roughness Index) and, for example, whole body vibration.

A measure of the pavement's bearing capacity will probably be introduced in the near future, based on data of the development of rut depth over time. The values for calculating whole body vibration are stored for every 10 cm of road length while most of the other measures are calculated and stored as mean values for 1, 20 and 200 metres. Sometimes values are also calculated for the road's homogenous sections in respect of for example traffic flow, speed and road width.

Since maintenance measures cannot be varied over short sections, maintenance will in practice be carried out on a number of 20-metre sections in the same way, often on the basis of knowledge of mean values for 200-metre sections. The type of maintenance that will be carried out in practice depends on the total need for maintenance measures on a longer section (several 200-metre sections). Often, measures are chosen that rectify all types of deficiencies on this longer section. An assessment of the cost of the measures normally requires that a separate calculation be made for all the maintenance measures carried out.

In PMS, values will be able to be delivered for 200-metre long sections of pavement with their condition on 31 December. In the calculation/forecast, previous measurements from the wearing course on the section in question are used. For example, the development rate of the rut depth from previous measurements up until the latest will form the basis for the rut depth per 31 December. The calculation is made at three levels of quality depending on the number of measurements carried out. The parameter that shows the largest relative consumption constitutes the basis for the calculation. Figure 4.9 shows an outline sketch of the change in condition value over time according to consumption model IV.

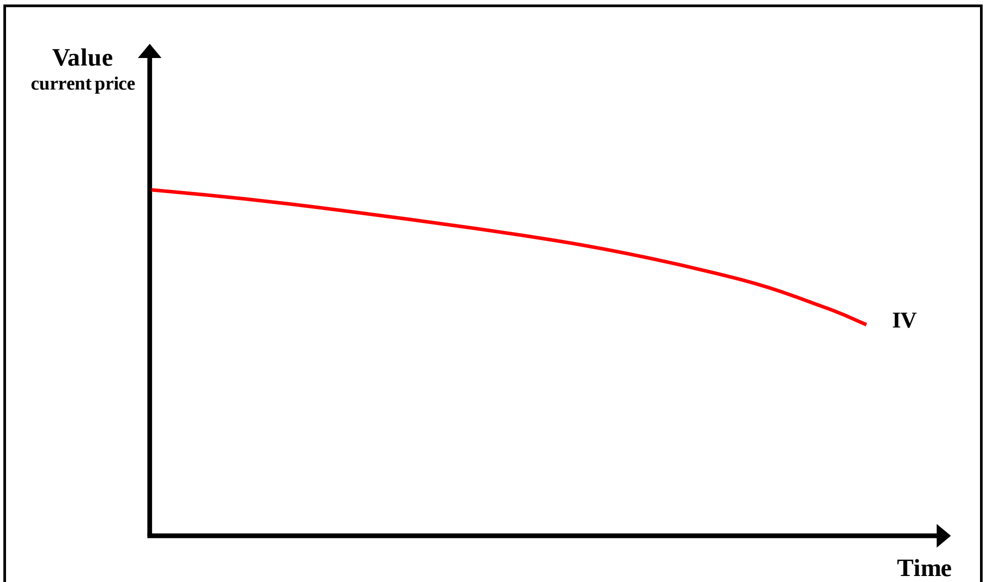

Figure 4.9 Outline sketch of the change in condition value over time according to model IV.

If a visual inspection is needed and perhaps samples taken in addition to the objective measurements in order to determine the actual quality of an asphalt pavement, data from such an extended inspection can be built up using a numerical scale. These additional condition values can then be treated in the same way as the laser measurements.

4.5.9 Model V - stepwise changes in condition and values

A multiple stage scale with stepwise changes in condition can be used, primarily for visual inspections of components. The condition graduations are illustrated by clear descriptions, pictures, photographs and/or films. For example, in the case of a scale from 1 to 4, the following designations might be described and illustrated:

1 Signifies a component in "as constructed" condition. No value reduction is made here.

2 Signifies a worn component in acceptable condition from the point of view of function. The component is approximately half-consumed. A reduction in value is made equivalent to 50% of the assessed cost to rectify.

3 Signifies an installation that has deteriorated to a functional condition corresponding to "worst acceptable". 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 component will be consumed. Otherwise, a residual value will remain.

4 Signifies a component that has passed its "worst acceptable condition" and that has a residual value. Measures should be carried out immediately, maybe at an increased cost.

Figure 4.10 exemplifies how the condition value can change over time according to model V.

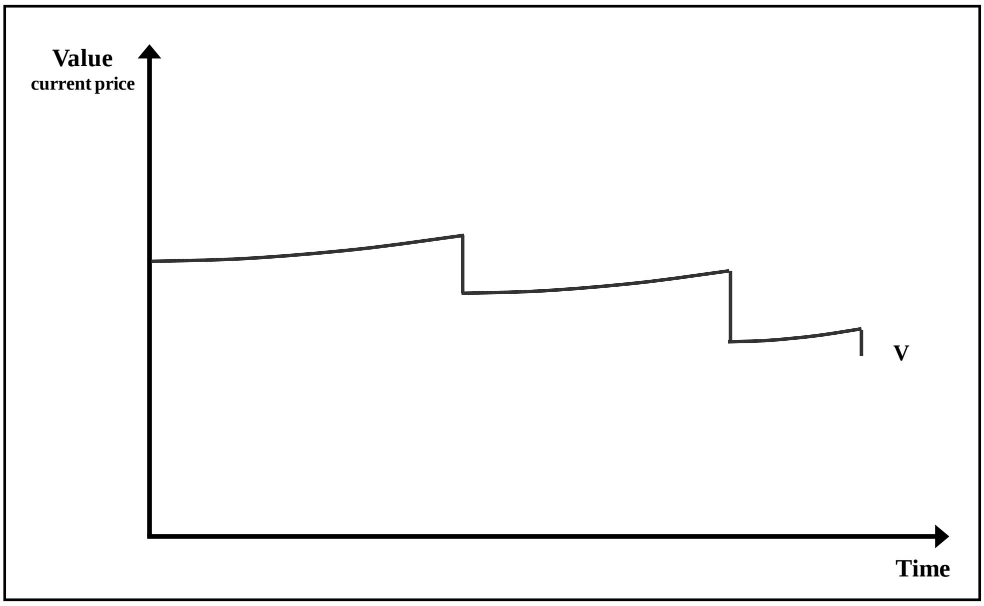

Figure 4.10 Outline sketch of the change in condition value over time according to model V.

4.5.10 *Model VI - depreciation according to predetermined rules*

Economic life varies with the type of component and is principally determined by economic factors in society and for road-users and road managers, but may also depend on purely technical circumstances. When actual consumption over a period is not known, the question is then one of how much of the total consumption margin according to plan can be allocated to a certain period. The question is comparable to the problem of determining fixed assets' depreciation principles in the external accounting. Depreciation according to plan normally follows a linear, degressive or progressive function. The linear function is the form most often used but annuity depreciation is also quite common. Figure 4.11 shows an outline sketch of the three alternatives.

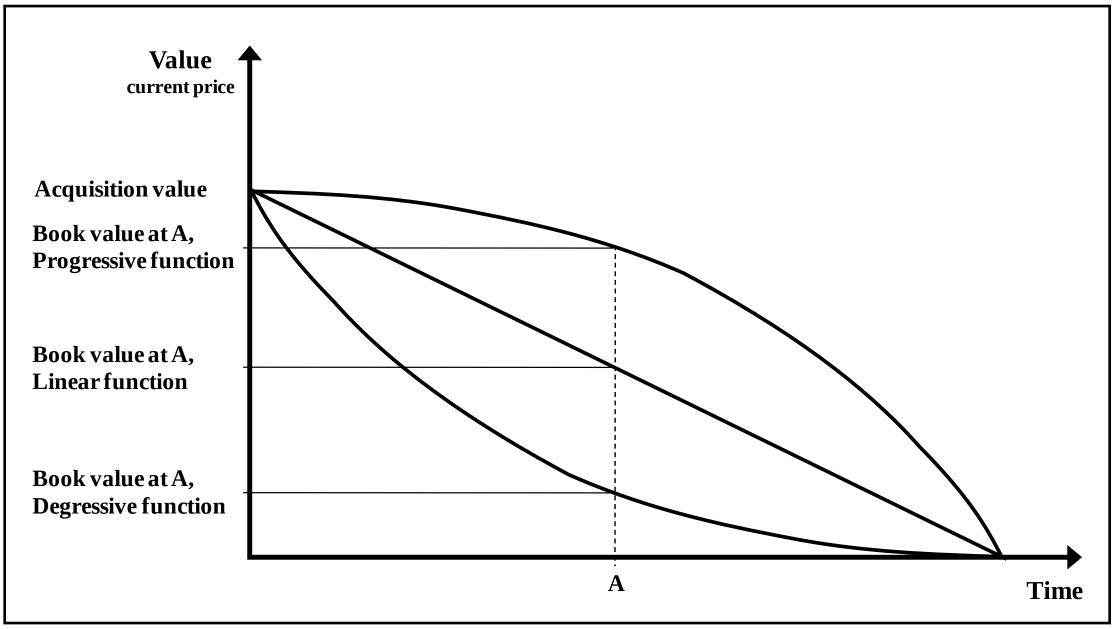

Figure 4.11 Booked value at the same point in time A according to three different depreciation models

For many component types, adequate knowledge exists of actual technical life and consumption (changes in value). The dimensioning technical life of the component type may constitute important basic information in decisions about length of life. This might for example be 20 years for a certain component type. Another known fact might be that the components are replaced after an average of 28.6 years. This would mean a safety margin for the construction in this example of 8.6 years or 43%.

The function in model VI should in principle be equivalent to a planned depreciation of the component type over its most probable life. In the example this is 28.6 years and the life that is ultimately determined may therefore be 30 years. Lives are determined so as not to risk exaggerating funding needs for replacements or reconstructions, i.e. a "reversed prudence principle".

For a component where condition or change in condition has not been inventoried but where good knowledge of technical life exists, planned depreciation should be able to be implemented according to model VI a below. The reduction in value may be full or down to an assessed residual value in a fixed length of life. Figure 4.12 illustrates the change in condition values over time with less function and value adding maintenances that do not have any influence on the life length. There is no doubt that the components in model VI a, will be replaced by new components, when they have reached their functional life lengths. The rising part of the curve to the right bottom point shows a residual value that is index-adjusted to the current price level.

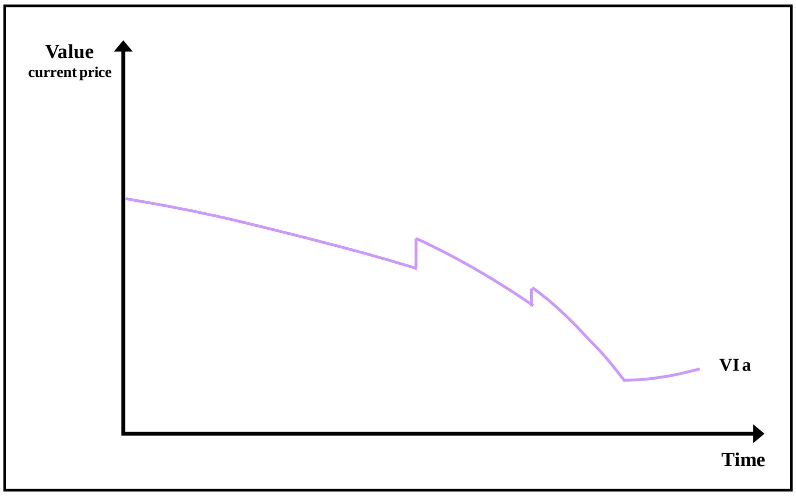

Figure 4.12 Outline sketch of the change in condition values over time according to model VI a.

For many component types the condition description will follow model VI a. In its simplest form, depreciation over the length of life is a linear function, which can be compared with the linear depreciation according to plan in the accounts. From the point of view of the quality of the condition-related value and the planning of road measures it is important that the depreciation reflect the actual consumption as accurately as possible.

There are also component types, where the condition is not continually inventoried, and whose functional life in practice can be very long. The principle of mechanical accounting according to plan for components of types that follow model VIb gives a fixed depreciation rate instead of a given lifetime. In practice, it is hardly any difference compared to VI a. A value-adding maintenance leads, for these component types, to an increase in the life expectancy that is proportional to the increase in value. Condition values for component types that are handled according to model VIb can be calculated in different ways.

Following a value-added maintenance action, the condition value is equal to the sum of the condition value positions before action and the new expenditure on the project. The sum is not allowed to be higher than the replacement cost of the component. The excess value is treated as a cost.

The simplest way to calculate the condition values after an action might be to replace the previous “year of production" in the mathematical expression with a calculated “fictitious year of production". This can be determined so as to give the correct value given the correct depreciation rate. The final year for the “worst acceptable” condition is calculated with the lifetime that follows the component types depreciation rate. Calculations are made at given prices. With this calculation method, the original expression with the replacement cost can be for further calculation of the component's condition values.

With the revised “as new" and final years in the mathematical expression, it is possible to use these years as the only in-data to calculate the component's current rate of consumption and condition value (see the chapters below). Figure 4.13 illustrates model VI b.

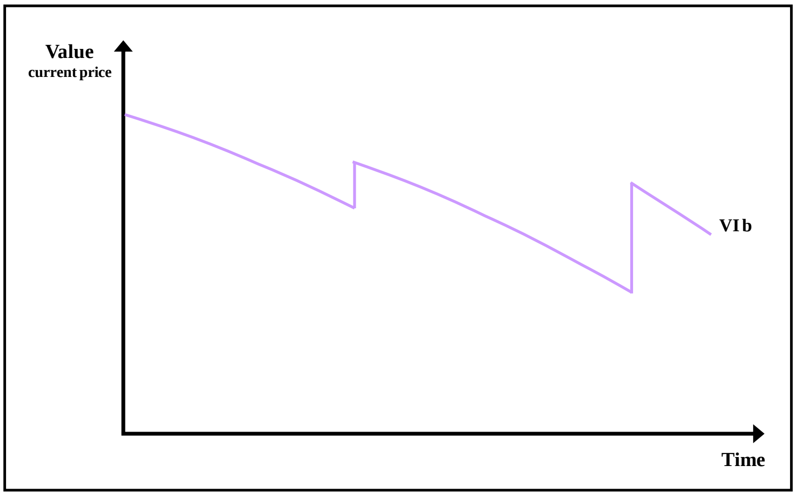

Figure 4.13 Outline sketch of the change in condition values over time according to model VI b.

A realistic determination of the depreciation function for condition description according to model VI can be made in several different ways. Using a statistical approach the model can be determined for every component type in question in a systematic manner. It is for example possible to:

- select about ten specialists on the component type in question and its upkeep,
- determine an appropriate and unambiguous condition scale for the component type together with the specialists (as clearly as possible in words and pictures),
- select at least about thirty occurrences of the component type in question of varying condition and with known years of acquisition, so that the whole range of conditions is represented,
- have the specialists individually and independently inventory and determine the condition of the (unknown to them) thirty something components chosen according to the adopted scale,
- compile the results of the specialists’ condition determination for each occurrence taking the actual ages of the components into consideration,
- fit functions to the condition determinations made by the specialists in respect of the components’ actual ages, analyse the functions and establish the function that will apply.

Fitted functions per component type can be devised in several ways on the basis of the specialists' assessments of all the roughly thirty components' condition in respect of actual age (e.g. on the basis of total material, mean values or median values). In model VI it is thus possible to determine a suitable function for the development of condition value over time for every component type. The specialists' assessments can also be used to set control limits for the component type's condition development.

The components economic value, consumption and life cycle cost are affected by the time when the action is taken and consumption occurs. The quality-related accounting is designed to reflect that the components' and the road managers' costs are correctly as possible even if the component type is not inventoried. This also applies to component types, which are composed of two or more essential parts with their own economic life. A component can also have a scheduled preventive maintenance. It is possible to adjust the depreciation rate for such a plan under the basic principle which applies to the "model VI" concept and achieve an automatic handling with good compliance with the "best knowledge". One such example of consumption model VI c with the Linkage coefficient (S) is detailed in Appendix 5. Figure 4.14 illustrates model VI c.

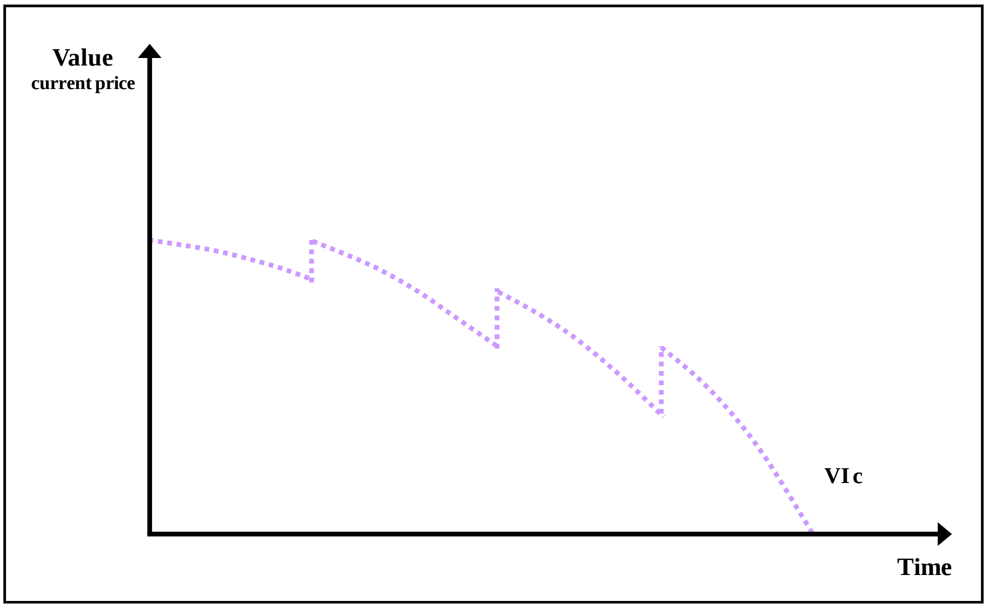

Figure 4.14 Outline sketch of the change in condition values over time according to model VI c

4.5.11 Relative consumption, R

Relative consumption (R) is used to determine a component's condition value of its actual condition (Q_A) in respect of the new "as constructed" condition (Q_B) and "worst acceptable" conditions (Q_S). How this "worst acceptable" condition and other condition limits can be determined is discussed in Appendix 4. In the appendix it is said that:

"It is important in this context that the road manager takes socioeconomically "optimum" limits for maintenance measures into consideration in those cases where they exist. The "worst acceptable condition" limit value for measures to be carried out is in this case synonymous with the “optimum condition” for maintenance measures. Henceforth the term “worst acceptable condition” will be used for “optimum condition”.”

R is calculated in the same way for all condition models using the following expression:

$$\textbf{Relative consumption, R} = \frac{\mathbf{Q_A - Q_B}}{\mathbf{Q_S - Q_B}}, \text{ where } Q_S \neq Q_B \text{ and } 0 \leq R \leq 1$$

Consumption models II, III and VI use a year for Q_B (”the as constructed year”) and Q_S (the year for ”worst acceptable” condition according to for instance the length of life or point of time for measure) and the current year Q_A. Component types that use consumption models IV and V have other parameters to describe condition and the parameter limits. The administration systems at present use, and will continue to use, for example rut depth in mm, IRI in mm, and/or condition classes according to some form of numeric scale.

If the component has some remaining value when “worst acceptable” condition value is reached, R might be greater than 1 in the calculated ratio. This means that “worst acceptable condition” has been passed. For all $R > 1$ the value is set to $R = 1$. Correspondingly, R may be < 0 when quality, for example at delivery, is higher than the requirement for “as constructed”. For all $R < 0$ the value is set to $R = 0$. Components that deviate with $R > 1$ and $R < 0$ are taken up in Chapter 5 on quality control with process control and learning.

A component may have more than one quality parameter to describe functional physical conditions. In such cases there are two natural principles to choose between to determine which quality parameter (which R value) to use when calculating a component’s condition value.

Alternative 1
The quality parameter is chosen that has the greatest relative consumption. This alternative means that the time factor will probably be the dimensioning factor for the calculation of the condition value. The quality deficiency chosen can be expected to reach the “worst acceptable” condition limit before the other deficiencies and thus be the determining factor as regards the time when measures are to be applied.

Alternative 2
The quality parameter is chosen that gives the greatest value consumption (lowest condition value), i.e. the greatest product of relative consumption and the standard cost of carrying out measures. Where the standard costs of the measures are different for the quality parameters, the choice of parameter need not be the same as in alternative 1. The principle in alternative 2 agrees better with accounting’s basic principle of not overvaluing assets but instead making careful value appraisals.

For the individual component, the difference in condition values calculated using the two alternatives will probably generally be very small. In a total perspective for roads and road networks, the differences between the alternatives’ values should be close to negligible. If other sources of error are weighed in the total road capital amount, which will exist despite the fact that “best available knowledge” is used, it will not matter in practice which alternative is chosen. However, a choice cannot be avoided and a wise choice is always better than a poorer one.

From the point of view of control, the transport policy's demands regarding socioeconomic effectiveness and customer satisfaction must be the most important starting points. The limit values for condition that are used in the accounting model and for control have been analysed and determined using this premise. Requirements to fulfil an accounting principle – that moreover have other purposes than operational control – should therefore be allowed to be ignored as regards this particular choice. It is therefore reasonable that the parameter that is chosen is the one that best supports control in accordance with the transport policy. In this case it is the parameter that shows the component's greatest relative consumption (maximum R of all the quality parameters' R values). Alternative 1 should apply. The aspect is thus chosen that when measures will be carried out (according among other things to road-users' expectations).

4.5.12 Residual value, standard cost of measure and the residual value coefficient

Residual value

A question that is closely linked to the "worst acceptable condition" for each component type is the residual value issue (see Appendix 4 on limit values). What is "normal" for a component type when the components' condition reaches "worst acceptable condition"? Are the components "normally" rebuilt or are they replaced with new ones? If the component type is usually "repaired" there is likely to be a residual value greater than zero and this value must then be determined.

Components where the material is worn out or aged or has deteriorated to the point where it is no longer functional are often replaced. In such cases repairs may not be economically viable, in which case this is equivalent to the condition value having reached its "worst acceptable" condition and that the residual value in the accounts should be zero.

Component types with residual value > 0 at "worst acceptable" condition are often the subject of extensive and possibly recurrent rebuilding (maintenance). Since the contractor's fixed costs constitute a considerable portion of the cost of applying a measure it may prove profitable to try to restore component's condition to as close to "as constructed" as possible by means of a major reconstruction. The analyses that need to be made of each component type in respect of limit and residual values and costs of applying measures should be coordinated.

Standard cost of measure

The cost of applying a measure can vary with the type of deficiency but is also dependent on a number of other factors to do with, for example, road category, road width, traffic density. posted speed, climate zone and bearing capacity. The cost is on the other hand only marginally affected at the "worst acceptable" condition level. For example, it "normally" has no significance as regards cost whether the "worst acceptable" rut depth is 15 mm or 20 mm. The cost of applying the measure in the example is practically the same.

For value reduction models II and III the cost of applying measures is calculated for each individually identified deficiency while models IV and V largely use general standard values also in the administration systems. All the administration systems deliver information about the cost of carrying out measures for each component occurrence. The cost of applying measures for component types that use models IV, V and VI thus exist as standard costs. The standard cost of a measure can vary in respect of specific factors in a circumstance algorithm in a similar way as for limit values. The circumstance algorithms should be investigated when the component type's limit values for condition and residual value are analysed.

In the case of "models IV, V and VI" component types, a component's condition can be improved from "worst acceptable" to "as constructed" by a measure whose price is equivalent to the unit price of the standard cost of the measure applied on the component's quantity (length). A component's condition value at any given time can thus be calculated as:

Condition value = Replacement value – R * Standard cost of measure

Standard costs of measures are used in several contexts and should therefore be regularly checked and adjusted to the actual costs of applying measures. Formula 4 also applies for component types that use models II and III. The assessed unique cost of applying measures for each component then replaces the standard cost of the measures in the formula.

Residual value coefficient, G
The standard cost of measures is to be used to calculate value reduction from the component's replacement value. The standard value must be index-adjusted so that it uses current prices. Since the maintenance measures on the component type will probably in all essentials also concern the same specific resources as the investment, there are two reasons that indicate that the component type's specific construction price index should be able to be used. With this approximation, it may therefore be appropriate to convert the standard value into a proportion (G) of the replacement value as follows:

Standard cost of measure = G * Replacement value $(0 \leq G \leq 1)$

Condition value = Replacement value (1 – R * G)

The size of coefficient G has significance for the size of the residual value according to the following relationship:

Replacement value – Standard cost of measure = Residual value

Residual value = (1 – G) * Replacement value

It might happen that the cost of applying the measures is greater than the replacement value, which means that $G > 1$. In spite of this, rebuilding may nonetheless be decided rather than replacement. It may be argued that the external costs to society and/or road-users are lower for rebuilding. It may also be the case that the registered replacement value is too low despite the index adjustment. After a check of the price index and possible adjustment of the replacement value, a value of $G = 1$ is set regardless of the outcome.

$G < 1$ means that a residual value will remain and that the component can probably not be repaired when its condition has reached "worst acceptable". $G = 1$ means that the component will have been completely consumed (value = 0) and will probably be replaced. When the value of G has been set (models IV – VI) or calculated (models II – III), a decision is also reached on the residual value issue, using among other things the values that the analysis and the calculation respectively have resulted in as regards the standard costs of the measures. G is called the residual value coefficient. If the approximation proves to give unacceptable errors in the index adjustment, it will be necessary to use a correcting factor for the component type.

There are in principle two courses for model VI that value reduction can take. One has a fixed end date regardless of what maintenance measures are carried out over the life of the component. For these types of components G is normally 1, which means that they have no residual value when the whole consumption margin has been used up and the component is replaced. Value reduction takes place down to condition value 0 at a predetermined point in time.

The other types of components, often having G < 1, are usually able to be maintained and thus be given a very long life. When the whole consumption margin has been used up, a residual value remains. The rate of value reduction is constant and without maintenance the condition value reaches it residual value at a predetermined point in time. If maintenance measures are carried out, the expenditure is capitalised at the maximum replacement value. A new end date when the condition value is equal to the residual value is displaced to a corresponding degree according to the value reduction rate that applies.

4.6 Data capture

Growth of road capital occurs in connection with road measures (investment and value-adding maintenance). Once the TAM concept's quality-related accounting model has been implemented, the financial information at component and component type level will be captured from the invoice via the accounting system.

The contracts for procured road projects should contain clearly expressed requirements as regards the invoices' structure – requirements adapted to the road manager's accounting of the projects. Prices are given per component type with quantity information. The totalled component type prices make up the contract sum. Regardless of the form of the funding or the contract, the information should have the same structure. The road manager has a contract register linked to a road project list where every project has information about contracted component type quantities and unit prices (cf. Chapter 8).

In connection with the final invoice, undisputed component types are to be approved (in respect of both quantities and unit prices) and revised as-built drawings delivered in a format adapted to road manager's system. Road management's need for information about each component's expenditures, locations and distribution would thus be properly adapted to computer processing from the outset. This requirement as regards construction contracts has been analysed by experienced staff at both the SNRA and by contractors. There is general agreement that this would function very well and the contractors probably already have the necessary technical aids in place for a rational handling. Savings that can be achieved with this contract structure compared to the present model are discussed in Chapter 7 on road management's sub-processes.

Pragmatic data capture should allow information about a component to be fetched to both the accounting system and the road and traffic data bank with a high degree of automation. In general, the client should demand that both contractors and consultants deliver digital as-built drawings, invoices and reports in suitable formats. Data capture should be a prioritised development area for the road manager. Appendix 8 contains examples of how trade and industry have been working for decades to make data capture more efficient.

Before the final inspection or “opening to traffic”, requirements should have been set to ensure that rapid registration in the RDB and the accounting system is possible. It is reasonable to demand that components actually in use be correctly booked already in the very first periodic statement, or possibly the first annual accounts, after a section of road has been opened to traffic.

Shared costs outside the contractor’s component type prices should not be distributed over the road project’s components by computer. They must instead be booked in their entirety against the appropriate component type under *Prerequisite items*. Expenditures and costs that may have been booked against super ordinate administrative items should be able to be analysed separately. Only at a later stage, and where deemed appropriate, can they perhaps be distributed over the components concerned and then only according to a principle, which is the same for the whole country. It may also later prove to be desirable and possible to book operating costs against the components concerned by computer. This would permit further valuable analyses and more efficient resource allocations to the advantage of road-users, trade and industry and society.

In an implemented TAM concept with quality-related internal accounting of physical infrastructure capital, the construction contracts contain prices per component type and a list of the component occurrences that are to be delivered or rectified. The sum of the component types’ prices constitutes the total value of the contract (the contract sum). Every component has a unique number and after the measures have been carried out must be reported to the road and traffic data bank together with the required information.

On the basis of a component type’s unit prices, the components’ final quantities must result in an acquisition or measure price for each respective component. The total amount must agree with the amount booked in the external accounting. The same investment expenditure is booked as an asset in both the internal and the external accounting but with different details recorded. The expenditure for value-adding maintenance will at least in part be booked as an asset in the quality-related accounting but booked in its entirety as a cost in the external accounting.

4.7 Summary of consumption models, condition-related value appraisal and accounting

Bridges and tunnels are inspected systematically and regularly (visually, by X-ray, or by means of analyses of samples, stress calculations, test loadings, etc) according to agreed inspection programmes. Maintenance strategies are drawn up when a deficiency is identified. Consumption model III can be applied. The *Bound wearing course* component type is measured systematically and regularly by means of laser equipment and results in measures of a number of physical conditions (ruts, roughness, cross-fall, texture, etc), Deficiencies and maintenance measures together with financial details can be found in the administration system. Consumption model IV is used for bound wearing courses.

Condition values for the *Bound wearing courses*, *Bridges* and *Tunnels* component types are based on well documented measurements, inspections and/or analyses. Structured analyses are also carried out to a certain extent of the condition of road structures in respect of bearing capacity using objective measurement techniques such as georadar, laser and deflectometry in combination with sampling (e.g. BÄRUND). The condition description is systematic and is drawn up when bearing capacity problems have been identified visually. Climate-related road management requirements that first and foremost concern the *Road constructions* component type group lead to more attentiveness and documentation in the administration system and model II will therefore be able to be used. Past requirements have concerned ability to protect the geotechnical constructions when other types of action are taken in the road area.

Some component types have detailed requirements in construction contracts as regards “worst acceptable” condition and about their upkeep – requirements that are followed up more or less systematically and regularly. Several of these components are already inspected visually around the country today according to the principles in models II and V.

There is no question that the number of component types that will need to be systematically inspected will increase as the volume of construction contracts containing function requirements grows. This means that systematically described conditions will to an increasing extent come to constitute bases for the control of maintenance measures. It will thus be important to find objective inspection methods of determining both initial and final condition (possibly in the form of condition values) when measures/construction contracts begin and end. The information will exist in administration systems, in more or less advanced individually developed PC systems or on loose sheets of paper in various places. The quality-related accounting can at any time receive structure information according to uniform principles and with good internal control, if the information is compulsory in the whole country.

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

The value of all right-of-way land (perhaps the entire group of *Prerequisite items*), all road structures, bridges, tunnels, and bound wearing courses may at a guess be equivalent to at least ¾ of all the road capital. In a test of the model on four sections of road with bound wearing courses, these components accounted for 80% of the sections’ value. For considerably more than half of the capital value of the state-administered roads, the individually determined current condition of each component occurrence according to “best available technical knowledge” can form the basis for the valuation of the road capital and its changes over time. The prerequisites for performing a condition-related valuation of road capital of good quality are therefore already rather good.

For the components that account for the remaining proportion (at a rough estimate less than 25% of the total value of the road capital) the quality of a condition-related valuation can be expected to vary. It will, however, gradually improve. If the condition of all the remaining component types were described according to the principle in model VI (a, b or c), this would anyway lead to a considerable improvement in quality compared to today’s accounting.

The bases for valuation of individual components must be documented (for example in the form of inspection reports and/or documented principles) so that the valuation can be verified and checked at a later stage. The administration systems mentioned above contain a requirement for structured documentation of condition. Consumption or value change models have been identified both in established applications in Swedish state-administered road management and literature reviews. The six consumption models are all graphically illustrated in Figure 4.15.

The figure does not show whether residual values occur or not. Each of the models can have or lack a residual value, which is determined for each component type in respect of the types of deficiencies that occur. Bound wearing courses can for example have residual values for rutting and roughness but probably not for instability and poor bearing capacity.

Some of the models share the same basic principles but we have chosen to describe the small differences that nonetheless exist by describing them individually. The year of acquisition and/or the maintenance year are registered for all component occurrences in all models.

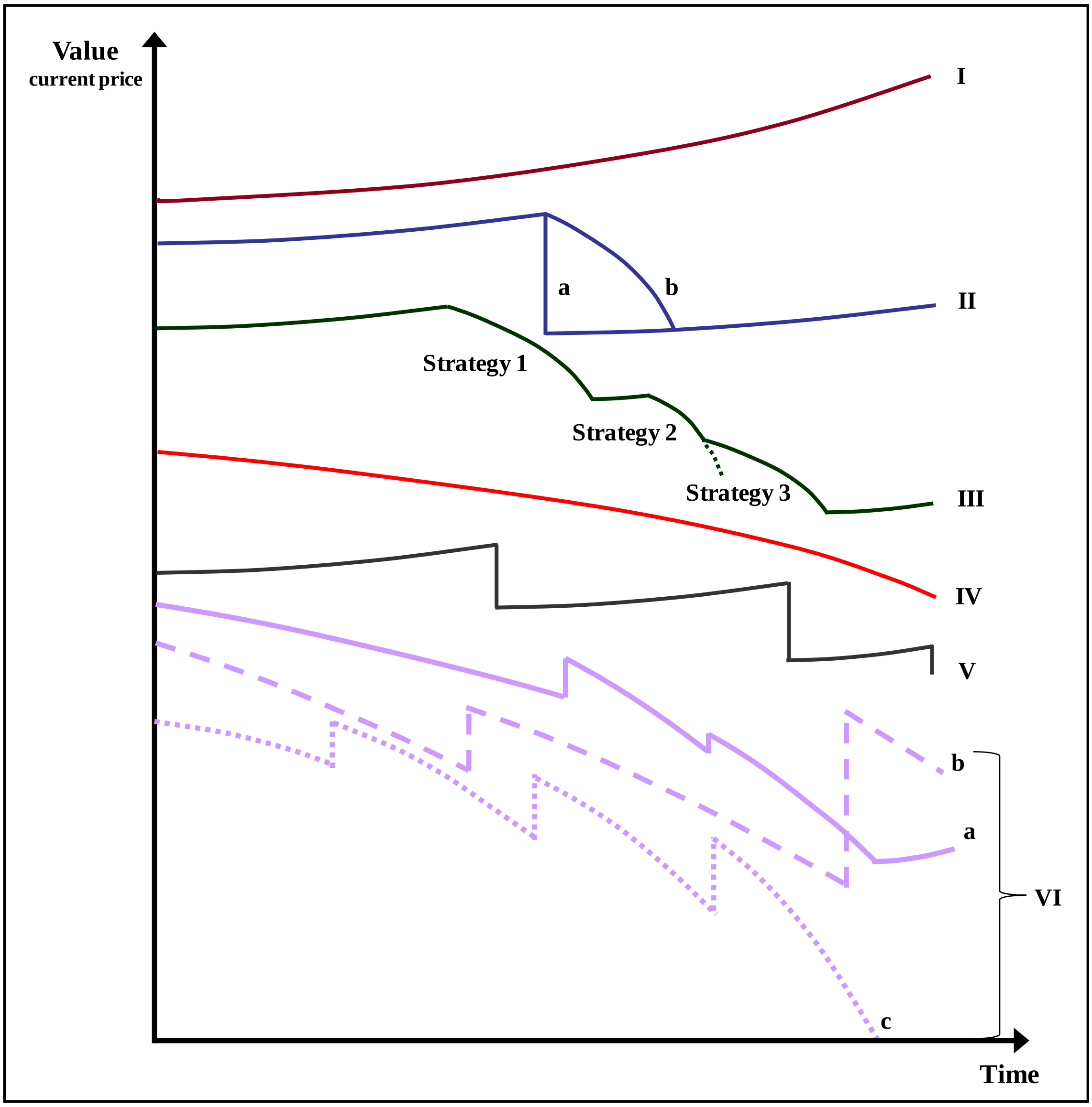

Figure 4.15 Outline sketches of six different models for describing a component's condition

The condition-related accounting must be verifiable against similar requirements that apply for traditional external accounting.

In their "worst acceptable" condition, components may have some value remaining. Maintenance in these cases normally has the nature of reconstruction or repair of damage and wear to a condition that as far as possible restores condition to "as constructed". In other cases the remaining value may be zero. In order to determine relative consumption and condition values both "best" condition and "worst acceptable" condition must be defined in detail.

The two figures below summarize the central concepts in quality-related value appraisal and accounting. The gateway figure 4.16 is a sketch over relationships between the applied conceptions in the quality-related model for valuation and accounting. In figure 4.17 presents the formula idea concept and the relationships that the model is based on, and also the introduced relative remaining consumption margin (T), which simply is 1-R.

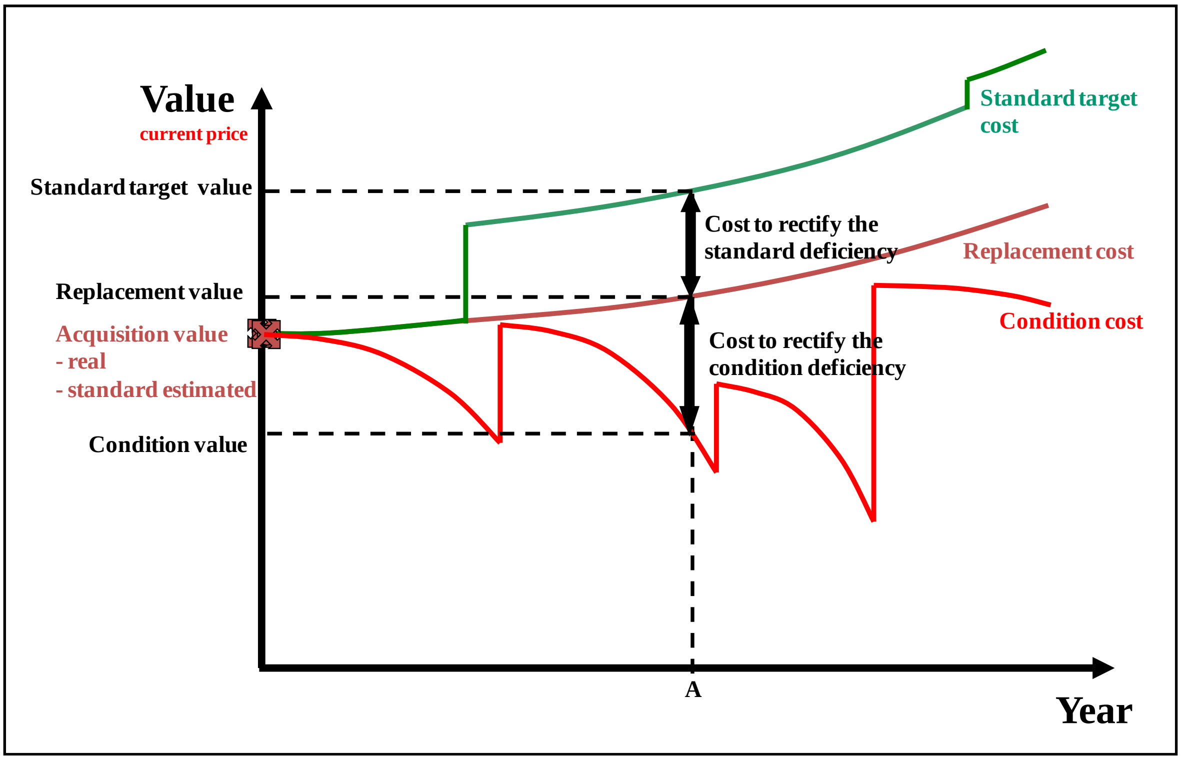

Figure 4.16 Relationships between applied conceptions in the quality-related valuation

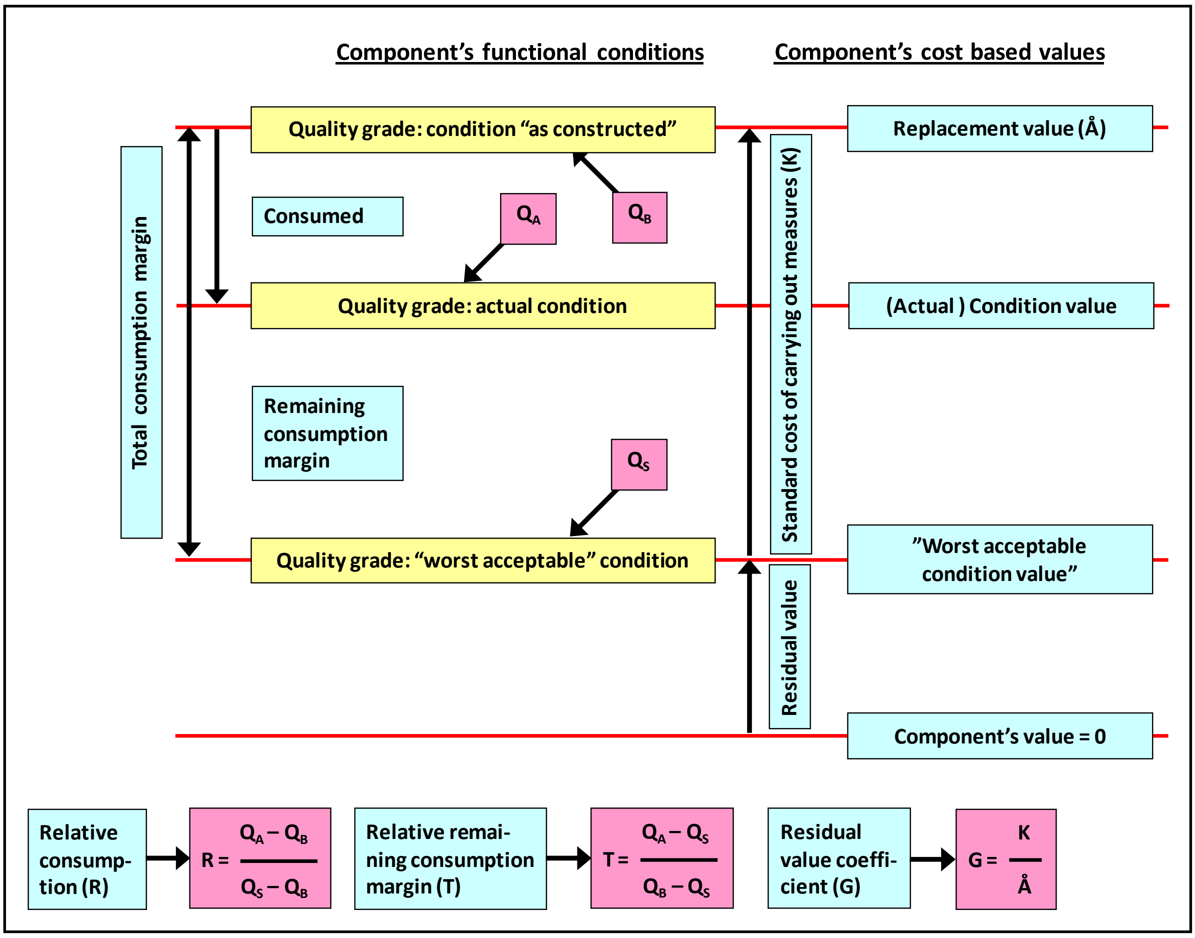

Figure 4.17 Relationships between a number of concepts that are important in the condition-related value appraisal

Components' physical consumption margin consists of the span between the condition's limit values for "as constructed" and "worst acceptable". With knowledge of a component's current condition, it is possible to say how much of the margin has been consumed and how much remains.

The proportion that has been consumed is called the relative consumption (R) while the proportion that remains is called the relative remaining consumption margin (T). The relative consumption is used to determine the component's condition value. Information about the relative remaining consumption margin can be used in different future analyses that we shall return to later.

With knowledge of a component's rate of consumption, the remaining consumption margin figure provides some indication of how much time remains before the component in question should be rebuilt or replaced. The relative remaining consumption margin is therefore useful information when planning both measures and funding.

Figure 4.17 also shows relationships between the quality's physical or functional condition measure "as constructed" condition (Q_B), current condition (Q_A), "worst acceptable" condition (Q_s), and relative consumption (R) and replacement value (Å), condition value, "worst acceptable" condition value, standard cost of measure (K), residual value and residual value coefficient (G). If we also bring the linkage coefficient (S) for component types using the consumption model VI c (described in Appendix 5) into the consideration the generic basic formula comprising all component types' actual condition value is:

Condition value = Å * (1 – S * R * G)

When a value adding measure has been taken, it must be observed in the formula with certain differences between the separate consumption models (II – VI).

By that, the Condition value consists of four items in the accounting system: the acquisition value, the reduction in value of the acquisition value, the index adjustment and the reduction in value of the index adjustment. This arrangement facilitates cross-checking against the external accounting. It is also possible to obtain other information in both fixed prices (the price level of the year of acquisition) and in current prices. Since components' actual life cycle costs, for example, will be followed up, there is significant learning to be gained from analysing outcome in respect of historical acquisition values.

5 QUALITY CONTROL, PROCESS CONTROL AND LEARNING

5.1 Background

Among other things, in one of the program declarations [65] of SNRA, you can read as follows:

> "External pressures, global competition, tax competition, etc are all increasing in Sweden. The conflict of objectives will become even more complex and tangible for a society that must be globally competitive, increase economic prosperity and at the same time ensure security and quality of life for its citizens.
>
> For the SNRA … this will probably mean that a focus will be needed on areas that can increase Sweden's competitiveness, in tandem with efficient, safe and environment friendly means of transport."

This might be a concise expression of the requirements that apply for the development of quality and efficiency in the road management process. The Government has also made clear its ambition as regards efficient transportation by appointing the commission that has now proposed a unified traffic agency for sea, air, road and rail transport. Customers' need for transportation will be strengthened for both industrial and passenger transportation and for society. The climate threat with global warming will further focus politicians' interest in transportation and an accompanying increased need for change in the sector. There can therefore be no doubt that demands will increase in the areas of efficiency, the environment and quality in transportation infrastructure management.

The pressure for change will also lead to demands for competitive and environment friendly development of trade and industry. Rapid, competitive development will in turn require pertinent information about the infrastructure capital and its deficiencies. Rational information should be based on "best available knowledge" of both society's and customers' demands and current condition, deficiencies in standard and condition, together with details of the cost of applying measures. In order not to be too resource-intensive, the handling of good quality information about the road infrastructure and its use needs to be supported by computerised structures. This will allow the long lead-times in planning processes to be shortened. Fast, efficient changeover processes in trade and industry can be expected to lead to corresponding demands for synchronised, fast planning processes in the public sector. Planning can be made more efficient purely by the fact that accurate, relevant basic information is available already when the processes begin. To meet society's expectations, planning itself may need to be developed into a continuously on-going, flexible process with a somewhat different type of funding than today.

Efficiency, sustainability, customer-orientation and a holistic view of transportation are excellent guiding principles for a change effort that embraces the entire transport system and are in good accord with the aims of Transportation Asset Management.

It is particularly important that these high ambitions also permeate infrastructure management processes in practice. Competence-wise, the SNRA, and a possible future traffic agency even more so, is expected to be the dominant player in the transportation market. In such a role it is

[65] From the Project report – S On the Way1.1

important to have knowledge of the customers' needs, of sacrifices and utility with regard to transportation, about sound procurement of new construction on a business basis, and operation and maintenance of infrastructure installations.

In quality-related accounting of the infrastructure capital "best available knowledge" is considered with regard to the standard of the infrastructure installations and condition on the basis of both social economy and road-users' expectations. The accounting is based on "best available knowledge" of any component and section of road, as regards costs, times when measures are needed and known deficiencies in condition and standard. This means that up-to-date information about how well customers' expectations are being met, when a measure will probably be needed, and at what cost, is always available.

The quality of a product (an item or a service) is traditionally judged in trade and industry on the basis of the degree of customer satisfaction, i.e. how far a product satisfies the customer's needs, specifications and expectations [66]. For business reasons, suppliers endeavour to have "loyal customers". Among other things, "loyal customers" are seen as potential ambassadors for the product in question. A common view is that a "loyal customer" is a "satisfied customer" and that a "really satisfied customer" cannot be secured until deliveries exceed the customer's expectations.

The linkage to the customer's direct preferences and willingness to pay for different products and services is in all essentials lacking in road management. The SNRA defines efficiency as a function of the factors "value and utility" and "productivity".

> "By *value and utility* is meant the relationship between customer-perceived quality and the price that the customer has to pay (value and utility = customer-perceived quality/price).
> By *customer-perceived quality* is meant all the factors that the customer considers when making a purchase, except the price.
> By *productivity* is meant that the services are produced in a cost-effective manner, i.e. the cost per produced service or product is as low as possible."

The customer's perceived utility of or satisfaction with a product is thus very important as regards quality and efficiency. Many successful organisations therefore have quality and management systems that encourage learning and continuous improvement of efficient processes and products that satisfy their customers. A fundamental principle in this context might in many cases be to exceed customers' expectations and create "really satisfied customers".

The SNRA's strategic plan contains strategies with linkages to the TAM concept. Two such strategies with a clear linkage to quality-related accounting are quoted below:

"….

– The SNRA shall actively use its procurement volumes to secure competition in the civil engineering market.

….

– Life cycle analysis shall be used to an increasing extent to achieve a low total cost for a road installation."

[66] According to the Swedish National Encyclopaedia, version of 15 October 2006.

Both these strategies are important for management's control and monitoring. It is essential that decision-makers have access to relevant bases for decision and that the underlying information is reliable and up-to-date. Questions of quality or internal control are for example kept constantly alive in discussions about accounting procedures, systems and data. To underline how very important the quality of the basic information is, responsibility for information and data is normally linked to people directly responsible for the operations of the company or organisation. Responsibility for quality is sometimes given formal status through signatures on important basic documents and documents containing important information. The board of an organisation, for example, signs the annual report in order to take legal responsibility for the information. Many of the organisation's stakeholders attach great importance to the annual report.

Quality-related accounting contains information that is intended for several of road management's sub-processes. In large organisations with extensive flows of data and many people involved, constant attention needs to be paid to the question of data quality. It is management's responsibility to monitor internal control and ensure that data capture for control, monitoring, analysis, learning and development of both processes and products is efficient. Quality assurance and internal control are nowadays computerised in order to be effective.

5.2 Problems and purpose

The continued development of infrastructure management is expected to lead to an environmentally sustainable and efficient transport system with an increased focus on the customer, international competitiveness, and quality. As it stands, infrastructure management has embarrassingly long planning processes (lead times). The construction sector is struggling with low productivity and reliability. Clients have difficulties in handing the development of projects' acquisition costs. The road manager has an insufficiently business-like approach, particularly in a life cycle cost perspective. It might therefore be desirable to analyse and discuss whether quality-related accounting would support the increase in efficiency being sought with regard to infrastructure management and, for example, in road management's sub-processes.

One conceivable example of such an increase in efficiency might be found in process monitoring and control itself. Control can in theory be based on continuous follow-ups of critical key ratios and indicators that describe the above challenges in a relevant way. The information in the quality-related accounting has a customer focus, quality and costs as its starting point. Data would therefore be able to support a continuous planning process and allocation of resources. Up-to date knowledge of quality deficiencies is an important prerequisite for this type of concept. Continuous follow-ups and monitoring of critical key ratios also allow undesired deviations from quality standards to be acted upon quickly.

Improvements should be able to be achieved by securing learning in the various sub-processes. This can be done by focusing on fast detection, fast analysis and fast dissemination of experience of both particularly successful and less successful activities and operations. Inefficiencies and errors must be identified early on in the process, negative non-conformities must be analysed and dealt with in order to limit the consequences for the customer. Knowledge gained from analyses must be disseminated through networks that cover the whole organisation immediately and systematically. Mistakes must not be repeated while good examples must be duplicated throughout the organisation as soon as possible. Short lead times in learning are an important success factor for efficient infrastructure management and should be able to contribute to a positive development of productivity in the construction sector.

According to this principle, it is permitted to make mistakes – but not to repeat them. Even mistakes contribute to a positive development of knowledge if handled correctly. In actual fact, divergent approaches and less successful courses of action have often led to new concepts for success after extensive analyses and long development processes.

The control and monitoring that we are looking at in this chapter occur in various forms in the process industry, where it is particularly important to identify problems in manufacturing early on. When a defective unit is detected, the manufacturing process is corrected as quickly as possible. Further processing of the defective unit is stopped. From an economic point of view it is not defensible to allow a defective unit to continue being processed because it would anyway not lead to a product that fulfils the applicable quality requirements. Continued processing would mean higher costs for pointless work that has already been identified, because the product could never be released onto the market.

Excellent opportunities should therefore exist to also make road management more efficient using a similar process control concept with strict requirements in respect of active control, learning and internal monitoring. Such a concept assumes that the bases for decision are of good quality and current. The purpose of this chapter is to theoretically describe the opportunities for a corresponding, qualified application of quality-related accounting according to the TAM concept.

5.3 Quality control

5.3.1 Quality certification of basic data in the model

The question of when the "optimal time" for a maintenance effort occurs is a determining factor for decisions about measures. There exist at least two function prerequisites for the component types. "Function type 1" refers to all components that have a connection between user effects and condition and in a socioeconomic calculation have a condition for which a minimum sum cost exists. "Function type 2" refers to other components where measures are to be carried out when their condition in a customer perspective reaches the limit value for "worst acceptable" condition. It is important to note that in theory one and the same component type can belong to both function types depending, for example, on traffic flow. Which function type is to apply is shown by the component type's "circumstance algorithm".

The way in which limit values are determined is another aspect of data quality. In order to certify the quality of data for different types of analyses, this type of aspect will also be quality certified for each individual component occurrence.

Actual acquisition values are booked with quality levels 1 and 2 for investment projects procured by unit price per component type. Level 1 is an offered unit price per component type.

Quality level 2 indicates that the value has been assessed afterwards by the contractor or the project manager on the basis of a priced list of quantities or acquisition values determined on the basis of actual contracted historical unit prices and quantities in the road investment. Information is retrieved from archived documents per project (object binders). When the values have been adjusted against a known acquisition value for the entire investment project a long time after the requisitioning of the project, they have quality level 3. For levels 1, 2 and 3, there should not be any difference between the total acquisition value of an investment project in the external accounting and the totalled component values in the internal accounting.

Level 4 is used to indicate standard values without adjustments. The standard values are based on mean values of actual prices per component type. Alternatively, the standard values may have been calculated per component type in "build-up" calculations for a typical component according to a "standard projection" using real unit prices at quantity level (different quantities [67] for historical acquisitions in the SNRA's calculation database). No adjustment is made in respect of actual acquisition value for the whole investment project. This level may contain unknown errors as regards both unit prices and components' quantities. It is not possible to recreate the original investment project but replacement values and existing components constitute the most relevant information here.

The balance sheet item for a component in the internal accounting has eight different quality levels with this approach. Four levels, 1 → 4, refer to the quality of the financial information while two refer to quality linked to uncertainties regarding quality requirements calculated from a socioeconomic point of view and as assessed by road-users. Quality of the data that is certified for all components' acquisition values can be structured as shown in table 5.1. Primarily data with the same quality grade should be used in comparative analyses.

Component function	**Quality of the value when booked**			
	1	**2**	**3**	**4**
Function type 1 (with known effect relationships)	Q11	Q12	Q13	Q14
Function type 2 (with no effect relationships)	Q21	Q22	Q23	Q24

Table 5.1 Structure of data in respect of need for use in analyses

It is known that the different component types' unit prices show varying degrees of spread; the unit prices for e.g. the component type *Wildlife fences* shows very small spread compared to the *Terracing, surface water run-offs, roadside areas* type. The same component type may also have varying spread in different parts of the country. Different kinds of variations in comparative analyses of the same component type should be made clear in the learning process.

[67] MF 95 and AMA – two description lists of road production quantities.

5.3.2 *Basic approach*

Processes [68] normally lead to products where actual quality randomly deviates from intended quality. To some extent, the deviations may be perceived as "quality's background noise" or "the process's inherent disturbances". Considerable systematic deviations or determinable quality-affecting variations can also occur. The latter kind may for example be the result of incorrect machine settings, operator error, material defects and/or bad decisions when considering other alternatives.

A number of statistical tools can be used to facilitate control and change efforts in processes (Statistical Process Control, or SPC). Variations in individual values, mean values and standard deviations can describe troublesome irregularities in a product's quality. The tools can be used for computerised detection and analysis of undesired deviations.

Since the objective is to achieve stability in the production process, causes and corrective measures are normally followed up in order to reduce the variations in quality in the process in a controlled manner. In Figure 5.1, the variations in a process that continues over a fairly long period of time have been sketched. Up to time t_1 the process is under control with mean value μ_0 and standard deviation σ_0. The process is only subject to "natural" random variations with resulting effects on mean value and standard deviation. The variations lie between defined lower (LCL) and upper (UCL) limit values in respect of what is acceptable quality-wise.

Between points t_1 and t_2 there is a "determinable" variation of type *one*. This leads to the process and mean value ($\mu_1 > \mu_0$) no longer being under control despite the standard deviation still being σ_0.

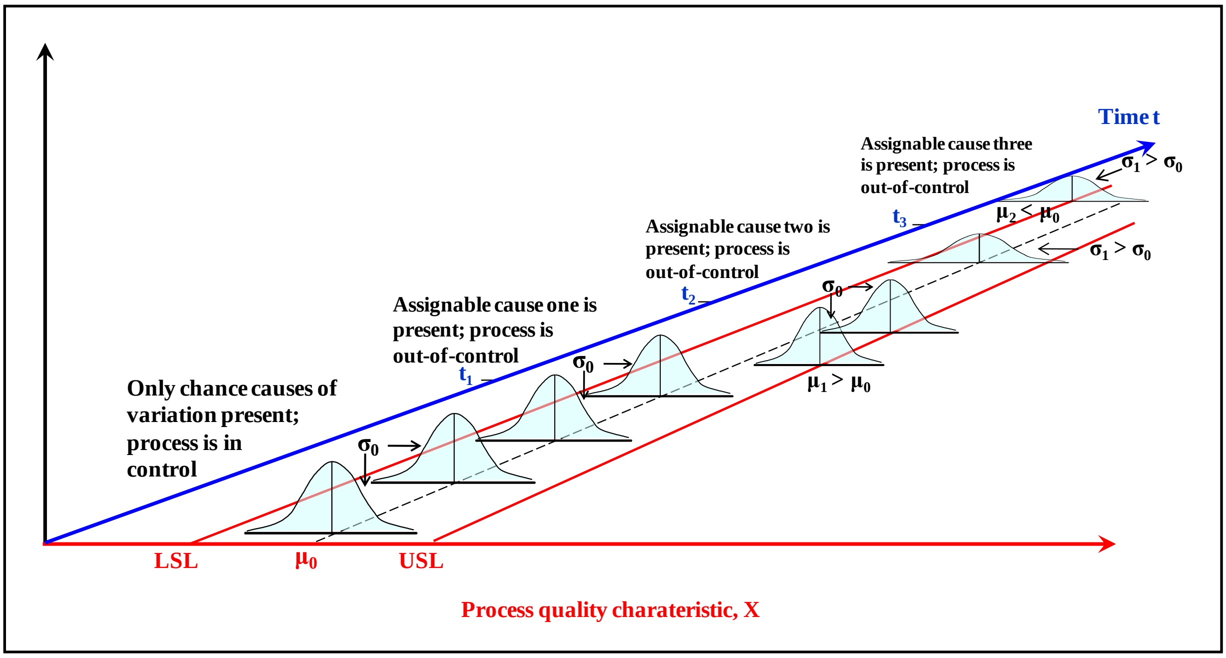

Figure 5.1 Chance and assignable causes of variation (Douglas C. Montgomery, 2005).

[68] Douglas C. Montgomery, Introduction to statistical control, 5th edition, 0-471-66122-8, USA, 2005, *Chapter 4-1 p. 148 and Figure 4-1, p. 149 ff.*

A “determinable” variation of type *two* appears and affects the process during the period between points t_2 and t_3. This variation results in $\mu = \mu_0$ and standard deviation $\sigma_1 > \sigma_0$. Neither process nor standard deviation is under control.

At point t_3 a new “determinable” variation of type *three* appears, with the result that the standard deviation becomes $\sigma_1 > \sigma_0$ and mean value falls to $\mu_2 < \mu_0$. From point t_3 on, neither mean value nor standard deviation is under control for the process.

In process-oriented activities and in “learning organisations” some kind of tool is often used to detect non-conformities in a process and measurements in order to maintain control of a desired development. A secured development assumes systematic analyses of deviations. The focus on deviations may be directed towards costs, measurements of quality, productivity, delivery reliability, and efficiency or similar in respect of the process’s critical factors. As tools, and to demonstrate the measures applied, one of seven well-known techniques, “The Magnificent Seven”, is often used:

1. Histogram or stem-leaf plot
2. Check sheet
3. Pareto chart
4. Cause-and-effect diagram
5. Defect concentration diagram
6. Scatter diagram
7. Control chart

Ensuring that road management’s processes are under control at all times would require access to systematic, quality-assured and relevant up-to date information about the processes’ critical factors. A secured, fast learning process is also needed. It is the nature of processes to require speed as regards detection of defects and deficiencies, analysis of possibilities for improvement, and correction. Fast learning is a critical success factor since errors must not be repeated time after time. It is just as important that opportunities for improvement be taken advantage of. Good examples and improvements must therefore also be quickly identified, analysed, quality-assured, implemented and monitored on a large scale.

Information in the quality-related accounting is verifiable, cost-based and up-to-date. It is based on “best technical best knowledge”, “best available knowledge of customer utility and socio-economic effect relationships” and stringent financial accounting principles. With this as the basis, it should be possible to verify whether road management’s important sub-processes are under control by continuously identifying “deviations from specified limits”. Accumulated needs for maintenance or maintenance backlog (Mbl) are examples of measures that describe whether the road management process is under control. The information can be provided from the system in the TAM concept’s internal accounting. Mbl is analysed and discussed in greater depth in Chapter 6.

5.3.3 Control limits

Henceforth, control charts (7) will be used to illustrate values relative to mean value and upper and lower control limits graphically. Theories regarding statistical quality control tools concern sample sizes, the meanings of statistical measures, how control limits are set and how combinations of measures should to some extent be interpreted. Control charts with control limits, that are used in continuous control and monitoring of processes, can also be used for improvement of quality, productivity and efficiency. With relevant data, monitoring can be performed at both individual level (component occurrence) and, for example, road network level. The principle is applied in the control and monitoring of traffic with known effect relationships and measured traffic data.

In many other contexts, monitoring is conducted using random samples with quality limits adjusted for samples. In trade and industry in the USA (Montgomery, 2007), limits for quality characteristics are often set on the basis of mean value (μ) plus or minus a multiple (L) of the standard deviation (σ**).** In order to maintain acceptable quality, statistical control limits should be determined on the basis of at least 30 occurrences of actual values for a component type. It is important to adjust statistical based limits by other analyses regarding the actual prerequisites. The intention is to make the control limits more useful for current process controlling and to reduce needs of further analysis. The lower (LCL) and upper control limit (UCL) for component type k can generally be based on the centre or mean value line ($\boldsymbol{\mu_k}$) according to the general formulae below:

$$\mathbf{LCL_k = \mu_k - L_k * \sigma_k}$$

$$\mathbf{UCL_k = \mu_k + L_k * \sigma_k}$$

Corresponding general expressions could be devised for value, cost or similar for components within the same component type at a specified age (e.g. number of four-month periods, t) or after the same usage (e.g. millions of equivalent vehicle passages, f). The centre or mean value line for $\boldsymbol{\mu_k^t}$ and $\boldsymbol{\mu_k^f}$ would be plotted according to:

$$\mathbf{LCL_k^t = \mu_k^t - L_k^t * \sigma_k^t} \text{ and } \mathbf{LCL_k^f = \mu_k^f - L_k^f * \sigma_k^f}$$

$$\mathbf{UCL_k^t = \mu_k^t + L_k^t * \sigma_k^t} \text{ and } \mathbf{UCL_k^f = \mu_k^f + L_k^f * \sigma_k^f}$$

Figure 5.2 illustrates the linkage between condition deficiency in SEK/m or comparative figures in respect of age or usage for components within one and the same component type. A specified value for a component’s condition deficiency (e.g. deficiency at point of “worst acceptable” quality of the *bound wearing course* type) can occur at different ages or numbers of vehicle passages. Correspondingly, the value of the condition deficiency can vary at a certain age or for a certain usage.

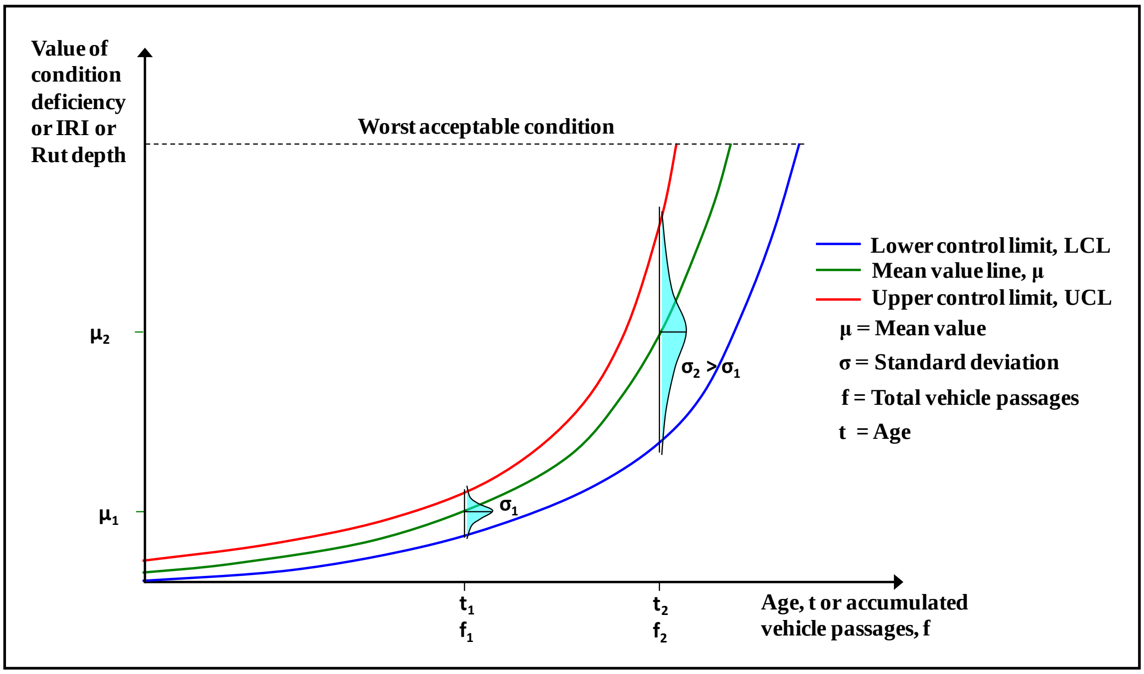

Figure 5.2 Outline sketch of pavements' quality deterioration due to number of vehicle passages.

Factor L is often set to 3 ("the 3σ method"). For L = 2, we speak about "early warnings". An important question as regards the quality of the control is how the limit values are determined. When the TAM concept has been introduced, the sampling issue will be less important. Any road-user considers the function on the section of road the he or she generally uses and is less interested in whether it is good in the country as a whole. In road management, the control limit technique should result in a well-developed way of making assessment and control more uniform over the entire country. Roads with similar traffic flows and other prerequisites should be given as similar limit values as possible for the same component type. Each section's component occurrences should then be continuously monitored against established limit values. This allows comparable road sections in different parts of the country to be analysed by computer.

Mean values and preliminary control limits (± 3 * σ) are calculated for at least 30 actual values. Should an organisational unit have an ambition to set its own control limits is it important that at least 30 actual values really are used to explore unique limits. When the limits are tested initially, single values may lie outside the control limit in spite of the fact that they are acceptable. They may also lie inside the limit value and be unacceptable. Values close to the limits must therefore be analysed at the very beginning and the limit values that are finally set must be quality-assured.

At any rate, there exist three different ways of assessing control limits on the basis of experience. One practicable way, and that is already in use, is to assess the limit values for resource prices. In the second approach, the component type is divided into populations or affinities with regard to known price-affecting factors. The third is a combination of the first two. Each of the three approaches is described in its own section below.

5.3.4 *Manual assessment of price control limits using approach 1.*

The work on construction price indexes has given knowledge of price proportions for each component type's resource inputs as regards acquisition values. Control limits can therefore be assessed by making a plausibility assessment of each resource input's variation in per cent. The principle is illustrated with an example of the *Guard rails* component type (see table 5.2).

With the resource price proportions stated below and from an actual mean value price of 520 SEK/m (index-adjusted value from the preceding year), a number of experienced road engineers (specialists) can assess acceptable deviations per resource input and for the total value. The value of the preceding year's UCL based on actual prices and standard deviation (for L = 3 in formula 1) can also be known when the specialists make their assessments. Knowing the value of the UCL should lead to individual specialists making an assessment corresponding to a new factor, L < 3. The limit values to apply are determined in a total assessment or as the mean of the road engineers' individual assessments.

Resource input	**Known price proportion**		**Deviation (%)**		**Assessed amount**	
	(%)	**(amount)**	**max**	**min**	**max**	**min**
Wages	21	109,20	3	3	112,00	106,00
Salaries	6	31,20	10	10	34,00	28,00
Machinery	29	150,80	5	5	157,00	143,00
Steel	35	182,00	3	3	188,00	176,00
Transportation	9	46,80	30	30	60,00	34,00
Total:	100	520,00			556,00	487,00
Assessed limit values:	---	---	5.8	5.8	550,00	490,00

Table 5.2 Example of a structure for assessment of control limit values

In the example, the control limits for the *Guard rails* component type's acquisition prices have been assessed to be ± 30,00 SEK/m from the index-adjusted mean price. UCL = 550,00, μ = 520,00 and σ = 13,2 (previous year's standard deviation) give L = 2.3 in the formula UCL = $\mu \pm L * \sigma$.

In the procurement of "erection of guard rails", the new average price (μ_{+1}) should be lower than the previous year's mean value price adjusted by the component type's assessed construction price index, i.e. $\mu_{+1} < 520$. The sector should be expected to show some improvement in productivity. The established control limits for L = 2.3 (490 and 550) are used during the year when procuring "erection of guard rails" and for new investments where tender prices for the *Guard rails* component type are to be monitored. If the price reduction $\mu - \mu_{+1}$ is substantial, the control limits should be adjusted correspondingly before they can apply. The resource inputs' price proportions, the development of the mean value prices and the value of L should be regularly analysed and commented upon by road management's specialists. Analyses and corrections should be documented and able to be reviewed in independent audits.

5.3.5 Manual assessment of price control limits using approach 2.

The individual component's design or characteristics are affected in respect of some component types by for example differences in circumstances. In practice, the different characteristics can lead to the component alternatives' acquisition prices having completely different levels. The intervals between UCL and LCL might be very large for such component types. They might be too large to be applied in practice as a basis for monitoring acquisition prices. Applying approach 1 would in many cases lead to quite absurd prices being accepted.

From the point of view of monitoring and control, it is important for many component types to clarify the circumstances that determine components' design or characteristics. Such circumstances might for example be the type of road, traffic flow or posted speed, but also other factors such as built-up areas and moisture in the road depending on weather and climate. For example, larger formats or more heavy-duty constructions are needed for certain types of road, speeds and/or vehicle weights. Built-up areas can lead to greater consideration for the environment when choosing a bound wearing course. It is for example known that many days' saturation of the pavement and/or higher speeds lead to significantly greater wear than for a dry pavement and lower speed.

Details of the circumstances mentioned above have been used for a long time as basic information, among other things in long-term planning. Information with this type of content has therefore already been registered in the road and traffic data bank (RDB) linked to the road network. Information about circumstances permits "enhanced" computerised monitoring, for example of acquisition prices. A component type can be divided into different groups in respect of the circumstances that are important when choosing the component's characteristics. Price intervals can vary for one and the same component type and follow defined rules in a "circumstance algorithm". Approach 2 assumes that the RDB either already has or can provide all component-related information in the algorithm and deliver it to the quality-related accounting. Each individual component occurrence would then receive the information that categorised monitoring and control requires from the RDB.

5.3.6 Manual assessment of price control limits using approach 3

Approach 3 is a combination of approaches 1 and 2. In the long term, it will probably come to be the most common approach, as a continuation of approach 2 with the computer-set limits for L = 3 (control limits = $\mu \pm 3 * \sigma$). According to approach 3, the limits are determined in respect of different circumstances in accordance with approach 2 and then via analysis in accordance with approach 1. For computerised follow-ups of a component's annual and life cycle costs, the best way to determine the limit values is to use approach 3.

The quality-related accounting provides details of, for example, individual components' annual cost in respect of depreciation or consumption. The plausibility of this type of costs can also be verified by computer in the same way as acquisition prices. For the *Bound wearing course* component type, for example, there are a number of factors that conclusively affect consumption. Such factors include traffic composition, the total traffic effort, posted speed and the pavement's moisture content. Good knowledge exists of different influencing factors and what pavement lives can be expected. For continued development and learning in the organisation, this type of follow-up and monitoring should be performed systematically for all paved roads.

One general issue concerns the balance between automated and manual work in follow-ups and monitoring. The distribution between automated and manual work will probably differ between component types, among other things due to lack of knowledge about cost-affecting factors and assessed utility. Knowledge will gradually improve iteratively through a systematic follow-up. The remainder of this essay describes structured computerised analyses. It is assumed that as time goes on these will be supplemented with experience, for example from in-depth analyses, in an active learning process.

5.3.7 Quality assurance of control limits for acquisition values

The quality of the acquisition values in particular is critical. The acquisition values are also important as regards for example consumption costs and life cycle costs according to the model that is applied here. This is the reason why the issue of quality assurance of acquisition values recurs.

A check of the initial acquisition value limit values should be coordinated with the determination of components' resource input proportions and component-adapted construction price index. Acquired price awareness from working with resource input proportions is an important prerequisite for assessing the plausibility of the calculated control limit values. The plausibility of total price intervals can be assessed and a plausible value established for L by means of logical reasoning with regard to reasonable deviations from the acquisition price's mean value for each resource input in turn. The method has been described earlier in an example in section 5.3.4 above.

Values that lie outside the set control limits are left unchanged if they can nonetheless be considered to be correct, while patently incorrect values are adjusted. When values are lying in the area between the control limits, this tends to confirm that the process's limits are well-balanced. Mean values and control limits are adequately explained, motivated and quality-assured for each component type through a careful analysis of resource input prices. Quality-assured mean values (μ) can be used as unit prices according to standard values in approaches Q13, Q23, Q14 and Q24.

If the component types' acquisition values need to be adjusted within the scope of a known acquisition value for an entire road project, it is important that unit prices for the project's other component types are adjusted correspondingly. The project's total acquisition value must not be changed. In a review of acquisition values it is essential to find and mark values that can constitute "Best Practice" for benchmarking purposes. New mean values, control limits and values of L should be calculated without any values that lie outside the worst control limit but should include adjusted values and "Best Practice" values.

5.3.8 Algorithms for depreciation/value reduction and accumulated LCC

Control limits must be adapted in a plausible manner using the best available technical knowledge, so that they can be used for each component in respect of actual prerequisites and environment. The limit values are calculated in respect of relevant value-affecting factors such as accumulated traffic effort, posted speed, and climatic/hydrological and/or geological area.

For bound wearing courses' life cycle costs for example, control limits can be related to the number of equivalent vehicle passages, posted speed, moisture conditions (zone or similar) and/or type of salted road. ‘Equivalent vehicle passages’ means that traffic composition and the proportion of heavy traffic are taken into consideration. A heavy vehicle can be equivalent to several hundred passenger cars from the point of wear. Computerised control limits adapted to relevant factors can reduce the amount of manual work and make in-depth analyses of deviations more efficient. A saturated pavement has proven to wear several times faster than a dry one and capability should therefore exist to take the wearing course’s moisture content or water saturation into consideration. Salting is a factor that has a strong impact on the wearing course’s moisture content. The limited test conducted by the Internal Auditing department on some comparable roads showed that wear increased by between five and seven times in damp conditions compared to dry. The contribution of an affecting factor should be established before it is built into the model.

In addition to the number of equivalent vehicle passages and posted speed, life cycle costs’ control limits for superstructures might also be able to have different zones for the number of meteorological freezing point vehicle passages and mineralogical conditions. Vehicle passages at freezing point are important from the point of view of frost heaves, which can cause superstructure layers to shift. An increasing number of such shifts will probably accelerate the structural degradation of friction materials. The types of minerals that occur in the area may be of importance for the quality of rock used in the superstructure material and can thus be a determining factor as regards the degradation rate. Degradation in itself is a slow process, but in areas with low-quality types of rock (e.g. high mica content) degradation will take place over a relatively short period of time. In poor material, the process can be measured objectively in connection with laser measurement of bound wearing courses. The examples of affecting circumstances described here should be worked into the “circumstance algorithms” (cf. section 5.3.5 above).

5.4 Process control

5.4.1 Computerised monitoring in sub-processes

Road management’s sub-processes can be monitored either continuously, or sufficiently regularly as to whether quality-related costs and values show any abnormal deviations. It is therefore possible to determine with satisfactory frequency if a sub-process is under control.

According to the TAM concept it is permitted to make mistakes but not repeat them anywhere in the organisation. Mistakes must therefore be quickly identified and dealt with in a learning process that exists for each sub-process. It is essential for road management’s results that deficiencies be identified quickly, to allow corrective action to be taken or warranty claims to be lodged without undue delay. Contracts with suppliers must contain appropriate and relevant warranties. Correspondingly, it is important to also identify good examples and propagate them throughout the organisation. The learning process is therefore a central element in monitoring and control and in improvement efforts.

The approach using computerised monitoring against control limits can be applied in several sub-processes (see Chapter 7). In the ‘Long-term planning’ sub-process, control limits can for example be applied for following up and monitoring the development of productivity, maintenance backlog, and for instance indexes and prices assumed in the plan and road management’s cost drivers.

The ‘Procurement’ sub-process can have control limits for components’ acquisition prices.

In ‘Short-term planning and follow-up’ control limits in the form of unit prices can be set for components’ annual costs and/or for accumulated life cycle costs (LCC) discounted to net present value for the year of acquisition. Follow-ups can also be assorted on the contractors that have nationwide coverage for use in the procurement process. Deviations against control limits expressed as percentages for deviations depending on time, quantities, and unit prices, can be used in the organisation’s continuous follow-up of investment and maintenance contracts. Also can project’s cost discrepancies according to established plan in the realization be mechanically analysed in running follow-ups with allocation at price each, quantity and time dependent causes. This kind of follow-ups of causes on discrepancies can also be automatically designed to projects in the established long-term plan.

Outline sketch 2 in section 5.3.4 Control limits, shows that the distribution of components’ values in respect of condition deficiency (consumption) can for example increase with increasing age or number of vehicle passages. The two control limits (UCL and LCL) provide an opportunity for computerised monitoring of whether components are following a “normal and acceptable” consumption cycle or that registered values do not contain significant errors. “Normal” values for components’ condition development, annual costs and LCC will gradually become known for all component types. Better knowledge will in turn generate new needs as regards division and monitoring and control.

5.5 Condition description model VI

5.5.1 Length of life

For many component types, the condition description will follow model VI, which in its simplest form is based on a linear reduction in value over an assessed length of life. It is essential that both costs and reduction in value reflect actual consumption as far as possible. A time function that reflects a real-world reduction in value can be constructed in several different ways. With a statistical approach, the function could be designed for each component type according to the following seven-step procedure.

1. Choose at least thirty occurrences of the component type in question of varying condition and for which the year of acquisition is known. When choosing the occurrences, the entire range of conditions must be exemplified.
2. Choose a number of specialists (preferably > 5) for the component type in question and for its management.
3. Together with the specialists, determine a condition classification with an associated scale and a description in words and pictures. The scale should define the component type’s different conditions as clearly as possible. The specialists should be able to understand and apply the scale when inventorying and classify the current condition of all occurrences of the component type.
4. Have the specialists, individually and independently of each other, determine the condition of the chosen component occurrences according to the adopted scale.
5. Compile the results of the specialists’ condition determination for each occurrence taking the actual age of the components into consideration.

6. Fit curves (or straight lines) to the condition determinations made by the specialists. Curves can for example be fitted to different types of values such as 1) the mean value with regard to age of all the specialists' condition classifications of each component, 2) the same as 1 but for the median instead of the mean value, 3) the mean value of the age of the occurrences in each respective condition class according to the specialists' assessments, and 4) the same as 3 but for the median instead of the mean value (see Appendix 2).
7. On the basis of the curves showing the development of the condition value in respect of age, a suitable function can be constructed for the decrease in value and the life of the component type. With information about the spread among the different assessors, it is also possible to determine control limits for the development of the component type's condition.

5.5.2 Residual value

The next important question with regard to condition description model VI concerns the residual value. Does the component type have a residual value when the value corresponds to the "worst acceptable" condition or is the component normally replaced with a new one when it has reached the end of its life? In cases where the component type is normally "repaired" its residual value must be determined. It can be determined as

Residual value = Replacement value – Standard cost of the measure

The replacement value is determined on the basis of each component's acquisition value while the control limits are based on the mean value of the component type's acquisition values. The condition value for a component after carrying out measures may not exceed its replacement value. The cost of carrying out measures is the actual expenditure for the measure that improves the component's condition.

The standard cost of a measure is the normal cost of a measure that improves condition from "worst acceptable" condition to "as constructed". The standard value is determined as a statistical mean value of a large number of actual costs of applying measures of the kind in question.

The residual value can also be seen as the net payment the road manager receives in respect of the old component when it is replaced. In cases where this type of payment occurs in respect of a component type, the residual value must also be determined as the statistical mean value of a large number of payments.

5.6 A component type's "healthy core"

Every component type has a fairly large number of component occurrences in what can be called a "healthy core". A period's "healthy core" thus contains all occurrences of the component type that have the following characteristics:

- an acceptable acquisition price from a business point of view,
- acceptable quality from a business point of view,
- acceptable condition values over the whole period,

- annual costs and costs for measures acceptable to the road manager over the period,
- acceptable accumulated life cycle costs hitherto during the period,
- acceptable consumption before and after measures at handover time, and acceptable values for the whole of the analysed period.

Periodical every component is classified according to the characteristics into one of the databases “best practice”, “normal” or “worst practice”. This means that the “healthy core” contains components with “normal” and also “divergently good” values (“best practice”).

Components with too high life cycle cost are considered in principle to be inefficient road management with likely cause found as the first occurred deviant characteristic (“worst practice”). This might be wrong if the customers see a greater value in the component than others or if the effect relationship shows that the component is nonetheless of benefit to society or perhaps even more efficient than those components with lower life cycle cost.

The relationship between life cycle costs and effectiveness for society must be analysed separately. The analysis may lead to a need for changes in a component’s “circumstance algorithm” and/or new control limits.

5.7 An efficiency analyses concept

It has been drawn up a mechanical supported efficiency analyses model from the data obtainable in the quality-related accounting. Here follows a short report on the two steps of the concept.

5.7.1 The first step in the efficiency analysis

In the initial phase of the first step in the efficiency analysis, component occurrences with deviating acquisition values and quality are selected and the information is noted in databases as described above. The first phase should take place early on in connection with commissioning the component (final inspection) when it is “handed over” or “opened to traffic” and/or when the invoice is processed.

In the second phase of the first step, component occurrences are sought that have condition values that have exceeded their limit values. This is outlined in figure 5.3 below where the components of both function types 1 and 2 have been sketched in separate curves. Indicators a or b (“function type 2 and function type 1” components) and c are calculated continuously, where

- **a** is a component occurrence’s condition value less its value at “worst acceptable” condition
- **b** is a component occurrence’s condition value less its “optimum” value for carrying out a maintenance measure
- **c** is a component occurrence’s condition value less its replacement value, i.e. the value of the condition deficiency

For “Function type 1” values, all component occurrences are checked in respect of whether b < 0. In those cases where condition $b < 0$ is met, the occurrence is noted with its value in a special database. There the number of years that the condition has been met is noted in a *time counter*.

For “Function type 2” components, a corresponding test is made of whether a ≤ 0. In the same way as for “Function type 1” components, details of the component’s a value are noted in a database. The number of years in a row for which condition a has been met is noted in the *time counter*.

The second phase is carried out at a suitable point at which a report is to be made. Components with a worse condition value than the applicable limit value will then have been listed in an database with the values of a and c or b and c, and the number of years that the limit value has been exceeded noted in the *time counter*.

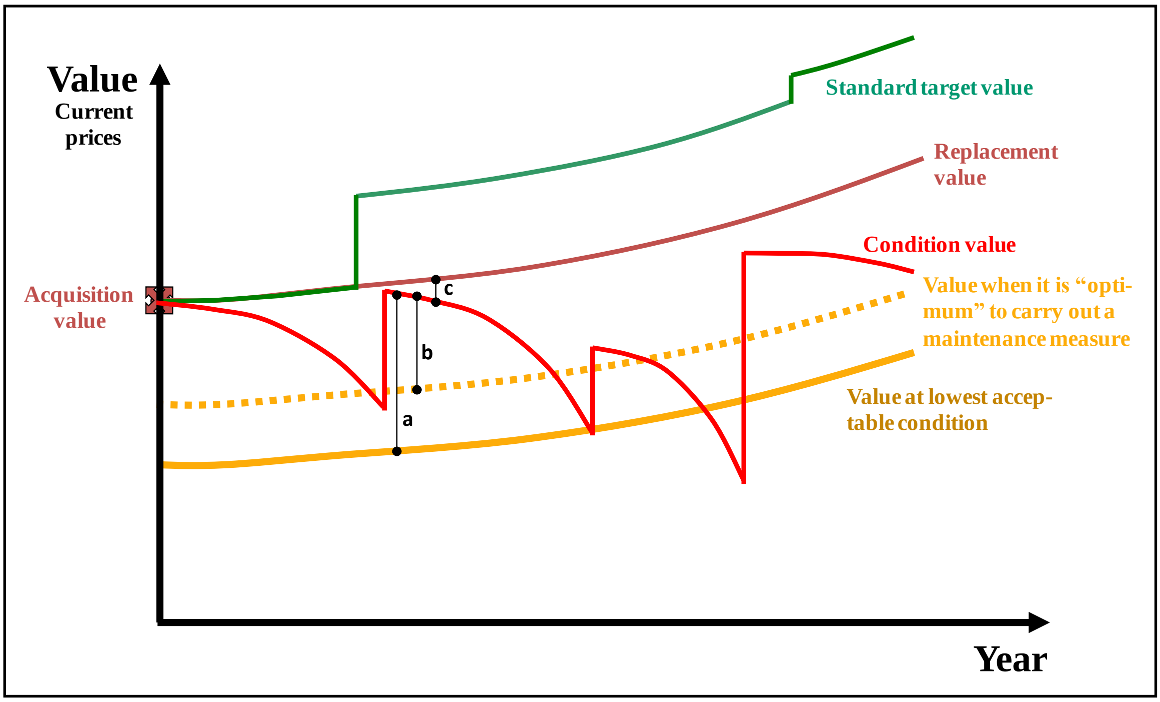

Figure 5.3 Sketch of analysable efficiency indicators

In the third phase of the first step, checks are made in respect of control limits for “normal annual consumption cost”. The control limits, that are determined according to the principles described above, must take factors relevant to the component type, for example type of road, traffic, speed, etc, into consideration. Those component occurrences that have a deviating cost development in respect of affecting factors relative to the control limits are noted together with the deviation in databases (see figure 5.4).

Deviations that exceed the upper control limit by u units (u < 0, UCL for annual cost – current annual cost) are noted in a database while those that exceed the lower limit by v units (v > 0, LCL for annual cost – current annual cost) are noted in another database.

Any occurrence of an excess portion of a value-adding cost of a measure, i.e. the portion that may not be taken up as an asset but as a cost is noted in a separate database. The third phase is carried out on the same occasions as the second phase.

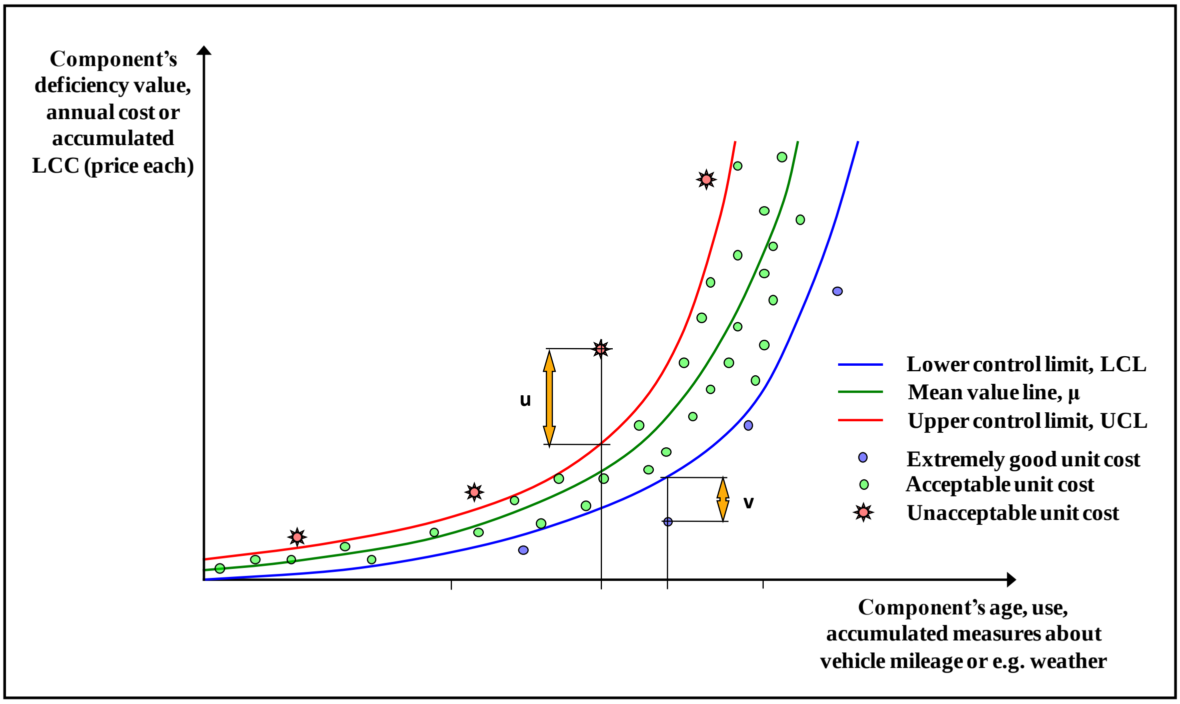

Figure 5.4 Check of component occurrences' development of costs (age, use etc.)

Component occurrences have been analysed early on in respect of deviations relative to control limit values and where detected these have been noted in fifteen separate databases. We shall continue with the second step that among other things concerns analyses of components' life cycle costs.

5.7.2 The second step in the efficiency analysis

In the second step in the efficiency analysis, those component occurrences that have deviating discounted and accumulated annual costs considering use, age etc are screened out. Costs that are concerned here have arisen out of the road measures new construction, improvement and value-adding maintenance. Component occurrences that fall outside the control limits for successively accumulated annual costs are probably to a large extent the same occurrences that already exist in any of the databases above. Also in this case, we differentiate between components' function types 1 and 2 by means of indication in two separate databases.

Successively accumulated consumption costs discounted to the year of acquisition for all years since the acquisition exist for all component occurrences. In the outline sketch (Figure 5.4) there are four component occurrences that, when a certain use or age is applied, have an unacceptable cost with u cost units outside the component type's upper control limit. All components that at the time have a difference less than zero between the upper control limit's value and the accumulated present value up to and including a certain age or usage are noted in a separate database. This means that the component's life cycle cost has hitherto been unacceptably high considering affecting factors relevant to the component.

Figure 5.4 also can show that the second step in the analysis identifies component occurrences with exemplarily low accumulated annual costs and the present value of the annual costs (v) or LCC. When an analysis of these occurrences' costs shows that the information in the accounts is reliable, they can be used as "best practice" in benchmarking.

In addition to the databases described above, there is also a database that contains details of every component that has been the subject of value-adding measures (maintenance and/or improvement). Such information includes the point in time when the measure was carried out, relative consumption before and after the measure and the change in the capital value during years when no measure was carried out. Any lost extension of consumption, any lost extension of consumption for the measure carried out, relative annual consumption ratio and expenditure for the measures are also calculated and documented. The average annual consumption for comparable components with the same "cause algorithm" is known. When a lost extension of consumption has attained a sufficiently high value, this indicates that the measure was either carried out on a component too early or on a component of too low quality. In the quality-related accounting, deviations of components' values and expenditure for measures can be identified by computer. There is also possible to automatic calculate value lost according to the standard cost of the measure.

The external quality deficiency cost can be found in deficient quality of a supplied measure. The deficiency is reported as a lost consumption margin for a new component for all component types that is noticed in the final inspection before it is handed over. A rational client will ensure that deficiencies are rectified by the supplier. Alternatively, the price of the component can be reduced or the agreed warranty period extended. What actually takes place is noted in the quality assurance system in connection with the final inspection and reported in a structured manner in the quality-related internal accounting. All in all, the life cycle cost should not deviate from what is normal for the component type after compensation, which must be verified in the follow-up. Also this kind of value lost can be quantified.

In order for the client to be considered to have incurred quality deficiency costs for a component, the same component must also exist in another database. If this is not the case, the client has managed to secure sufficient compensation in some form for the low quality supplied. The contractor or the sector has lost much of the potential value added, so quantified information should be discussed in the learning process.

Table 5.3 below illustrates which database combinations (X) indicate where road management has probably failed in financial terms. The same row may contain more than one X provided control limits are adjusted regularly on the basis of "best available knowledge" there will be less probability that greater utility might have motivated the cost increases. Here it is also stated whether it is reasonable to assess the failure in financial terms as the deviating LCC value (the difference between a component's values as regards LCC and the upper control limit).

No.	Databases							Calculable cost (Yes/No)
	A	C		F		R	H	
	High acquisition price	Quality deficiency at acquisition with		High annual cost (are there any excess amounts?)		Measure carried out too early	High LCC	
		deduction	measure	yes	no			
1	2	3	4	5	6	7	8	9
1	X						X	Yes
2		X					X	Yes
3			X				X	Yes
4				X			X	Yes
5					X	X	X	Yes
6						X	X	Yes

Table 5.3 Combinations of deviations in separate databases that indicate undesirable cost increases caused by road managers

For each component type, all component occurrences in the databases according to Table 5.3 caused unnecessary costs in respect of road management. Database *H* contains all deviations from LCC calculated by year. The total LCC deviation relative to the upper control limit for LCC (quality deficiency cost) at the price levels prevailing in the acquisition year are allocated to the earliest of the years that occur in database *A*, *C*, *F* or *R*.

Schematically, it can then be assumed that the quality deficiency arose the year that a problem was first identified and noted in a list. An identified quality deficiency of a component will thus have the whole cost of the deficiency calculated at the price level of its year of acquisition but the cause dated the year the problem was first identified (cause year). The quality deficiency costs deriving from components in *C* seem to be the result of substandard production while components in lists *A*, *F* and *R* have if anything been caused by quality deficiencies in the road manager's decisions. Of course there is still a need of complementing assessment on differences in customer effects for every component type analysed.

Using this principle, the quality deficiency costs (road management's ineffectiveness) can be handled automatically in the model. In the next step, all deficiency costs are adjusted to the price level in the analysis and totalled by component for their cause years. Ineffectiveness of the road management with defined improvement goals can be followed up. For example, the goal might be to reduce ineffectiveness by 50% over five years relative to the quality deficiency cost in year before. With the help of a quality deficiency function a forecast can also be made based on actual historical values.

5.8 The learning process

In the quality-related internal accounting, all components' acquisition values are quality certified. This allows for example computerised comparisons to be made of components of the same quality. Quality has been established in respect of how the acquisition value was determined and what condition requirements apply for the component (socioeconomic or customer-assessed). Another possible selection can be made in respect of RDB factors in the “circumstance algorithm” that describes the factors that influence the deterioration of the component.

The third possibility is to first define desired road networks using the selection that can be made in the RDB system. One of the selections described previously can then be carried out for the components in the selection (the component population).

Every road-user keeps an eye on his or her transportation costs along the route they use for their transportation needs. When a road section’s condition and standard are unsatisfactory, they therefore find it unacceptable for the road manager to claim that “the state-administered roads are nonetheless good on average”. Road-users make comparisons and refuse to accept that other road-users are able to drive and carry out their transportation on higher quality roads in other parts of the country.

Inexplicable, unjustified differences in condition and standard in the road network have a disturbing effect on road users and can also increase the risk of traffic accidents. Since every road has its own customer-related quality values that must be fulfilled, from the customer’s point of view it is essential to detect any deficiencies on every single section early and carry out the best possible road management there.

Continuous process control based on the quality-related accounting has as its starting point the overall objectives of the transport policy on the basis of “best available knowledge” of technology/engineering, customer demands and economic relationships. The monitoring of deviations in the control of the processes is systematic and carried on persistently against the efficiency objective in the transport policy. This secures uniform road management around the country against the condition limits in respect of “the economically optimal condition for society” and the “worst acceptable” condition for road-users and society.

Structured follow-ups, checks and analyses with monitoring of component occurrences’ deviations in quality, value, and the development of costs and/or value, will contribute to result-focused control. The TAM concept aims to induce learning and knowledge that can prevent inefficiencies. In processes, the aim is therefore to avoid deviations from “healthy” values, costs and key indicators.

The learning process is therefore a central element in the TAM concept. The learning process comprises fast detection, fast analysis and fast dissemination of knowledge in networks that cover the whole organisation. It is a fundamental principle that failure will not need to be repeated anywhere in the country, while good examples, on the other hand, must be known and able to be duplicated throughout the organisation.

For the road manager, early detection of a deviation allows the necessary corrective measures to be carried out in order to minimise the number of road users affected. Early detection of a deficiency can also increase the road manager’s possibilities, to force the suppliers to carry out corrective measures under the terms of the warranty. This implies that the road manager contracts a reasonable development of components’ quality with the suppliers. A reasonable level of quality can be defined by the control limits that apply. The result should be that the contractors step up their quality assurance efforts and in the long term improve substandard component types.

This development is favoured by allowing production methods and concepts to vary to a certain extent without customers having to experience embarrassing differences. Differences and errors have on many occasions given new knowledge that in turn has led to positive development. In order to create good prerequisites for the positive development of road management, it is therefore important to allow people to make mistakes. On the other hand, they must not be allowed to repeat mistakes. This is another important reason for identifying and analysing unfortunate deviations and errors quickly. Information about errors should make it less likely that they will be repeated in other parts of the organisation.

It is just as important to identify positive deviations and good examples so that they can be analysed. Here, it is instead a matter of creating prerequisites for the good examples to be repeated throughout the organisation.

The quality-related accounting provides possibilities for early identification of deviating development of a component's function and quality. This can often be seen through an abnormal development of costs and/or value. The characteristic and critical values and/or costs should therefore be identified for each sub-process, since they can sometimes also function as indicators of how well the process is running.

Computerised monitoring of deviations in critical values and costs in important sub-processes in infrastructure management makes it possible to maintain central control over an extensive organisation even if it is decentralised. Fast identification of "good and bad examples", fast analyses and fast dissemination of new knowledge in networks also make is possible to pursue a systematic improvement effort and effective learning.

Prices, costs (annual consumption and LCC) and different non-conformities can be selected per component type and contractor. With a dynamic dialogue about development, other experience and verifiable facts, the construction industry should be able to improve its productivity development. Other fundamental ideas include:

- early indication of good and poor development trends in components,
- fast corrective measures, preferably carried out by the contractor concerned,
- feedback to the contractor of knowledge of the life cycle perspective in respect of previous deliveries,
- positive development of productivity can be stimulated with bonuses, penalties and long warranty periods.

The sub-processes' critical measures are identified and discussed in greater depth in Chapter 7 on road management's sub-processes. Important sub-processes in road management in this respect are long-term planning, operational planning and follow-ups, procurement, project management and booking and reporting. In chapter 5 we also have discussed the use of these indicators to verify that the sub-processes are under control. Anyway the most important for our concept of an efficient transportation asset management is to see to it that systematic learning function in all sub-processes. Chapter 6 deals with the important indicator "Maintenance backlog".

6 MAINTENANCE BACKLOG

6.1 Background

In the 1950s road management focused on investment in new roads and reinforcement and surfacing of gravel roads. By today's standards, the traffic effort was small and road-users' moderate expectations concerned better alignment, greater width and bearing capacity and a bound wearing course on gravel roads. The focus and road users' expectations were thus in agreement. The maintenance problem on national roads increased as the volume of paved roads and the traffic effort increased. In the 1970s, engineers began to discuss in earnest the problem of not being able to carry on road maintenance to keep pace with wear, degradation and road-users' expectations.

In the mid-1970s, most of what is termed backlog referred to the volume of bituminous pavement in the form of a "second dressing" that is not carried out in time on newly opened investment or improvement objects. Traffic was allowed in such cases to wear down the "first dressing" for too long. The information about "maintenance backlog" was largely well-defined, intelligible and verifiable relative to a regulatory framework for when a pavement's "second dressing" should be carried out. Most of the roads constructed in the 1950s and the roads that have been gradually improved (here referred to as "unconstructed" roads) with bound wearing courses were not designed to cope with a markedly increased traffic load. However, the traffic effort and the need for maintenance continued to increase in a way that came to concern more and more kinds of components and measures.

It is often profitable to rectify a deficiency at an early stage and as a preventive measure, but many kinds of deficiencies can only be detected early by trained road engineers. One of the difficulties is gaining understanding for the need and arranging funding to carry out the measure. Politicians who do not see a problem are not greatly inclined to prioritise unintelligible needs for measures over the obvious needs of for example healthcare, education and care services. Preventive measures on roads are perceived as long-term needs while needs in care services are acute and short-term. The road manager's communication about maintenance and funding needs is to a large extent a credibility problem.

The road manager's assessment of maintenance needs over the years varies in quality but the qualified road engineers' assessment should largely reflect real needs. It might, however, seem to be an unsatisfactory state of affairs that it is impossible to check the assessments made in the road manager's request for further funds for road maintenance. In the National Road Administration's appropriation request from 1977/78, we can read the following about the accumulated maintenance needs:

> "On state-administered roads there is an accumulated need for maintenance amounting to approx. 2,000 million SEK at the estimated cost level for 1978."
>
> "The normal appropriations should be sufficient to maintain the level of service and sufficient to maintain the valuable social capital that the roads constitute. There is to be no destruction of capital."

In the appropriation request from 1979/80 we can read:

"on state-administered roads there is an accumulated need for maintenance in the form of deformation damage and neglected ditching amounting to approx. 1,500 million SEK at the 1980 cost level."

The 1983/84 appropriation request states that:

"the backlog of road maintenance measures that cannot be carried out due to shortage of funds, amounts to considerable sums in the case of state-administered roads."

In the appropriation request for 1991 we can read:

"At the end of 1988 the backlog of pavement maintenance amounted to no less than 3,800 million SEK. The total backlog of different road maintenance measures amounts to approx. 5,500 million SEK.

Together with the figures that have been presented in recent years [69] and disregarding variations in quality and vague definitions, the SNRA's figures in respect of the maintenance backlog (Mbl) have continued to increase. For this to be considered serious, however, Mbl figures must be correctly valued and presented. If not, there are other serious problems – problems that might indicate that state-administered road management is being conducted without satisfactory controls. Figure 6.1 is an attempt to visualise the Mbl information provided by road engineers at different times with a third-degree polynomial adjustment.

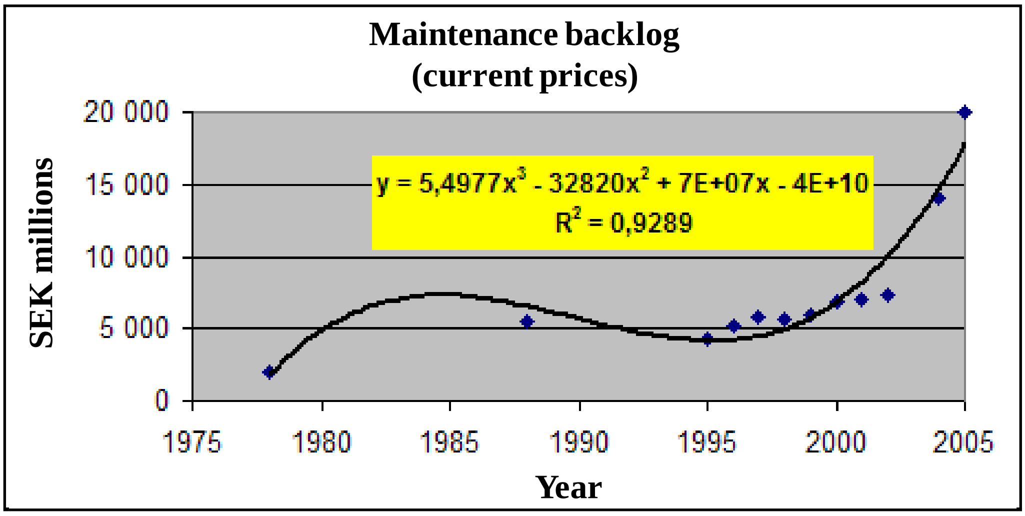

Figure 6.1 Development of the "maintenance backlog" based on information from the SNRA

This picture is supported by actual events. During the late 1980s and up to the latter half of the 1990s, major reinforcement measures were carried out, mainly on bridges but also on stretches of road with reduced bearing capacity. The measures were carried out on roads needed for heavy industrial transportation and were funded by a special bearing capacity allowance. Following the reorganisation in 1993, productivity in road management increased significantly until the latter half of the 1990s, when increases in administrative costs gradually undermined large portions of the increase in productivity. It seems reasonable to assume that both the improvements in bearing capacity and the productivity increase in road management

[69] Source: SNRA (Gunnar Tunkrans, Jaro Potucek and the Annual Report for 2005)

may have reduced the Mbl as shown in Figure 6.1. The SNRA's official forecast is that the curve will flatten out after 2005 with the expected appropriations,

The Mbl figures reflect insufficient funding of road maintenance over a long period of time. In the road manager's opinion, the reason for the backlog is that the appropriations have been too small – an opinion that politicians want to see presented in a credible manner. *Such a presentation must show both that there is a road network of an unacceptable condition and that the funds appropriated have been used effectively.*

The term Mbl has several messages. There is often a "hidden" coupling to the question of responsibility for road maintenance. The road manager can "naturally" not take full responsibility for the quality of the road network with insufficient funding. The amount allocated for the Mbl thus implies some degree of freedom from responsibility or provides a "concrete measure" of how diffuse the issue of responsibility for road management is. As an important player in community planning, the road manager sends a message to the public and trade and industry that they must approach their politicians if they want better transport conditions.

The Mbl concept itself also sends a message that costs, for example, can be expected to be higher for maintenance and operation than would have been the case if measures had been able to be carried out at the "right" time. At the same time, society is reminded that its costs have been "unnecessarily high" for transportation in a substandard network.

Other concepts and expressions used to describe an accumulated need for maintenance include, for example, "maintenance debt", "neglected maintenance", "maintenance mountain", "overhaul need" and "service and repair need", "improvement need", "maintenance deficiency" and "funding backlog". Graphic expressions such as "the maintenance situation is like a ticking time-bomb" are also heard. None of these have a clear definition but all of them refer to the fact that maintenance measures have not been able to be carried out in time and/or to a sufficient extent.

However, it is clear that an accumulated need for maintenance has arisen and that the cost of meeting these unavoidable maintenance needs can be expected to be higher in the future. In a worst case scenario, the "maintenance debt" will have to be paid by coming generations and not by the generation that caused it. The messages are easy to understand and are used all over the world without having uniform definition.

Literature studies show a picture of a global credibility problem in the physical infrastructures sector. The politicians, who are responsible for striking a balance between short and long-term needs, act as if deficiencies in the infrastructures are exaggerated by road administrations. At the very least they believe that the measures are not so urgently needed and that the effects are long-term.

Time in power is short and the responsibility for funding can therefore be laid on the next period's incumbents. It is more appealing to prioritise faster, tangible results. For tactical reasons, road managers will sometimes adjust their descriptions of deficiencies to what they consider they can actually discuss with the politicians.

Another consequence of delayed measures is that small, almost imperceptible cost increases are gradually passed on to the users of the infrastructure. This probably causes society's total costs to exceed the “optimum” point – a point that today is extremely diffuse and therefore cannot be discussed either. In summary, it is clear that traditional reporting does not provide the necessary information for a meaningful discussion between road managers and owners (decision-makers) when it comes to the road network’s financial needs. This is an important reason why the graphic expression Mbl has come to be used. In order for the quantification to be credible, however, Mbl needs to be able to be verified on the basis of a clear definition.

6.2 Definitions and estimation of maintenance backlog

6.2.1 Mbl in the transport sector

Maintenance backlog (Mbl) and similar expressions are used within public administration in discussions concerning the funding of maintenance measures carried out on fixed assets. Responsible officials approach the owner and request funds for pressing maintenance. An argumentation can sometimes be discerned in the definition.

Below follow some definitions [70] relating to maintenance backlog found in the literature.

> “Backlog is commonly defined as the estimated accumulated cost of improving the condition of all roads in a road system to a defined acceptable minimum level for the function in question.” [71]
>
> “The nationwide study of funding backlog conducted in 2003 investigated the required funding need over ten years to reach a defined functional standard compared to the expected funding. Funding backlog is defined as the difference between the two levels of funding.” [72]
>
> “Maintenance backlog in respect of a road feature to restore the feature from its present condition to a defined level such that the feature fulfils its intended function over a normal life-cycle”. [73]

There are also examples of key ratios or coefficients that describe the backlog.

> “Backlog relative to need, where need is defined on the basis of specified limit values for service or condition.
>
> - Coefficient defined as postponed maintenance expressed in SEK relative to the replacement value (resource index for condition)
> - Coefficient defined as deterioration or depreciation relative to the replacement value (debt index)” [74]

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[70] For lack of time the English definitions are translated back from a Swedish translated version.

[71] Transportation Research Board of the National Academies, NCHRP (National Cooperative Highway Research Program) Synthesis 330, Public Benefits of Highway System Preservation and Maintenance – A Synthesis of Highway Practice, ISBN 0-309-07007-4, USA, Washington, D.C., 2004

[72] Main Roads (2003) Statewide Funding Backlog Study: Report on the Road Network, Report CR 6403-1, Road Asset Management Branch, Department of Main Roads, December 2003. Comment. This definition includes funding needs for investment to maintain the road network’s function.

[73] Hansen, Morten Wright, Stensvold Børre, Beregning av vedlikeholdsetterslep ror riksvegnettet, Vegkapital, Statens vegvesen, Oslo, 2003 (Calculation of maintenance backlog in the national road network, Road capital, National Road Administration, Oslo, 2003)

In 2003, the Swedish National Road and Transport Research Institute, VTI, was directed by the Government to review the proposals put forward by the SNRA and Banverket (the Swedish Rail Administration) concerning maintenance and operation strategies. The report [75] contains important comments regarding the expression "maintenance backlog" and its use.

> "A process that in this way attempts to identify the best use of a certain resource on the basis of reasonability assessments and comprises, however, leaves large gaps on other respects. For example, is it not possible for a person not directly concerned to determine the magnitude of the so-called maintenance backlog. In order to decide how much resources "should" be allocated for road maintenance in relation to the allocation of resources stated in the planning framework, much more precise information than that presented is required. After completing our review, we cannot, therefore, determine whether the backlog is greater or less than the SNRA claims, or for that matter whether any backlog actually exists."

> "The implication of the circumstances that have been presented is that the backlog, that is to say the volumes of measures that "in fact" would be required in order to ensure that the standard of the road is of an acceptable standard, has been estimated on the basis of extremely vague premises. Unless the independent scrutiniser is given a clear, uniform definition of what is meant by "fundamental standard" it is therefore not possible to understand from the report why there is claimed to be a maintenance backlog."

> "We feel that both for pedagogical reasons and for reasons of credibility that there is cause to once and for all try to define "objective" measures of what is to be considered a good road standard or, conversely, the target level at which a measure should be initiated. Where resources are insufficient to satisfy these targets without having to accept a lower road standard before a measure is carried out, this is to be considered a backlog in the sense defined above. Such a clarification of definitions and measures would make it possible to carry on a discussion regarding any insufficiencies in the reasoning in the model and how non-model-calculated effects should be taken into consideration. It would also give us a clearer understanding of how the budgetary limits affect both the need for measures and the backlog."

In a draft from 2005 for a feasibility study of a Road Management System conducted by the SNRA, we find the following view of "maintenance backlog". [76]

> "A standard is often expressed as a set of limit values for a number of condition variables. If these limit values are exceeded a measure should be carried out. If the measure is delayed a backlog arises against this standard. The size of the backlog is defined as the cost of optimum measures carried out on the road components where the

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[74] NCHRP Transportation Research Board of the National Academies, NCHRP (National Cooperative Highway Research Program) Report 551, Performance Measures and Targets for Transportation Asset Management, ISBN 0-309-09847-5, USA, Washington, D.C., 2006

[75] Gudrun Öberg, Mats Wiklund, Jan-Eric Nilsson, Granskning av Vägverkets och Banverkets förslag till drifts- och underhållsstrategier, VTI-rapport 492-2003, Linköping, augusti 2003 (Review of the National Road Administration's and National Rail Administration's proposed operation and maintenance strategies. VTI Report No. 492-2003, Linköping, August 2003)

[76] Jaro Potucek, Vägverket, Stev, Road Management System (RMS) - En förstudie (Utkast), Borlänge, 2005 (Road Management System (RMS) – A feasability study (draft), Borlänge, 2005)

limit values have been exceeded. If the measure is carried out too early we get a “superstandard” and an unnecessary cost.

The backlog at any given time is defined as the cost of all postponed maintenance measures (measures that should have been carried out according to the standard but that are still waiting). It should be noted that a postponed measure can change the whole action strategy. Instead of the postponed measure, it may be better to wait a few years and carry out a different, more far-reaching and more expensive measure. The delay is a measure of the “debt” to the road capital. The delay carries with it higher annual costs for maintenance and/or traffic costs and sometimes also increased operating costs.

Following up or inventorying the actual condition against the target standard makes it possible to point out sections of road that at a given time have exceeded limit values, i.e. are showing a backlog. This makes it possible to list the sections by condition variable, total their length, area or traffic effort, sort them according to various criteria, draw them on maps, etc. By applying optimum standard measures on the road sections at known unit prices, we can thus obtain an estimate of the cost of the maintenance backlog.

As an economic measure, the delay can be summed. Volumes of road sections (length, surface, traffic effort) should be summed, however: adding together 5 km of country lane that needs sealing costing 50 SEK/m and 5 km of motorway that needs to be rebuilt at a cost of 10,000 SEK/m would lead to absurd conclusions.

Maintenance delay is a simple, representative measure of the road network’s condition (a better term could be found). However, in the simplified arrangement, we should consider working with three parts:

- Delay with regard to technical condition
- Delay with regard to the functional condition of minor roads (against the fundamental standard)
- Delay with regard to the functional condition of major roads (against a standard calculated as profitable).

An appropriate division between minor and major roads could be made at 2,000 AADT [77].”

A road’s function and lack of function are expressions used in road management and also in connection with maintenance backlog. Functional deficiencies are often related to inadequate trafficability, transport quality and safety. The consequences of the deficiencies may be reduced permitted weight resulting in more traffic, lower speed resulting in longer journey times, lower comfort levels causing increased wear and tear both on people and vehicles, higher fuel consumption and environmental loading and more accidents that injure people and animals and cause damage to freight and vehicles.

All of these lead to some kind of sacrifice and cost. The road capital method categorises functional deficiencies by the type of measure needed. If a deficiency can be restored to the same standard by some form of maintenance measure, it is regarded as a condition deficiency. Where a deficiency can be rectified by investment (new construction or improvement) that raises the standard of the road, it is considered to be a standard deficiency.

[77] Average annual daily traffic (AADT)

In cases where a section of road is open to traffic that it is not in fact designed to cope with, it is very probable that severe damage will be caused that will result in higher operation and maintenance costs. For example, a “Load Class 1” road may consist of an unconstructed road or a road previously constructed as a “Load Class 2” or even a “Load Class 3” road. This is often expressed as the “Load Class 1” road having functional deficiencies. In the model, this type of functional deficiency is equated with condition deficiency. In practice, this is handled by maintenance of the road to the same standard according to the road-users’ expectations of a functioning “Load Class 1” road. It does not involve any improvement of the road to a higher standard in its existing alignment. At the SNRA improvements are counted as investments.

If, on the other hand, a road is open as a “Load Class 2” road but industry needs a “Load Class 1” road, the measure involves an increase in standard through an investment measure (new construction or improvement). In this case the functional deficiency is a standard deficiency, which is not included in the Mbl concept in the road capital model. Mbl concerns only maintenance and condition deficiencies. What the SNRA’s document says about function (technical condition and basic standard) appears on the other hand to concern standard deficiencies. The difference between standard and condition is not clear in the SNRA’s presentations and reports.

The SNRA’s document states that: “The delay carries with it higher an annual cost for maintenance and/or traffic costs and sometimes also higher operating costs.” In theory, it is not difficult to see that both operation and maintenance costs can be increased by a Mbl. This is not however shown in the SNRA’s work. It is difficult to find concrete examples of cost increases supported by the SNRA’s current accounts.

Sometimes a decision is made to carry out more drastic measures on a section of road or perhaps no longer carry out general maintenance on it. For economic reasons, maintenance should naturally be limited on such a section. When the change finally takes place, the remaining disposals should be as small as possible.

The issue of financially sound relations or conceivable transactions between generations sometimes comes up in the public debate. A generally accepted rule appears to be that each generation must bear at least their own costs. In this perspective, a maintenance backlog suggests that a maintenance debt has been built up, which has so far not been funded but will be passed on to future generations. Issues of claim and debt for the physical transport infrastructure and the transportation which has thus been, and is, made possible, however, can hardly be considered in such a narrow perspective.

In Sweden the replacement value, for example, of the entire existing state road network is estimated to be close to 1,000 billion SEK. Approximately two billion are loans with the Swedish National Debt Office while the remainder has for a long time been funded by appropriations, and depreciated and thus already paid many years ago. According to the SNRA, the maintenance backlog amounts to approximately 20 billion SEK. The accuracy of these figures is not certain and it will be considerably higher when the TAM concept has been implemented. It will also be meaningful to study the generation problem as regards the transport infrastructure more closely. The generation problem should, however, be considered in a wider perspective.

A financial settlement between generations may, for example, include difficult and probably considerably larger cost items for accrued prosperity and also environment debt items. However, these social issues of an almost philosophical nature will not be further discussed here.

Working documents in the SNRA's implementation projects concerning condition-related reporting of road capital contain the following summary of current concrete approaches for assessing the maintenance backlog:

> "The SNRA is now working on calculation of the maintenance backlog as regards paved roads as follows: There are three levels of standard/condition value.
>
> - Level 1: value as new, acquisition value, replacement value.
> - Level 2: standard target value according to the NPVS (National Plan for the Road Transport System), based on a politically decided cost ceiling.
> - Level 3: lowest acceptable standard based on road users' perceptions.
>
> In practice, costs are held below the ceiling according to the NVPS by the SNRA often being assigned a lower budgetary limit in letters of appropriation and its annual budget. The maintenance backlog is now calculated as the funds required carrying out optimum maintenance measures i.e. that give the lowest road management cost in the long-term, on sections below the target standard as regards condition. We thus have both a business economic and a socio-economic perspective.
>
> The sections of the road network below the target standard value as regards condition are identified. The criteria are IRI value and rut depth, surface standard, edge slump, cross-fall (measurement) and surface run-off (visual inspection). The calculations are based on the IRI and rut depth values in some fifteen classes, grouped by AADT and posted speed. Road category or type is not considered. The costs of measures have been assigned standard costs. In practice, AADT + posted speed + IRI will give a cost in SEK/m^2. The calculations are made in an MS Excel spreadsheet by Stev [78], who is/are also responsible for compilations of the maintenance backlog.
>
> Which measure is later carried out is identified, assessed and costed by the region's pavement strategists and pavement engineers."

As a final comment on the road-related definitions, it can be said that:

1) It is important that the concept of maintenance backlog encompasses more types of component than pavements.
2) It must be possible to identify the sections/components that are considered to make up the backlog.
3) Maintenance needs are about measures related to defined and verifiable deficiencies in condition and not in standard.
4) All components included in the calculation of Mbl should be able to be verified before and after carrying out the measure.

[78] An office in SNRA

5) The road manager should also have an idea of the proportion of the backlog that may be due to insufficient funding and inefficient road management (the road manager's improvement potential).

6.2.2 Mbl in other sectors

As is clear from Westerlund (2008), maintenance backlog is being discussed in many sectors. One example is a discussion in Lind & Hellström (2006) on the subject of municipal maintenance strategies and maintenance plans with a focus on school buildings. [79]

The report states, for example, that defining maintenance backlog is problematic considering the fact that the value of the objects falls because it may be rational during certain periods to let the values fall. Another definition that is under discussion, is that maintenance backlog occurs if we carry out so little maintenance today that we will be forced to carry out so much more in the future. It is emphasised, however, that it is difficult to assess this in practice due to uncertainty regarding future requirements and costs. The report also discusses a more multidimensional definition that states that a maintenance backlog exists if;

- "The technical standard of most of the buildings is low in relation to newly constructed buildings.
- Relatively large resources go to emergency maintenance.
- These emergency measures are such that they can be expected to recur relatively quickly.
- Most things indicate that the type of buildings in question will be needed for a long time.
- Continuous replacement of actual buildings with new produced ones would be very expensive"

6.3 The maintenance backlog model in the quality-related accounting

6.3.1 Introduction

The purpose of this section is to describe ways of defining Mbl, using the quality-related accounting model as the starting point, on the basis of requirement stated in the transport policy. A further aim is to identify the prerequisites for quantifying Mbl based on the best available knowledge of roads' deficiencies in condition.

To be credible, Mbl and any quantifiable amounts relating to Mbl must be able to be verified for the entire road network's components taking requirements regarding socio-economically efficient road management into consideration. It is practically impossible to determine condition relatively to a criterion for all the approximately 1.5 million components uniformly by hand in a short time. For quality reasons, therefore, it must be possible to make a computer-based calculation using systematically collected data and quality-assured routines.

[79] Anders Hellström, Hans Lind, Kommunala underhållsstrategier och underhållsplaner - med fokus på skolbyggnader (Utkast till slutversion), KTH, Januari 2006 Municipal maintenance strategies and plan – with a focus on school buildings (Draft of final version), Royal Institute of Technology (KTH), January 2006)

Considering that Mbl will be linked to the road component's real condition, the term is not dependent on any boundaries being drawn between operation, maintenance and investment. Mbl is based on perceptions of deficiencies in the condition of the existing components. It is important that deficiencies in condition as presented in the reference model are not confused with deficiencies in standard. It is also important that a clear structure exists of components' deficiencies and how they are established and valued. Condition must also be related to as great an extent as possible to how it affects road-users and society.

In summary, it is clear that the need to communicate in terms of Mbl is largely a result of road management's current lack of an accounting method and cost concepts suited to their purpose. Condition, deficiencies in condition and, thus, Mbl, cannot be determined from the accounts. For the same reason, Mbl cannot be quantified in terms of the cost of applying measures on the basis of the information in the accounts.

An appropriate definition and a model that can be used to calculate "maintenance backlog" should allow largely automatic selection and calculation. Accounting principles have become more international and the same difficulties are therefore experienced around the world. The expression "maintenance backlog" is discussed internationally in a similar manner as in Sweden.

The hypothesis is that it is possible to show how the TAM concept's accounting of quality-related road capital as regards "impact for society and road-users" can support:

a) an appropriate definition of "maintenance backlog",
b) a computerised, credible quantification of the "maintenance backlog" and
c) an assessment of the distribution of responsibility between the road manager and the politicians for the Mbl that arises.

6.3.2 The TAM concept's Mbl model

The term Mbl comprises components in far too bad a condition in relation to the applicable limit values. Figure 6.2 shows two such theoretical limit values for a component's condition-related value. One is "*Value at worst acceptable condition*" and the other "*Value when it is 'optimal' to carry out a maintenance measure*". The limit values are results of socio-economic assessments and road-users' quality requirements and expectations. The values are expressed in the same measurement parameters that are used when describing a component's condition and when calculating condition values.

Four periods P_n ($1 \leq n \leq 4$) are marked in the figure. Below these, the condition values are lower than at least one of the theoretical levels, which is a basic prerequisite for Mbl occurring. The three primary questions that need to be discussed are: "What conditions apply for Mbl to exist?" (Chapter 6.3.3), "How is Mbl to be calculated?" (Chapter 6.3.4) and "How great a proportion of Mbl should be funded by the road manager and the politicians, respectively?" (Chapter 6.3.5).

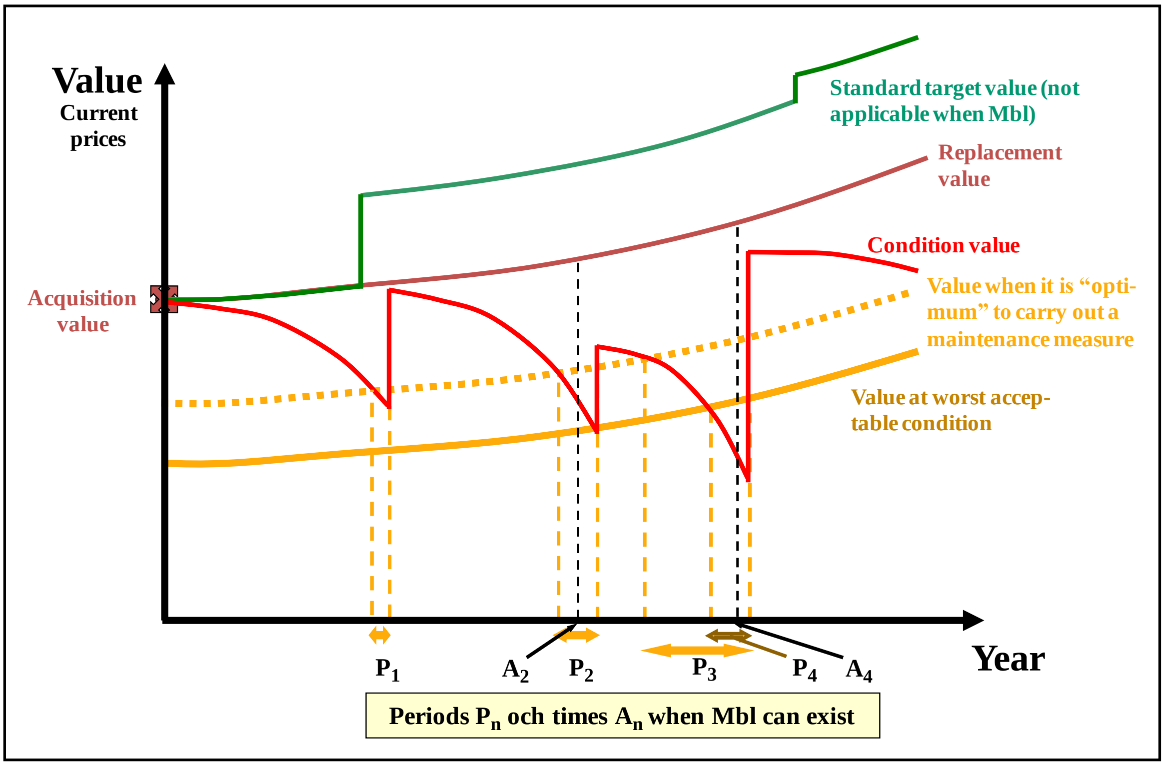

Figure 6.2 Sketch of periods when Mbl can occur.

6.3.3 What conditions must apply for Mbl to exist?

At points A_2 and A_4 in periods P_2 and P_4 the condition of the component can be unacceptable (Figure 6.2). The condition deficiencies must be unambiguously related to the factors contained in the concept of Mbl. It is obvious that the maintenance of a component with lower condition values than "value when it is 'optimal' to carry out a maintenance measure" is in a sense insufficient in the case of "Function type 1" components. Correspondingly, the maintenance of "Function type 2" components with condition values lower than "value at worst acceptable condition" is insufficient.

In this context, the limit values must have been determined on the basis of "best available knowledge" of socio-economic linkages and politicians', society's and road-users' expectations. The limit values should not be adjusted after funding since such an adjustment would make it difficult to steer measures towards attaining the objectives of the transport policy. The size of the appropriations may be a result of budgetary compromises taking little account of the long-term transport policy.

There are very many examples in the road network of components whose condition is worse than or equivalent to the "lowest acceptable". Physically or functionally, the maintenance of the component has been poor. However, not all unsatisfactory conditions are necessarily the result of a funding problem. There may be several rational reasons for waiting before carrying out a maintenance measure. Four common reasons are:

- Decisions to wait before carrying out a maintenance measure are sometimes made due to lack of clarity in the planning for a particular section of road. A decision may have been made regarding physical planning to carry out extensive measures on the section in question. Carrying out a maintenance measure would then be equivalent to “throwing money down the drain”.

- A decision has been made for financial reasons to co-ordinate and procure a maintenance measure with other measures at a later date.

- Prices in the construction market are temporarily too high. It would not be possible to defend the prevailing price level for a maintenance measure in a financial perspective, so the measure is postponed.

- If the condition of a component deteriorates quickly, it may unexpectedly fall below its limit value. It may then be reasonable to make time for analysis, consideration and planning of an effective maintenance measure.

Further, inventories compiled by several assessors cannot be made “completely uniform”, so it is sometimes not possible to claim that a lower level when inventory is taken is unavoidable. *A component whose condition value has passed a limit value cannot automatically be counted as Mbl in this sense*. There are therefore several good reasons why a shortest period P needs to be set, below which the condition value of a component has exceeded its limit value, in order to be able to be included in a Mbl value.

When the result of a socio-economic analysis begins returning higher net costs for society and road-users than for rectifying a deficient condition, a component’s “optimum condition value for carrying out a maintenance measure” has, as has been stated before, been passed. For a component or components concerned by socio-economic calculations, how the individual component’s limit value is to be determined must be established. It is probable that special circumstances must exist, for example a sufficiently great traffic flow, for the “optimum” value to be returned in a socio-economic calculation (see further the discussion in Appendix 4.)

The *bound wearing course* component type probably has such a socio-economic algorithm, where an “optimum” limit value for maintenance measures is returned for roads with high traffic flows. According to the objectives of the transport policy it is important that limit values steer the road manager’s maintenance measures on a socio-economic basis. Considering the cost to individual road-users the condition may nonetheless be permitted to be lower, but not lower than “worst acceptable” condition. In principle there are therefore two types of limit value for the maintenance of components. One is based on socio-economic calculations for transportation by road as a whole and the other on the impact for the individual road-user. One and the same type of component can thus have different functional and quality requirements depending on the type of road (e.g. European highway or gravel road) and location where the component occurs. Principles therefore need to be established for what is to apply. The limit value can for example be determined for each component on the basis of prevailing circumstances with the support of a special socio-economic algorithm where traffic flow is one of the parameters.

Wear and degradation normally take place slowly. The financial consequences for road-users and society of marginal differences in wear and condition are difficult to determine with any accuracy. What cost differences arise, e.g. in the case of a twelve-month postponement in carrying out a measure on a “normal” road? The road manager must have created a high degree of trust and confidence to be able to communicate funding needs together with issues concerning deficiencies, Mbl and impact on road-users and society. It is therefore important for credibility reasons that all this information can be verified.

The conclusion is that the term Mbl should include all components whose condition has been lower than the established limit value for that component for a sufficiently long period of time. By way of suggestion, “sufficiently long time” could be a period of at least two years (≥ 2 years). The limit value is in most cases a “worst acceptable” condition based on “best available knowledge” of road-users’ and society’s requirements and expectations. In special cases, there may be known linkages between a component’s condition and impact on road-users and society, and the limit value should therefore be set as “optimum condition value for carrying out a maintenance measure” in a socio-economic calculation. The maintenance backlog (Mbl) will not then include maintenance delayed for “natural and/or rational reasons” at the same time as all condition limit values that have been exceeded are assessed according to “best available knowledge” in respect of the transport policy’s objectives.

6.3.4 How is Mbl to be calculated?

General

It is clear that the size of the maintenance backlog is to a large degree dependent both on the limit values set for condition and on how effectively road maintenance appropriations have been used. It is therefore important that the limit values set for condition valuation are based on requirements that can be proven to result from the transport policy. It is also a reasonable requirement that components’ poor condition has existed for a sufficiently long period of time in order to be included in the Mbl group. Over and above this, the road manager should be able to plausibly show that available funds have been used effectively and that the reason why a maintenance measure has not been carried out is in all essentials insufficient funding. It is also useful if the road manager can describe the effects of Mbl on road-users and society.

In discussions with politicians about the cost of applying the measures and funding needs, the road manager has an advantage in the form of knowledge and a certain amount of “private information”. The road manager’s “private information” consists of facts about the road transport system’s deficiencies in condition, standard and cost of applying measures, and about the effects of the deficiencies for road-users, trade and industry, and society. One known phenomenon [80] is that the owner, in his capacity of financer, may suspect that the road manager is using his advantage in the form of information and knowledge to produce descriptions that serve the road manager’s own purposes. A certain degree of distrust is natural, healthy and perhaps even necessary in similar discussions of budgetary needs.

The relationship between socio-economic cost per vehicle kilometre and the component’s condition value is shown in the two groups in Figure 6.3 for occurrences of “Function type 1” components (with a limit value set “around the ’optimum’ maintenance time”) and “Function type 2” components (with “worst acceptable” condition) as limit value.

[80] Paul Milgrom, John Roberts, Economics, Organization and Management, ISBN 0-13-223967-1, Prentice Hall, New Jersey, 1992

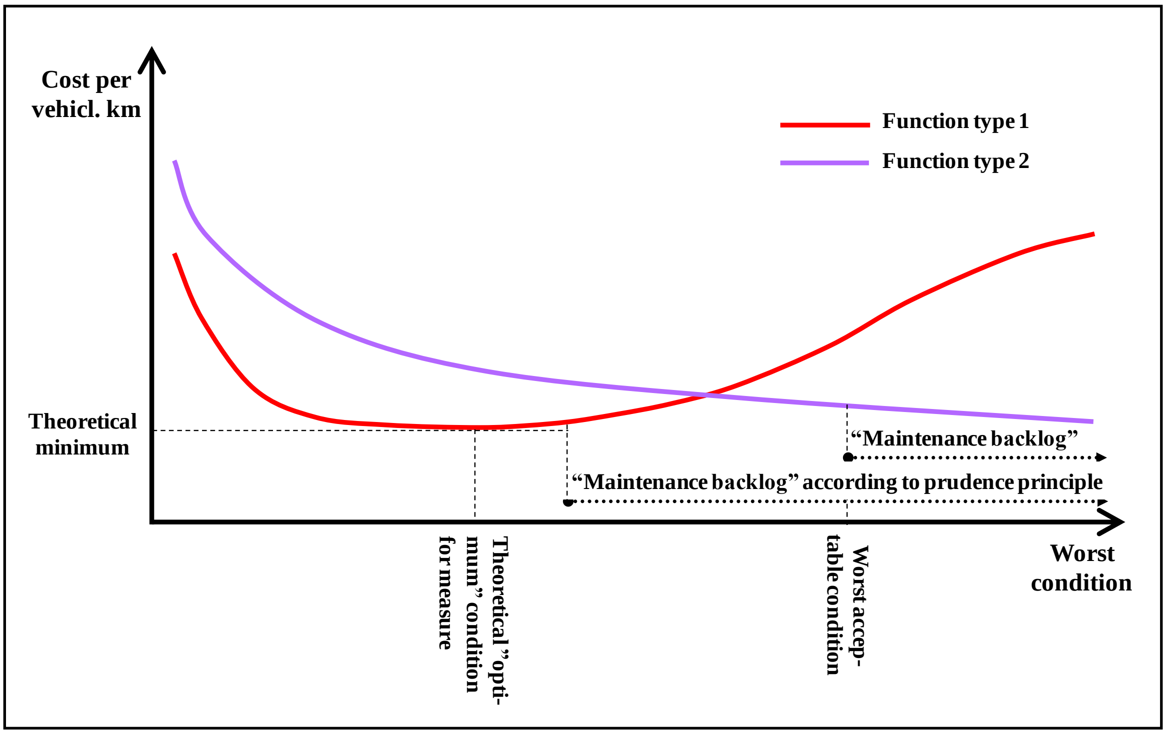

Figure 6.3 Outline sketch of "maintenance backlog" for component's different function types

The question "*How is Mbl to be calculated?*" should be answered on the basis of the definition of Mbl that applies and in respect of the issues that Mbl is intended to elucidate. Components whose condition is too bad and that are included in the Mbl must be restored to an acceptable condition by means of maintenance measures. In practice, a poor condition should almost always be restored to "as constructed" because the fixed costs represent a relatively high proportion of the total cost of the maintenance measure. From the point of view of liquidity, expenditure for this type of maintenance measure should therefore be able to be fully funded. Increased expenditure relative to the component type's "normal" standard cost of applying the measure may also occur in cases where condition is significantly below the limit value for "worst acceptable condition". For these known cases and component types, a list of standard costs with a factor greater than 1 must be drawn up.

Insufficient funding leads to increasing deterioration of components' condition. The consequences may be serious to either a greater or lesser degree. In practice, what happens is that road managers, in their eagerness to increase the number of satisfied customers in the short term, due to lack of capital choose to increase the volume of "cheap *ad hoc* solutions". Well aware that this is highly inappropriate, their excuse is often that "it costs money to be poor". It has also been proven scientifically that the total maintenance cost is higher with *ad hoc* solutions than with planned preventive measures (Sherrie Koechling, 2004 and Peter Ekdahl, 2001).

Another consequence of insufficient funding of road maintenance is that costs are rolled over onto road-users and other sectors of society. When road maintenance is reduced on such types of components as road structure, surface run-off, bridges and wearing course, road-users' and society's costs increase. The ratio can often be considerable, so that one SEK saved on road maintenance might for example be equivalent to an increase in cost of two SEK for road-users and society.

In the TAM concept limit values are systematically analysed and assessed in a socio-economic perspective per type of component, types of road and circumstances as regards effects for society, road-users, road management, and what is politically defensible. It has also been established that without a uniform, systematic and verifiable review, it will be difficult to attain any credibility for the road manager's theoretical assessment of limit values for Mbl. As experience of the consequences of these estimated "optimum" values, costs and intervals grows, the need might therefore arise to adjust the information in the model at a later date.

Mbl can be expressed as different values. It can be seen as

I) The total expenditure for restoring all the Mbl components' unsatisfactory condition to "as constructed" effectively.

The expenditure can also be seen as

II) The result of, for example, planning of measures where the expenditures arise as result of the maintenance measures. A planning strategy might for example be to improve the condition values for the "unhealthy" components so that the mean of their condition values is equal to the corresponding mean for the "healthy" components.

Mbl can also be seen as

III) An annual cost and average increase in appropriations and/or detached volume of production, so that the Mbl components can also be maintained in the same way as the "healthy" components.

On the other hand, in none of alternatives *I-III* does Mbl contain any costs for retroactive recovery or compensation for losses incurred by society and road-users as a result of earlier poor maintenance.

General information about calculating Mbl

The question "*How is Mbl to be calculated?*" is answered on the basis of the quality-related values a, b, c and d in Figure 6.4 taking funding and responsibility issues into consideration.

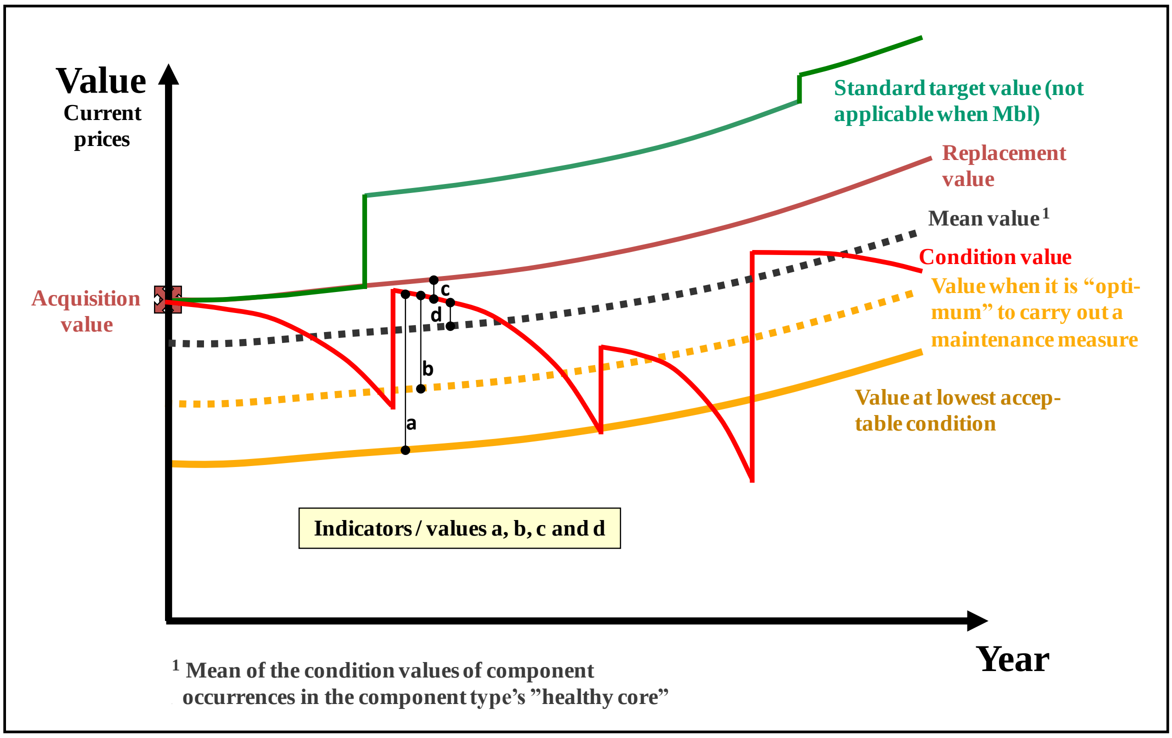

Figure 6.4 Sketch of indicators / values a, b, c and d calculated by computer

Values **a**, **b**, **c** and **d** are assigned the following content and definitions:

- **a** is a "Function type 2" component's current condition value less its value at "worst acceptable condition" (*remaining utilisation*).
- **b** is a "Function type 1" component's current condition value less its "optimum" value for carrying out a maintenance measure (*remaining utilisation*).
- **c** is a component's current condition value less its replacement value**,** i.e. the value of the condition deficiency (fully *consumed*)
- **d** is a component's current condition value less the mean value of the condition values for all occurrences of the component type in "the healthy core" (*deviation from "the healthy core's" mean value*). The component type's "healthy core" does not include components that have been added or removed over the year or where the components have condition value a ≤ 0 or b < 0, since they are then assumed to be deficient in quality or ineffectively managed.

When quality-related accounting has been introduced, newly opened road projects will gradually provide information based on real prices for all the project's components. The new components thus begin to deliver condition and cost data based on real prices. All four values a, b, c and d will be calculated continuously by computer for each occurrence of the component. A period length P is established by testing the value in the E list's *time counter* for potential Mbl components.

The mean condition value and mean annual cost are calculated for each component type's "healthy core" of component occurrences. Substantial quality deficiency costs in the case of annual costs are component occurrences with an annual cost that, for example, exceeds the upper control limit (UCL) set for each component type (may sometimes be able to be determined by means of an algorithm for influencing factors). UCL is sometimes expresses as the mean value (μ) plus a multiple L of the standard deviation (σ), $UCL = \mu + L * \sigma$ according to Chapter 5 on Quality control and learning in the control of the process.

At time A_2 (see figure 6.5), the component's condition value is lower than "the 'optimum' value", $b_2 < 0$ (for "Function type 1" components) but greater than $a_2 > 0$ ("Function type 2" components). The component's corresponding condition value during period P_4 (A_4) is worse than or equal to the established limit value "worst acceptable" condition value ($a_4 \leq 0$ and $b_4 <$ 0).

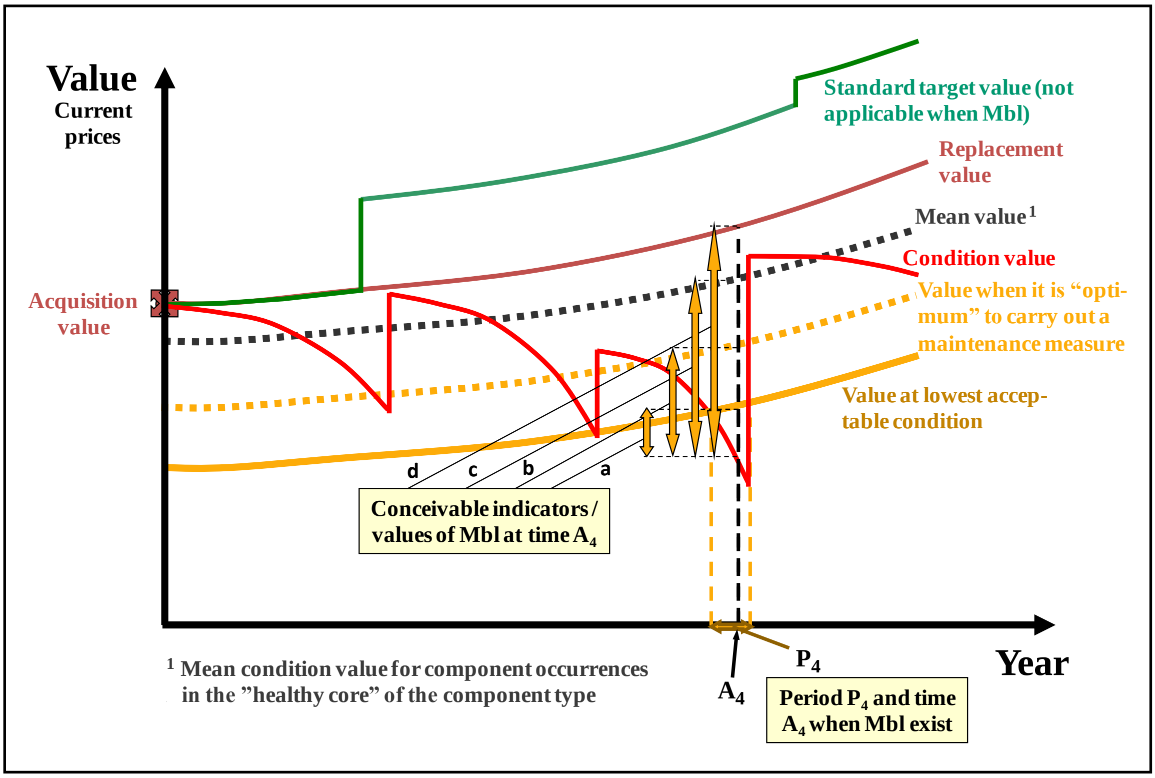

Figure 6.5 Conceivable indicators of values for describing Mbl at time A_4.

According to the reasoning above, Mbl can only arise when the condition value has been below either the "'optimum' value for carrying out a maintenance measure" ($b < 0$) for "Function type 1" components or lower than or equal to the "worst acceptable" condition value ($a \leq 0$) for "Function type 2" components for a sufficiently long time. Using general aids it is a simple matter to seek the components that meet the requirements regarding quantities a and b on a large scale.

To summarise, the value combinations of a and b that occur are listed in Table 6.1 where 1 (= true or possible case) and 0 (= false or impossible case).

Compare Figure 6	Possible magnitudes ($a \neq b$)			
	$a>0$ $b\geq 0$	$a>0$ $b<0$	$a\leq 0$ $b>0$	$a\leq 0$ $b<0$
Condition value of ”Function type 1” component	1	*1*	0	*1*

Compare Figure 6	Possible magnitudes of a			
	$a>0$		$a\leq 0$	
Condition value of ”Function type 2” component	1		*1*	

Table 6.1 Possible combinations of values of a and b, with *italicised 1* for Mbl.

To fulfil the condition that applies for Mbl, a component’s condition value must either be lower than the “optimum” value (function type 1) or lower than the “worst acceptable” value (function type 2). These values must also have persisted for a sufficiently long period of time. According to the definition, Mbl can theoretically only come into question for ”Function type 1” components when $b < 0$ has persisted for period $P \leq$ e.g. 2 years (irrespective of the value of a) and for “Function type 2” components when $a \leq 0$ has persisted for period $P \geq$ e.g. 2 years.

In Appendix 6 some more details on how to calculate Mbl in the alternatives I-III is presented.

6.4 How much of the Mbl depends on low funding?

If the road manager for example claims that the Mbl has been caused by insufficient funding, it should be able to be plausibly shown that

a) available funds have been used effectively (and, if not, the proportion that may have been used ineffectively),
b) that the Mbl components has been on a list of items for action for a long time and despite “great financial efforts” have not been dealt with. The phrase “great financial efforts” in this context means that there are no other reasons besides insufficient available funds why the measure has not been carried out.

One might form the impression from the previous sections that the volume of Mbl that has arisen has been caused by insufficient funding. However, the entire responsibility for Mbl can probably not be laid on the owners/politicians/financers. In practice, it might even very well be so that the amounts approved are greater than they would have needed to be if road management had been pursued more effectively.

Before the road manager can “submit an invoice” to the politicians, the effectiveness of the maintenance should therefore be assessed. At the very least, the road manager should expect politicians to need to be convinced that the maintenance activities are effective before a supplementary invoice can be accepted. With the road manager’s point of departure in the transport policy, the effectiveness requirement, which is a function of “value and utility” and “productivity”, applies. The road manager has therefore probably tried to assess the “utility” of maintenance measures. These assessments, however, are not made in a systematic and structured manner are therefore difficult to verify today.

In the TAM model, the limit values for condition have been set for both “when it is optimum to carry out the maintenance measure” and “worst acceptable” condition. This ensures that the socio-economic assessments in respect of maintenance measures can be made uniformly according to the “best available knowledge” in the whole country. The endeavour to carry on effective maintenance activities can thus focus on productivity and quality. Every product and service is to be produced in a cost-effective manner, When this is checked, by computer, any non-conforming results (both successful and less successful) are documented in order to be able to be analysed and if necessary rectified, but also to be able to be used in learning and the development of the processes. Some types of failed measures should be able to be influenced and are regarded as inefficient road management. The road manager’s learning process must ensure that such failures are not repeated anywhere in the country. It is important that this type of failed measure can be identified by means of a computerised system.

6.5 Effects of Mbl

It would be of value to the debate about Mbl if more light were shed on how insufficient funding can lead to costs being rolled over onto road-users in a way that affects both private motorists and trade and industry. Society is also affected when the total cost to Sweden Ltd increases. A cost increase in regional areas that are financially weak is particularly onerous. A systematic effort according to the TAM concept would in all likelihood lead to an overall more effective distribution of the costs between road-users and society (including the road manager).

There are a number of known correlations between condition and effects in respect of components and component types of function type 1. The effects of Mbl for road-users and society can therefore partly be assessed on the basis of “best available knowledge” of condition – effect relationships. The consequences can be categorised in three main groups.

In group 1, representing “Function type 1” components, the effects for both road-users and society will largely be able to be described in financial terms. For both group two and group three, the consequences for society will partly be able to be elucidated in financial terms. On the other hand, there is no directly indicated financial consequence for road-users.

Group 2 contains those component types that are coupled with safety, laws and regulations. Safety concerns both installations and traffic while laws and regulations refer for example to traffic control and order on the roads. The intended function must be maintained by a satisfactory margin for these component types. The third group consists of the remaining component types that are important as regards experience aspects, such as comfort and aesthetics.

For groups two and three it would be possible to describe the consequences for road-users and society in financial terms in an appropriate manner by applying a new type of funding. For example, charges that reflect road-users’ willingness to pay in a road pricing system might contain undertakings, fines and/or discounts for road users linked to components’ condition.

Another form of inefficiency is when learning is not systematically secured through benchmarking, benchlearning or other similar processes in an organisation. The learning process involves detecting, analysing and disseminating experience gained from good and bad examples both inside and outside the organisation. The differences in for example the organisation's own operations must be analysed on the basis of identified best practice and improvement goals must be defined so that the increase in efficiency will advance the organisation to at least that level. In this respect it is important to follow up the progress of the improvement effort, set new goals, etc continuously. The TAM concept provides an excellent foundation for this type of activity with a focus on component types and single component occurrences. Costs, life cycle costs and effects for society and road-users can be elucidated on the basis of "best available knowledge".

It might be a little safer and sometimes more stimulating to identify regional best practice in the TAM concept. It is important, therefore, that the information in the TAM concept is accessible and easily identifiable so that they can be analysed and goals defined for the improvement effort. Product and process development can be followed up continuously and verified. It should be noted that the information that the TAM concept can provide in the form of proportions of resource types is a significant aid in the analyses. The data was produced per component type when the component-adapted index series and control limits were defined. The knowledge is maintained by means of regular checks and revisions and can be used when defining improvement goals.

When differences between the results of the organisation's own operations and best practice are to be analysed, it can first be determined whether the difference can be explained by differences in acquisition price, condition development or, for example, upkeep. The proportions of resource types and tolerance ranges can then be analysed. It is important to emphasise that proper use of the TAM concept allows the focus of the improvement effort to be placed on essentials and the substantial potential in the road management process.

6.6 Mbl in Norway

In Norway [81] much the same method is used to determine Mbl as currently in Sweden. At regular intervals or once a year, the backlog is calculated using standardised formulae at macro level on the basis of assessed mean values for different types of road. In the same way as in Sweden, this method does not permit any single individual road to be identified that is in itself in agreement with the standards and that accumulated together with other individuals would give the total value of Mbl.

The value calculated in that way cannot be verified but at a sufficiently high accumulated value might well be a good indication of the situation. One weakness is that it is easy to adjust standard values with arguments that are difficult to refute. An insignificant adjustment of the standard values may often have a substantial impact on the Mbl data. The insignificant adjustment may also be difficult to verify since it cannot be identified physically.

[81] Hansen, Morten Wright, Stensvold Børre, Beregning av vedlikeholdsetterslep for riksvegnettet, Vegkapital, Statens vegvesen, Oslo, 2003 (Calculation of maintenanace backlog in the national road network, Road capaital, National Road Administration, Oslo, 2003)

6.7 Conclusions

One objective of the TAM concept is to enable information about components' costs, values and changes in value and about good and bad examples, Mbl and effects to be obtained in a flexible manner. Information about Mbl, for example, can be obtained using computer software per component occurrence, road, type of road, contractor responsible for the basic package, operating manager area, municipality, county, road management region and for the whole country. According to the principles, the information is based on actual costs and expenditure and on "best available knowledge" of deficiencies, socio-economic effects and customers' expectations.

It has been shown that the component occurrences included in the Mbl can be identified in the TAM concept and the quality-related accounting. Expenditure for restoring Mbl and the long-term annual cost of maintaining restored components can be calculated automatically in the concept. Ineffective road maintenance and the total improvement potential relative to best practice can also be assessed using the software. The funding needs that the road manager puts before the politicians can thus be qualified with the funding that the road manager himself should be able to create through efficiency measures. The sub-process concerned can also be identified in respect of principal causes of quality deficiencies (ineffectiveness) and the magnitude of the costs involved in rectifying the deficiencies assessed per component type. The components concerned can be pinpointed and analysed.

Organisations that are carried on with "learning" in an active quality effort must identify and analyse both poor and successful products continuously. Identification itself is a prerequisite for enabling a "functioning learning process under controlled conditions". The follow-up is another prerequisite. In order to stimulate creativity in autonomous development processes it is necessary to have functioning reward systems and clear descriptions of organisations' problems, weaknesses, opportunities and improvement goals.

7 ROAD MANAGEMENT'S SUB-PROCESSES

7.1 Introduction

The State has extensive responsibility for funding of public interests and competition for a share of the national budget has become fiercer. Requirements regarding results, result reporting, transparency and verification have increased. The road management process, and in particular the sub-process for drawing up long-term operational plans, involves not only authorities, municipalities, organisations and companies but also individual citizens.

Efficiency, a holistic view and customer orientation in road management are demands that can be derived from the objectives in the transport policy. The demands have been the guiding principles for road management and its improvement efforts for a long time. Efficiency includes both customer utility and productivity. Customer-orientation, on the other hand, is more a question of the road manager's treatment of customers and their participation in processes. The guiding principles are in good accord with the aims of Transportation Asset Management.

In order for the road management process to be able to be provided with information that fulfils the transport policy's requirement as regards socioeconomic effectiveness, qualified road engineering, societal and economic competencies need to interact and be taken into account. To be useful, the information from these competencies must be quality-assured and appropriate and satisfy purposes and needs in a number of fields of operations. The quality-related internal accounting summarises these competencies' "best available knowledge" in financial requirements and terms and is based on effectiveness according to the requirements stipulated in the transport policy. The possibilities that the TAM concept offers in the different sub-processes will be discussed here, but before moving on a few words about customer focus are in place.

The road manager has interpreted the transport policy to mean that measures carried out on roads are to be prioritised first and foremost in respect of measurable effects for road-users and society and secondarily satisfy road-users' known and unknown needs. In order to achieve effective road management in socioeconomic terms, it is therefore important to have knowledge of the connection between on the one hand roads' physical function and on the other measurable effects for road-users and society. The SNRA's planners and economists are considered in this respect to have "best available knowledge" of socioeconomic calculations, effect relationships and road-users' preferences, in other words what in practice should give customer satisfaction.

In the accounts, a cost-based value appraisal is made of road components' functional standard, condition and deficiencies. The limit values as regards what constitutes acceptable condition are determined on the basis of known relationships between components' condition and effects for society and road-users. When there are no known relationships, the interpretation of road-users' expectations can be a guiding factor when determining the limit values. Information about condition values, quality deviations, maintenance backlog, and other non-conformities is based on socioeconomic effectiveness or customers' expectations.

Five central sub-processes in road management will be elucidated in this chapter on the basis of possibilities offered by a TAM concept with accounting of quality-related road capital. These sub-processes are:

- Long-term planning,
- Operational planning and follow-ups,
- Procurement,
- Project management of road projects
- Accounting and reporting.

All of the sub-processes are interlinked (see Figure 7.1). Customer contact is especially emphasised in long-term planning while feedback mainly takes place via the Accounting and reporting sub-process. The time between initial contact concerning a need to take action and the final report is in most cases very long – normally between ten and twenty years. But there are also examples of considerably longer periods. Shorter periods than ten years are the exception. In the physical planning, customer contact takes place regularly while the actual effects for road-users and society are determined by contract at the time of procurement and in completed road projects.

Physical planning provides the quality-related accounting with basic information. It is assumed that the data is captured rationally using modern technology. Road management should for example be able to copy technical solutions that have existed in the private sector since the end of the 1980s. In interaction with road-users, trade and industry and society, the road management process must be steered and monitored so that it contributes effectively to “make good journeys possible” [82].

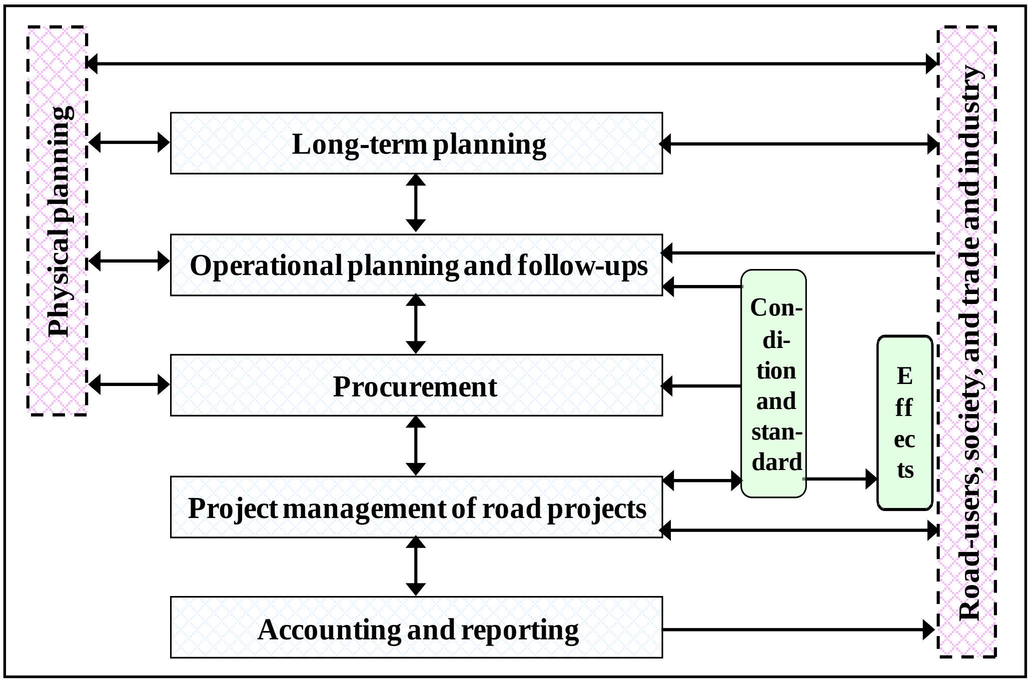

Figure 7.1. Sub-processes in road management’s core operations

[82] Strategic plan for the SNRA 2005 – 2014, Draft decision, version 0,7, Vägverket, 10 June 2004, Borlänge

The purpose of this essay is to give some examples of appropriate bases for road management's sub-processes taken from the quality-related accounting and other positive aspects that follow from the TAM concept.

7.2 Long-term planning

7.2.1 General

Planning is divided into one process for long-term planning and one for short-term operational planning and follow-ups. The prerequisites for long-term planning with its associated financial planning framework are set by Parliament. The remaining prerequisites for executing the long-term plans and special assignments in the short-term perspective are set by the Government.

The long-term plan for the national road network (the National Plan for the Road Transport System, NPVS) is proposed by the board of the SNRA but decided by the Government while the regional county-wise plans for the remainder of the road network are fixed by the respective county administrative boards. Should a county administrative board's plan be appealed, for example by the SNRA, the Government has the final say. Road management's operational plans and budgets are fixed by the board of the SNRA. Long-term plans and appropriations are divided into operation, maintenance, investments, or, for example, sectoral tasks, but also by the purpose of the measures, for example bearing capacity, road safety, regional development, the environment, etc. The plans:

- cover a period of at least ten years (e.g. 2004 – 2015),
- are revised and renewed approximately every four years,
- are drawn up in respect of the transport policy objectives in volumes for which scope exists within the fixed planning framework,
- are directed towards ranking urgent road measures by socioeconomic effectiveness ("utility per invested SEK" or net present value ratio) within the planning framework,
- are based on more or less well underpinned knowledge of needs, alternative measures, prerequisites, cost of applying the measures and effects (the quality of the underlying information varies from standard values in a concept drawn up at an early stage, calculations from pre-studies, studies of roads, work schedules/construction documents to contracted prices in ongoing projects).

7.2.2 Problem overview

To achieve an effective customer focus in road management it is important to have knowledge of deficiencies that are of importance to the customers. It is therefore necessary to systematically register all deficiencies in the road network. This is one of the TAM concept's fundamental preconditions since deficiencies in the infrastructure burden road-users and/or society with other costs or other sacrifices. For reasons of efficiency, deficiencies should be registered in the RDB in an appropriate manner with important information and links to the roads in question. As soon as a standard deficiency has been identified it must therefore be documented with proposed measures, the cost of the measures estimated using standard values, and the effects for road-users and society. The rule should be that if a deficiency has not been registered according to a defined, quality-assured procedure, it does not exist. It can therefore not be taken into consideration in the planning.

It is not acceptable for details of a deficiency to exist only in the head of an administrator, on a notepad or in a personal document in a computer and then be taken up in the planning process with “oral arguments and persuasion”. Such a way of going about things would then be the sole privilege of people in responsible positions or people who are close to those who are performing the planning process. In order for infrastructure planning to be part of societal planning in an effective manner, transparency is needed together with easily accessible information of good quality.

Difficult, significant planning issues concern items that affect energy, the environment and the climate. Regardless of whether people have been made aware of these influencing items, they are nonetheless affected by planning decisions. In the assessment of the consequences for the three items mentioned of investments in the infrastructure’s physical components, the TAM concept’s correct quantification of actual consumption is very valuable. Consumption can be considered at resource input level, where knowledge of LCA exists, to assess environmental impact, for example the effects of greenhouse gases. With knowledge comes the possibility to consider consequences in decisions about planning, key ratios, control limits and other means of control, to prescribe alternative production methods and materials and to direct research and development resources in a sounder manner. According to the “every little helps” principle, substantial effects can be achieved provided that knowledge and good incentives for sound choices exist.

Emissions from traffic are a global issue that require political courage to address. Perhaps the most important means of control today is carbon dioxide tax on vehicle fuels. The TAM concept provides additional possibilities for sustainable control and monitoring. Internalised cost-based road pricing would also allow the results of in-depth LCA-focused resource input analyses of all the component types in the infrastructure to be taken into consideration. New knowledge should also lead to limit values in respect of condition that consider components’ environmental loading, for example in the form of greenhouse gases. The SNRA, for example, was the first government agency [83] to prohibit the use of freon-aerated insulation materials in frost blankets – a small yet colossally important first step on the road towards a healthier development of the industry. A strong environmental commitment has existed since the mid-1980s and this must be supported with good quality bases for analyses in order to obtain in-depth knowledge of LCA and continue the work according to the “every little helps” principle.

Generally speaking, there is a great need to shorten lead times in the planning process and improve effectiveness, flexibility and transparency. The plans are accompanied by great expectations in all sectors of society that roads will be improved. All too often, though, the result is disappointment on the part of those who have involved themselves in the planning when the measures that were planned do not materialise. The implementation of the plans cannot be funded in competition with society’s other needs and cost increases, and price development often prove to be greater than the upward adjustment of appropriations.

[83] In the environmental initiative from the end of the1980s (reported in the SNRA’s report no. SA80A 2007:4268, 28 February 2007)

Process model

In the letter of appropriation for 2002, the Swedish Institute for Transport and Communications Analysis (SIKA) was commissioned by the Government to investigate how the direction of the planning could be approved in the next planning round. SIKA's study [84] discusses problems and different planning models.

The long-term planning has developed over a great many years. SIKA found that models based on instrumental, technical or financial rationality are used around the world. In Sweden the planning process is sequential and it is assumed that it will result in a plan that is socio-economically effective ("optimised") in respect of the applicable objectives in the transport policy.

Over the past fifty years, changes to this form of planning have been relatively small. In all essentials they have been aimed at fine-tuning technical rationality. A weakness in the technical rationality model that SIKA's report takes up concerns the transformation from produced orientation basis to a relevant political basis for decision. The present planning process based on technical rationality is considered to be weak, which can be explained by a lack of receptiveness, early freezes in abstruse projects, difficult theoretical calculations and lack of transparency. The difficulty in reconciling the politically possible with the technically rational has led to a debate about the planning philosophy and alternative planning models, often with a market-like content. The latter models have communicative or strategic rationality and give a communicative planning process.

It has proved to be easy to achieve ineffective action by consciously underestimating costs and overestimating utility or vice versa. Strong lobby groups and/or involvement on the part of society and trade and industry can result in financially ineffective plans where less profitable projects are prioritised over more profitable ones.

SIKA wants to see a wider (even cross-border) system perspective in the planning [85]. Road and rail traffic are components in a total transport system in Sweden and also internationally. However, measures other than physical investments in the system can contribute to satisfy society's needs with greater socioeconomic effectiveness. SIKA also points out the need for better interaction between planning of the transport infrastructure with other physical planning in society. It is also emphasised that system analyses require good analysis tools, bases for calculations, and forecasts, for example of economic growth, climate policy and fuel prices.

When the 1994 – 2003 planning process had been concluded, the SNRA commissioned an evaluation from Sinova AB as to how the planning process had been perceived by the players involved and how the process had functioned [86]. In many places in the report, the assessment is that the SNRA is a professional organisation and the general conclusion is that:

> "most players are fairly satisfied with the SNRA's behaviour. They feel that improvements have been made, mainly as regards:

[84] Strategic Infrastructure Planning – Short-term and long-term prerequisites for development, SIKA Rapport 2002:22, December 2002, Stockholm

[85] SIKA's report to the Government about the long-term strategic planning of infrastructure investment for the 2010 – 2019 period, 27 June 2007, Stockholm

[86] Evaluation of the road management planning process 1994 – 2003, Final report submitted to the SNRA, Sinova AB, Per Arvidsson, Björn Eriksson, 14 October 1994, Stockholm

- Descriptions of objectives, the nationwide approach, the holistic view, alternative focuses, and the route philosophy.
- Greater commitment and openness on the part of the SNRA.
- A shift of interest from roads to people and road transport systems.
- Documentation, underlying material and readability of the final documents.
- EIA [87] – but only as a first step in the right direction."

External players in the process had seen the SNRA's endeavour to adopt a holistic view, customer focus and openness. There were, however, a number of negative comments and problems and these are taken up in the following sections.

Planning prerequisites, information about standard, condition and effects

This point concerns expressing all information about the road network in respect of standard, condition, deficiencies, measures and effects in a clear manner and making it more accessible. The following problems were taken up:

- There was no methodical survey of needs underpinning the planning.
- The municipalities want to be involved in the process at an earlier stage.
- The SNRA's people had an advantage as regards knowledge and information.
- The underlying material and information was provided late and the time for processing was limited.
- The planning process was long and contained very extensive documentation.
- The plans were perceived as finished, the list of objects overfull and receptiveness inadequate.
- The planning process was perceived as difficult to overview with incomprehensible prioritisations.
- Objectivity in the way issues were handled was questioned.

Planning issues concerning fairness between generations and regions

In economic research, the issue of fairness between generations (and geographical areas) often arises. Has every generation borne its own costs and what are the effects for different geographical areas? In Japan, researchers have drawn attention to these issues, in particular in respect of the transport infrastructure [88]. The issues should be considered in the long-term planning.

Future generations may find it more difficult than today's to bear the financial burdens that continued development of prosperity requires. It is therefore unacceptable to put further financial burdens on coming generations unchecked. The long-term planning should therefore include ensuring that every generation bears at least its own costs.

The generation problem set is not paid sufficient attention in today's planning process. One of the fundamental problems is that standard and condition deficiencies in infrastructure are not

[87] Environmental Impact Assessment, EIA
[88] These issues importance in Japanese research was made clear at SVF conference at Jönköping, Sweden in October 2004 with among others the researchers Kobayashi Kiyoshi, Ejiri Ryo and Kitazume Keiichi from Japan.

reported in a clear manner. Other problems are that values and road management costs as they are presently reported are misleading. In order to compensate to a certain degree for these deficiencies in the official external accounting for road management, the road manager usually presents details of the "maintenance backlog". This corrective information and in particular the amounts that are stated are uncertain and therefore have low credibility in the eyes of politicians.

A similar problem set is when investments are made in a region to stimulate development but when much of the benefit is enjoyed by a neighbouring region. It may even very well be the case that most of the benefit is reaped by trade and industry in another region. The problem here is how to distribute funding, costs and other sacrifices fairly between the regions and users concerned.

Low flexibility and effectiveness in the planning process

Stakeholders and players in the long-term planning process have expectations regarding the outcome of the planning and opinions regarding the road management system as a whole. The following problems can be mentioned:

- Municipalities' need for road measures in the state-administered road network was not discussed in the process.
- Uncertainty about when road objects will be implemented impacts other municipal planning negatively.
- In some cases, the effectiveness of the planning process and the entire road management system was perceived to be very low.
- The conflict between increased traffic and the environmental objectives was not dealt with satisfactorily.

The European Commission's white book from 2001 with an agenda for a common transport policy by 2010 is to be updated for the next 10-year period. A communication from the Commission [89] presents different strategies for the continuing discussions leading up to the next white book in 2010. It describes the great importance of a functioning transport sector for prosperity and the need for a clear, sustainable long-term vision for the continued development of the complex transport system. At the same time, the document points out in several places the political difficulties in handling the necessary development, for example:

> "Transport policies have a very direct impact on peoples' lives and tend to be highly controversial: citizens should be given better information on the reasoning behind policy decisions and on the available alternatives. A better understanding of the challenges ahead is a precondition for public acceptance of the solutions.
>
> Greater public involvement in transport planning can be ensured by recourse to participatory instruments, namely open consultations, surveys and stakeholders' representation in decision processes."

[89] A sustainable future for transport: Towards an integrated, technology-led and user friendly system, KOM(2009) 279 Final, Communication from the European Commission, (signed by) Jordi Ayet Puigarnau, 17 June 2009, Brussels

> "The transport system involves complex interactions among political, economic, social and technical factors. The sector can only thrive if policy makers are capable of providing sound planning, adequate funding and a proper regulatory framework for market operators."

The need for effectiveness is emphasised several times in the document. The Commission would like to see coordinated, cross-system, unified long-term sustainable planning with an extra emphasis on reduced emissions of greenhouse gases. Individual parts of the network must be fully integrated and interoperable. They also want to see correct pricing of all modes and means of transport with internalised external costs to make natural customer-driven effectiveness in the transport system possible.

> "Internalisation charges to complement revenues from energy taxation are likely to be necessary in any event, since excise duties on oil derivatives will presumably decline with wider diffusion of vehicles running on alternative sources of energy.
>
> The transport sector has to become increasingly self-financing also in relation to infrastructure. "

Cost development, price development and cost drivers

One special problem in the long-term planning is to assess and gain control of the projects' cost development. The problem proves to be underestimated when the plan is implemented.

Follow-ups of long-term plans

It has been established that following up the plans needs to be performed better and that deviations that occur should be systematically analysed and discussed.

7.2.3 Comments on problems in the long-term planning

The process model

The establishment of a TAM concept within the EU would improve possibilities to harmonise demands as regards the infrastructure's standard and condition and give the international construction industry greater possibilities to compete in a larger, more uniform market. If there for example need to be claim differences between components' conditions, the TAM concept should have them very visible, so that values can be assigned in a uniform cost-based manner. Best Practice should be identified immediately to make it simple to implement international benchmarking at component level also in an LCC perspective.

With a constantly ongoing and flexible planning process "similar to a building permit procedure", perhaps in tandem with a normal one, where a project's funding is included as a factor from the outset, unnecessary planning effort and physical planning will be able to be avoided. The calculable state funding should be a declared willingness to pay to attain particularly important effects for society. The subsidy's proportion of a project's acquisition value can thus vary between 0% and 100%. As the physical planning progresses, the details of the standard deficiencies are updated in the transparent accounting. In the TAM concept the "best and newest" data quality is therefore always available to everyone.

Those projects that begin will very likely have secured funding, which means that expectations will also be balanced. Financially, every project is treated individually but will be assessed with a holistic view of the transport system. Several measures will therefore sometimes need to be assessed in one context. Responsibility for the quality of the project calculations rests with the people running the project. It is also they who first and foremost bear the responsibility for financial deviations. A few years after the project has opened for traffic an actual cost calculation is made in respect of the effects obtained. This calculation leads to a final settlement of the state's funding. Repayment of financial debts is made through a simple efficient road pricing system.

This or an equivalent concept, which is supported by the quality-related accounting, leads to considerably shorter lead times in the planning process. The efficiency, flexibility and transparency of the process increase at the same time as participating players' and other stakeholders' expectations become realistic. The incentives to hold back price and cost increases for those who are to be responsible for the funding will be based on sound principles.

There can hardly be any intrinsic political value in preventing an investment that has predominantly positive effects on environmental, industrial and societal development. An investment may for example have a distinct and positive effect on the reduction of greenhouse gases. The total net present value ratio may not be sufficient for the project to be prioritised in the plan. Or there may be political reasons for a project being given lower priority in the plan than it should have in theory.

With a reasonable proportion of state funding, parts of the local community and trade and industry might in some cases be able to provide the remaining funding. The state funding could be calculated equally in all projects in respect of for example effects that are particularly important to attain for society in general. The local community and/or trade and industry would also be interested in obtaining further effects from an investment. There might be many reasons for local co-financing. It might for example be a matter of urgency to reroute traffic to reduce disturbance or risks in densely populated areas or make development of new areas of land possible.

Inefficient plans can partly be counteracted by laying responsibility and the consequences of incorrect calculations on the people in charge of implementing the project. The principle that every project be treated individually from a financial point of view would also mean that conscious or unconscious errors do not impact other projects. The Government is willing to pay for specified effects and no others. When the actual cost calculations are made, the final state undertaking is fixed on the basis of the actual outcome in respect of the effects concerned. Any occurrence of projects that are not implemented due to incorrect or unfavourable calculations will still make the plan troublesomely ineffective. However, openness and transparency in the TAM concept enable extensive external reviews to be made of the information used in the planning process.

The proposed continuous planning process increases flexibility and may possibly satisfy a need for better interaction between the planning of the transport infrastructure with other physical planning in society. New needs would not then need to wait for the next planning round. They would be unaffected by freezes in the plan and would not need to compete for priority in the plan. Even if this were to succeed with today's model, it may later be found that insufficient funding nonetheless leads to unsuccessful interaction and coordination of society's investments.

Prerequisites in the TAM concept

In the basis for decision, the TAM concept has introduced a customer perspective also in existing actual relationships. All known functional deficiencies in standard and condition are documented with cost-based value appraisals. Value appraisals of road capital are based on effectiveness demands and customer requirements. Documentation of deficiencies is a fundamental precondition for it to be possible to systematically implement customer-related improvement efforts effectively. The quality-related accounting of road capital makes it possible to select deficiencies described according to "best available knowledge" for any sections of the road network and make general analyses of:

a) Cost-based standard target values, replacement values, condition values, the remaining consumption margin and differences between on the one hand standard target values and replacement values and on the other replacement values and condition values.
b) Data on expected consumption, maintenance or replacement costs and accumulated life cycle costs for every component in the entire state-administered road network or totalled by component type.
c) Cost of applying measures for different kinds of deficiencies in standard and condition per component type.
d) Effects for road-users and society and net present value ratios for measures to rectify deficiencies.

At the time of planning, the quality of information about costs and effects of conceivable measures varies. Data on traffic and traffic flows also constitutes important information in the socio-economic calculations. The TAM concept contains all identified standard deficiencies, systematically documented and linked to the road network with quality-certified information. The status information indicates whether the figures have been assessed using standard values or produced at one of the stages in the physical planning process. If the net present value ratio is not sufficiently high for a measure to be entirely funded by the state and included in the ordinary plan, it should be easy to give a preliminary figure of how much the state would contribute through co-financing or a state subsidy.

The complete TAM concept should make it possible to make a computerised review of all standard deficiencies with their associated proposed measures in respect of financially assessed effects for road-users and society cost-effectively for the entire road network. The object's total cost-effectiveness can be shown together with an estimated preliminary state subsidy based on the effects taken into consideration by the state when deciding on funding. Correspondingly, all components in the road network that were considered in the review to belong to the *Maintenance backlog* group can be listed and analysed. The TAM concept would facilitate more flexible continuous planning.

With the full TAM concept, it would also be easier to make general analyses of goal attainment with alternative approaches as regards measures within regions and nation-wide and assess fairness between different regions. The size of the maintenance backlog in different regions can be clearly illustrated and taken up in a discussion of fairness between generations. It is also possible in the long-term plan to set goals for the internal improvement effort in respect of expected reduction in quality deficiency costs, increased productivity and efficiency, and also follow up goal attainment by computer (see Chapter 5).

One important aspect is that the information in the TAM concept is generally accessible, enabling many of the analyses to be made at a central level. This reduces the risk of manipulated, misleading and tendentious information.

The full TAM concept strengthens the bases for political monitoring and control. Control can be exerted transparently through the standard approved by the politicians and "worst acceptable" condition being allowed to form the foundation for the value appraisal. They would also be able to decide what differences between municipalities can be accepted in comparable circumstances. It would be easy for the politicians to follow up deviations against the stipulated standard and limits for condition, efficiency and productivity development, the volume of "maintenance backlog", price trends and, for example, the development of road management's cost drivers.

To summarise, it is clear that the eight problems (points) under the planning prerequisites can all be resolved with the TAM concept, since:

- All known deficiencies and needs for measures are systematically documented according to "best available knowledge" and with road linkages in the road and traffic data bank (RDB).
- Municipalities have continuous access to all documentation relating to deficiencies according to "best available knowledge" for control, complementary additions, dialogue and funding planning before beginning any process.
- The SNRA provides all the investigatory materials for every possible project and any advantage as regards knowledge and information is kept to a minimum.
- Information in the RDB is updated continuously with "best available knowledge" and kept easily accessible together with all the underlying material (e.g. initial information about deficiencies, preliminary study, investigation, work schedule).
- The planning process begins individually when the initiative is taken to carry out a measure without waiting for an official commencement time. The process is as long as needed in order to secure funding and all legal requirements in the physical planning. Different activities in the physical planning can run in parallel provided that the applicable legislation is adhered to.
- The list of objects in the plans can be continuously added to with projects where state funding is estimated to be equal for all projects with an established willingness to pay for effects that are particularly important for society (e.g. reduce emissions that affect the climate). No sensitivity is needed but implementation according to applicable legislation in a process similar to a building permit procedure with a defined responsibility also for funding (perhaps containing a simple road pricing system).
- Prioritisations apply only to those projects that are 100% state-funded because there may, among other things, be capacity problems in the organisation. The physical planning will probably also lead to a natural order of priority regulated by how complicated the different steps are.
- The regulatory framework for how the state's willingness to pay is to be estimated must be clear and to a large extent standardised in relation to for example traffic, length of road, speed, emissions, and safety on a well defined part of the total transport system. An investment in public transport should for example be able to count in the effects of a

reduction in commuting by car. All projects are as far as possible calculated objectively and verifiably using the same regulatory framework.

With an open presentation of "best available knowledge" concerning deficiencies in the traffic system, different stakeholders can plan for important improvements. A simple example is given in Appendix 7.

Fairness between generations and regions

Using the quality-related accounting, funding problems of the “maintenance backlog” kind can be balanced and verified in detail by region, road network, component type, etc. The information can be verified and its plausibility assessed in the external audit and presented in notes in the balance sheet. Externally verified analysis results regarding the road network’s standard and standard deficiencies can also be presented in a note together with the effects achieved for road-users and society from rectifying deficiencies.

With the examples of information given above and other pertinent details from the balance sheet, the long-term planning can facilitate analyses of fairness between regions and generations. Algorithms for control limits, which can be defined in the long-term plan, should naturally also take this kind of fairness aspect into account.

In the quality-related accounting the value appraisal of the road capital is cost-based and condition-related. It contains correct information about opening and closing balances and actual road management costs according to “best available knowledge”, for example for single years, five- or ten-year periods.

Using the information in the quality-related accounting a computerised forecast can be made of when and how much funding will be needed for each component in the future. Among other things, every component has information about its current condition, consumption horizon, historical actual annual consumption and costs of measures. Totalled annual funding needs, for example for the next ten-year period, can be selectively compiled, for example by component type, road network and region. In addition to this it can then be added the funding of “maintenance backlog”, retrieved from the system, for the same selection of roads. For a selected road, all known deficiencies in standard with the assessed cost of rectifying measures and the most important effects for road-users and society according to “best available knowledge” can also be presented.

The control limits that can be defined in the plan concern components’ acquisition values, standard values, condition values, annual costs, LCC costs and, for example, the total value of component types’ maintenance backlog. Open, quality-related accounting would make external verification of the quality of both the information and road management more efficient, since there are so many stakeholders in the transport system. Any unacceptable differences in quality between regions and the transportation prerequisites of competing trades and industries would be easy to detect.

After the mid-1970s most investments have in plans been ranked by descending socioeconomic effectiveness (the first year’s return or net present value ratio). In addition to this, county administrative boards, county councils, local authorities and other stakeholders have stated what special investments they would like to see. The road network’s standard, condition, deficiencies in standard and condition relative to requirements derived from the objectives of the transport policy and the effects of the deficiencies for road-users and society can be presented in maps and tables in the TAM concept. This basic information according to "best available knowledge" of road capital, deficiencies and deficiencies' effects should constitute valuable basic information for planning in a fairness perspective regardless of planning model.

During the planning process some regions and county administrative boards will usually complain that the distribution of road appropriations is not in reasonable proportion to needs and, for example, the region's proportion of the country's population, GDP or the region's other infrastructure construction. The TAM concept (quality-related accounting) can in a flexible way for example by geographical area, and changes over time illustrate:

- the road capital's replacement value, condition value, and standard target value,
- the deficiency values in standard and condition,
- the maintenance backlog per component type,
- the effects for road users and society of suggested measures,
- the most likely needs of financing to keep all components in "healthy core" condition,
- the road management ineffectiveness per cause and contractor.

The values of road capital and their development can be put in relation to other information about traffic effort, speeds, etc. Underlying information for political decisions can thus illustrate the prevailing circumstances in a nuanced way.

Flexibility and effectiveness in the planning process

It is hardly possible not to share the main thrust of the opinions and needs expressed in both Swedish and European ambitions. The planning process will, however, take considerably longer when all complex contexts, aspects, considerations and respites are to be satisfied in a practicable plan. Flexibility can be expected to fall unless nothing drastic is done about the present order of things and funding. Longer lead times will at the same time make coordination with society's and trade and industry's other planning difficult and probably also reduce trade and industry's interest in taking responsibility for parts of the infrastructure's funding. Once again, it is clear that it is not viable to involve a great number of players in the process only to later experience the disappointment of not being able to fund the plans. The European Union's view that the transport sector must gradually become more "self-financing" can hardly be ignored. This means at the same time that the responsibility issue needs to be reviewed.

In the TAM concept, the road manager provides quality-assured, relevant and easily accessible road, traffic and effect data. Other investments in society should be able to be coordinated with other measures in the physical transport infrastructure in a natural way. Changes are constantly taking place in society, for example a company locating a certain facility in a certain place – changes that should logically influence roads' need for standard and planning. The quality-related accounting contributes to consequences of such action or an initiative undertaken in society's interest can better be analysed with a system view before any decision is made. Decisions can therefore be made with a good idea of the effects on the transport system. The forecasts of how traffic will develop upon which planning is based and the changes in traffic flow(s) that measures will lead to, also affect the consumption of road capital and future funding needs for maintenance.

As mentioned before, planning should also include the funding of infrastructure measures. Their planning should be able to be done continuously or whenever the need for infrastructure measures is brought up by society or trade and industry. Planning that includes funding reduces uncertainty as to when a measure can be carried out and should contribute to making expectations realistic. Figure 7.2 is an outline sketch of such a planning model.

In the proposed model, the state's financing function works to an established, known regulatory framework for the state's willingness to pay for certain effects. On the basis of the assessed effects of the measure, the total amount of state funding can be calculated for the project. As the project develops, formal requests are submitted to the financing function on three occasions. The function responds with conditions and financial advance notifications. Once the project has been opened to traffic and has been in operation for a while, a final settlement is made of the state funding in respect of a number of parameters that are important as regards willingness to pay. The settlement is made with regard to the party that has driven the infrastructure measure and that has pledged the required collateral. Construction credits are converted into loans that are paid back via a simple road pricing system where the terms and conditions and repayment priorities follow pre-determined rules.

After every phase of physical planning, a request for "state building permission" is submitted to the function. The function issues an advance notification and terms and conditions relating to the building permission request, which together with the funding notification constitute important input data for the next phase. A decision on the building permission question is made when the work schedule is adopted.

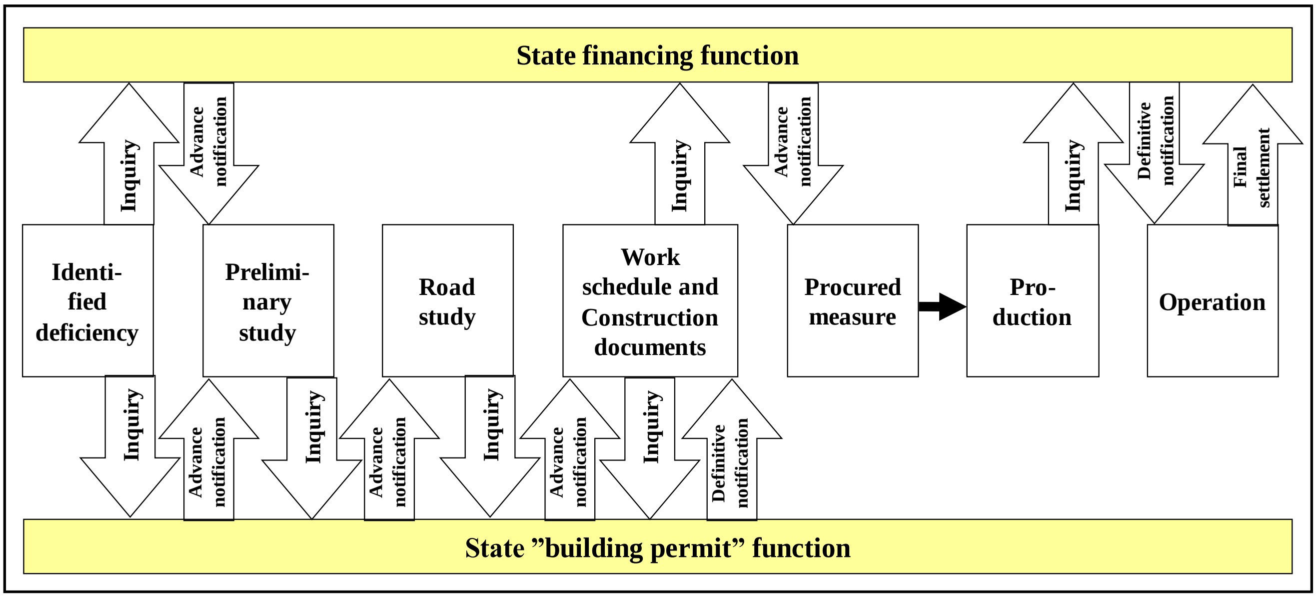

Figure 7.2 Interaction between physical planning and building permission and financing functions

The last two points (about effectiveness and the goal conflict) are important but demanding. Initially they may lead to a planning process that is even more difficult to overview and has considerably longer lead times. The TAM concept offers a systematic, structured approach that with knowledge of resource inputs and their proportions allows LCA to be performed for every component type. The knowledge gained of total energy and environmental aspects can gradually be introduced into decisions on plans and operative road management. Simple road pricing systems can also be used for financial traffic control. The effectiveness of the planning process can increase as quality-assured, good knowledge and underlying information becomes available at the very beginning of a measure's planning process. It will also increase as the process can begin when a need arises and not a few years later when a plan that is in effect is beginning to become obsolete.

Other phenomena, adaptations and developments in society may require information about deficiencies and risks in the transport infrastructure. As was made clear above, society and trade and industry need a flexible planning process. Clearly expressed visions and objectives are necessary starting points for such a sound, flexible process. At least in the short term, it may be relevant to for example use the "state's willingness to pay" technique to reduce certain costs, for example in respect of transportation vehicles, traffic accidents, emissions of greenhouse gases, and regional imbalances.

There are several reasons why many people who have been involved in the planning process have with a feeling of disappointment found that the plans' "promises" are either very delayed or in many cases fail to materialise. For example:

- cost increases occur in ongoing projects or new ones that start up,
- reprioritisations are made soon after the plans are fixed, for example for reasons to do with industry policy,
- complaints are made about projects with early start-up dates in the plan, leading to delays and unfavourable adjustments to the plan,
- the wrong indexes have been used to calculate the prices of measures in the plan or the appropriations that are needed to carry them out.

The complex system linkages that SIKA points out would rather seem to indicate that the lives of the plans can be expected to be shorter and that the need for flexibility will increase. Proposals concerning coordinated planning between the agencies and SIKA in a permanent organisational form should mean all in all more efficient planning with demands for greater competence in the planning process.

Another conclusion might be to completely abandon the unified planning ambition, since the issues become so complex that it is pointless to even try to achieve "lasting optimum solutions for a complete system in a state of technological change". Regardless of ambition and conclusion, the need remains for society to provide good basic information and data in respect of the actual situation as regards transportation. Without good quality basic information, no effective investment decisions can be made.

A socio-economically effective development of the planning process would be to plan and assess needs as they become apparent instead of waiting for the next planning round. In the sketched alternative planning process, a review would be natural every time a project's preconditions change in any respect. The funding issue is present at all times with fair co-financing requirements.

The EU document declares both that new infrastructure is expensive and "requires proper management, maintenance, upgrading and repair", and that the transport infrastructure has hitherto given Europe a competitive advantage. In the face of stiffening international competition and tough financial budget scrutiny by the state, the TAM concept's customer-related arrangement of costs and effects can provide a better basis for planning infrastructure management.

Price trends and cost drivers

For some component types the influence of resource inputs with substantial price increases is substantial. The TAM concept continuously monitors critical resources' price trends, the component-specific construction indexes and road management's cost drivers. The client, who is the one who approves the long-term plan, should define the control limits that will apply during the planning period.

In the long-term planning process, any problematic index development would be able to be shown quite clearly. Price development targets and control limits should be able to be defined. For the component types and resources that show the greatest price increases and relative price increases, strategies should be drawn up, for example in connection with operational planning, to try to slow the trend. Resources can be assigned to research and development of products and work methods. Experiments and trials can be conducted to find alternative technical solutions. Different business-like strategies can be worked out, for example new partners or forms of contract.

Follow-ups of long-term plans

In the TAM concept the development of resource prices and the prices of component types can be analysed in different ways (via official indexes and via actual price trends). Cost drivers are such resource prices that to a particularly great extent need to be monitored and followed up. For the period up to the next plan, a plausible, acceptable price trend can be specified with values for both "warning limits" and control limits. Using the control limits that have been set, both theoretical and actual price trends can be monitored by computer and followed up for component-specific construction price indexes, specified critical resources, and for cost drivers.

The projects should be documented in an appropriate manner in the plan (see section 4 below). It would then be possible to also follow up and analyse any deviations that arise in the long-term plan, and determine their causes, in connection with regular operational follow-ups. In this case, deviations are divided into causes dependent on time, quantity, and unit price. Control of how the long-term plan and the individual road projects are implemented is important for the continued planning of the funding.

Some examples of possible continuous follow-ups of the long-term plan that could be computerised in the TAM concept:

- deviation against the plan's estimated price trend per resource input,
- deviation against the plan's estimated price trend per component type,
- deviation against the plan's estimated price trend for cost drivers,
- projects' cost deviations distributed by causes dependent on time, quantity, and unit price,

- deviation against the plan's estimated reduction of the "maintenance backlog",
- deviation against the plan's estimated productivity improvement,
- deviation against the plan's estimated reduction of quality deficiency costs,
- deviation against the plan's estimated improvement of the component types' average LCC,
- changes in the road capital's condition values and different types of standard deficiencies distributed by different road networks, types of road, regions and, for example, municipalities.

One of management's most important management tasks is to actively drive the improvement effort according to the ambitions in the transport policy. An effective improvement effort requires system and quantities for value, cost and effect that can be followed up. These preconditions exist in the quality-related accounting. The planning process is already today resource- and time-intensive and will become even more comprehensive if more requirements are introduced. There is therefore good reason to examine whether it is possible to tone it down to perhaps only comprise the largest investments and focus on investments that concern several types of transportation and need to be coordinated time-wise.

It should be possible to express transport policy requirements to a large extent in terms of measurable key ratios and limit values for the road network's quality. Such quantities are measured continuously in the quality-related accounting in respect of the infrastructure's standard, standard deficiencies, condition and condition deficiencies. It also includes information about effects for road-users and society, calculated for example for a rectified standard deficiency. With efficient continuous follow-ups of relevant key ratios the importance of the planning process would be able to be toned down, at least for minor measures.

It would be possible to monitor this type of key ratios and limit values determined in the transport policy by means of the system. To achieve as efficient a transport system as possible, the infrastructure manager's responsibility would then need to be supported with the authority to review the operations for minor measures (and investments) within the limits of the key ratios.

Today's shared responsibility and weak monitoring and following up is hardly a successful concept. Clearer responsibility for the quality of the physical infrastructure, a new funding concept and a more efficient planning process would give rational opportunities to monitor quality development in a meaningful way. Following up the responsibility for what actually takes place in the road network would thus become more important in control and monitoring than in planning.

7.3 Operational planning and follow-ups

7.3.1 General

Operational planning, budgeting and follow-ups are important elements of internal control. The Swedish National Financial Management Authority (ESV) describes internal control [90] like this:

[90] National Financial Management Authority, http://www.esv.se/top/ordbok.4.381a53100506cbef9800045.html, 20 July 2007

> "Internal control comprises both financial control and performance management. Internal control also comprises both administration-oriented control instruments and instruments for internal control. Examples of administration-oriented control instruments are leadership, organisational culture, organisational structure, distribution of responsibility, planning and follow-up dialogues and quality assurance. Examples of instruments for internal control are rules and procedures, e.g. authorisation rules.
>
> Authorities' internal control, in the same way as all control, must be adapted to specific situations in order to be successful. Adaptation to specific situations refers to adaptation not only to the type of operations, the size of the organisation, and external factors, but also how far development of the authority's internal control has progressed."

Operational planning is thus part of performance management and budgeting is part of financial control. According to ESV:

> "Within the state, the concept of financial control has been adapted to the state's operations and activities. Since the objectives of the state's operations and activities concern both finances and outcome of the operations and activities, the concept of economics control has been defined to comprise both performance management and financial control."

The relationships between performance management and financial control in economic governance are shown in Figure 7.3 [91] and are described by the Ministry of Finance as follows:

> "Economic governance in the State is based on overarching political visions and objectives. Given these visions and objectives, performance management means that the decisions regarding objectives and focus for different types of operations should be based on documented results and experience. The financial preconditions should be in balance with the objectives and performance requirements established for the authority. The planning phase of economic governance, with decisions on goals and frameworks, therefore assumes a follow-up and evaluation phase where the total result is assessed, i.e. both goal attainment in performance management and resource consumption in financial control and the relationship between them. This assessment constitutes a basis for decisions concerning objectives, orientation and resources. Properly functioning, efficient government operations assume that financial control and performance management not only complement each other but also interact well. It also assumes that all stages in the decision and implementation chain take responsibility for their part of the process as regards clearly expressed aims and guidelines and also in respect of good quality bases for decision."
>
> "Performance management has a definite meaning within the scope of economic governance that means that the goals in the form of authorities' performance and/or effects in society are linked to government resource input to a greater or lesser degree."

[91] Management control for effectiveness and transparency, Ds 2000:63, ISBN 91-38-21333-8, ISSN 0284-6012, Ministry of Finance, 2000, Stockholm

"The individual operations' purpose, nature and preconditions vary, however, and economic governance must therefore be adapted to different needs. In other words, it must be adapted to operations."

"Economic governance has a central role in political decision-making as regards financial and budgetary policy and in the day-to-day administration of government operations since it defines the framework for their scope, orientation and content, and resource consumption. Economic governance that is mainly practised within the scope of the budget process is at the same time part of a larger control perspective – public administration policy."

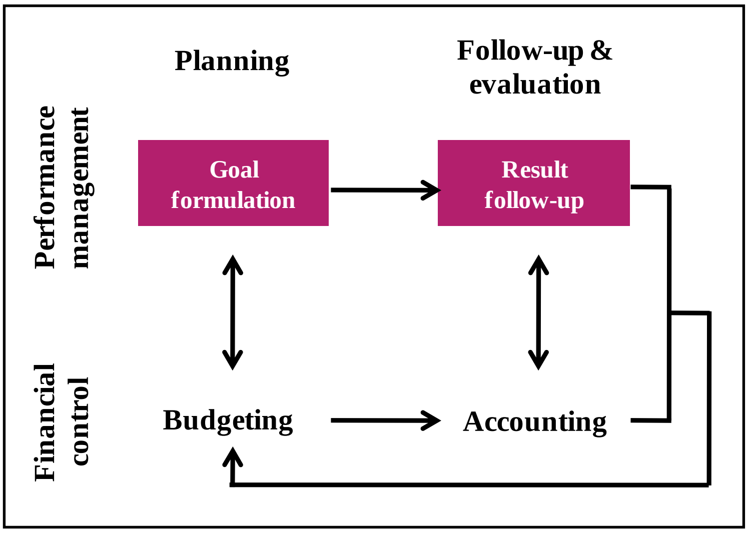

Figure 7.3 Relationship between performance management and financial control

"The purpose of public administration policy is to create forms of organisation, control and management that provide prerequisites for the three basic values *democracy, legal security and efficiency*. These values require that public administration:

- execute its duties in accordance with the decisions made by Parliament and the Government,
- make materially appropriate decisions on the basis of legislation and other statutes and that individuals shall be accorded the opportunity to have their case heard in a court of law, and
- achieve intended results and attain the goals set by the Government and that this shall be done cost-effectively."

According to ESV:

"Economic governance is a tool to realise policies. Parliament has decided the following goals for economic governance:

- create prerequisites for good control of the state's finances
- allocation of resources in accordance with political priorities
- high productivity and efficiency in the use of the state's resources."

Over the past 25 to 30 years, political control of the SNRA’s operations in annual letters of appropriation has undergone a substantial change. This is described schematically in Table 7.1 and Figure 7.4. It can be seen that the number of personnel restrictions, appropriations, allocations and regulations of a financial nature has gradually fallen while the number of elements that may be regarded as management by objectives and assignments has increased. The requirements regarding feedback to the Government have also changed.

Year	Personnel restriction	Appropriations	Approprtiation items	Operational goals	Key ratio reporting	Feedback requirement regarding	Financial regulations	Assignments
2003	No	3	12	25	Yes	Operation objectives	No	6
1992	No	11	25	0	No	Transport policy objectives	Yes	5
1978	Yes	12	47	0	No	Performance	Yes	0

Table 7.1. The Government’s letters of appropriation to the SNRA, 1978 – 2003 [92]

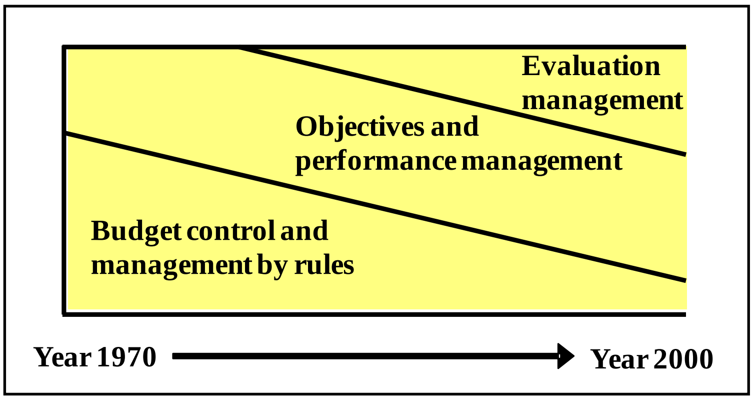

Figure 7.4 Transition from budget and management by rule to evaluation management [93]

7.3.2 Problem overview

Annual planning,

Once a year the infrastructure manager’s internal planning process is based on fixed long-term plans, interpretations of the transport policy and its objectives and the Government’s letter of appropriation. It is done iteratively against the established financial frameworks (allocations and any approved procurement). Operational planning is conducted as an element of performance management and must among other things:

[92] Presentation by Ulf Lundin, 2003
[93] Figure by Mats Stigendal, 2003

- comprise a three-year period with the highest precision for the first year of the plan based on underlying information of higher quality than in the long-term planning,
- be oriented towards "optimising" and coordinating resource utilisation within actual road appropriations, so that the highest possible productivity is attained,

The internal directives that are drawn up for each operational planning round have gradually become more extensive. The prerequisites have been repeated year after year in longer and longer texts. For the more strategic sections, a separate planning document has been produced. "The strategic plan" [94] with its in-depth documents is an internal steering document, the purpose of which is "to remove decisions of a more strategic nature from operational planning."

This is also a way of increasing "the interaction between divisions and the national level, at the same time as the amount of work required to draw up the annual operational plans" is reduced. In the balanced scorecard technique it is also appropriate to work to a strategic operational plan.

In the strategic plan, which has been approved by the SNRA board, interpretations are made of the transport policy, concrete values and overarching priorities. Problems and challenges are identified that can be addressed in road management. The SNRA's role in society is clarified and the authority's ways of working described. The transport policy's requirements and road-users' needs are interpreted with a holistic view of internal goals and strategies with estimates of the resources required to implement them. Within the scope of the strategic plan, documents are drawn up by the respective divisions that among other things show the division's contribution to fulfilment of the plan that is to be implemented. Figure 7.5 shows how the various documents are connected.

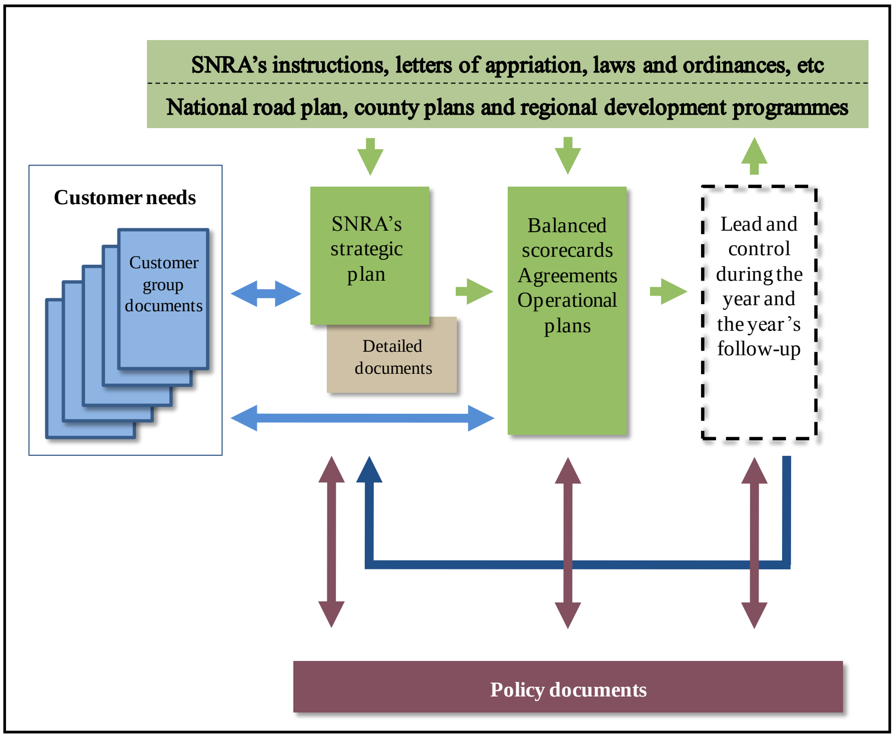

Figure 7.5 Documents etc in the SNRA's planning and control of road management

[94] Strategic Plan for the SNRA 2005-2014, SNRA publication 2009:56, ISSN 1401-9612, 2009:05, Borlänge

Agreements are reached between organisational levels at the SNRA in so-called balanced scorecards with the five focus areas Client focus, Customer focus, Internal/Financial focus, Development focus and Employee focus.

Budgeting

The final approved budget is a consequence of the planned operations and forecast future financial events at the time the budget is drawn up. In road management the budget comprises planning balanced costs relative to known revenues – revenues that in all essentials consist of granted appropriations. The operational budget is detailed as regards projects, processes and performance and organisation units. Performance is a concept in planning, budgeting and follow-up activities, that in the case of road management refers to those services and products that the SNRA is to deliver to society and road-users. Reporting to the client is to be made with an emphasis on these deliveries and on certain effects that are achieved.

Performance is about how the SNRA in monetary terms carries out the work that according to the planning should correspond to a functioning network during all hours of the day. It also concerns the execution of measures relative to those in the long-term plan in different road networks in different parts of the country. The plan contains operational, maintenance, improvement and new construction measures that to some extent have been judged to correspond to society's and road users' needs. It is essential for the client to be able to monitor performance relative to the appropriations granted, productivity development, measures decided in approved plans, and effects in the transport policy.

Quality problems in the bases for economic governance

According to a parliamentary decision, economic governance is a tool to realise policies. The governance must create prerequisites for adequate control of state finances but also make it possible for the resources to be distributed in accordance with political priorities with high productivity and efficiency in their use.

For one of the state's single largest assets, viz. road capital, there is a need to improve financial control. In road management, resources are in all essentials allocated according to political priorities. In many cases, priorities would have been different if the bases for decision had been of higher quality. For example, investment projects often prove to be subject to substantial cost increases. With more accurate details of costs, a project's lower net present value ratio might have lowered its priority in the plan. A cost increase in a high-priority project also leads to postponement of subsequent projects, effectively making it more difficult to coordinate with other undertakings in society. No reliable information exists for assessments of productivity and efficiency.

No details exist of state road management's annual consumption costs in respect of different component types in different road networks, for different parts of the country, for specific roads and in total for the whole country. Today, the appropriation for operation and maintenance is perceived as the cost of road management, which would mean that if no appropriation is granted for a particular year, the cost of road management is also zero for that year. The road manager compensates kind of misleading information by reporting the volume of "maintenance backlog" – a volume that for instance would increase in a year without appropriations. The consequences of low appropriation levels and inefficient road management are described with a figure for accumulated, unfunded maintenance needs (Mbl). In external checks, the figure has proven to lack credibility (see Chapter 6).

Follow-ups

The follow-ups of the budget or operations that are conducted today focus on being able to report how appropriations have been used. The linkage to the long-term plans is not really clear. There is no information about the actual cost of administering the road capital. It is difficult to identify best practice at the authority because no real benchmarking is done.

Before invoicing on account began to be applied as a matter of routine, it was very difficult to allocate items to periods and make forecasts. With invoicing on account the invoices will follow an established payment plan and not actual production. If invoicing is also postponed until after the turn of the year due to ordered changes and additions, the forecast over the whole year will largely be the same as the budget. The following year's budget for the project can then take extra orders from the previous year etc. into consideration. Any difficulties in making a forecast will only concern the orders and other adjustments that are made during the last year of the project.

In other respects the follow-up will comprise quality deficiencies other deviations to the extent that the project manager chooses to report them. In "normal cases" no systematic, independent checks and analyses are made of how the projects are progressing other than in scheduled random checks in connection with internal quality audits. External quality auditors often take part in the review of how the project's quality assurance system is functioning.

Observations with regard to quality, for example in connection with the final inspection (good or bad examples) are today documented in the quality system but are not reported to the internal accounting. It is therefore difficult or impossible to identify financial information with regard to observations made in respect of quality.

Six main points

The process is intended to create prerequisites for monitoring and controlling the organisation's operations and activities on a continuous basis. Road management's problems are not about reporting what the appropriations have been used for, but the resource allocation itself and the description of how well the appropriations have been used and the results of this use. The lessons can be summarized in the following six main points:

1) Misleading accounting of road capital and of road management's costs.
  a. impedes continuous measurement of road management's goal attainment
  b. impedes continuous control of road management's productivity development
  c. impedes continuous control of road management's efficiency development
  d. impedes stimulation of the road construction industry's productivity development
  e. contribute to slow development of forms of contract and cooperation
  f. lead to quality deficiencies in reports to the Government with reduced credibility as a result
  g. lead to uncertain political control that can restrict the road manager's possibilities**,** to be given access to appropriate, more flexible funding and to be given greater responsibility for customer satisfaction and goal attainment.

2) Resource allocation, control, monitoring and analyses are made more difficult by the deficiencies described in 1) above, since
a. there is no systematically documented relevant information about standard deficiencies and condition deficiencies
b. there is no objectively appraised description of the status of the roads' components
c. road management's cost follow-ups are misleading for different roads around the country.

3) The "maintenance backlog" figures are an attempt to compensate for the deficiencies in 1 above:
a. for which neither their components nor structure can be identified**,** verified or followed
b. that have low credibility both inside and outside the SNRA.

4) The deficiencies under 1 and 3 make analyses of road management difficult. The analyses are of the following types:
a. LCA of road management and of the road network's different components.
b. LCC of the road network's different components for different types of road in different parts of the country
c. benchmarking of road management's**,** components' and alternative executions' costs
d. cost driver analyses of road management (component types' price trends, expenditure costs and life cycle costs) .

5) Road management's quality and improvement efforts and learning are hindered by the deficiencies under 1 and 4
a. in continuous control and monitoring there are no early indicators of deviations that need to be rectified .
b. in continuous control and monitoring there are no early indicators of deviations that must be addressed in the learning process in order to be quickly taken up in later activities

6) The contract structure is not reflected in the accounting and is not harmonised with the needs of control, because
a. forecast quality, which is a consequence of the structure, has often proven to be low in maintenance and investment projects
b. inappropriate incentives and weak possibilities for verification as a consequence of the structure with all negotiations can contribute to cost increases
c. development towards the high level of detail in the AMA model, probably increases the contractors' already high cost of administering the contract *and*- makes the project manager's work on forecasts more expensive and more difficult to improve (see section 7.5 below).

All in all, there are a great many problems with considerable improvement potential in the existing costly model for financial control and monitoring via operational planning, budget, follow-ups and analyses. The problems affect not least the learning and issues regarding road management's credibility, incentives, improvement efforts, efficiency and possibilities for alternative funding. The intention is to clarify whether the proposed TAM concept can create a foundation for developing continuous financial control of state-administered road management.

7.3.3 Comments on the problems described

Misleading accounting (points 1 and 2)

In theory, budgeting is used for financial planning of solvency and results during the period, and the financial position at the end of the period. In road management, the balance sheet does not have the importance that it should be able to have. This is first and foremost due to the existing principles for the accounting of road capital. These principles result in the information in the balance sheet not corresponding to the needs of control and monitoring of road management operations. The low value of the information has been known for a long time [95].

Every road management region has hundreds of road projects under way over the course of the year. A great many of these projects turn over millions of kronor a month. Regional management may find it difficult to review the financial status of all projects on a regular basis. In principle, financial control involves financial control of defined projects, assignments and activities/operations against the budgets fixed for them and the appropriations granted. Experience has shown that the budget is normally relatively high at the beginning of a project. When invoicing on account is applied, there is therefore a risk of over-invoicing at the beginning of the projects, because the contractor is also endeavouring to achieve the best possible solvency in the projects [96]. Invoicing on account reduces the client's deviations against budget. At the same time, however, capital utilisation becomes less efficient.

With appropriately designed contracts (see section 7.4 on procurement) cost deviations can be analysed by computer. Deviations over the contracted or budgeted period can be assigned to causes dependent on time, quantity, and unit price and uniform forecasts made. The client will thereby probably be able to use his capital much more efficiently and to a certain extent also his human resources.

Significant cause-dependent deviations can be detected early, despite the fact that the sum total of the deviations in a project may amount to very little or even zero kronor. This is a very important quality issue in monitoring and control. With the TAM concept, management has a good overview of any problems deviations as regards total production per appropriation with forecasts of good, steady quality. Deviation causes and uncertainties as regards quantities, unit prices and times can be handled with the possibility to make resource usage (appropriations and employees) more efficient. The bases for long-term financial planning linked to the approved long-term plans are also improved.

It is thus possible to improve project follow-ups. Financial control, follow-ups, monitoring and reporting do not today include the road capital's values, consumption costs or road management's total outcome or productivity. Somewhat incisively, we could say that unsatisfactory quality and unacceptable life cycle costs in respect of components will lead to

[95] Already when the SNAR first began booking road installations as assets, in 1994, the authority's management decoded to complement it in the internal accounts with a condition-related appraisal of the road capital. Information about the road capital's value, changes in value and costs would be used for control, monitoring and reporting of road management.

[96] E.g. the Internal Audit department's report makes it clear that Vägverket Produktion "in previous final accounts have reported a substantial increase in the balance sheet item 'Invoiced not yet generated revenue'".

new measures with project budgets without the organisation having access to knowledge from systematic learning.

The information about the maintenance backlog in reports to the Government is an attempt to correct the distorted picture that the accounts give at the same time as the message is that the amount stated is to be seen as the cost of as yet unfunded measures. It is implied that road management operations have been carried on as efficiently as possible and that it is a matter of new appropriations.

Identifying and dealing with deviations is one of the more important tasks in controlling and monitoring. In the TAM concept's process control (cf. Chapter 3) identification of deviations is extremely valuable. In addition to the possibility to take corrective action to minimise negative consequences for road-users and society, learning is important in the different sub-processes. Control limits are therefore used to make continuous control more efficient here.

In order to make monitoring of deviations more effective, a so-called factor algorithm is used. In the algorithm, the control limits are adapted to circumstances in respect of different influencing factors. A component's capital consumption over a year expressed per unit (generally metres of length) can then be related to the "normal" consumption for components with equivalent prerequisites according to this algorithm.

This technique of identifying successful and not so successful road management using control limits adapted to circumstances can be used to selectively conduct in-depth analyses of deviating components. A properly functioning learning process will therefore enable good practices to be copied nationwide on a large scale. Correspondingly, less successful practices will not need to be repeated anywhere else in the organisation. This part of control is included in the important change process. The approach is based on the perception that components that showed deviating costs both at an early stage and later on will show life cycle costs that deviate in a corresponding manner. Among other things, the discounting supports this.

Improvements in reporting follow-ups and monitoring should facilitate important actual cost calculations and analyses, in order, among other things, to be able to develop forms of contract and cooperation between road managers, consultants and contractors. They can also constitute important background information for reporting of road management to the Government and Parliament with higher quality than in the present annual report.

An important principle is that the TAM concept's information about standard deficiencies and condition values is available to everyone. External checks and dialogue are important to secure the best possible quality information in social planning.

When the politicians' monitoring possibilities have been sufficiently improved, it should be possible to open up for a less restricted kind of funding of road management. The road manager should be able to be given greater responsibility for the funding of road management. It should then be possible for the road manager to also be given responsibility for the effects for society and road-users of the infrastructure's quality.

Internal verification

Today the focus is on a contract's quantities in different work phases that have adjustable quantities. The contract concept forces the project manager, more often than not alone, to reach thousands of agreements on quantities with contractors in one or several projects. In practice, the quantities and the agreements are generally more or less impossible for anyone else to check.

Through the use of quality-related accounting of road capital the focus is automatically shifted to components that have largely verifiable quantities even after the project have been opened for traffic. Together with the control limits technique, this will improve internal verification quite considerably. We shall return to the issue of internal verification in Section 7.4 on procurement.

Maintenance backlog

This point concerns maintenance backlog and has been discussed in Chapter 6. The credibility of information about maintenance backlog should increase when the figures can be calculated by means of the system in the quality-related internal accounting of road capital. The analysis clearly indicates the components and the maintenance measures that should have been undertaken. The poor quality of the road network has meant that road-users have had to bear unnecessarily high costs. The funding of unacceptable deficiencies that are not rectified risks being passed on to future generations.

Quality-related accounting allows the situation to be monitored. Improvement targets for eliminating the “maintenance backlog” can be detailed and followed up. It is also possible to get an idea of how much can be funded by increasing efficiency in road management and reducing quality deficiency costs and how much must be funded by means of extra external resources. The follow-up is made per physical component and can be accumulated in different ways.

Life cycle analyses and benchmarking (point 4)

This point mainly concerns the possibility to make LCA and LCC analyses on the component level, and conduct benchmarking and analyses of road management’s cost drivers. Here the focus is brought to bear on the first three points; the TAM concept’s technique of using resource input analyses for acquisition values in respect of cost-drivers was dealt with in Chapter 4.

Quality-related accounting enables consumption costs and remaining consumption margin to be reported for each component occurrence. It is therefore possible to predict with reasonable accuracy when each component occurrence will be scrapped or reach its “worst acceptable condition value”. Component occurrences’ scrapping times can for example be compiled for those component types that have a negative environmental impact. Final replacements and disposals can be planned and coordinated in a funded multi-year project of known scope. Procurement can be made with a focus on certain component types with a certain type of environmental impact with requirements for secure handling of known volumes. This will then facilitate the practical handling of components’ entire environmental life cycles (LCA).

In the quality-related accounting a component’s gradually accumulated life cycle cost is followed up by computer taking both the interest rate used for costing and actual price increase into consideration. When the component type’s construction price index is updated, the year’s real discount factor is calculated and stored. The year’s value reduction without any price adjustments is a cost that can be converted to give the purchasing power the acquisition year. The six consumption models give different quality on component costs and their discounted values. Other costs that are paid after the acquisition date can be converted to acquisition year figures in the same way. The procedure will therefore elucidate the consequences of actual rate of consumption and the price trend.

Best practice can be identified and internal benchmarking facilitated from deviations against control limits. Both the gradually accumulated and final LCC should be analysed when new acquisition decisions are to be taken. There is also good reason to make continuous analyses of component types' different alternatives in view of variations in purchasing power and as regards future funding needs.

Learning and improvements (points 5 and 6)

The internal improvement effort requires among other things knowledge of what different things cost and what is good and what is not good. A rational improvement effort needs accounts that support the work. No special projects or external investigating resources should be needed to determine the costs of road management's products (road components).

At the present time projects for both investment and maintenance measures are very detailed in structure. It is obvious that the structures for example make forecasting and rational handling of deviations difficult. The structure fuels cost increases and low development of productivity. In order to investigate the possibility to raise the quality of the forecasts a test was made in 1997 [97], where the contractor submitted better basic information on the basis of the applicable contract structure, i.e. on the basis of priced quantities in the contract, Theoretically, it proved to be possible to handle the detailed information and deviations from the contract but the process was very time-consuming. Better quality with the existing contract structure was judged to involve too much administration to achieve and hardly defensible from a financial point of view.

The financial and technical knowledge about components has a clear customer focus in the quality-related accounting. Control limits are based on socioeconomic assessments and customers' expectations. Component occurrences that for example show deviating acquisition values, consumption and life cycle costs, can be identified continuously by means of the system. Deviating component occurrences can be identified early and analysed in depth. In the learning and improvement process good examples can be copied quickly throughout the organisation while bad examples can be rectified quickly to reduce negative effects for road-users and society. Early detection and fast learning can prevent bad road management being repeated. Summed-up the quality-related accounting of road capital makes it possible to systematically make computerised compilations of, for example

- changes in each component occurrence's replacement value, condition value (as regards index adjustment, improvement, maintenance, quality deficiency cost and consumption) and, for example, maintenance backlog,

- the same totalled by component type per road, road network, municipality, region, other area, contractor etc,

[97] Berth Jonsson, Lars-Erik Sollander and Knut Henriksson conducted the test on a road project in the SNRA's Central region. The contractor was Vägverket Produktion.

- development of productivity and efficiency and price trends in the handling of the road capital's different component types,

- cost drivers in road management in respect of important resources,

- status and changes concerning the road capital's different types of deficiencies in standard and condition,

- quality deficiency costs broken down by deficiencies in products or decisions,

- the parts of the cost deviations that are dependent on unit price, quantity or time in ongoing road projects,

- road management's consequences for the objectives in the transport policy regarding for example transportation costs, the number of people killed or injured on the roads, noise and air pollution, for example in the form of greenhouse gases, for components that are unsatisfactorily maintained or show standard deficiencies,

- the improvement potential for "inefficient road management" per, for example, road network and/or region.

7.4 Procurement

7.4.1 General

As long ago as the 1960s the procurement model for new construction was developed in Sweden into forms that are still recognisable in the SNRA's procurements. The forms for operation and maintenance contracts were based on the model for new construction but have mainly been developed over the past seventeen years, beginning in 1992. It was then that the "client and contractor" roles began to be used in operation contracts. At the same time, the directly ordered autonomous operations were gradually discontinued. Swedish road management primarily uses all-in contracts and performance-based contracts [98]. The life cycle aspect has begun to be discussed in the following terms:

> "The approach in the new Finnish procurement strategy is based on life cycle responsibility where the road manager's costs are optimised for construction and maintenance and must also cover traffic costs and environmental impact. The client first and foremost stipulates functional requirements and the contractor is given great possibilities for innovations and optimisation of the maintenance. The contract period in the model is 20-30 years."
>
> "In projects that concern maintenance work, the life cycle model is not used but the life of work carried out is spoken about instead. The model has been developed furthest as regards pavement work where rutting has been the criteria for pavement life."

In road management, performance-based contracts have for a long time been the predominant form of contract. Over the past decade the volume of all-in contracts in the form of functional

[98] SNRA, Customer-supplier Strategy, version 1, 1 September 2005

contracts has varied widely. The SNRA's forecast is that the volume of all-in contracts will stabilise at just fewer than 40%, i.e. at the same level as in 2006 and 2007. The basic packages' operation and maintenance contracts are all of the all-in contract type.

In Norway and Finland, more forms of contract are used than in Sweden. Statens Vegvesen in Norway, for example, has three major demonstration projects that comprise planning, construction, maintenance and operation over a period of 25 years. In the form of contract that in Sweden is called OPS ("Public Private Cooperation Project") the contractor is responsible for the funding of the investment. The corresponding form of contract exists in Finland under the name Public Private Partnership (PPP).

The contractor is paid by the road manager in a manner agreed for each OPS/PPP project. Payment may for example follow a payment plan or depend on the number of vehicle passages. The contract period is sometimes fixed and in such cases the contractor receives the total amount that the period permits. Other contracts may be valid until a certain total amount is reached. When the contract period has expired the installation is handed over to the client, normally without any further payment but often with a demand that the installation be of a defined quality.

In the strategy for the continued work on developing forms of procurement, the SNRA is endeavouring to increase efficiency in road management and improve forms of cooperation with the contractors. The focus is on developing the client's "procurement responsibility" into a clearer "operational responsibility" and the contractors' "resource responsibility" into a clear "production responsibility" as shown in Figure 7.6.

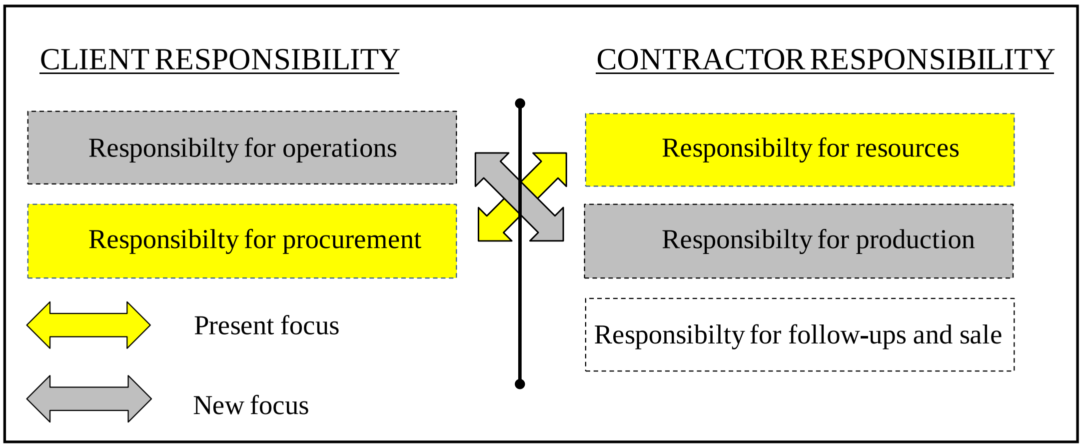

Figure 7.6 Outline of the strategic development's focus as regards the parties' responsibilities [98]

The work of improving the enquiry documents, standard and quality specifications and orders has been going on since the early 1990s. The improvements are a result of the endeavour to develop roles and responsibilities in the client-contractor model. It is a development that involves business risks, which is why progress has been so cautious in Sweden.

In the *Procurement* sub-process focuses on issues such as businesslike execution, distribution of risks and responsibilities between contractor and client the content of the contract and the contract's significance for the parties' incentives, internal monitoring and control, and consequences for the project manager role. It is discussed how the TAM concept can influence these aspects in present procurement and contract concepts. The problem description has been drawn up on the basis of a literature review, discussions with experienced purchasers at the SNRA and experience from analyses and building construction.

7.4.2 Problem overview

The SNRA believes that the quality of tender documents has improved in recent years. This improvement has led to the documents containing more requirements, which have become increasingly more comprehensive and complex. The consequence of this development is that risks linked to the requirements have increase and more time and resources are needed in the suppliers' work with tenders. The development of the tender documents may be one of the explanations why nowadays it is only the major contractors who are interested in operation and maintenance contracts. There are now only four major contractors remaining in the Swedish market, which is a problem in itself.

Low profitability and productivity development

General problems taken up in the SNRA's strategic plan are the low profitability and poor productivity development in the industry. It has been claimed for a long time that profitability has normally not been higher than 1–3%, to be compared with an ideal 6–8% to make it possible for the contractors to run development projects of their own. Productivity development has also been low despite extensive structural changes.

Cost increases in projects

Auditors' reports [99] and the strategic plan discuss projects' cost increases and the distributing responsibility and risk between client and contractor. The SNRA puts significant resources into continuously updating the calculation database in connection with procurements. On the basis of unit prices in the database the SNRA makes its own calculations in respect of road objects being cost by the contractors in order to check the tenders that are submitted.

Despite the client's calculations and assessments, the trend is that there will have been all in all considerably more cost increases than cost reductions by the time the projects are concluded. Cost increases mainly due to increases in quantities cannot be explained by errors in planning or deficiencies in project calculations. Regardless of what has been said about planning and calculations, increases in quantity are results of negotiations and/or agreements between the client and the contractor.

Furthermore we have to repeat that neither with the private players nor the road manager do life cycle perspectives extremely often comes up in the discussions about what measures are needed. The importance of cost increases therefore is completely unknown in a life cycle perspective. On the other hand may the lack of life cycle analyses be the most serious problem in the client's evaluations of submitted tenders. The client has insufficient knowledge of road capital's life cycle aspects as regards both energy, environment and climate consequences (LCA) and costs (LCC).

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[99] Annual Report by Internal Audit department for audit year 2007, AL 60A 2008:3475, adopted by the board on 14 February 2008
AL 60A 2008:3475, Internal audit of an investment project on national road 73, AL 60A 2007:24087
AL 60A 2008:3475, Internal audit of two investment projects on the E4 European Highway, AL 60A 2008:743

Deficiencies in internal monitoring and control

The procurement process and contracts must in as sound, legal and unambiguous a manner as possible ensure that requirements and agreements can be implemented in road management in accordance with the owner's expectations. Interaction takes place on the client side of road management between the democratically elected national politicians (the representatives of the owner) and the person responsible at the SNRA (the person responsible for administration in accordance with a distribution of work between board and Director-General).

The owner must get the person responsible for administration (the Principal-agent problem[100]) to do what the owner wants him to do (via the transport policy, plans, government letter of appropriation with appropriations, directives, etc). The person responsible for administration must in turn get his subordinates to do what he wants them to do (via plans, directives, goals, the budget, balanced scorecards, order of delegation, etc.) and so on down to the project manager responsible who is to do what his immediate superior wants him to do (via the budget, order of delegation, contracts, etc). The project manager must get the contracted contractor to do what has been agreed in the legally binding construction contract.

In the chain of players on the client side, there are a number of incentives for each player's actions. Example of the client's players' incentives and incentive-like factors are the following:

1. A working day free of conflict makes life considerably more pleasant than one filled with conflict. Conflict-free solutions, for example, are therefore chosen, with compromises and agreements, when an issue is judged to remain unknown to superiors in the organisation or when such a solution in any case would not upset any superior.
2. Disputes can for example arise when contract interpretations are claimed. Conflict-free solutions are chosen if, for example, it is known that a superior prefers to reward people who create peace and harmony in the organisation with a salary increase or promotion over people who are "always" creating disputes. Disputes that in extreme cases can even lead to personal "punishment" in all certainty lead to extra work for superiors and costs for legal proceedings.
3. In negotiations with contractors, cost increases can easily be approved if one's experience is that superiors accept explanations such as the increase being due to planning errors or uncontrollable factors such as a different technical solution due to prevailing circumstances, etc.

Relations between the project manager and the external site engineer follow the same pattern. The fewer the problems that end up on the project manager's desk the more the site engineer is appreciated. When more people in the chain submit information, the client may also end up in a situation where information "gets lost", is withheld or even becomes misleading when it is needed for negotiated agreements (adverse selecting [100]). The latter may even be conscious if the external site engineer's loyalties lie with the contractor. The risk of "Moral Hazard" situations [100] occurring increases, i.e. incorrect information is brought to light after an agreement has been reached and an unexpectedly expensive bill is to be paid.

[100] Economics, Organization & Management, Paul Milgrom, John Roberts, ISBN 0-13-223967-1, 1992, New Jersey

With growing knowledge of details in the project one is working on, a knowledge advantage will develop on the part of the contractor – an advantage that he will be able to put to use to obtain extra payments as soon as a suitable occasion arises. Below are listed a few examples of what the agent's (the contractor's) incentives can lead to in negotiations with the principal (the client).

1. The contractor "only" brings up for discussion the quantity changes that are to his advantage in a, tactically speaking, long-term financial perspective (creates trust or direct increases in income). The client's experience is that projects' quantities generally increase (see below).
2. The contractor will from experience open a negotiation with a high bid with a bargaining margin. The client, whose attitude is that an agreement reached with taxpayers' money must be sound and fair, begins the negotiation with an offer that can be justified if a check is made.
3. The contractor has the best internal information (private information [100]) and the own reward incentive is strong. An advantage as regards internal information will therefore be exploited to the full in order to maximise results and thereby one's own reward.
4. According to Swedish negotiating tradition, a negotiation always ends in some kind of settlement/compromise where both parties can feel satisfied on the basis of their opening bids. The players on the client side have a reward incentive to avoid "messy" situations and disputes that can be raised to higher levels in the organisation, as the contractor very well knows.

When a project is procured the client "normally" has the most comprehensive internal information. The client has for many years devoted his time to learning in depth about the project's circumstances and prerequisites. It is also the client who has driven the project to the point where it has become an approved work schedule with the details thoroughly discussed and complete with full specifications, construction documents and tender documents. However, it is a third party that has best information of all – the consultant who carried out the planning on behalf of the client.

Contractors who submit tenders work their way through all the documentation and can for a limited time make their own complementary studies. It does not need to be assumed that the preparatory work may include interviews with people who have worked on the project for the client. The worst scenario from the point of view of internal control is an established collaboration between the consultant and a contractor already during the planning phase and that incorrect quantities are consciously entered in the construction documents. The tender that is submitted does not only consider a production calculation but also tactical considerations based on other information about the project that has been acquired. It also reflects factors such as order status, available resources and financial prerequisites for a foreseeable period of time.

The contactor selected will in a short time have the best internal information. The amount of detail in a contract is probably important as regards the contractor's possibilities to use his internal information for price adjustments to improve his own results. The more details there are, the more "negotiation opportunities" there will be alongside possibilities to use his advantage especially considering the negotiating parties' incentives.

One damaging factor as regards internal control is also the fact that the construction industry does not have a spotless reputation. Profitability in the industry is asserted to be low and over the years many irregularities have come to light, including “bogus” invoices, cartels, bribery, “black work” and bookkeeping offences. The risk of irregularities cannot be underestimated and the industry must act to improve its reputation with the taxpayer. It is especially important that the client create prerequisites for the industry to be checked and “cleared” of any suspicion of criminal behaviour. Construction should be an exciting industry of the future that must find new sound forms of contract with better distribution of responsibility and better prerequisites for sound profitability and good productivity development. It is our conviction that the TAM concept can contribute to this.

Expensive contract administration

An experienced contractor has judged that contract administration in today’s concept with many thousands of adjustable quantities in major projects costs the equivalent of 1-2% of the total value of the contract. In later and new projects the even more detailed AMA structure will apply, which will probably lead to even higher administrative costs. For the total road management, including the client’s costs, this will probably entail unneeded costs amounting to hundreds of millions of kronor every year.

7.4.3 Comments on problems in procurement

General

The restructuring of the construction industry has led to a situation where only a few nationwide construction companies remain. The development of the tender documents with increasing amounts of detail and requirements may also have contributed to the fact that it is only the major contractors who have the capacity to be interested in operation and maintenance contracts in road management. The problem might be able to be reduced by inviting tenders for assignments that have simpler and less demanding tender documents, for example for upkeep of a few specific component types.

The quality-related accounting’s focus on components and component types makes it possible to have a tendering procedure whereby contracts for many years’ upkeep of one or several component types can be awarded in a controlled manner for extensive areas, along certain roads or in certain road networks. Data exists for producing computerised detailed tender documents with information about probable annual need for measures per component type for different road networks, roads or areas of roads. The TAM concept also means an immediate switch for the contractors from resource responsibility to a very clear production and product responsibility (cf. Figure 7.6), which is in agreement with the development that the SNRA desires. It would also be stimulating for the construction industry.

It might well also lead to several small but specialised construction companies with nationwide coverage that are very interested in developing certain component types and making production methods, plant and tools more efficient. With road management that has its focus on handling the climate issue and resolving the life cycle problem, there will in all certainty be competitive alternatives to the present component types and production methods. The road manager’s unambiguous responsibilities mean that problems and desired development must be clearly expressed and new procurement alternatives must begin to be discussed. As a natural consequence, an LCA perspective and focus on components in road management can open up for innovations and new contractors. With many separate upkeep assignment, today's large contractors would be able to take responsibility for planning and coordinating road measures in a region.

This specialisation might reduce the problems of low profitability and poor productivity development in the industry. A shift in focus in the contract concept from detailed activities to delivery of components will further strengthen this. Today the contractor has to lay as many metres of conduits as possible or excavate as much as possible since this is what can be invoiced and generate as large a profit as possible. A focus on the components and the life cycles will mean that they will instead have to do things more efficiently, exploit synergies between different work activities, and choose better methods and materials also in a life cycle perspective. The challenge for the contractors in the TAM concept will be to press down the total cost per produced component and thus increase their net profits.

Price trends and cost increases in projects

Price trends are presently followed for consumer price index, operation index, road index, ferry index and administration index. These indexes can provide a rough description of road management's price trends at an overall level [101]. At the SNRA the possibility also exists to follow actual price trends according to the detailed AMA structure. This can be done using the data collected in the calculation database. This detailed level consists of thousands of quantities. With this very extensive information, it ought to be possible to identify quantities with extremely deviant price trends. On the other hand, it may be more difficult to see what they mean for road management overall and whether they can be regarded as road management's cost drivers.

The TAM concept's construction price indexes are specific to each component type. The indexes consist of baskets of Statistics Sweden's official resource input indexes in respect of the proportions of the resources for each type. The focus in the TAM concept's procurements is on the component types. Theoretical construction price indexes exist for each component type. The actual price trend for each component type can be seen in the quality-related accounting.

The follow-up can show how much of road management's total investment expenditure is attributable to which component type. Since the amount of each component type's investment expenditure is attributable to a specific resource input, it is also possible to determine each resource input's share of road management's total investment expenditure. Road investments' cost drivers can be identified at resource input level and what it/they mean in the total picture can be determined. Strategies to counteract the price trend can be devised and goals set for them and followed up using the system. The TAM concept seems to improve the prerequisites for making computerised follow-ups and analyses of price trends and preventing an undesirable price trend.

In the TAM concept, performance-based contracts can be executed exactly as before and the construction documents can follow the detailed AMA structure if the industry so requires. The

[101] "Up until the mid-1990s, both the road and operation indexes roughly followed the consumer price index but the road index has subsequently developed faster so that for 2004 the road index for is 9% and the operation index 21% higher than the consumer price index. Regional administration shows the same development and for 2004 is approx. 18% higher than the consumer price index while the index for central administration has largely followed the consumer price index." (The SNRA's customer-supplier strategy, 1 September 2005)

contract should on the other hand not be based on the quantities according to the AMA structure but on the quantities of the components in the contract. Additionally, a few quantities that are critical as regards risk distribution can also be regulated.

To begin with, the new concept would mean that the contractor needs to extend or change the planning. The client may then be forced by the planning consultant to finance additional assignments. Additional assignments should gradually cease as the market adapts to the new order. The AMA quantities take on a partially new role since they are only used in the contractor's "build up" calculations and cannot be adjusted later in the contract with the client.

In order to partially compensate for this, the project engineer's responsibility can be augmented with a quality guarantee for each quantity stated in the construction documents together with tolerance intervals or limit values. If the contractor can show that the actual quantity for example exceeds the upper limit value, the consultant or his insurance company must pay cost compensation. Wide intervals will lead to higher prices for the contractors. Consultants with wide intervals will therefore be valued lower when a project engineer is being procured.

With this concept, the responsibility for the quality of the information is redistributed. Any interaction between contractor and consultant in connection with submitting a tender will have considerably less impact and on a considerably smaller number of quantities and uncertainties in the contract. The number of quantities priced in the contract will be able to be reduced from a few thousand to at most about fifty. The client's risks associated with the quality of the consultant's quantities and any irregularities are considerably lower with the TAM concept.

Most of the up to about fifty adjustable quantities in a road project will be able to be verified at later stages up until the time the road object is opened to traffic. In this arrangement, the consultant must take responsibility for the quality of the underlying calculations according to AMA that he refers to in the planning documents. The contractor, who offers the unit-priced list of quantities per component type, can use any calculation model he chooses (buildup and/or top-down calculations). The client takes responsibility for the physical design and other requirements regarding details in the documents and must therefore be liable for the costs than can arise out of adjustments to the design or other requirements during the course of the project.

The smaller number of negotiations and greater control opportunities offered by the TAM concept reduce the importance of the client's difficult circumstances, lack of information and the starting point for the negotiations. The basic preconditions of the new contract concepts should have a clear reducing effect on the prevalent quantity increases that cause substantial cost increases in road projects and inefficiency in the road management.

Relationships exist between several components and quantities. Plausibility assessments of many detailed AMA quantities can therefore be made as long as quantities are in all essentials theoretical measures. The quantities in addition to components that may also need to be adjusted (e.g. excavated earth and rock) are critical elements from the point of view of quality, which is another reason why the client should anyway make extensive checks.

Rational capture of relevant data for control, analyses and learning

The road manager has great faith in a functioning market and competition when procurements are made. Nonetheless, road managers have been making their own price calculations (build-up) and assessments (top-down, e.g. the successive principle) for a long time, at least for major projects. To ensure good quality of calculation data in independent examinations, the unit prices in submitted tenders are registered in the SNRA's calculation database. The basic financial information used when considering tenders before making a decision is at the AMA structure's level of detail. At the same time, the predominant fundamental premise at the SNRA is that every road project taken as a whole is unique and has unique costs [102].

Detailed financial background information according to the AMA structure remains with the project manager. Financial forecasts should therefore be made using this material since it is at this level that the project's costs change. However, it is a demanding task when the contract contains thousands of adjustable quantities. The accounting system's financial follow-up comprises instead the contractor's "on account" invoices. The project's other expenditure items come from other sources. The total amount of the investment (the acquisition value) is booked as an asset within five years of its being utilised.

Even if every road project taken as a whole may be unique, this does not apply to the prices of all road components. On the contrary, variations are small for a great many kinds. This fact alone shows that the financial focus should be on the TAM concept's component types. Analyses of variations in the prices of resources made before the control limits were set can therefore show that some component types' prices are unreasonable. Some types with reliable control limits are excluded, the remainder require further analysis. In such cases there should be some room to manoeuvre in the procurement process, so that construction contracts, for example, are not divided up by component type. Data capture would in all certainty be more efficient for types with specialised contractors and would even be a strategic means to increase productivity in the industry.

In the TAM concept input data would be delivered to the quality-related internal accounts by the contractor having been quality-controlled by the project manager. data contains the information about road capital and road projects that the road manager needs for financial control and monitoring. Before the project is handed over to the client, revised as-built drawings are drawn up that at the same time constitute input data to the road and traffic data bank (RDB) and let us say digitally signed status record per component type appended to the final invoice. Data capture in the TAM concept should be efficient and satisfy the need for control, verification, reporting, learning, analyses and business professionalism.

Other weak conditions in the internal verification

The worst scenarios as far as internal control is concerned are when irregularities occur. The TAM concept cannot prevent irregular collaboration between, for example, contractor and consultant (project planner). But the TAM concept can limit or lessen the consequences of such irregular collaboration quite considerably. The number of cost-influencing factors that can be manipulated is reduced. Many of the quantities can also be verified afterwards, which

[102] This conclusion was reached in the Finance department's Metre cost project, when it was concluded in the mid-1970s. After several years' work on, among other things, regression analyse of extensive data from a great many road projects, it was clear that the number of price-influencing factors and the spread of the information regarding the individual factors are both substantial.

considerably reduces any less than honest site engineer's room to manoeuvre. It is also more likely that errors in quantities, negligence and "carelessness" will be detected.

The risk of large-scale irregularities occurring is also considerably reduced since there are considerably fewer items that cannot be verified. The number of non-verifiable items is reduced from sometimes thousands to just a few. More attention will also be paid to "non-verifiable" items since they consist of the activities that are most essential in the quality assurance system. Another restrained factor in addition is that it normally needs several involved people to perpetrate irregularities.

However, it must be pointed out that since only a few items' quantities can be increased, the risk of detection is considerably greater. In order for it to be significant and have a sufficiently interesting effect on price and profitability, an increase in quantity for just one item or another should lead to a deviation that is detected in the course of continuous process control and verification. A more detailed check will then be made by internal auditors or by other staff not involved in the project or its management.

7.5 Project management

7.5.1 Introduction

The project management referred to here, concerns delimited road projects in the form of new construction, improvement and value-adding maintenance. Project management of other measures in the road network are in this context considered to be operation. There are indications of serious shortcomings in the routines at the disposal of the heavily loaded project manager with or without the applicable regulatory framework and routines being followed. The following extract from an audit report [103] helps us appreciate the situation:

> "There are indications that suppliers are given better terms than agreed in contracts and that different levels of assessment exist for applying fines/deductions without any special reason for doing so."

In the same audit report we can also read that:

> "The project manager is often the only person in the projects with significant authority and great responsibility and often makes decisions about changes, additional and cancelled work, settlements and fines, and to make or not make deductions for quality deficiencies on the basis of his own competence and without any significant insight from or verification by anyone else."

All in all, this shows that internal control is a problem in the present way of working and the contract structure in use.

[103] AL 60A 2008:3475, Internal audit of management of changes, additions and deficiencies in road projects, AL 60A 2007:20510

7.5.2 Problem overview, general

Several of the problems touched upon in the foregoing are perhaps most serious in the project management itself and the administration of the projects. The project manager is overburdened with tasks as a result of the construction contracts for which he or she is responsible. A project manager can be responsible for a major project with thousands of adjustable quantities. Another example is where the project manager is responsible for perhaps more than fifteen smallish projects with a combined total of several thousand adjustable quantities. In both cases, the project manager is responsible for a great many negotiations or agreements with the respective contractors.

The project manager generally has some form of technical education. His or her competence and interest are therefore more focused on quality issues and technical/practical solutions in production than on administration. Many are the project managers who over the years have complained loudly about the administrative burden. Nonetheless, administrative work is given highest priority since it affects the project manager's relationship with his or her immediate superiors, including questions about the organisation's confidence and trust and the person's reputation.

In issues concerning incentives, internal information, internal control, cost increases, forecasts and invoicing on account, the project manager is the central figure. Despite the fact that deficiencies, weaknesses and problems with regard to these "issues" largely depend on the way of working and the prevailing cost structure, the project manager is regrettably the person upon whom suspicion of irregularity is cast when costs develop "abnormally". The project manager should instead be regarded today as a "victim" who is forced to work with inappropriate incentives and in procedures with unsatisfactory internal control.

7.5.3 Comments on general problems in project management

It is management's responsibility to eliminate risks and problems in the organisation and oversee internal control in an efficient manner. Once implemented, the TAM concept leads to changes in the project manager's work and vulnerable position. However, the project manager will continue to alone have extensive responsibility together with authorisation to make decisions. A great many project risks can on the other hand be reduced and internal control considerably improved in many areas. The differences that are most clearly noticeable if the TAM concept is introduced are that

- the project manager is given more time to control the quality and function issues that are critical to the project, but also for information and interaction inside and outside the organisation by

    - the number of negotiations and agreements on adjustable quantities being radically reduced from thousands to at most about fifty in a major project,

    - the project manager being for example able to run over the project at the end of each month together with the contractor (sometimes perhaps together with one or more other people) and jointly determine what is billable and at the same time discuss (document) quality issues, problems, measures and other things,

  - the invoice in this way containing all the necessary information for the client's financial follow-up and verification with basic information for computerised forecasts and analyses of deviations divided by causes dependent on time, quantity, and unit price,

  - the project manager being able to comment upon the computerised forecasts and analyses, e.g. with information about discussions with the contractor about quality issues, problems, measures and other things when authorising the invoice,

  - almost all quantities being able to be measured as time allows in the knowledge that they will be verified before the final inspection, when the as-built drawings will be revised by the contractor in a format that at the same time constitutes input data to the road and traffic data bank (RDB),

- the project manager also has more time when decisions are to be made about changes, additions and cancellations, settlements, fines and consequences of quality deficiencies,

- the project manager is given clear responsibility for the final financial report (input data for booking of assets) and verification of the revised as-built drawings (input data to the RDB). In the final report, both client and contractor attest each component type's status. This means that all financial transactions have either been finally settled between the parties and that only the warranty period remains to be agreed or that issues remain to be resolved. Not until the as-built drawings have been approved and the final report signed is the final invoice paid.

The financial significance of the problems arising out of incentives, lack of internal information and the basis of the negotiations is reduced. Both parties know that it is largely only correct verifiable quantities that have any significance for what the contractor can invoice. The project management function becomes more structured and transparent. Invoicing on account can cease. Allocations to periods and forecasts for road projects will be basically handled in the same way throughout the organisation. Information about the projects is relevant and leads to better quality in control and monitoring. There is no doubt that internal control is considerably improved by the TAM concept and that suspicion of irregularity can no longer be cast upon project and construction managers since they work to mandatory routines.

7.6 Accounting and reporting

7.6.1 General

The Internal Audit department again take up shortcomings in accounting in the board-approved audit project "Transparency in Control" [104] (later renamed "Transparency in Accounting"). Their conclusion is "that internal control and monitoring in respect of reporting performance, road capital and consumption of appropriations is unsatisfactory." They note the following:

[104] AL 60A 2008:3475, Transparency in control, AL 60A 2007:12067

"If the people responsible judge certain information to be so important that the organisation is burdened with planning, booking and following up this information, it is also important to secure high quality of the information through clear instructions and definitions and properly functioning internal control. Otherwise, there is a risk that the information will not be reliable, which may lead to errors in reporting and wrong decisions.

The aim of the audit is to assess transparency in the SNRA's reporting of performance and financial codes as regards the linkage between road capital and appropriations (letters of appropriation and long-term plans) and the appropriations' distribution among investment, operation & maintenance and bearing capacity.

The SNRA has a complex financial model with many dimensions and accounting concepts that have been added over the years as information requirements have increased and other changes have taken place. Knowledge of the financial model and its components varies for many staff both centrally and in the regions but in our assessment there is no-one who has full knowledge of the model, including everything from planning, accounting and financial systems to follow-ups and the annual accounts, and who can assess the consequences of different changes."

The board [105] share the risk assessment as regards the need for reliable and correct reporting, "Inadequate transparency in reporting of operations in the financial model, among other things as regards installations", and that the risk needs to be avoided.

7.6.2 Problem overview, general

The fact that today's accounting of assets in road installations cannot be used for control, monitoring and reporting of road management is a problem. It is impossible, for example, to see road management's costs, life cycle costs or functional changes in value over the year. One indication of the need to correct the information in the accounting system are the recurrent maintenance backlog figures, which unfortunately lack credibility. The information is compiled separately outside of the accounts. In the case of some road component types, usable information for control and monitoring comes from unrelated technical administration systems.

"Best available knowledge" of components' physical function and deficiencies is highly detailed and contains technical concepts and analyses that are difficult to grasp. The requirements stipulated in the transport policy regarding socioeconomic efficiency and customer focus further complicate continuous control and monitoring. The complexity of these aspects is not structured to allow "best available knowledge" to be used for reporting and supplying user-friendly, relevant information. The low ambitions in the accounting system mainly consist of verifying deviations against budget and appropriations granted and producing a "clean" audit report.

However, we can now see with some satisfaction that interest has again been aroused in the Internal Audit department's old opinion that high quality information about the road capital

[105] The SNRA's operations analysis for 2009 – Risks in and opportunities regarding internal control and monitoring at the agency, HKe, AL 10A 2009:21387, 27 May 2009, Borlänge

should be used in order to achieve better control, monitoring and reporting of road management itself.

7.6.3 Comments on general problems in accounting and reporting

The internal quality-related accounting of road capital is systematic and transparent. Internal control in routines is subject to the same quality requirements as the external accounting. The information is based on "best available technical and financial knowledge" and the starting point is the requirements in the transport policy regarding socioeconomic efficiency and customers' expectations.

The road capital accounts can provide up-to-date basic information about the road capital and its consumption costs (standard value with different types of standard deficiencies, replacement value, condition value and remaining consumption margin). The accounts can also provide information about changes in capital distributed by index adjustments, value-adding maintenance, improvement, new construction and consumption costs, and about the effects of rectifying deficiencies in standard. The information exists for all components in the entire road network but its quality varies. Quality certification of data about acquisition value exists for all components.

In addition to the basic information already mentioned, there are figures for accumulated quality deficiency costs, inefficiencies, maintenance backlog and the road capital's future funding needs. Components can be identified and located in the road network and information can also be verified by physical inspection. All information can be obtained for different components aggregated over e.g. roads, road network and regions, and for any average annual daily traffic, and/or supplying contractor.

Road sections can be homogenised in respect of most of the attributes in the road and traffic data bank and the PMS administration system. Access to up-to-date information about the road network may also be of importance as regards sectoral tasks and exercise of authority. In the TAM concept information about components' positions, condition, deficiencies and the effects of measures is based on "best available technical knowledge". The TAM concept creates order in the road installations and their components – an order that many people in the SNRA's regional organisation have been asking for a long time. The increase in the number of component types that the concept requires is largely achieved by making today's voluntary component types mandatory. This gives road management access to a database common to the whole organisation with considerably greater potential for use than the present one.

Since the quality-related accounting of road capital is linked to internal accounting, the quality requirements will also automatically be higher in the procedures for technical reporting. Special verifications and authorisations will be needed to make changes in the road data. A change in a component's information in the RDB might lead to a financial event in internal accounting. Many of these events will be handled by computer, so the verification routines will need to be secured.

Quality-related internal accounting according to the TAM concept can thus provide a basis for continuous control, monitoring and follow-up of operations. It can also provide a basis for notes in the annual report's balance sheet and income statement and for the statement of operations. The maintenance backlog is calculated in the system by component and in total. An assessment can also be made of financing the elimination of the backlog, partly in terms of the authority's own potential for increased efficiency and partly in terms of the need for external funding. It is also possible, for example in tables and maps, to present values, deficiencies in standard and condition, index adjustments, growth and consumption for the different component types and the total road capital.

7.7 Concluding comments

The SNRA's operations analysis for 2009 [106] among other things takes up the following "very serious risks", which have all remained since 2007 (in brackets):

- Deficient risk analyses of the road network lead to inadequate risk management (5.2.2.1)
- Dimensioning of road installations is not sufficiently risk-based, which increases the likelihood of deficiencies. This has been particularly highlighted due to climate changes (5.3.1.7)
- Inadequate detour networks lead to socioeconomic losses, e.g. the Essingeleden motorway and the Tingstad tunnel (5.3.2.2)
- Insufficient transparency in the reporting of operations in the financial model, among other things as regards installations (not, however, noted in the 2007 operations analysis)

Efforts to reduce the risks in the first three of these points may have been made over the years but the risks are still considered to be "very serious". In the TAM concept this type of deficiency is documented as soon as it is identified. The documentation contains details of measures' costs and effects for road-users and society. The different types of standard deficiency are registered in the RDB together with their locations in the road network. They can then be listed, analysed and presented in tables and maps. Since the accounting is transparent and easily accessible to everyone, many people can contribute to pointing out deficiencies and risks in the transport system.

The fourth "very serious risk" is fully eliminated by quality-related accounting of road capital. Control of road installations' deficiencies in standard and condition, remaining deficiencies, the year's consumption of road capital, the cost of all these, and measures carried out during the year are reported quite transparently and verifiably. Since the information is based on "best available knowledge" and the requirements of the transport policy, it is directly usable in continuous control, monitoring and reporting.

The application of control limits enables deviations in the form of successful and less successful road management to be quickly identified and analysed. Rapid detection prevents repetition of errors while good practices can be copied throughout the organisation. Measurable targets can be set for productivity improvements and followed up continuously.

Maintenance backlog can be identified and calculated per component within the system. The remaining consumption margin is known for every component, as is annual consumption,

[106] AL 10A 2009:21387

making it possible to forecast measures in the form of replacement and reconstruction with good accuracy. The annual funding needed to maintain the quality of the road network can also be calculated. It is also possible to use the system to calculate the quality deficiency costs distributed by poor road management decisions and unsatisfactory component quality. All information can be presented by supplier (contractor) and used to improve business professionalism.

8 IMPLEMENTATION OF CONDITION-RELATED ACCOUNTING

8.1 Background and purpose

In 1994, after a thorough review by external experts, the Director-General [107] of the Swedish National Road Administration (SNRA) at the time took the decision to adopt the condition-related accounting method proposed by the authority's Internal Audit department. It was never implemented, however, primarily due to changes in the SNRA's management in spring 2005. The TAM concept was therefore not even contemplated during more than ten years of road management. In the mid-2000s, during a visit to Norway, the Director-General [108] was made aware of better possibilities to communicate road management's needs in terms of road capital to the politicians. The Ministry of Industry, Employment and Communications had by then already conducted a study of the TAM concept's condition-related accounting, which showed that information about road capital in the condition-related accounts is more appropriate for control and monitoring than the corresponding information in the external accounts.

The work of drawing up documents for a project to implement condition-related accounting began in September 2006 [109]. In 2007, the Director-General officially commissioned the implementation of condition-related accounting in a project [110], and has also formally approved the project directive [111] dated 16 May 2007. The project directive states that the licentiate thesis, the study conducted by the Ministry of Industry, Employment and Communications and the SNRA's report shall together constitute the foundation for the implementation. The project directive further states that the projects shall have been concluded by 2010.

Due to illness, a new project manager was appointed in 2008. The project lost pace and was put on the back burner until the new project management team took over in autumn 2008. The new project manager also had other high-priority assignments relating to the ongoing planning of measures in the long-term plan for 2010-2020. After the new project management team took over, some basic issues began to be discussed again. Our focus turned more and more to completing this thesis and attendance, monitoring and involvement in the implementation project declined and finally ceased.

[107] Per Anders Örtendahl, (PhD (Economics), (DG from1982 to 1995)
[108] Ingemar Skogö, BSc (Econ), (DG from 2001 to 2009)
[109] The IA model is described in a licentiate thesis. The case study conducted by the Ministry of Enterprise, Energy and Communications in 2004 (engaged consultants: Öhrlings PriceWaterhouseCoopers) at the SNRA and the National Road Administration is primarily based on the IR model. The SNRA's final report of the same study, but slightly extended, was presented in 2005. During 2006 another preliminary study also confirmed that the model prerequisites from 1992 still apply as regards information in existing administrative systems and that they can still be used for calculating condition-related values of road capital. Using standard values, this preliminary study estimated that the road capital's replacement value probably totals between 315 and 886 billion SEK. In other contexts, values of between 900 and 1,000 billion SEK have been given..
[110] According to the directive, the concept will to be based on the licentiate thesis A model for quality-related valuation and accounting of road capital, Berth Jonsson, KTH, Stockholm, 2005, Värdering av vägar och järnvägar, (Valuation of roads and railways) Öhrlings PriceWaterhouseCoopers, Stockholm, 2004 and Slutrapport Invärdering av vägkapital, (Final Report on Value Determination and Booking of Road Capital, SNRA, Borlänge, 2005
[111] EK 10A 2007:2151

What is reported here concerning the implementation project comprises the period from September 2006 up to the change of project management (summer 2008). The purpose of the chapter is to follow the implementation during this introductory phase of the project and present some of the most important problems and discussions.

8.2 About the project in general

8.2.1 The problem description in the project directive

The problem description is given below as it is formulated in the project directive:

> "The SNRA today systematically describes condition development in the road network in several respects, e.g. as regards bridges and pavements, and has special management systems for this. What is lacking, on the other hand, is a complete picture of the road network's collective condition. Such a measure can probably not be expressed in a convincing manner other than in financial terms.
>
> One problem, according to the Ministry of Industry, Employment and Communications, is that the basis for decision that the Government and Parliament receive today lacks clear, measurable, monitorable parameters that can constitute a basis for systematic follow-ups and prioritisation of measures. Nor is there any relationship between condition, how it changes over time, and the need for investment and maintenance measures.
>
> The SNRA's term *maintenance backlog* and the calculation of its magnitude have not always been able to be communicated to the Government and Parliament in a constructive manner."

The SNRA thus has problems communicating intelligibly with the "owner" about the road network's functional condition and the physical measures currently needed. It is moreover difficult to measure and follow up for example what maintenance in road management has meant and where the maintenance backlog is and how it has been calculated (according to a report to the Government by the National Road and Transport Research Institute (VTI) [112]).

8.2.2 Purpose of and expectations from the project

The project shall have implemented a model for condition-related accounting of road capital by 2009 at the latest. This will then allow the SNRA to provide the Government and Parliament with financial feedback that reflects actual condition and the linkage between appropriations consumed, condition and funding needs better than today. The project directive states that: "The road capital model that is based on a collateral calculation system that retrieves information from the SNRA's internal accounts, among other sources, will for example clearly show a falling value of road installations if necessary maintenance measures are not carried out."

[112] Gudrun Öberg, Mats Wiklund, Jan-Eric Nilsson, Granskning av Vägverkets och Banverkets förslag till drifts- och underhållsstrategier, VTI-rapport 492-2003, Linköping, augusti 2003 (Review of the National Road Administration's and the National Rail Administration's proposed operations and maintenance strategies, VTI (the National Road and Transport Research Institute) Report no. 492-2003, Linköping, August 2003)

It also details expectations that “Knowledge of the value of the road capital and how it changes from year to year will create new possibilities for comparing regions, counties and areas”. The directive also states elsewhere that comparisons will also be able to be made between municipalities, areas and, for example, roads with a certain type of traffic. The information referred to concerns changed condition values of the entire road capital over time including retroactively valued and added conditions. The information also includes growth and consumption of road capital. The directive states that “condition-related values of the road capital and changes in the values will be included in the SNRA’s annual report”.

The directive further states that the road capital model’s business economics approach will lead to “increased efficiency in the SNRA’s administration of the assets that the road capital represents”. The SNRA’s credibility is expected to increase generally. The model’s information should also lead to better resource allocation/distribution by the Government and Parliament between the infrastructure agencies and within the SNRA.

8.2.3 The scope of the project

The directive states that the road capital model shall comprise the entire state-administered road network and that values must be able to be verified physically. Valuations “shall as far as possible be based on actual acquisition values and take the fact that the road’s different components have varying lives”.

The implementation project is delimited to comprise “system design, value determination and booking, capital growth and capital consumption up to and including 2009. The project will initiate the implementation and commissioning of procedures for future reporting of road capital including administration”. The project concerns these three parts of the model, i.e. “retroactive value determination and booking”, “capital growth” and “capital consumption”.

Retroactive value determination and booking of road capital comprises the work of taking up the components in the existing road network as assets. Component data, termed phenomena in the present road and traffic data bank (RDB), shall be quality controlled, corrected and if necessary added to. Standard values and construction process indexes per component type are to be drawn up. All components will then be supplemented with their year of acquisition and a historical acquisition price calculated using standard values.

Capital growth comprises the work of arranging the prerequisites, so that component data can be captured in road projects concerning new construction, improvement, and permanent maintenance.

Expenditure figures will be captured via the financial accounting systems in Agresso. A minimum requirement is that road projects can deliver both the total contract sum divided by the component types that occur and the revised as-built drawings in digital form when the final invoice is submitted. It must also be possible to carry out the model’s index adjustments to current prices by computer.

Capital consumption comprises the work of determining as realistic a reduction in value as possible for each component by computer via a number of depreciation models where each component uses a model. Condition data for pavements can be retrieved from the Pavement Management System (PMS) and for bridges, tunnels, etc. from the Bridge and Tunnel Management system (BaTMan). Condition data for other component types will be retrieved for example from the road maintenance administrative system (RMD). The majority of component types, with a total value equivalent to approx. 20% of the road capital, will have their reduction in value based on their assessed technical life according to “best available knowledge”.

It has been determined that “the SNRA’s balance sheet contains approx. 12,000 objects constructed after 1954 with a total value of approx. SEK 90 billion.” The value of the road installations in the balance sheet can be compared with the replacement value of SEK 900 billion for the entire state-administered road network. Actual maintenance is carries out on all components on all 98,000 km of the road network. The cost of the implementation project can be put in relation to the magnitude of the replacement value of the entire road capital. The project’s costs can also be related to the need for information to underpin effective resource allocation or the administration of capital with follow-ups, monitoring and reporting.

8.2.4 The project’s finances

The implementation project has a budget of SEK 5.5 million for 2007, 14.0 million for 2008 and 12.0 million for 2009. These amounts include central and regional costs in respect of

- project administration with a description of the basic model,
- drawing up a requirement specification,
- a preliminary study of the RDB with a handbook describing the retroactive value determination and booking,
- drawing up the necessary unit prices and construction price indexes
- system capability for handling retroactive value determination and booking, capital growth and capital consumption,
- setting up computer access to 1) financial data in Agresso, 2) component data etc in the RDB and 3) condition data etc in PMS, BaTMan and the RMD.

A revised rough assessment of the total cost was presented on 16 June 2008, together with the model’s annual administrative costs including operation and data capture.

- Development of TRAV	SEK 21 million
- Inventorying for RDB	SEK 8 million
- Administration of TRAV	SEK 7 million/yr
- Data capture and maintenance, total	SEK 13 million/yr
- of which the cost in respect of RDB data is	SEK 8 million/yr
- and the cost of the project manager’s/contractor’s extra tasks is	SEK 5 million/yr

There is a conviction that the information from the condition-related internal accounting will make road management more effective but no benefits have yet been assessed.

8.2.5 Comments on the project directive

The following comments can be made concerning the project directive:

A. First of all, the implementation does not include those parts of the quality-related accounting that concern standard deficiencies and effects. The project is delimited to the condition-related accounting.

B. The project does not state whether the model is intended to support control, monitoring and analyses of the road management process. However, this does not exclude a stepwise development of quality-related accounting in accordance with all the possibilities that the TAM concept offers. It should be mentioned here that after extensive discussions important parts of the model have nonetheless come to be considered in TRAV.

C. The differences in opinion between different players within the SNRA can be discerned already in the chapter in the directive that outlines its purpose. At that early stage, when the directive was drawn up, the conflicts were resolved through the rider, that the economist responsible demanded, viz. that the accounting "should be based on a collateral calculation system that retrieves information from the SNRA's internal accounts, among other sources". For the SNRA's economists, this rider about "a collateral calculation system" was an absolute necessity.

D. It was clear very early on to the project's working group that the schedule in the project directive was too short. No action has been taken to rectify this.

With the support of the project's steering committee, the project client caused considerable delays almost from the outset. Several time-consuming additional demands were thrown in from the very beginning. For example, at one of the very first meetings it was demanded that the project should describe in detail final results that the project was intended to solve – before the work had even begun. Another example is that issues that have already been dealt with, accepted and decided upon, have been brought up time and again. Yet another that alternatives to components as cost bearers have been discussed. These examples of the steering committee's behaviour have created disarray, uncertainties and delays in the project.

8.2.6 Risk analysis

Early on in the project, a workshop was conducted to identify risks that the project was to identify and handle. The expectation was that the project's working group would study the results from the workshop and quickly draw up an action plan to deal with any risks that were considered serious. A risk assessed as "serious" was defined as the following combination: "Serious effect on the ultimate objective" and "High probability of the risk being realised" [113]. Such a "serious risk" exists in respect of the following events, factors or issues:

1. that the linkage to the external accounting might meet with legal obstacles,
2. that the present accounting model may prove to be an obstacle to a road capital model,
3. that the achievements in the external accounting might not be possible to use in a road capital model,
4. that the quality of the data in the RDB might be insufficient,
5. that any delay in the system design work will make it impossible to keep to schedule,
6. that the user group's levels of ambition are not correctly described,
7. that the road capital model is too detailed,
8. that the deliveries will not be made and/or that there are too many sources of error,
9. that different systems provide different data for the same things, to the detriment of verification and credibility,
10. that deficient descriptions of user's needs will lead to poor user-friendliness and/or intelligibility,

[113] According to the same model as in traditional Vulnerability analyses with a focus on the consequence of an event

11. that the road capital model is not explained to the users sufficiently well,
12. that the system cannot sufficiently motivate people to deliver input data of good quality,
13. that competence is insufficient to produce an efficient system design and system architecture.

The risks and problems assessed as significant in the analysis and on later occasions are divided into two groups according to their cause; a) opposition within the organisation and b) technical difficulties. The thirteen “serious” risks in the analysis belong to the technical difficulties group.

8.3 Comments on opposition from within the organisation

In development projects it is normal to have strong real user representatives in a steering committee that can make interpretations and assessments on the basis of a user perspective and various use cases as the project progresses. There were weak user representatives on this project’s steering committee out of a process perspective. The steering committee’s economists and technicians made their own interpretations of the directive very early and had their own expectations regarding the project’s results. Discussions that have arisen have in general therefore not been able to be based on knowledge of the control and monitoring that the model supports. The discussions have sometimes resulted in agreement on decisions like “common sense should prevail”.

Somewhat incisively expressed, the project will not develop solutions that run counter to “common sense”. Without needing to understand the unity of the model or what the idea of the TAM concept is, this type of wording leaves it open for everyone to make their own interpretation of what constitutes “common sense”. The steering committee also declared early on that decisions and opinions might be revised. The experienced project manager was perturbed at the project’s prerequisites. In “normal” projects a subsequent activity can be based upon a decision made earlier. Uncertainty about the prerequisites was strengthened by the steering committee also initiating new approaches that came to have a drastic affect on the work already being done by the working groups.

An example of a new approach was when the working group should investigate possibilities to divide Sweden into a grid to which information about roads and finances would be assigned. Existing information about roads and most road components can be found in the RDB. The information was not intended to be used in the system but the financial data would be assigned to the relevant squares in the grid. Another example of a task for the working group is to search around the world for an existing, functioning road capital model with a road and traffic data bank and an administration system. At the SNRA, the general opinion is that the Swedish IT solutions for the RDB, PMS and BaTMan are technically speaking the best in the world. This opinion is based on experience gained from extensive international contact in various networks and collaborations. An external consultant was commissioned to conduct a situation analysis [114]. Nothing new was brought to light compared to what can be found in my licentiate thesis [115] from 2005.

[114] Johanna Dillén, Stina Hedström, Susanne Nielsen Skovgaard, Report Road Asset Management Benchmarking Study, WSP Analysis & Strategy, Stockholm 2008
[115] Berth Jonsson, A model for quality-related valuation and accounting of road capital, KTH, Stockholm, 2005

Another task that was laid upon the working group was to describe the benefit of the model in different activities and operations – something that in principle should be done by the client. Here, the steering committee is looking for solutions to details that the project is intended to solve before the work proper has even begun. These details were not critical to the implementation and it was known from the very beginning that opinions would differ. A logical approach is for experts in the field to be given the opportunity to prepare the issues before any principles are established, since credibility based on "best available knowledge" is a solid quality concept. The problem with "common sense" as a the starting point is that it leaves too much room for decision-makers' own opinions and general knowledge instead of detailed knowledge, knowledge of the organisation's activities and operations and experience, and above all a sound holistic view of road management. The steering committee therefore constitute a significant risk as regards the system's quality.

The client's lack of experience of the road management process may be considered to be the foremost explanation for the steering committee's uncertainty and their various proposals and demands. At the same time, it must be regarded as a healthy sign that people in positions of responsibility who do not have sufficient knowledge of processes and problems are unwilling to take binding decisions on something that is not fully clear to them. The project's situation has been troublesome but is probably not at all unique. The project's critical success factor, acceptance of a sufficiently long implementation period and sufficient resources for development, will therefore be strongly dependent on the client's competence, attitude and creative ability.

8.4 Comments on technical difficulties

8.4.1 Comments on the risk analysis

Comments on risks 1, 2 and 3.

No legal obstacles have been found during the course of the project's review of prerequisites. It also became clear that the present accounting model does not constitute any obstacle to a road capital model. However, it is important that the analysis work continue for example investigating in detail what will be required of the interaction between the different types of accounting.

At the first meeting with the client it was emphasised that the present performance structure of the accounting would not be affected. This means that the structure needs to be expanded. The performance structure contains, for example, a fixed division of the road network, which is not needed in the road capital model, where the RDB's flexible data extraction programme will be able to be used. The performance structure has been severely criticised by road management users and some adjustment would probably be very welcome. The present performance structure, however, does not constitute an obstacle to an implementation of the road capital model but it would be surprising if no attempt were made to simplify the structure in connection with the implementation.

No new circumstances have arisen in respect of the first three risks since the beginning of the 1990s. Nor has anyone hitherto found any obstacle to implementing the road capital model.

Comments on risks 4, 8 and 12.

A closer look at typical problems associated with risks 4, 8 and 12 gives rise to the following comments.

- The project's acquisition value is incorrect

Any expenditure at all can in principle be included without detection in a project today, as long as all concerned are in agreement. The figures are not used because everyone knows that they are misleading. The road capital model reduces this risk factor, since all expenditure in the road project must be accounted by component type (including any extraneous and incorrect data). Unreasonable values are detected by the system's plausibility checks via actual quantities and contracted unit price per component type (especially if Kn1 is applied). The risk factor is reduced because 1) data can be verified by the system in several ways, 2) actual quantities in most cases can be verified later, and 3) value items are not appreciably affected by negotiations or agreements. Figures will be able to be scrutinised in the external audit and independent inspections. Since the quality of the information is of importance for the measures that are planned and the budget that can be obtained, a local motive exists to achieve high quality in the handling of input data. If a component is missing in the RDB it will not need a maintenance budget.

- Quality deficiency costs

These are almost impossible to detect or make visible as things stand. This means that deficiencies in underlying information are not discussed or acted upon either. They will in future be highly visible and possible to use as a basis for learning and improvements. If, for example, deficiencies exist in the underlying information, these too will be detected, discussed and improved in "open accounting in the RDB". Deficiency costs that are due to delivery errors and careless manual handling of data will be able to be detected. All financial data is accounted at component level and it is there that checks are made. Minor errors, however, will be difficult to detect when they do not lead to deviations outside the monitoring and control limits that have been set.

- The road management cost

This is not known today and can therefore not be analysed and discussed. Instead, the knowledge substitute "maintenance backlog" is reported – information that does not have any great credibility either inside or outside the SNRA. In the future they will be subject to benchmarking, by means of which erroneous underlying information may be detected to a great extent. The road management cost will be correct and details of the "maintenance backlog" will be able to be retrieved from the accounting by computer and in a uniform, more credible manner.

Comments on risks 5, 6, 7 and 9.

5: The schedule has been questioned from the outset but no corrections have been made.

6: The user groups' levels of ambition are not known because no users have been identified in the present organisation. It is therefore a matter of urgency that prospective users be involved in the project.

7: The road capital model has been considered to be too detailed since 1992. It was also the issue that the members of the implementation project's working group first concerned themselves with. In every discussion and review over the years, the issue has resulted in completely insignificant corrections to the list of component types that has existed since the first proposal. The only apparent difference is that the number of component types has increased from the original 32 to the present 54. There was, however, a subdivision into a number of component attributes. Today, the working group wants a "1 to 1" relationship between component types (phenomena) in the different systems. The number will then increase to 54, since the elimination of an attribute will give a new component type. The working group is in all essentials agreed that all component types are needed. Only marginal differences in opinion exist between the project's members. Opinions may change a little during the course of the project.

9: Input data for the road capital model must be based on "best available knowledge" and actual expenditure and costs. The system having the best quality information will supply the data. Data from the road capital model will take precedence and describe "the truth about the road capital". Today there can exist several "truths" for one and the same item, calculated using standard values, based on random samples or general knowledge. The road capital model allows information to be produced from all-inclusive data instead of from random samples.

Comments on risks 10 and 11.

These are important points! Great effort must be out into manuals and training. No good descriptions exist at present and there is no known equivalent system on which to test user-friendliness and pedagogics. These aspects must be taken into consideration early on in the implementation project in the same way as a number of future users should be brought into the project so that they can influence access to data for analyses and reports. The prospective users should also be involved in the final design of the manuals and the training.

Comments on risk 13.

This must not be allowed to remain as a risk. Ample competence exists at the SNRA and there are external resources, so the risk must be considered more as a lack of financial resources. Good quality data and systems exist and it must be possible to transfer data between the SNRA's existing systems. Otherwise, an effort will nonetheless be made to increase the systems' flexibility and usability.

8.4.2 The model's component types

No question has been discussed as often and for as long as that of the number of component types. The matter was discussed in depth as long ago as 1992-1994. The working group was also of the opinion to begin with that there too many. Economists are used to using rough standard figures for road types such as motorways, 9-metre roads, gravel roads, etc. In the accounts, expenditure and costs are assigned to the corresponding rough division via performance. Administrators of individual components, for example individual bridges (component type *Bridges*) have financial data of varying quality at the level of structural elements (e.g. edge girders). The administrative systems contain quantities of technical and financial information for each individual component – information about its present condition, need for measures to be taken, deadline for carrying out the measures, the types of measures and the cost. The information constitutes a basis for assessing financial needs in time and magnitude in order to carry out the planned measures.

Physically identifiable components with “best available knowledge” of their current condition, deficiencies and cost of applying measures already exist for the equivalent of 80% of the entire replacement value of the road capital. The remaining approximately 20% consists of a quantity of different component types with completely different technical service lives. The question now concerns what knowledge a road manager must have of the road capital, the cost of road management, of customer-driven need for measures and the business transactions and construction contracts that concern the road capital.

Division into component types is one of the linchpins of the road capital model. Each component type has a life cycle with its own degradation process. When the road capital has been valued in and registered at component level, the components will thereafter constitute bearers of, for example, information about financial events such as growth and consumption.

Three main criteria have been formulated for what characterises a component type in respect of need for effective control, monitoring, following up, analysis and reporting. The main criteria for a component type are that the occurrences must have 1) clearly stated quantities and be physically identifiable, 2) a consumption cycle for the type in question and/or length of life, and 3) a significant value, at least in total, for all occurrences of the component type.

There are also other factors that can indicate a component type, e.g. that there are 4) quality requirements regarding upkeep and condition, 5) already existing phenomena in the RDB, 6) significant upkeep costs and/or other needs to keep track of the component occurrence in the basic operation package and/or 7) a great need to be able to visualise occurrences in benchmarking or LCC, cost driver, productivity/efficiency analyses, etc.

According to 5) above, one of the factors that supports a component group in its own right is as far as possible to use both existing items in the RDB with its phenomena and the structures in the PMS and BaTMan administrative systems. The fact that a phenomenon type already exists indicates a need as regards road management. Several phenomena will be changed from optional to mandatory in order to create comparability between regions, roads and road networks. A few new types such as geotechnical constructions will be added.

When dividing into component types some practical adaptation was necessary in order to avoid difficulties. In the case of roundabouts, interchanges, bus stops and canalisation structures, all occurrences of formations, draining systems, lateral areas, superstructures, wearing courses, bridges etc. are included in the project’s relevant component type for superstructures etc. On the other hand, when erosion protection is a part of the bridge structure, no differentiation is made in BaTMan.

“Normal” culverts are included in the surface water run-off system in the terracing/surface water run-offs/roadside areas component type. Large culverts are inspected individually and are detailed separately in BaTMan. In the case of rest areas and foot and cycle paths, bridges (that are registered under their own component type) are not included. Other items like terracing, superstructures, wearing courses, etc are kept together in the component types rest areas and foot and cycle paths respectively.

The working group has conducted several analyses to settle the component type issue, e.g. the total value of the different components.

8.4.3 Cross-checks between internal and external accounting

The SNRA's economists have opposed the inclusion of condition-related accounting in the internal accounting. They have argued in favour of the valuation and booking of road capital being accomplished in a calculation system based on standard values. The Director-General, however, has emphasised the credibility issue and the need to use actual expenditures and costs. The economists have regarded the demand that the condition-related internal accounting be able to be cross-checked against the external accounting as unreasonable and impossible to accomplish. The different opinions on the cross-checking issue have probably been based on misconceptions.

There is quite naturally nothing against which to cross-check information that only exists in the condition-related accounting in the external accounting. On the other hand, plausibility assessments can be made for this type of item. The road manager should also already have made corrective adjustments to all the data that can be handled by computer. In the random samples that the external auditors later need to make as a basis for their opinion as to whether the internal accounting can in all essentials be considered correct, there will be no reason to find any inexplicable non-conformities.

In the SNRA's implementation project it was chosen to base retroactively entered acquisition values on calculated standard values adapted to reality using a number of price control algorithms. The acquisition years are already known. The principle for cross-checking or comparing the value of the internal accounting with the external accounting is, within the framework of the individual investment project, to

1) total all components' replacement values per each component type,
2) convert each component's replacement value to the price level of the investment's acquisition year using the respective construction price indexes so that components with a more recent date of acquisition in the RDB are assigned an acquisition value converted for the date of the investment project,
3) compare the sum of all component types' acquisition values with the investment project's acquisition value in the external accounting with regard to an reasonable agreement on the values according to the same acquisition year.

For components in a known investment project it is possible to demand complete agreement when the quality of the data is good and the acquisition years agree with the road investment for all components. If no information is available about an investment project, a plausibility assessment of the acquisition standard values relative the stated control limits. Maintenance costs in the external accounting can be verified against the sum of all maintenance items booked as assets in the internal accounting during the year. This type of check should be made every year for each component type and documented in order to be able to be included in the following year's plausibility assessments.

8.5 Eight preliminary studies

Eight preliminary studies were conducted in the project (see Appendix 8 for details). The implementation issues studied were.

1. *Component types in BaTMan* and how they can be related to the proposed component types in the new model. The necessary adaption turned out to be rather moderate. “The structures are inspected continuously at a maximum interval of six years and all damage as regards condition documented. A “fictitious cost of carrying out measures” is given for each structural element and totalling the cost of measures for each component type is thus not expected to present “any major problems”. The “fictitious cost of carrying out measures” is not equivalent to the cost of restoring the structural element to its original condition. When BaTMan delivers data to the quality-related accounting the “fictitious cost of the measures” must therefore be adjusted to the corresponding value that is normally used in operational planning and budgets.
2. *Component types in PMS*. Here it was proposed, after a thorough review of the pros and cons of each of the two principles, that "the division into wearing course components be defined and described in the road and traffic data bank (RDB). Every road is in some way divided into parts that constitute wearing course components. The division may be done freely in the way that is judged most appropriate for TRAV. Information about the division can be retrieved to PMS and forecast condition values can then be calculated for each respective component. This makes it possible to create components of a given length, e.g. 400 m." It was also concluded that completeness needs to be improved in the road and maintenance data system (VUH), and that the forecast models must be reviewed and improved.
3. *Other component types*. This also concerned how far data for these components could be retrieved from existing systems and aspects of dimensioning technical life lengths. In many cases there are insufficient information about actual life-length and it was recommended that a principle of prudence should be applied meaning that the longer of the possible life-length should be chosen in order not to overestimate the cost of the road system. This was also believed to increase the credibility of the model. A detailed investigation was also made about which depreciation model according to plane that should be used for different components.

The next two studies concerned how other existing systems should be linked to the accounting model.

4. *Interaction with the road and traffic data bank (RDB).*
5. *Interaction with the AGRESSO accounting system.*

The first approach is to test the possibility to have “road objects” as a common concept and linkage between respective components’ information in the accounting system and the RDB. The financial information would then be able to be linked to the components’ situations and other information in the RDB. The preliminary study emphasises the importance of stating who will be responsible for the different links in the chain early on in the process.

It was unanimously decided that there for instance would be no problem or any unreasonable effort involved in allocating the actual total expenditure for a project to the occurring component types on the basis of settled, priced quantities at hand-over time, The revised as-built drawing, that the contractor already today is obliged to provide when the project is handed over to the client, contains most of the information about the project’s definitive component occurrences. It will therefore not be difficult to allocate a road project’s total expenditure to the component types and then to the component occurrences in a road object module linked to invoice processing and the accounting system.

A routine for this module was also sketched. All component types undisputed at hand-over time are signed by both the contractor and the client in an official record of what was ready for final invoicing. For all occurrences of signed component types the acquisition value and acquisition date (e.g. the time it was “opened to traffic”) are thus ready for registration in the condition-related internal accounting. As soon as the revised digital as-built drawing has been delivered and the final invoice is to be paid, the components’ details are registered in the internal accounting. Component types that are the subject of dispute can be registered as agreements are signed and the invoices accepted.

The implementation project’s ambition is to make project control more effective, reduce contract handling costs, reduce cost increases in projects and make data capture more efficient. This naturally affects present routines, roles and systems. The preliminary study had been expected to give a general picture of the consequences for accounting, routines and interval control. The indisputably highest accuracy as regards components’ acquisition values is obtained, provided that the priced bills of quantities in the contract contain the component types’ unit prices and that it is the components’ quantities that are adjustable and the basis of factors.

6. *Component types’ unit prices when booked retroactively*. As described in Appendix 8 several alternatives where investigated and there were also case studies carried out.

In the chosen alternative the unit prices will be able to be taken directly from information in the calculation database or similar data sources. The remaining unit prices will be calculated in the same way as in planning contexts, when the road object’s costs are estimated. “Typical” component types will be “designed” and costed on the basis of the prices in the calculation database or similar data sources. The work will be carried out by engineering consultants and some of the SNRA’s calculation specialists.

7. Component types’ construction price index. SNRA already today uses a number of price indexes and in this study the main question was whether a small number of broader indices could be used without too much loss in quality.

“With the clear wording that we have in TRAV regarding the importance of separate indexes for each component type, we have here chosen as many as 17 different indexes. And even more indexes and/or index combinations are conceivable, which would then require a thorough analysis effort to secure greater accuracy.”

The preliminary study highlights the importance of using a “correct” index. The rationales should form frameworks for a more detailed review of indexes. The preliminary study of unit prices proposes a detailed calculation of unit prices on the basis of the structure based on the General Material and Workmanship Recommendations (AMA). The assessment is that the index issue for the component types is best handled in parallel with the work on unit prices. In this context, it should also be rational to assess what resource types affect the unit prices and what the proportion of each respective resources type is of the total unit price.

With high quality work on indexes and regular cross-checks between applied index and actual price development per component type, the price development should be able to be explained.

Computerised analyses can be made of road management's cost drivers. Good quality as regards the proportions of the types of resources for different unit prices will also constitute good support for analyses of how the construction contract market functions competition-wise. It also gives a good idea of real interest levels when decisions are to be made about investment or continued maintenance.

8. IT-solutions for the condition related accounting of road capital (TRAV). A number of flow charts and figures were produced to show how different types of data should be handled. The study also discussed definitions, correction measures on data, and risks related to changes in the organizational structure and the surrounding systems.

"One fundamental principle is that each operational object is created only once in a system, but is supplemented with information from other systems when operational events occur and that one system is responsible for concluding an operational object. Other systems will have access to data through well defined interfaces to shared registered where they can see their operational view of the objects. This requires that the concepts (the operational objects) and their linkages (relations) be well-defined in a common cross-system information model."

8.6 Concluding comments

If the final solution turns out to be that the different component types' prices for performance-based contracts and/or other forms of construction contract are not given until after the event as an information item in a final invoice, this will have a negative impact on the quality of the information. The price per component type could be rather arbitrary – provided that the total of all the component types' costs is equal to the finally settled contract total. The SNRA, that has an explicit objective to be the world-leader in operation and maintenance needs to be able to monitor productivity and price development, cost drivers and competition in the market. There is also a need to identify *best practice* and bad examples for the learning process. Most of this could be handled by computer if the performance-based contracts are based on priced, adjustable quantities for the component types in the road object in question.

The investment's acquisition value will also be accounted as an asset in the case of the other forms of contract and accuracy per component type should therefore be secured in the same way. Here, the contractor would also need to provide details of length of life and life cycle costs per component type. With the TAM concept, this information can be compiled by the road manager at the time of the tender evaluation of performance-based contracts. The form of the contract would not then involve any significant differences in the tender evaluation itself.

Data capture and updating have been estimated to cost approx. SEK 14 million a year in the implementation project. The price is perceived as an additional cost for handling the model with all the old tasks unchanged. If data is captured at source using rational methods and its content can be used directly for the control and monitoring of the operations, the net effect may very well instead be cost reductions. The present work duplication will be eliminated. If procurements, agreements and project control were made more effective in line with the model's proposals, the annual cost savings will be substantial.

A recurrent shortcoming in the implementation is that there are no designated users of the data that the model delivers. At a subsequent stage in the implementation project, various uses will be tested.

To most members of the working group, the problem of obtaining financial information at component level is “an unsolved issue” where it remains for the SNRA to decide on the quality the information will have. The quality level is specified in the road manager’s order to the contractor. The contractors will provide the information the client wants – a statement that is rather obvious but which is nonetheless verified by one of the major contractors. In theory, the specification will also determine the magnitude of the cost reductions that the road manager is to achieve. The positive aspect is that the higher the quality the road manager chooses, the greater the cost reductions for road management.

The question of cross-checks or plausibility assessments of differences between booked values in external accounting and condition values in the quality-related accounting is probably the result of misunderstandings. The differences that can be assessed in a qualified way are on the one hand the total of all components’ condition values in an investment object and on the other, the total booked value of the same road object. The road objects’ condition value consists of a total of four items per component contained in the object while the road object’s booked value consists of two. The components’ acquisition values totalled for the object must be the same amount as the entire road object’s acquisition value in the external accounting. This assumes that the acquisition dates of the components and the entire investment object are in agreement. The index adjustment is a separate item while the cost reduction is applied to both the index-adjusted value (in one item) and the acquisition value (in a separate item). The external accounting contains accumulated linear depreciations as an item in its own right that covers the entire asset-accounted investment object.

It is possible to verify that the acquisition values are in agreement even several years after the acquisition while other items must be analysed and their plausibility assessed individually. If deviations are found, it may be necessary to study individual component occurrences’ ages, changes in the form of additions and removals, history, investments made and value-adding maintenance on one of the road object’s components. In such cases the plausibility of the deviations can be assessed as index-adjusted to both the replacement values in question and the historical year of acquisition.

8.7 The future of the implementation project

The Government has made radical changes in the transport authorities’ organisations. The Swedish Transport Agency came into being on 1 January 2009, taking over several responsibilities, including the traffic registry and large parts of the SNRA’s sectoral responsibility.

On 26 June 2008, the Government decision “to appoint a special investigator to review and analyse certain operations and functions at agencies in the transport sector, principally within the areas of responsibility of the SNRA, the National Rail Administration, the National Swedish Administration of Shipping and Navigation, the Civil Aviation Administration (LFV), the Swedish Civil Aviation Authority, the National Public Transport Agency, the

Swedish Institute for Transport and Communications Analysis (SIKA), the public enterprise Swedish State Railways (ASJ) and the Board for Shipping Support. [116]

The question of the formation of a joint Traffic Agency has been studied up to 1 April 2009. The proposal includes setting up a unified Traffic Agency – a proposal supported by the SNRA in its s comment on the circulated proposal dated 17 June 2009. [117]

"The study's proposal for a unified traffic agency, changed and strengthened Government Offices, a parliamentary commission, and evaluation and follow-up function, a new planning system and an independent basis is a logical continuation of the efforts to make the work done by the Government Offices and the traffic agencies to make operations and planning more efficient."

The SNRA writes in its comment something that the TAM concept has also always maintained, but in other words, viz. that

"Follow-ups and evaluations conducted by independent bodies are needed, as are independent and impartial basic data for planning. The latter is not the least important; without reasonably objective basic data and transparent methods of calculation and analysis, the organisation's efficiency and professionalism will be of minor importance. A unified traffic agency assumes supplementary measures. Other parts of the proposal, on the other hand, can be implemented singly or in combination without disrupting the balance between driving, balancing, and monitoring/controlling forces."

In a first step in the SNRA's and the National Rail Administration's change effort, it has been decided to merge the agencies' respective financial, HR[118] and IT functions into shared centres (finance, HR and IT centres) with a manager responsible for each centre. The mergers must have been effected and the centres functional by 1 January 2010. The centres shall then provide both agencies with full support. As far as accounting is concerned, the work has led to a focus being placed on getting the external accounting and a new business system to function. In an equivalent change for the two agencies' IT functions, a merger of the IT environments presents great challenges. The implementation project has had lower priority in the change effort. Together with the project manager's priority of completing measure planning in time, this has led to a low level of activity in the implementation project.

The implementation project can therefore not be expected to take off until the Government has come to a decision as regards merging the traffic agencies. It is also appropriate to wait for such a decision in order to secure the best practical application of the TAM concept throughout the entire new area of operations.

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[116] Citat från SOU 2009:31, Effektiva transporter och samhällsbyggande – en ny struktur för sjö, luft, väg och järnväg, 1 april 2009 (Quoted from Swedish Government Official Report no. 2009:31, Efficient Transportation and Community Building – a new structure for water, air, road and rail, 1 April 2009)
[117] The agency's comments on the proposal are registered as document no. SA10A 2009:15668
[118] HR = Human Resources.

9 ANALYSIS AND DISCUSSION

In this chapter the main ideas and conclusions will be summarized

9.1 Road management's prerequisites and culture

According to SIQ [119], a sound improvement effort aimed at increased efficiency begins with good order, systematic follow-us, quality in analyses and a secured learning process. Special attention is paid to aspects that affect customer satisfaction. The SNRA has experience of all local concepts for road measures not being best practice and of greater knowledge, for example, of pavements not leading to fewer and better pavement concepts. Together with the customer perspective are follow-ups, checks, analyses and learning central starting points in the quality-related accounting.

9.1.1 The transport policy's requirements regarding socioeconomic effectiveness

The limit value for each respective component type's "worst acceptable condition" must have a decisive significance for when a measure should be applied. If the defined limit value with its associated circumstance algorithm is incorrect, the maintenance measure risks being ineffective. The value is set on the basis of the transport policy's demand for socioeconomic effectiveness according to "best socioeconomic knowledge". The analysis comprises for instance environment-oriented LCA analyses that include effects on climate factors. As described earlier the limit values are also the results of analyses of society's and road-users' expectations, road management, the politically possible (fairness aspects and similar considerations) and a socioeconomic calculation.

A suitable time for a new measure will be able to be predicted with good accuracy, with effectiveness as the starting point also in this case. It will be possible to make computerised follow-ups of the successively accumulated actual consumption cost as a measure of effectiveness. The LCC per unit of length measure (or per unit) can be analysed for all components whose condition value has not passed the "worst acceptable limit value" for an unacceptably long period. Among comparable components within the same "circumstance algorithm" the principle is that the lower the unit value the more effective the road management has been. Analysis results can be compiled by supplier (contractor) for each component type.

In order to push development forward, for example, towards e.g. increasingly more efficient pavements, control limits can be set on the basis of values for best contractor even if the differences compared to others in the industry might be relatively small. Positive quality and productivity development (the denominator in the effectiveness ratio) should be able to be further stimulated through bonuses, penalty systems in the procurements and similar for the different contractors.

[119] SIQ's model for customer-oriented business development, Swedish Institute for Quality, April 2008, Göteborg

9.1.2 The "doesn't apply here" syndrome: analyses, price trends and price-fixing cartels

Internal accounting where the components constitute the foundation provides good prerequisites for control and monitoring of the road management process. Information exists that allows rational continuous checking to be performed by means of control limits. In-depth analyses of homogenous data can also be made through flexible selections in the road and traffic data bank's extraction programs.

Analyses can for example be based on data extracted from substantial extracts from fully comprehensive bases in respect of traffic, speed, accident and/or environmental information, administrative details (e.g. contractor) and/or components' properties (attributes). Various financial data can be analysed for listed homogenous components, such as acquisition values, annual consumption costs, replacement values, condition values, accumulated life cycle costs, deviations relative to different control limits and maintenance backlog. Analyses can for example be made in respect of age and accumulated traffic effort over the entire lives of components, and different mean values and standard deviations can be calculated.

With knowledge of resource prices' proportions of total prices, qualified assessments can be made of how the construction market is functioning. Differences exist as regards technical prerequisites but such differences in general only concern one or other type of component, resource or factor that affects a few resource prices or similar. In this respect, the same analysis structure can be used to handle the "doesn't apply here" problem. Using quality-assured bases, the differences that actually exist can be made visible for objective discussions of what they signify or lead to and not merely be dismissed with a comment like "doesn't apply here" or "we are unique".

Knowledge of resource prices' proportions and thus of their impact on the total price gives an understanding of a reasonable magnitude for a deviation. The same technical possibility to check and explain each respective component type's price trend, to detect unsound construction markets and price fixing cartels and, not least, monitor road management's cost drivers is also available at any time. It will therefore no longer be possible to claim "doesn't apply here" or "we are unique" if the statement cannot be checked, analysed, explained, and discussed in an objective manner.

9.1.3 Customer focus

Customer focus means for example that one tries to understand and satisfy customers' needs to the highest possible degree. According to marketing theory, satisfied customers are obtained when their expectations have been exceeded.

A deficiency in road management normally means increased costs for road-users and society. A real customer focus therefore involves a serious effort by the road manager to rectify deficiencies in road management. A customer-oriented effort must therefore begin with identifying deficiencies that occur. Physical deficiencies in road management that affect road-users and society (the customers) may concern the road network's condition and standard but also the service given. Customers' contact often concerns substandard service of a short-term "emergency" nature such as snow clearance, de-icing, temporary closure, signage, etc. Major efforts have been made at the SNRA to capture and quickly process customer's complaints and views primarily concerning road service.

The quality-related accounting handles physical deficiencies in need of permanent measures (investments and value-adding maintenance) where physical planning (preliminary study etc) is normally required. The accounting concept requires good order in the SNRA's road and traffic data bank from the outset as regards the road network's components and deficiencies. All deficiencies are therefore rationally and systematically documented in a structured manner.

Each component's condition is constantly monitored against the customer-based limit value "worst acceptable condition value" in the quality-related accounting. If any component's condition is lower than this limit value, the condition deficiency is indicated in the financial accounting. The remaining consumption margin of each component that has a margin that can be expected to require action during a particular planning period will be made visible during the course of planning. When the condition has been exceeded for a sufficient period of time, the component will be placed in the maintenance backlog group, which means highest priority as regards funding measures.

Information about deficiencies in standard is kept readily available by means of the central road and traffic data bank. At each step in the physical planning process, "best available knowledge" about costs of measures and effects is kept current and easily available for day to day operations and, for example, long-term planning. One critical issue is to secure the quality of the information regarding deficiencies in standard from the outset, i.e. when a deficiency is first identified. Decisions regarding deficiency in standard and need for measures at the time a need is initiated must be taken at a high level in the organisation. At least two qualified assessments and expressed opinions must have been made before a decision can be taken. One of them should have been made by a specialist in the field in question (road safety, environment, road design, bearing capacity, customer relations, etc) and the other by a road engineer with recognised skill. In the physical planning, each step concludes with a formal decision at a high level in the organisation and update of the deficiency information in the road and traffic data bank.

9.1.4 After centralised economic planning

Somewhat incisively we could say that "a standard value is a value that on average can be good and can be perceived to suit everyone and everything despite the fact that it is not necessarily right for anyone or anything." During the era of in-house operation and maintenance, resource allocation was probably the most important aspect of the central operations organisation. The main focus was therefore on developing and using adequate distribution models and standard values. In practice there was little interest in the customers. After many years of applying the principles of centralised economic planning, the follow up validated the model applied and the standard values. The analyses that were made were based on information from the operative side and were to a great extent based on standard prices and tailored reports. The real prices and costs of operations were never checked or analysed by the operations organisation.

For the road manager, the economic truth about the operational side and its products consisted of the information from the centralised economic planning model. The road manager had no real knowledge of the actual cost of operation and maintenance. Deficiencies in the control and monitoring of operations led to overall low development in productivity. The possibilities offered in the plannable production volume were poorly exploited and efficiency was low because planning was based on incorrect prices.

The TAM concept is based on another approach to resource allocation where the customers (road-users and society) are at the focus of process control. Actual condition constitutes the basis for resource allocation. Rapid detection and analysis of costs and condition development that deviates from "normally acceptable" are central to the model.

The internal quality-related accounting constitutes support for the process control of road management and the learning that is so essential to an improvement process. Identifying, analysing and disseminating knowledge of "good examples" are just as important as identifying, correcting and effectively preventing "bad road management". When, therefore, the analysis shows that ineffective road management is being repeated, the problem becomes a management issue of competence instead of financial resource allocation. What can be done by the people responsible for road management, is to redistribute responsibility, increase the staff's competence, reinforce human resources or replace staff. This type of measure assumes that the accounting model quickly detects deficiencies in the road management, which is one of the fundamental requirements of the TAM concept.

There is an arsenal of possibilities to influence a contractor that should be built into contracts. Examples of such measures include penalties, mandatory action when a quality deficiency is identified, deductions from payment, prolonged warranty period and/or, for example, consequences in subsequent procurements. The basic principle must be that a deficiency caused by the contractor must be rectified at the contractor's expense without any negative economic consequences for the purchaser (and the road users). External quality deficiency costs must be paid by the external party, possibly with an offer from the purchaser of training. Internal quality deficiency costs are met with internal resources accompanied by the required training or similar measures. The customer must be affected by the quality deficiencies to the smallest possible extent and definitely not by the deficiencies remaining, recurring or that it meets with resource punishments.

With the proposed routines, the TAM concept's internal accounting will not lead to the establishment of new "misleading truths" about road capital and road management in the activities that the accounting covers. Quality deficiency costs are followed up in the TAM concept in respect of type of deficiency and, if possible, its cause. The model ensures that control and monitoring in the road management process can focus on life cycle costs, effectiveness, learning and development. The basic aim of customer satisfaction secures by current monitoring and control of components' functional status.

9.1.5 Interaction between different competencies and the integration of IT systems

Swedish and international experience that it is difficult to achieve an efficient interaction between different competencies and systems in road management is one of the central issues in the road capital model. The model must take advantage of specialists' "best available knowledge" about each respective component to achieve the highest quality in monitoring, control and reporting. This "best available knowledge" refers to:

- what is a functionally acceptable condition (according to claims about "as constructed" and socioeconomic effectiveness, customers' expectations etc.) and thereby the technical consumption margin,
- a component's current functional condition,
- actual acquisition value for new construction (investment in a new component),

- actual expenditure for improvement (investment in an existing component) or value-adding maintenance of an existing component, and the cost of restoring a component's condition from "worst acceptable" to "as constructed",
- actual "normal" life cycle cost per component type and "circumstance algorithm",
- actual price trend per component type and in construction price index thoroughly price of resources.

The challenge when developing the TAM concept's model was to design it so that "best available knowledge" information about the road network's individual components can be transferred automatically between different systems and reported in financial terms in a comprehensible manner . The "best available knowledge" information that the model uses comes from "the economists' accounting system" (items three and four in the list above), Statistics Sweden (item six), the social economists' systems (item one), and the engineers' administration systems and the road and traffic data bank (items two and five).

Day to day control of road management operations, according to the objectives of the transport policy, must be carried on with the highest possible socioeconomic effectiveness. It was therefore important when constructing the model to also use "best available knowledge" of linkages between each component's functional condition and socioeconomic effects or knowledge of what is acceptable to the road-users. This is to ensure that the focus has been on the customer as regards the information delivered by the model in every decision situation.

The TAM concept's internal accounting model handles the various competencies' "best available knowledge" information with a distinct focus on the customer using the simplest known principles and good accounting practice. The intention is that the design of the model will ensure that interactions between different competencies are uniform and systematic in a way that minimises work duplication and the use of standard values. The data must be of the highest possible quality and it is therefore essential that the model be part of the internal accounting with actual expenditures as its foundation and subject to internal control. Management must be sure that the information is based on "best available knowledge" from all the specialists concerned and appraised on the basis of socioeconomic effectiveness and/or customers' expectations.

The model's information must be delivered in such a form that everyone with responsibility for monitoring, control, follow-ups and reporting is able to understand it. The model's financial information would thereby be the only "truth" about road management and thus the common starting point for continued interaction with the owner, road-users and operators and internally within the road management organisation.

9.2 Two different accounting concepts

9.2.1 The quality-related accounting's opportunities and weaknesses

There are great differences between the information from the two forms of accounting – the traditional accounting and the quality-related accounting. Road installations' depreciations according to plan in the SNRA's traditional accounting paint a negative picture (long-term deterioration) in parts of the road capital's, despite massive maintenance measures. The major part of the road capital is missing from the accounting and consumption costs cannot be broken out. The quality-related accounting shows the actual value and change in value (consequences of real consumption and sustainable measures) of the entire road capital. It shows for instance all component occurrences’ consumption costs, successively accumulated life cycle costs, quality deficiency costs both in administrative decisions and in production, contractor statistics, and actual quality value according to socioeconomic effectiveness and customers' expectations.

The administration systems contain the data that is needed to visualise in the experts’ technical terms what the quality-related accounting makes clear in financial terms. Data concerning e.g. the *Bound wearing courses* component type is measured by independent consultants and transferred in refined and evaluated form “according to the best technical concepts” via PMS to the quality-related accounting. The same applies for bridges and tunnels in BaTMan and for road structures in connection with bearing capacity investigations such as BÄRUND in VUH (the road maintenance administrative system). Results in respect of the transport policy’s demands concerning “best socioeconomic knowledge” are made visible for the operations manager comprehensibly in financial terms. Every component’s condition can be monitored and checked.

In the present concept for accounting of the road capital, bound wearing courses, for example, can be distinguished. A great deal of work is required to obtain actual expenditures for pavement measures from archived project documentation and this is therefore not possible for practical reasons. PMS today therefore contains a mixture of realistic figures and standard values.

Specialists’ analyses in PMS do not need to be, and probably will not be, made visible to the responsible decision-makers if the results are uncomfortable. Pavement experts have no incentive to, for example, disseminate information about their own failures. To a large extent, the expert has often personally provided the basic information for pavement measures and thus influenced decisions regarding “abnormally” early measures, for example. The expert has also been responsible for checking production quality and for the client’s contact with the contractors. This reduces the possibilities for a learning process.

9.2.2 The quality-related accounting’s opportunities

The quality-related accounting model provides appropriate information for several of the road management processes, such as for

- *long-term planning* (deficiencies, risks, consumption costs, life cycle costs, remaining consumption margins, productivity, efficiency, cost drivers etc),
- *short-term planning / budgeting / follow-ups / financial control* (resource requirements, resource allocation, resource consumption, resource usage, economic results, reporting, internal and external benchmarking, costing etc),
- *procurement* (status, function- and quality-focused requirements and contracts in a life cycle cost perspective, measures, etc),
- *management with prognosis and monitoring of production according to contract* (computer-aided analyses of cost deviations into unit price-, quantity- and time-dependent causes etc).

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 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 LCC).

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[120] 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 principle is stable and annual depreciations will be based on actual values.

Quality factors of long-term significance manifest themselves correctly in annual "depreciations" when real (actual) values are used. According to the theory behind condition-related accounting, depreciations must reflect changes in components' condition as well as possible. Quality defects in production will be 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.

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. These increased year costs are 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.

Efforts have been made in earlier chapters 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.

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[120] This refers to the SNRA's experience in its operations of problems with standard prices for machinery in the so-called MCF system and the regularly updated prices of friction materials in the stores model that was also linked to the settlement of appropriations. The principles of the five-year plan of operations were based on similar ideas 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, computer support and continued development instead of on analyses of actual cost, productivity etc.

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 in the accounting.

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.

In the quality-related accounting, the quality of component information in a road network may vary. The acquisition value may be the actual value, actual adjusted standard value or a standard value. The quality of the condition value can be classified on the basis of "degree of objectivity" and "degree of forecast" depending on which consumption model is used.

When the road network's components are retroactively "valued in", there is no better quality of available information than actual adjusted standard values or pure standard values. The SNRA's implementation project elected to use circumstance algorithms and standard values across the board despite the fact that actual adjusted standard values to a large extent were available. As components on retroactively "valued in" roads are successively replaced, certain components will be given actual acquisition values. On an old section of road, the quality of information about one and the same component type may therefore vary.

Compared to a traditional accounting using six component types quality will still be able to be controlled much better in the quality-related accounting. A model with six types provides no possibility to control the quality of the information. If one, two or a few more actually existing components in the road network are replaced in one of the six highly composite component types, control of quality will be lost not only as regards condition values but also acquisition values. Benchmarking of components within one and the same type will require advanced inventorying, searches of archived material and analyses with a high content of standard values.

Analyses and learning will be complicated and will probably require separate systems with work involved just as is the case with the quality-related accounting. The problem, however, is to capture the actual expenditure. Standard values will therefore presumably be permitted in the administration system, if anything is to be gained from the "simplification". This means lower quality analyses and slower learning, since extra investigatory resources, special studies where checks are difficult or impossible, will be needed.

Large savings can be made by using the quality-related accounting compared to the present system. The quality-related accounting uses correct data of the best conceivable quality captured directly at source in the form and with the content that all road management operations can make use of. Analyses are fast, as are the possibilities for corrective action and learning without costly consultant studies and quality-impairing standard values.

9.2.3 Different starting points regarding approaches to information

Road management engineers can roughly 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. At the SNRA, there are examples that indicate that this problem is a very real one.

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 or a maintenance project. 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 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.

The TAM-concept model 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 (laser measurement, bridge and tunnel inspections, BÄRUND etc, according to description models II, III, IV, and V) for the “major items” than for the “less significant” items (forecast depreciation over a predetermined period or depreciation rate, which can easily be done by computer in the accounting system in description model VI).

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.

9.3 Effects in the organisation

In the organisation, comments like “the ‘people upstairs’ don’t know what they are doing” and “the ‘people downstairs will have to deal with it” have often been heard. Control, monitoring and a living continuous improvement effort with up-to-date information based on “best available knowledge” would probably reduce such harmful distances between different levels in the organisation. It is therefore important that operations’ “correct conditions” can be presented, analysed and discussed on the basis of the actual state of affairs.

The economists have had poor knowledge of the issues handled by engineers. The engineers have correspondingly had insufficient competence in the issues handled by economists. Over and above this are issues concerning the transport policy’s demands for socioeconomic effectiveness, a customer perspective and a business-like approach. To understand the model, knowledge is needed of already ongoing activities and operations and existing logistics (the documentation and data capture including information processing) both in the technical administration and the accounts. An understanding of issues concerning internal control and quality assurance is also needed.

In brief presentations, it is not surprising that the model appears to be complex, despite the fact that in practice it does not require more work or set any new requirements. The model is entirely based on the operations carried on today but with a demand for structured coordination, transparency and verifiability. The result is that the quality-related accounting can thereby ensure that the entire organisation understands the result of all the shared work that it is possible to analyse the result and carry on a systematic improvement effort. Many analyses that should be made, but that have never been made because they require substantial resources, will be made using the system. Data will be captured at source and will not need to be registered twice or be replaced by standard values.

It often is pointed out that there are too many details in the quality-related accounting. All these details do exist in the road network. No one knows exactly how much each component type represents. The motives in the implementation project to have that many types have been many. The common denominator, except for one or other prerequisite item, is that they are physically distinguishable and that:

- they are planned, analysed and entered in drawings in connection with the physical planning for investments and maintenance measures,
- they are constructed according to technical requirements and as-built drawings or in adjusted positions.
- their actual positions are entered in revised as-built drawings,
- each one is registered in the road and traffic data bank (sometimes as voluntary phenomena)
- they can be precisely located in the road network in tender documents for basic operations packages,
- they are maintained according to requirements stipulated in operating contracts,
- they are replaced when needed according to the regulatory framework in force or experts' assessments,
- they represent values amounting to billions of SEK per component type.

There is no longer any doubt that road management needs a new platform for its continued development. The implementation project has established that technical, financial and socioeconomic knowledge can be brought together to constitute "best available" information. The continued development of operative control and monitoring should be able to use this information as its starting point. The counterarguments heard in these often abstruse discussions are very close to factors that are usually mentioned in the theory of monopolies' X-inefficiency [121].

9.4 Internal control, IC

The TAM concept improves the quality of information in the accounting in a decisive way. The information becomes usable for resource allocation, monitoring and control, analyses, and improvements of the road management. The level of ambition for internal control is high and there is a natural focus on openness, continuous improvement and customer satisfaction. Especially evident is the ambition in the model's focus on process control, with fast detection of deviations in the form of, for example, life cycle costs, good examples, inefficiencies, maintenance backlog and costs in ongoing projects distributed over causes dependent upon unit prices, quantities and time. Other important activities as regards making road management more effective with the support of the TAM concept are benchmarking and control of cost drivers.

The internal control (IC) problem in today's activities and operations is a serious one and has been created by the contract concepts that are applied. The TAM concept adjusts the focus from, for example, excavating as large unverifiable quantities as possible to producing components in fully verifiable quantities, where the challenge is that they must have lower life cycle costs and/or better effects.

[121] Formulated by Harvey Leibenstein in the 1960s, where X represents many small trickles of inefficiencies, which are difficult to trace in organisations not exposed to competition.

It is relevant and appropriate for the monitoring and control of road management's sub-processes that the road capital's figures are in current prices related to replacement value and continuous price and cost trends. The information for computerised checks and learning in the road management process is improved compared to information in a model where figures are based on fixed prices at the level of the year of acquisition for each respective component. This has a positive effect on internal control. The TAM concept's basic accounting idea is that the capital value will automatically follow "best available knowledge" of technical and functional condition.

For the most important component types, information about components' actual condition and consumption comes therefore from sources independent of the operator responsible and the person responsible for the accounting. Model VI applies for other components, i.e. a technical life according to "best available knowledge". Index adjustments and value reductions of index adjustments are reported separately and for each component occurrence. Road management's cost drivers are quite clear, which should lead to a sound focus in control where, for example, underlying information exists to allow real interest trends to be considered in decisions about measures.

The quality-related accounting is based on great openness with control limits to allow deviations to be detected quickly. Control limits and learning processes are major features of the internal control. The construction price index has the structure that is needed to be able to perform in-depth analyses of how well competition functions in the construction market. Road management's cost drivers are identified and have strategies for action, with defined goals, that can be monitored in continuous follow-ups.

With the quality-related accounting, internal control is performed efficiently at the level where the costs are generated. The accounting is transparent and can be verified externally long after the project has ended. The quantities that cannot be checked afterwards are few and can therefore not be manipulated into substantial deviations without being detected in plausibility checks. Information needs at all levels of the organisation concern the components with a large number of computerised follow-ups, checks and analyses for each component individual from the time it is commissioned and for the rest of its life with lifelong significance for the contractor.

During the course of a run-through with practised project managers for investment projects, it was clear that the component level would function excellently in the operative control of projects. The main structure of the information would thus be the same for all road management competencies and organisational levels. This would mean a much stronger internal control that would benefit the entire construction industry. It could also affect the distribution of responsibility between client, contractor and any project planning consultant.

9.5 Standard values

Experience of using standard values is not good. Cross-checks were neglected while incentives and follow-ups reinforced the inaccuracy of the standard values.

In the road capital model, the standard cost of carrying out measures is important for calculating the magnitude of the value reduction for those components that use consumption model VI. Two cases can be distinguished as regards this calculation. The first applies for those components that are replaced or considered to be entirely consumed. Here, the standard cost of carrying out measures is equal to the cost of acquiring a new component, i.e. the replacement value. The standard value is in this case the original acquisition price adjusted for price trends (construction price index). The most serious error that can occur in the value reduction mainly depends on inaccurately assessed length of life – an error that is automatically corrected against reality when the component is replaced. The successively accumulated life cycle costs are adjusted retroactively. The follow-up of lengths of life and life cycle costs will lead to better quality in the accounting and the standard values should therefore in the first case not "normally" constitute any significant quality risk as far as control is concerned.

The second case concerns components that are considered to have a substantial residual value and that are repaired, upgraded or rebuilt by means of value-adding maintenance. There is a risk here that the value reduction will deviate from reality in those cases where the standard costs of carrying out measures have been inaccurately assessed, which means that the residual value is incorrect. In order to minimise the errors, continuous computerised follow-ups are made of maintenance costs and calculated actual residual values. According to the principles that apply for determining a component's condition value after measures in respect of an upper control limit, the values in the accounts are automatically adjusted to reality. The standard value does not therefore constitute any significant quality risk as regards control in this case either.

The SNRA's implementation project elected to use standard values together with circumstance algorithms to assign values to components in connection with the retroactive "valuing-in" of the road capital. This is an example of "best available knowledge" being used in a context where other possibilities have been discarded. When the valuing-in is complete, the values are upgraded to "truth". The quality of the components' values will gradually improve not only in connection with replacements but also when improvements and value-adding maintenance are carried out.

Earlier negative experience of using standard values in the accounting will therefore not be able to be repeated. Computerised signalling can be used in the model to indicate when standard values deviate sufficiently much from actual expenditures. Values and costs will contrary to earlier experience be of higher quality as the model's application increases and follow-ups are made. The quality of information about a component type's future funding needs year by year will also gradually improve since the forecasts are based on increasingly better standard costs of measures.

9.6 Culture and quality issues in process control and learning

In process control, it is important that the control systems detect inefficiencies and "best practice" quickly so that corrective action can be taken and/or confirmatory analyses performed without undue delay. The learning process must quickly ensure that mistakes are not repeated. It is equally important to quickly identify, analyse and disseminate knowledge of good examples so that they can be copied and repeated throughout the country. The concept with checks and analyses for learning is supported by allowing differences and creativity in order to create a dynamic environment for improvement. Strictly shared working concepts would not provide good bases for improvements. This may be compared to the financial analyses of organisations that book financial events using uniform standard values without cross-checks against actual expenditures.

In customer-oriented road management the present principle cannot be allowed to continue to apply where [122] it is more important to allocate funds according to what is considered to be "right" in relation to "circumstances" than to actual needs. With a real customer focus, "a road manager's lack of ability" must not further punish road-users, who are (and perhaps have been for a long time) sorely affected by "bad road management". By using control limits in the follow-up, "bad road management" will be detected and indicated automatically by the system so that corrective measures can be taken at an early stage.

This type of quality problem in the road network will be a matter for management. If "bad road management" is repeated, action must be taken to raise competence, reinforce human resources, redistribute responsibilities and replace personnel or other similar measures. There is an arsenal of possibilities to influence a contractor, for example penalties, deductions from payment, prolonged warranty period and/or consequences in subsequent procurements that should be built into contracts. The principle must be that it is not the road users who are to be affected.

The quality-related accounting supports cross-checks, analyses, benchmarking and learning in road management's various sub-processes. Strategies and goals that can be followed up can be defined in order for example to allay the development of activities' and operations' cost drivers. The process control's analyses and continuous monitoring of deviations are also elements of stronger internal control and stimulate a "healthy" development of the construction industry. This should be welcomed by all serious contractors in order to improve the industry's not too good reputation.

Quality-related accounting used in process control with continuous cross-checking of critical values and key ratios must have a well-considered attitude to how information is to be handled in the continuous improvement effort and to staff. It is important that good results can be rewarded. To achieve success, an organisational culture is needed that is adapted to what management wants to achieve.

In several articles (e.g Flyvbjerg 2007, 2008) [123] "Reference class forecasting" is proposed as one curb against cost overruns. The method has also been endorsed by the American Planning Association:

> "The new method achieves accuracy in projections by basing them on actual performance in a reference class of comparable actions." (Flybjerg 2008 p 3).

The idea is that instead of (only) doing an "inside" view prediction, thinking in terms of prices and quantities, one should take an outside view and compare with earlier similar projects. The

[122] Jaro Potucek at the SNRA's technical division, the administrator responsible for resource allocation at the SNRA, gave the following opinion about the distribution principles: "Distribution of, for example, pavement funding according to statistical information such as road network, length, width, traffic flows, geographical zone etc gives *one* result. Distribution according to condition, something that in a longer perspective does not reward capability, gives *another*."

[123] Flyvbjerg B., (2007), Policy and planning for large infrastructural projects: problems, causes and cures. Environment and Planning B: Planning and Design, vol 34 pp 578-597.
Flyvbjerg, B., (2008) Curbing Optimism Bias and Strategic Misrepresentation in Planning: Reference Class Forecasting in Practice. European Planning Studies, vol 16, No 1, pp 3-21.

quality-related accounting model presented in this dissertation gives this type of information. It is for instance possible to produce indexed comparable information out of the different algorithms per component type, “best practice”, averages and “worst practice” for all component occurrences, and/or per contractor (“best” and “worst” in sensitivity analyses).

9.7 Procurements and cost increases

The quality-related accounting:

- Improves possibilities for cooperation, not least since there will be fewer conflicts and “unsound” quantity negotiations, which will increase profitability. Better information, greater openness about, for example, deficiencies in standard / need for measures and more effective social planning allow creativity and new solutions in order to identify pressing investments.

- Gives better quality information about productivity, costs, life cycle costs and quality deficiency costs. Possibilities for benchmarking are better, which will in turn lead to a focus on improvement efforts throughout the industry.

- Provides scope for more efficient planning processes, where many requirements can be replaced by responsibility for delivered components and where this can for example be expected to follow consequences of deliveries with high successively accumulated life cycle costs.

- Provides political scope to increase responsibility for the transport sector and the market’s players since control possibilities are vastly improved. According to the planning model presented, with both scheduled long-term planning and road projects according to the “building permit principle”, the state would be able to continue to fund the part corresponding to the predetermined net present value ratio in respect of specific effects for society and nothing else. The remaining parts will need to be funded in the same way as the market funds all other important investments.

- Will probably lead to a healthier culture with a focus on customer satisfaction and improvements on the part of both the client and the rest of the sector. The cooperating climate between the players will have “sound” incentives for improvements.

- Through a financial focus on components will be able to increase the content of specialised equipment and/or industrialisation etc with an accompanying need for standardisations.

The view here is that projects’ cost increases are primarily due to the contract concept and the problems that arise out of the negotiating parties’ differences in incentives and private information. Cost increases are not primarily caused by systematic errors in project planning and/or calculations. Using the component structure instead of AMA structures in contracts reduces the number of negotiations and agreements about what the client is to pay from several thousand to just a few tens of components. Payment to contractors in the TAM concept is principally based on the components' quantities and a few other quantities that are important as regards business risks. The vast majority of the quantities will be able to be measured and checked at a later date, even when the project has been completed and opened to traffic.

In the TAM concept's contracts, every component type has in general a unit price and an adjustable quantity. A few more adjustable quantities may occur if they are judged to have substantial significance as regards the contractor's risk costs for the component type concerned. For these will the unit prices and adjustable quantities determine the unit prices of the component type. Most of the adjustable quantities in the contracts will therefore be able to be measured and checked after the road project has been opened to traffic. From the point of view of internal control, it is of importance to be able to establish that the possibility to conceal irregularities in unverifiable quantities will to a great extent no longer exist. This should be welcomed by the serious players in the industry. Since most of the adjustable quantities so very clearly are to the contractors' advantage, one can nonetheless expect substantial opposition to this type of change. The contractors will in all certainty emphasise the risk costs in calculations and business if the contracts contain any uncertain quantities.

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9.8 Life cycle perspective and productivity development

With quality-related internal accounting, the road manager is given good knowledge of every component occurrence's life cycle costs. The model allows the components delivered by the contractor to be related to the requirements stipulated in the contract as regards development of accumulated life cycle costs from the actual "date of delivery". In day-to-day process control the components' development can be monitored by the system over the entire warranty period. The focus on monitoring is in order to detect deviations against acceptable expected or contracted life cycle costs early on (deviations against upper and lower control limits). Exceptionally good or bad components are normally detected at an early stage. Naturally this only applies to component types that are inventoried, in order to determine condition (at least 75% of the total road capital). For "model VI" components that are not subject to inspections, the truth about the component will not be known with certainty until the end of its life, when replacement or rebuilding is planned.

The more component types that are regularly inventoried the better the life cycle perspective will function for the control of construction contracts. It goes without saying that if the road manager is not interested in or lacks knowledge of components' condition development, no such requirements will be stipulated in the contract or followed up.

In order to stimulate development in the direction of increasingly lower life cycle costs with maintained or increased customer utility, several levels of control limits can be set. Both bonuses and penalties can be linked to these limits. In the day-to-day follow-up the different contractors' deliveries of components can be followed up individually over a sustained period so that, for example, differences in life cycle costs are highlighted and considered in future procurements. The contractor's focus and creativity should in this way be shifted from e.g. excavating the largest possible quantities and preferably invoicing larger excavated quantities than actually exist. The focus should instead be brought to bear on developing as cost-effective components as possible in order to be the "best supplier" and win procurement privileges or quality bonuses.

It is not only the possibility to increase profits, through clients being prepared to pay more for components with a lower life cycle cost than for ones with a higher life cycle cost. The prerequisites should also be good for obtaining patents or design protection for innovations and improvements to components. For example, it is more difficult to obtain a patent for intelligent machinery layouts in earth excavations or adjustments of existing machinery or tools in order to increase productivity or profit in excavation work.

All in all, the shift of focus from earning money from work tasks and quantity increases to increasingly cost-effective components, should lead to a gradual positive development of productivity. Goals can be set both for productivity improvement and reduction of inefficiencies that can be followed up continuously by computer in the belief that “things that are measured get done”. Good examples and failures are quickly detected, analysed and taken up into the learning process with the intention that errors and mistakes must not be repeated while good examples must be imitated and exceeded.

9.9 Summary

To summarise, it may be noted that road management is still undergoing a significant change in culture. Present development, where socioeconomic effectiveness with a focus on society's and road users’ needs, began tangibly in the late 1980s. This means among other things that environmental, cultural and ethical values are emphasised early in the physical planning of transport infrastructure together with accessibility and safety. In Sweden, the TAM concept was reinforced from the outset by influences from Japanese work on quality and SIQ’s principles for continuous improvement and learning. Today, politicians are once again putting great emphasis on the fact that transportation must be regarded as consisting of holistic issues and not issues that can be resolved by the different modes of transport and the infrastructures [124] separately.

The transport infrastructure manager should secure the information need that exists in an efficient TAM concept when consultants and contractors are first engaged. The question of data capture should be monitored at every stage of the process. It should go without saying that data capture should be taken seriously and conducted in an efficient manner with the content that the organisation’s most important and most costly resource (the personnel) needs. Those systems that need to exchange information with each other in order to work well must be able to communicate with each other. No system can really be the “personal property” of a particular competence.

For example, it is essential to arrange things so that as good as all properly motivated needs for financial information can be satisfied through digital transfers from the accounting systems. Duplicate registrations performed by qualified personnel must be eliminated and standard values will not need to be used in order for correct data to be obtained. In order to achieve high efficiency in the organisation’s activities and operations, control, follow-ups, cross-checks, analyses and learning must be able to be based on data of high quality and not questionable “general knowledge”. Without functioning cross-checks against the real picture, there is a risk that “general knowledge” and standard values will be cemented and confirmed by the organisation’s activities and operations. Really good results come from correct

[124] Effektiva transporter och samhällsbyggande – en ny struktur för sjö, luft, väg och järnväg (SOU 2009:31), Slutbetänkande av Trafikverksutredningen, ISBN 978-91-38-23181-4, (Swedish Government Official Report no. 2009:31, Efficient Transportation and Community Building – a new structure for water, air, road and rail, Final report by the Traffic Agency Study) Nils Gunnar Billinger, 1 April 2009, Stockholm

information and from management and specialists understanding each other and being able to "pull in the same direction".

In today's performance-based contract concepts, and probably also other forms of contract, the data capture issue is not considered. For example, the road manager can hardly have any other use for the contractors' unit prices and quantities according to the AMA structure than to provide the calculation database with more input data. The revised as-built drawings that the contractor must deliver to the road manager when a completed investment project is handed over cannot be used today as input data to the road and traffic data bank. When a new stretch of road is opened to traffic, an external consultant must be engaged to once again enter the same information now that the project has been completed. The data then has to be entered in the road and traffic data bank manually in a separate, subsequent step. The delay in entering the data is often a year or more since the tasks are not prioritised. Until the data has been entered, higher levels in the organisation make decisions based on incorrect information.

It has also been established that internal control of road projects would be vastly improved merely by the fact that control measurements can be made afterwards. Uncomfortable suspicions of irregularities would be radically fewer. The construction industry, often the subject of distrust and doubt, seriously needs to improve its tarnished reputation. With the TAM concept cost increases would be radically reduced, which is not, however, the same as saying that price levels would automatically fall. Healthy competition with a focus on components' life cycle costs and effects for customers would stimulate creative contractors in the "right" way.

The transport policy contains explicit requirements regarding socioeconomic effectiveness in infrastructure management. The TAM concept's quality-related accounting provides access to up-to-date information according to "best available knowledge" of the costs and effects of rectifying deficiencies in standard. If would be more effective if this could apply to all transport modes' infrastructures. The quality of the information must be secured through decisions about deficiencies being taken at a high level in the organisation for each respective transport mode. Decisions should be preceded by at least two qualified reviews. One can for example have been made by a specialist in the field concerned by the deficiency while the other may have been made by an infrastructure engineer who is known to be skilled.

When a measure is planned for some transport mode, the possibility must exist to overview all types of deficiencies in all the transport sector's infrastructures with assessments of costs and effects. With several transport modes involved the need for openness is greater. The solution must not automatically be to prioritise the transport mode that has the most vociferous advocate or the most users. It is the total effectiveness that must be in focus.

Openness allows the possibility to review needs for action efficiently in a context and achieve synergies and coordination gains with solutions that embrace more than just one transport mode. All in all, effectiveness should then be higher than if every transport mode acts separately, at different times and on the basis of isolated knowledge of its own need for measures. It is for example not difficult to appreciate that coordination reduces the risk of work duplication and adjustments but disruptions in society will also be fewer. It is also easy to understand that the contractor's costs for establishment, removal and administration will also be lower. Customers (road-users and society) are satisfied by a need for measures inside a geographical area being dealt with effectively and on one single occasion. The potential savings are judged to be considerable but ultimately depend on the political will to change and increase efficiency.

Possible uses of the quality-related accounting were among other things presented in the Chapter 7 on sub-processes. The model was scrutinised in depth by external experts in the early 1990s. In somewhat modified form it was analysed by PriceWaterhouseCoopers (PwC) at the direction of the Ministry of Industry, Employment and Communications, and between 2007 and 2009 reviews and analyses have been made within the SNRA's implementation project. All in all, the analyses should show that the quality-related accounting can make road management and its sub-processes more efficient at the same time as political control and monitoring are improved.

The Government has now (3 September 2009) decided that the SNRA, the National Rail Administration (Banverket) and parts of the Maritime Administration will be combined into a common Transport Agency as of 1 April 2010. In reviews of culture made at the SNRA and Banverket by the Government's special investigators [125] the business culture is seen as functioning in a "drainpipe". The investigators also report that, "There is in general a weak culture of follow-up in the infrastructure sector" and "This means that knowledge of effectiveness is today's processes is insufficient". Many have experience of both the SNRA's and Banverket's organisations and see the differences that the investigators also confirm, viz. that the SNRA has a more open and extrovert culture compared to Banverket's more introverted culture.

This makes it natural to assume that the culture at Banverket leads to at least as little interest in checks as at the SNRA. One conceivable way of "correcting" this type of culture problem in the new Traffic Agency, that in the future will deal with road and railway track management, is to focus on openness, control and learning early on. The Traffic Analysis agency, which will be formed at the same time as the Traffic Agency, needs good prerequisites for analyses, including information about traffic and the physical transport infrastructure.

The platform for continued development of road management that the quality-related accounting constitutes should be of interest in this phase. The most common arguments against this are:

1. There are far too many components.
2. Financial input data cannot be obtained for components.
3. Technical input data cannot be obtained for components.
4. The IT systems concerned cannot be integrated.
5. The "benefits" from a quality-related accounting system are not correctly described in the research and implementation project.
6. "We mustn't fool ourselves into believing that the SNRA can change that!" has been claimed as support for a failed businesslike approach.
7. The assessed costs of the implementation project are considerably underestimatede.

[125] Nils Gunnar Billinger, "The SNRA and Banverket should be replaced by a Traffic Agency", press release, 1 April 2009.
Gunnar Malm, "Community Building in a Traffic Agency" – Decision following steering committee meeting on 10 September 2009, Dnr AL10A 2009:22325, Decision by Director-General on 10 September 2009, SNRA, Borlänge.

8. The systems’ and/or the computers’ capacity is insufficient for quality-related accounting of 65 component types with a total of many million component occurrences and runs several times a year.
9. “We’ve always done things this way and been successful” so no changes are needed.

In earlier chapters it has been shown that none of these views are supported by strong arguments.

The final questions concern what conclusions can be drawn as regards the hypothesis of the existence of a relevant, dedicated internal accounting of physical road installations according to the transport policy’s requirements:

1. That there exists a possible verifiable value appraisal in accordance with good principles, where “experts’ best available knowledge” about every installation’s functional condition can be used to advantage,

2. That the functional value appraisals can be based on “experts’ best available knowledge” regarding socioeconomic effectiveness and society's and/or road users’ expectations,

3. That the financial value appraisals and costs can be presented in current prices on the basis of actual expenditures and costs,

4. That efficiency in the road management process can be sufficiently improved through using the model to a level corresponding to the extra costs that the model may cause,

5. That political monitoring and control of the entire road network can be sufficiently improved so as to cancel out the extra costs that the model may cause.

It must be considered to have been established that the first four hypotheses are true since the value appraisals are based on the installations’ functional quality and that this quality is determined relative to socioeconomic effectiveness and society's and road users’ expectations. The quality-related accounting according to accepted principles is as far as possible based on actual expenditures and costs. The implementation project has also examined and attested the effectiveness issue.

Politicians’ demands and credible reporting and communication were possibly the most discussed issue when the project initially was commissioned. All examinations of the issue have resulted in trust in the reported information. Politicians, on the other hand, are accustomed to attempts to manipulate, especially in budget contexts. Thankfully, they are generally suspicious and their trust is thus best won gradually through openness and ample opportunities for control.

The quality-related accounting fulfils this type of demand but has in practice not been examined by the politicians directly responsible today. Over the seventeen years of questioning and discussions no better concept has been presented in this respect. Road management’s “best available knowledge” must be taken into consideration to the extent that it has significance for the functional value of the road installations.

The research assignment concerned the valuing and accounting of the road transport infrastructure. The Government has now decided to amalgamate principally the SNRA, Banverket and parts of the Maritime Administration into a common Traffic Agency. The quality-related accounting has attracted some interest from Norway’s coastal shipping authority, from researchers in the area of electricity distribution, and from the association of municipal highways managers.

On closer examination, it becomes apparent that the model can be used just as successfully as for roads for valuing and accounting of all other physical infrastructure. This thus applies for maritime and aviation installations, railways, water and sewage networks, street, cycleway/footpath and park installations, electricity, telephone and fibre networks, and installations for wireless communication. There is no doubt about the model’s usability in these areas since in all probability special administration systems exist for the various critical components in the infrastructures. It would also be interesting to see the quality-related valuation principle and accounting further elucidated in research in respect of the valuation and management of special purpose properties.

In the transport sector, more knowledge is needed of the linkages between components’ functional condition and effects for society and road-users but also about customers’ preferences in general. In this context it cannot be emphasised enough how important knowledge of the components' life cycle perspective as regards energy, climate and the environment is. It is vitally important that this type of “best available knowledge” really influences the components' limit values for condition in order for these aspects to be also taken into consideration in monitoring and control in reality.

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Appendix 1 Road management: Basic prerequisites and culture

During many years of analyses of Swedish road management but also of practical activities at most operative levels, extensive experience has been gained. This experience is primarily in respect of the organisation's culture, relations to customers, effectiveness, learning and internal control.

This appendix will highlight seven specific areas of particularly significance. These are

1. *Road management's technical prerequisites*
2. I*nteraction between different competencies and systems*
3. C*entralised economic planning*
4. *Cost increases and follow up*
5. *Life cycle perspective*
6. *Productivity*
7 I*nternal control*.

Experience and known consequences are described under the respective headings. The other sections also contain issues arising out of experience and need, which have been identified both in practice as well as in theory through literature reviews and analyses.

1. Technical prerequisites

1.1 General description

In a road management perspective, Sweden is often regarded as an "elongated country pointing in the wrong direction". The climate varies enormously, where the frost index [126] in the northerly parts during extreme winters can exceed 70.000 h°C while in the southern areas (Falsterbo) it may be close to zero. In principle, the frost depth increases with increasing frost index and some areas in the far north have permafrost. Large quantities of snow, however, can greatly reduce the frost depth, especially where it is left "untouched". Local differences in frost depth can therefore cause problems. This is for example the case at elevated locations, where the wind may keep the snow depth low, for example on uncleared roads or where the cold penetrates deep into the road structure around open culverts. Parts of the country are proportionately rainy while others can be fairly out of rain.

Quaternary conditions and the properties of the soil types also vary in different parts of the country. The same soil type's properties can differ in wet and dry conditions and during periods of transition from frost to thaw and vice versa. There are particularly difficult areas with very deep layers of glacial clay or that contain various types of ground frost sensitive silt. Stiff consolidated clay can be managed from a construction point of view but in areas where glacial clays have leached for a long time, the risk of landslides may cause problems. The probability of a landslide occurring increases for example when these types of ground do not have a balanced earth pressure, are water-saturated (capillary water can reach very high) and are exposed to vibration with transient increases in pore water pressure (from earth tremors, heavy freight traffic on roads or railways, etc). Other types of problem occur here and there in areas with fenland, lakes, rivers and other open water, and shorelines and riverbanks. On the

[126] The frost index here is the sum of only negative average hourly temperatures during one winter season.

other hand, there are also areas that are favourable in a construction perspective, with for example gravelly moraine, boulder ridges or sandy heaths.

The bedrock geology (mineralogy) also varies widely. There are for example water-bearing weak sedimentary rock types and firm eruptive rock types with technically complex zones of montmorillonite (”rock that turns into liquid clay” under conditions of moisture and low pressure). There are large areas of slaty types of rock that have low resistance to erosion and poor properties from a construction point of view. On the other hand, there are technically favourable types of metamorphic rock, formed under high pressure and that are results of the transformation of existing sedimentary or eruptive types of rock. Sometimes ground moraines occur so compact that they must be treated as if they were species of rock from a construction engineering point of view.

It is a fact that the variations in fundamental technical prerequisites for road management of which a general outline was presented above can also be very local. It is also a fact that the technical prerequisites can be of crucial importance as regards the best constructional solution for some of the road’s component types but by no means for most of the others. Measures and maintenance concepts for an existing road can also affect the technical prerequisites but often to a more limited extent than during the construction phase. Another factor that influences the concepts that are actually applied is access to machinery in the area where the needs exist. It may sometimes be difficult to justify the “technically best” choice of machinery and/or materials financially. For example, the transportation costs for having access to “the best choice” may be too high if production volumes are small.

Taking all this into consideration it is not difficult to understand that many local technical concepts have been developed over time not only for investments but also for maintenance and measures to rectify functional deficiencies in the road network. The concepts have often proved difficult to question without detailed analyses. A great degree of freedom has therefore come to prevail when making local decisions regarding the best action to take. Along with this has followed a great degree of freedom when deciding an acceptable physical and functional condition for the road network’s different components – opinions that have almost always been related to funding possibilities. “Everyone” declares that they want to accomplish more and even better measures in the road network but that there is no “money”. Combinations of questions of what concept to apply, functional condition and funding are complex. Therefore they have been difficult to discuss without detailed knowledge of the whole picture, what functional requirements actually apply, and local conditions and prerequisites. “Local freedom” has therefore prevailed for a long time.

The transition to customer focus strongly called these freedoms into question. One overriding conception was that a road-user must not be subjected to inexplicable changes in standard and condition while travelling. During the course of the debate, scientific studies were presented that showed that some kinds of variability in standard can also increase the number of road accidents. The change in culture towards customer focus gained wide acceptance in the organisation, while the restrictions on freedom to decide on the best action and what is functionally acceptable, on the other hand, came to be seen as “central control”. Representatives of the regional divisions opposed not only this kind of progress but also efficient checks and evaluations.

The SNRA had for a long time a rationalisation function that evaluated different production methods and choices of machinery. The function also actively disseminated its technical expertise and distributed results of analyses within the organisation. The introduction of requirements regarding quality assurance systems with self-checking, efficient follow-ups with actual cost calculations, and a secured learning process contributed to the function's demise. With the new orientation towards customer focus and quality assurance, a fundamental shake-up of the culture at the SNRA became necessary.

Management's strategy document and policy statement "the Signpost" [127] with its associated eight areas of strategic priority (the 8S model) was based on Japanese concepts that place the customer at the focus. External experience from similar strategic development of an organisation's culture was that it would take at least six years to put a new culture in place counting from the beginning of the 1990s. The organisational change of 1993 (with the Traffic Safety Administration) and the successive exposure to competition of all in-house production at the SNRA's Production Division partly contributed to make it difficult to pursue a focused development process.

1.2. Some consequences

A number of factors may in general vary in a maintenance measure. For example, in the case of pavement measures such variable factors may concern binder (soft to hard), binder content, voids (sealed to open), stone size and stone quality. It is also possible to hold different views of the technical concept in the form of hot or cold aggregate, aggregate application, surface treatment, rut repair, partial repairs, milling with reapplication of new aggregate, milled aggregate supplemented with new or regenerated aggregate from stocks, etc. The great number of technical concepts for measures leads to questions in the purchaser organisation about how well the contractor industry is functioning and to questions about life cycle costs to which we will return later.

In the 1980s, pavement operations came to be included more systematically in the Internal Auditing department's audit plan, since the pavement industry was judged in the risk analyses to have the highest risks of all [128]. Reviews and analyses over the years showed, among other things,

- that the requirements regarding voids in pavements needed to be adjusted as there seemed to be a "critical void for the occurrence of water overpressure" (cf the phenomenon of unstable ground under conditions of pore water overpressure) with ravelling and sudden rutting as a result (the example of the E4 European Highway in Östergötland) [129],

[127] The strategy document and the 8 areas for focused action in an 8S model, where an example similar with the 7S that was presented in the book The Art of Japanese Management. What can we learn?, Richard Tanner Pascale, Anthony G Athos.
[128] Berth Jonsson, Per Westberg, Rune Djupfeldt, Gunnar Hägglund, contribution to discussion regarding the troublesome competition situation in the area of pavements, 15 March 1990, Borlänge. The discussion was carried on with the SNRA's management and contained strategic proposals for handling the problems and resulted in a directive from the D-G being given to the SNRA's three regional managers at a directors' meeting in Ystad in 1990. This was followed by meeting between the D-G and the management teams of Sweden's largest contractors.
[129] IA's opinion (Berth Jonsson) was checked with research institutes in the USA before the structural engineering instructions' (BYA) regulatory framework was changed.

- that resource allocation needs to be adjusted geographically around the country (from south to north) [130],

- that wet pavements (including the effects of salting) seemed to be able to have between five and seven times higher wear than equivalent dry pavements with the same traffic and speeds [131],

- that a great many local pavement concepts had been developed – concepts where not all could be "best practice" [132],

- that ballast material was periodically the pavement component type's cost driver and critical resource, despite a lack of competition in the bitumen market [133],

- that there was insufficient competition in the pavement construction industry in the west of Sweden without the organisation itself "realising" this (see the Procurement sub-process) [134].

The Internal Auditing department (IA) had developed an analytical model [135] to determine whether competition in the marketplace was functioning satisfactorily and whether prices were sound. A large-scale IT support in IA's analytical model would be developed. In this way, IA would contribute to discussions, learning and improvements not only within the area of pavements but also in other critical fields of activity and concerning road management's cost drivers. By decision of the Director-General, IA was therefore going to expand its analysis capacity by two or three people in spring 1995. Road management's effectiveness and quality and environmental efforts would thus be able to be followed up and analysed independently of the organisation's activities and operations to a greater extent. IA's independent status and risk analyses were seen as strength in carrying out this task.

IA's development plans [136] were cancelled by the SNRA's new management in spring 1995, in which a new ordinance concerning internal audits at government authorities [137] also played a part. According to the ordinance, IA came to be linked to the SNRA's board instead of to the Director-General. 1995 saw no analyses of effectiveness from IA. The board was responsible for the quality of the risk analysis and for approving the audit plan after consulting the National Audit Office. By 1996 it was clear that IA could not count on being granted more technical resources for independent analyses of road management's effectiveness and efforts in the areas of quality and the environment. Despite the high risks in the less than satisfactorily functioning pavement industry, neither it nor other operations or activities were analysed in the audit along the lines of the development previously decided upon.

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[130] IA's study and analyses were carried out by Berth Jonsson and Alf Lundgren
[131] IA's study and analyses were carried out by Berth Jonsson, Rolf Norberg and Mats-Rune Heijenstedt
[132] IA's study was carried out by Berth Jonsson and Rune Djupfeldt
[133] IA's study was carried out by Berth Jonsson and Rune Djupfeldt
[134] IA's study was carried out by Berth Jonsson and Rune Djupfeldt
[135] IA's analytical model was developed by Berth Jonsson and Rune Djupfeldt
[136] Administered by Monica Henriksson, Human Resources Director
[137] Ordinance (1995:686) concerning internal audits at government authorities and others, in force from 1 July 1995

In an attempt to maintain IA's focus on independent technically qualified analyses, IA proposed at a board meeting that an audit committee be formed [138]. According to the proposal, external and internal auditors, quality and environmental auditors and a member of the board would be represented on the committee. The idea was that the need for continued analyses of activities, operations and markets would have been obvious to an audit committee. The proposal was rejected [139]. In practice, this also took away IA's ability to perform technical audits, which had existed since the 1960s (administration audits, later called effectiveness audits). IA retains its competence to conduct accounting audits.

The lack of independent technical competence makes it in practice impossible to identify and put forward uncomfortable analysis results regarding, for example, road management's effectiveness in the face of a well-rooted "doesn't apply here" syndrome. Experience has shown that it can also be difficult to question activities with strong technical foundations and technical competence. Audits of technical activities without technical competence with a content of assessments based on group interviews with the people being audited have taken the place of independent analyses for several years [140]. The group interview concept can educate accounting auditors in technical considerations to some extent but makes arbitrary contributions to road management's development. In answer to a question in spring 2000 about the focus on reviewing pavement operations in internal audits, the reply was given by an internal auditor that the area is no longer paid any special attention.

The operative side was intended to develop from an over-sized "in-house" organisation into a functioning contracting business. The objective of this development was to establish a profitable, robust, learning organisation with a customer focus. The position it started from was the market's by far most practical expertise with road production, machinery and equipment adapted to the organisation's operations. There was also a culture of independence with strong support in a "doesn't apply here" syndrome, low cost-awareness and limited interest in benchmarking, openness and the life cycle perspective, and unaccustomedness to calling matters into question.

To a corresponding degree, the client's organisation suffered from considerable "naiveté" and blind faith in a "soundly functioning" construction market. In order to secure a sound development that would in some way compensate for the lack of internal questioning, the qualified independent checks and analyses would have needed to have been extended in scope. Instead, the limited ability to perform independent analyses that had existed for decades was removed. It seems as if the SNRA's board, and also the external auditors, did not sufficiently consider the risks involved in this significant change in culture. It should also be mentioned that the accounting had never been adapted in order, for example, to facilitate the detection of a lack of competition in the marketplace. The accounting is carried on at highly accumulated levels, which is why almost all deviations land in already accepted "doesn't apply here" explanations.

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[138] Berth Jonsson, the proposal was repeated in a letter to chair of the board on 9 May 1996 reg. no. AL60 96:1385, Borlänge

[139] The board decided according to a board member's opinion that "the members of the board do not receive payment, which includes this type of extra involvement".

[140] Tord Johansson, Audit Manager, in the SNRA's magazine Våra vägar ("Our roads") issue no. 3, 1997 pp 6 – 9, and InternRevision ("Internal Audit") issue no. 2 1999 pp 15 – 17, ISSN: 14018950, interview reported by Arne Zetterström

In 2001, an asphalt cartel was uncovered that had been formed by at least five contractors in Götaland and Svealand in 1993. Pavement prices had gradually increased to the point where they were finally 20% too high. During the period up to 2001, the cartel was estimated to have cost the taxpayer more than 4 billion SEK in extra costs in the state and municipal sectors together. The purchaser's ingenuousness, level of acceptance, lack of analysis and questioning had facilitated the unhealthy development of the market.

When the extent of the price collaboration was to be determined and assessed, the SNRA's engineers used the model that IA had developed and that had been planned to be used as a matter of routine on a large scale from and including 1995 (at 1994 prices). It is highly probable that the analyses would have highlighted the incorrect pavement prices in the same way as IA had previously done in western Sweden (report from 15 March 1990).

As knowledge has grown on pavements and bridges through analyses in the SNRA's administration systems, the requirements regarding the two component types have become clearer. Development has been in the direction and better concepts. In respect of pavements, however, VTI [141] showed through comprehensive tests of different types of pavement in their pavement testing machine that there is still considerable room for improvement.

> "Experiments in VTI's road test apparatus show that asphalt pavements have a great span as regards stability properties. A large number of pavements were tested and the differences between the best and the worst pavements tested were very great."

The test of the TAM concept's quality-related accounting model that the Ministry of Industry, Employment and Communications conducted at the SNRA in 2003 also indicated clear possibilities for improvement. One improvement, for example, is the use of limit values for pavement condition when a measure is to be carried out. At the same time, it is easy to see that the condition requirements in respect of most component types are vague. The requirements may sometimes be difficult to concretise. More precise details are sometimes stated in the tender documents for basic operations packages. The initial lack of detail has little by little led to greater knowledge and higher quality and the lack of clarity has thus been able to be reduced. In general, however, real differences contribute to road-users possibly perceiving varying quality in the road network.

1.3 Summary

The culture that has developed at the SNRA partly as a consequence of large variations as regards basic technical prerequisites can be summarised in a "doesn't apply here" syndrome. Shortcomings in follow-ups, checks and analyses, and also as regards knowledge, have made it easy to defend local concepts. The lower level of ambition in independent analyses and questioning have from a technical point of view probably led to substantial losses for the taxpayer. A life cycle perspective is almost completely lacking in financial accounting and procurement decisions. The "doesn't apply here" syndrome, from the time when operation and maintenance was in-house, has instead been transformed, with the advent of procurement of contractors in competition, into a financial "we are unique" syndrome with a strong element of defence of business deals done and procurements made.

[141] Stability studies using VTI's pavement testing machine. Study of bitumen-bound layers, VTI-aktuellt ("VTI news") 6/99 referring to VTI notat 30-1999, Torbjörn Jacobsson, Fredrik Hornwall and Safwat Said, Linköping Dec 1999

It is easy to see the necessity to prioritise continuous follow-ups and checks/inspections of road management actually carried out (not only of deviations against budget). Continuous systematic analyses in a life cycle perspective and learning in the client organisation, which is responsible for road management but which is increasingly losing its competence.

With the road-user at the focus of road management, quality-certifying the road network clearly would make matters easier. A distinct structure would, not least, simplify communication about expectations from road management and understanding how satisfied or dissatisfied road-users in fact are or should be. Quality levels before measures arbitrarily chosen by road engineers should no longer be accepted.

2. Inadequate interaction between different competencies and systems

2.1 General description

In the road manager's organisation, every competence has dealt with its own affairs and specialties and separately without any cross-border collaboration. Up until the mid-1980s, for example, there were two economies. One had been developed by engineers and was handled in different cost systems with their origins in manual engagement bookkeeping (single entry bookkeeping principle) and the other by economists in an organisation-wide expenditure system (double entry bookkeeping principle). The cost system existed for construction (70B followed by the ABIS project with version 80B and later EAB) and operation (70D, ADIS with 80D). Corresponding systems also existed for fixed assets used in the SNRA's activities and operations (FONDIS with the machinery pool store system MCF) and for, for example, administration (ADMIS with various personnel systems) All executive control was based on the cost systems and at an overarching level the cost and expenditure systems were reconciled in connection with the annual accounts and appropriation settlements.

Information about the road network and the road installations were originally handled by statisticians (Statistikbyrån) in a separate road and traffic data bank (VDB and later NVDB [142] and GVT). One large group of users was for example road management's planners (long-term plans). Special administration systems were developed for the technical administration of road management's more important components. Bridge administration had a manual ledger for a long time, which was followed by a computerised bridge data system (now BaTMan [143]). Pavement administrators used two systems in the early days (pavement statistics in the construction organisation and the pavement data system shared by the entire authority). Both systems were later incorporated into the pavement management system PMS. Operations were supported by technical support systems developed for the purpose (operation and maintenance by STÅNGA and VUH, for example) while investments (new construction and improvements) for example had support systems for aggregate allocation, network planning (ICL's system followed by PC tools) among others.

Political economists and to a certain degree also engineers developed special planning systems where socio-economic calculations could be made ("EVA and Effect relationships 2000"). The systems constitute support, primarily for long-term planning. One of the things

[142] The National Road and Traffic Data Bank and Common Road and Traffic Data
[143] Bridge And Tunnel Management system (BaTMan), covering bridges, tunnels and other constructional works such as large culverts, pile foundations, troughs, support structures, ferry berths, jetties and quays. The system today also included the bridges in the railway network.

learned is that the knowledge is not used in a specially structured way to customer-orient day-to-day road management or to improve the dialogue with the road-users. It is used, on the other hand, in the dialogue with other planners and politicians.

The systems mentioned above constitute part of the total number of systems within road management, where each one has its own purpose, quality requirements and users. Experience has shown that it has been and still is extremely difficult to get the systems to communicate with each other even if the same type of information is used. This is partly due to purely technical difficulties but probably also to different competencies not understanding each other, are prepared to do necessary adjustments and, for example, not always using the same concepts and definitions.

2.2 Some consequences

Communication between engineers and economists has not always been simple and it has not been uncommon for there to be several "truths" about the organisation. There are innumerable examples of this. For example, on one occasion engineers and economists discussed a specific deviation for hours. Eventually they realised that the misunderstandings in the discussion concerned the elementary issue of the sign for a budget overrun. In the expenditure system, the overrun amounts had a minus sign, while the corresponding item in the cost systems had a plus sign.

Another example concerns assessments of needs for measures costing billions of SEK. Information about needs was gathered from all 24 road administrations by means of a number of local systems. The first total amount in respect of the information delivered was not credible. Two further weeks' work on the same question resulted in a threefold upward adjustment of the original figure. The issue has been plagued by vague concepts and definitions. The biggest problem, however, was that the quality of the information in all the local systems had varied widely and probably would not have passed an independent review.

Since the latter half of the 1980s there has been only one system for financial accounting (at present AGRESSO) with several support systems for, for example, project management (PLS) and road installations (VERA). At the SNRA, the accounting system is a clear example of a system that can be regarded as the accounting economists' "own" system. Among other things, despite years of continual pressure, they have not managed to accomplish computerised transfers of information from the accounting system to road management's important administration systems (PMS, BaTMan and VUH).

Input data to the different systems has required and continues to require considerable duplication of manual effort. Since the endeavour is to reduce or simplify work duplication, the consequence has been that standard information has often come to be used. Quality requirements and expectations of the information that the systems deliver have determined the accuracy of the standard values; the lower the quality requirements the rougher the standard values. Conducting follow-ups and making cross-checks and verifications have not been as interesting. "General knowledge and truths" in an area of competence that are based on information from a system may even have come to be misleading or at least in conflict with "truths" based on information in another system. We may suspect that systems can contain different standard values for the same or similar information but with somewhat different definitions.

2.3 Summary

In summary we can say that in Swedish road management engineers work with technical information and standard financial figures administered in special administration systems. Economists work with financial information in accounting systems. Political economists work among other things with standard values for prices, effect relationships and valuations of utilities and sacrifices administered in separate planning systems. Among other reasons, standard values are used because it is not possible to transfer actual figures from the accounting system. The accounts are very often not prepared for cross-checks to be made. Special studies involving consultants are often needed. In practice, the difficulties in making cross-checks lead to their not being made.

Several different considerations and types of information with different units (kronor, mm, rut depth, IRI, bridge damage, different customer requirements, etc) must be weighed together into unambiguous decisions in management's control. Not the least difficult task is to systematically and uniformly take the requirements regarding socioeconomic effectiveness and the customers' expectations into consideration when the underlying information is based on different judgements and levels of ambition. Follow-ups and control are made difficult by the fact that information comes from several systems and specialists where the players may have different views of, for example, periodisations and needs.

The total cost of inadequate integration and interaction between important competencies, including the use of standard values, work duplication and the existence of several truths, is considerable. Within the PIARC organisation, questions concerning the problem of inadequate integration between support systems for different areas of competence are recurring issues. This might well be an indication that international experience is similar to that in Sweden. System integration and data capture are therefore urgent areas for improvement.

3. The planned economy

3.1 General description

In many large companies, the armed forces and government authorities, internal control has followed the principles of centrally planned economy for a long time. This also applies to the SNRA that began as a result of a military initiative and with military management [144]. Planned economy has been applied with a focus on the organisation's costs in relation to granted appropriations. Important experience of consequences that have arisen in operations in practice has been gained through IA's effectiveness audits (among other things of the total activities and operations of three distinctly well-run areas of activity during 1986). The consequences are in principle not a result of the planned economy model but rather of the focus applied in the model. Follow-ups were wrongly focused and knowledge of incentives that arose was inadequate. In addition, the necessary checks against the real world were never carried out.

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[144] The principles have been developed from The Royal Board for Public Road and Water Structures (1841 – 1883), The Royal Board for Road and Water Structures (1883 – 1967), The National Directorate for Roads (1967 – 1983), and The Swedish National Road Administration (1983 – 2010). 1 April 2010 the National Road Administration will become part of the new Swedish Transport Agency.

Annual cost allocations for the operation and maintenance of state-administered roads were distributed using sophisticated planning models for approximately 280 operational areas around the country. All operation activities were carried on “in house” with the support of hired resources (rented trucks and construction machinery). A rough allocation of resources was made at the central level. Possibilities existed to fine-tune the allocations regionally (at the county level). In addition to the cost budget for anticipated measures, it also included frameworks for the number of trucks, graders, wheel-loaders and other resources per operational area. The allocation models were able to take a number of factors into account, such as types of road, traffic flows, and, for example, types of wearing course, different areas’ terrain, geology and types of weather.

In calculations of the operational areas’ prices and costs, standard values, standard prices and knowledge of circumstances that affect costs, for example binding central agreements, were used. The costs in respect of personnel, own machinery and own vehicles were standard values. Central agreements were entered into with suppliers (e.g. call-off contracts for road salt and steel blades for snow ploughs and graders) and with industry organisations (e.g. for transportation and construction machinery). Major purchases of trucks, graders and other machinery were also handled at the central level.

When the allocation models showed that an area needed a half or a quarter of a grader, principally for maintenance of gravel roads, resources equivalent to a whole grader were generally allocated. In order for the grader not be questioned, it was then often used for work that could have been carried out more effectively with other resources. Regardless of how few hours a day a truck, for example, was used in practice, eight hours of use were reported. Time was reported by means of booking costs to a work account. Time used also functioned as an internal signal that the resource was needed. Time also affected the operational area’s hourly price based on the prime cost principle. With the same total cost for the resource, the operational area’s hourly price decreased the more hours that were reported. On the other hand, the trucks’ average speed was extremely low. It was not unusual for the reported time used and distance driven to give average speeds for trucks as low as 10 km/h.

Each area had a full complement of snow ploughs – and some in reserve in case one or more were damaged. All operational areas around the country also had their own staffed workshops. In a separate review of the workshop resources in the operational areas along the border with Norway, it was clear that the workshops were principally justified by the fact that ploughs could break down and need to be repaired outside normal working hours. IA’s [145] review of the workshop personnel’s time registration in the areas studied showed that this had occurred once in one of the areas over a period of several years. It also showed that at the particular depot where the weekend work occurred, the closest neighbour was a panel beater’s workshop. When asked, the panel beater replied that he would naturally repair snow ploughs even outside normal working hours if requested to do so.

The positive thing about the operational areas’ workshops was that many creative designs and inventions came to be developed to support road operation. This possibility to build and test designs that lead to greater efficiency was probably also one of the main reasons why the areas demanded their own workshops so strongly. In the debate about the workshops, this was not, however, one of the reasons that the road managers put forward particularly clearly. In addition to their own workshops, all the operational areas also had a complete store with a

[145] Review carried out by Berth Jonsson and Alf Lundgren

manager. The stores' managers' basic attitude was often that no part was to be out of stock when someone needed it. This attitude naturally affected the size of the stores.

The follow up of activities and operations comprised resource consumption per work account relative to budget. Significant deviations from budget in the operational areas resulted in administration in the form of explanations, justification, and/or financial consequences for the following year. If an operational area had funds over in any account when the budget year came to an end, there was a clear risk that the following year's budget would be lower [146]. There was also local concern that a budget run-over would later have negative consequences for the volume of operations and for the area being allowed to have resources of its own. For this reason, purchasing and manufacturing to stock, for example, would often increase towards the end of the year if the budget was judged to have too large an under-run.

Budget over-runs, on the other hand, did not automatically lead to a bigger budget in following years. The consequences of deviations and road managers' "normal" aversion to administrative duties such as comments, explanations and arguments, provided strong incentives to minimise the deviations against the budget's different accounts. Most accounts therefore showed good agreement with the budget year after year. Only one or two selected accounts, that were often difficult to check and of only minor importance, were singled out as necessary to bear sizable deviations. This was made easier by the fact that the activities and operations in the operational areas were in practice never verified but only followed up in financial terms relative to a cost budget. After many years' application of the allocation models, the follow-up came in all essentials to be in agreement with the budget and thus confirmed the planning model's standard values for prices and costs.

The people at the central level who were responsible for the rough resource allocation had poor knowledge of the condition of the road network. In the regions it was somewhat better and locally the road managers naturally had the best knowledge – knowledge that was however not satisfactorily documented. An energetic, eloquent road manager could for a particular operational area exploit his advantage as regards internal information (private information) to gain advantages and exceptions from the general allocation model.

Another experience of the planned economy that had negative consequences was that production rationalisation could lead to resources being cut back the following year since the need for resources was smaller (the ratchet effect). Resources could then be transferred to areas that had not rationalised and therefore had a greater need. Professional pride and the "not invented here" phenomenon were possibly implicit motives for not adopting new concepts. It was often easy to find arguments why a particular rationalisation would not work in a particular area. Road managers' arguments like "it would never work here" were seldom questioned since the internal information deficit engendered uncertainty in people who would in such cases express their doubts. Nor were in-depth analyses needed either, since the plans seemed to be in good agreement with "reality".

IA's effectiveness audits provided further experience of road management's control and monitoring. The organization had pointed out three studied areas as particularly good and well-run. The areas had the best reputations in their respective counties. The counties – in the north of Sweden, central Sweden and the south – in turn had especially good reputations in the operations organisation. All plans (such as ditching and gravelling plans) and work carried

[146] Recognised phenomenon in centralised planning theory under the Ratchet effect concept

out during the whole of 1986 were studied in all three operational areas and all stocks were inventoried. For some road projects, costs and time and machinery reports, choice of machinery and equipment and the trucks' time-mileage recorder cards were analysed in detail. Prerequisites were also reviewed on site in respect of types of soil and the machines' actual capacities and unit prices.

The working day began and ended at the depot even if the project was several miles away and was being carried on over a long period of time. Work began at 7 am with everyone getting together to review the day's work. The vehicles were then loaded with the tools and materials that would be used during the day. Most crews had left before breakfast at 9 am. On the journey to the site or project the vehicle stopped for the crew to have breakfast between 9 and 9.30.

In an extensive ditching project over a wide, easily excavated sandy pine heath, two rented excavators were for example engaged together with the operational area's own trucks. The time-mileage recorder cards and other documentation showed that the work was carried out between just before 10 am and just after 2 pm every day and that one of the machines probably had 50% lower capacity than the other. Suddenly, the excavator with the higher capacity disappeared from the site. On closer investigation it was found that the driver had repeatedly complained to the site management about the way the work was organised. He felt that work started too late and ended too early and that there were not enough vehicles during the day for him to achieve the capacity that he might have. In order to satisfy the driver, the trucks would for example have had to begin and end their working day at the project site instead of at the depot.

One possible scenario is that if the driver's demands had been considered, the personnel would have protested. Perhaps even disharmony or disputes would have broken out. Disputes about ingrained routines might have involved the union, which might then have led to problems at a higher level in the road administration's organisation. All in all, there were not sufficiently strong reasons to rationalise the work with uncomfortable decisions and a risk of disharmony in the operational area. The site management understood that there was an imbalance between the excavators' capacities and the transport vehicles and one of the excavators was therefore removed. The low-performing, unobtrusive excavator driver was the one who remained.

3.2 Some consequences

The consequence was that the workplace was able to maintain the good atmosphere at an expense to the taxpayer of a considerably shorter section of ditch for the tax money provided. Continuous follow-ups where costs that arose were compared against a budget for the year's ditching work did not capture the problem of insufficient capacity and/or too high a cost per metre for the ditching. At a national conference on operation and maintenance, road management representatives claimed the opposite, viz. that very extensive and effective ditching work had been carried out over the year. Follow-up and analysis did not function sufficiently well to be able to be used in the internal improvement and learning process.

The independent analysis of the effectiveness of the operational side had been made by the IA's internal technical auditors. All in all, they had solid practical experience of operations and in general good knowledge of how the operative side "normally" functions. In their assessment, the analysis results from the three operational areas could be extrapolated to give a rough idea of the potential for improving operations for the whole country. In addition to remarking that control and monitoring of road management against the overarching traffic policy goals could be improved, the potential for improving operations for the whole country at 1986 price levels was in their opinion:

- increased productivity by at least 20% (1 billion SEK annually),
- capital productivity by at least 40% (500 million SEK),
- improved cash management by at least 12 million SEK annually.

The operations organisation's conviction that the standard values were correct, the lack of insight about the operative side's reality on the part of the people responsible, and an unwillingness to "admit failures" meant that the results of the effectiveness analysis were extremely difficult to communicate within the organisation. At the beginning, almost no-one on the operative side believed the actual costs. For them, the standard costs had become the real picture of their own organisation's prices. The allocation model applied with its associated standard values had become more real than reality itself for "all those" who worked with the follow-up, but also for most people who had an incentive to confirm the picture. Anonymous letters however, were received stating that the IA department had been far too cautious in its assessments and that the improvement potential was more likely 40% than 20%.

At the end of the 1980s, in a contribution to a discussion[147], IA took up the question of an alternative financial model, where "road capital" and details about roads' standard and condition (relating quality to function) would play a central role in financial control and control of road management.

IA's analyses from 1988 provided an objective foundation for the SNRA's possibilities for improvement. The Director-General was given a mandate (political consent) to decide [148] to expose all production to competition and to introduce a new organisation from1992. With the help of the prevailing boom, the rationalisation was able to be carried out with few if any personnel issues with unacceptable solutions. The subsequent analysis by the finance department showed that the productivity increase on the operations side after 1992 had in practice freed up an annual production capacity of at least 1 billion SEK. Capital productivity exceeded IA's cautious calculations since some road depots were also able to be closed. Cash management has also been improved substantially more than the assessments that IA made on the basis of the experience from the three well-run operational areas.

One important conclusion from the effectiveness audit is that efficient, regular follow-ups and checks of the standard values used against actual activities and costs are absolutely essential when standard values are used. Otherwise, substantial losses may result. This applies in particular to activities and operations where the incentives are problematic. IA's audit also corroborates the existence of phenomena such as the "ratchet effect" when the principles of centrally planned economy are applied.

[147] IA's contribution to the debate, 20 June 1989, reg. no. AL 60 A 89:1450.
[148] The management team's decision was based on large amounts of information and a great many ideas, of which one important contribution came from IA on the subject of improvement potential – investigated by order of the Director-General.

The centrally planned economy according to a five-year plan for operations is no longer the predominant principle for resource allocation. However, the following declaration was made by the responsible administrator [149] of resource allocation for operation funds.

> "Distribution of, for example, pavement funding according to statistical information such as road network, length, width, traffic flows, geographical zone, etc gives *one* result. Distribution according to condition, something that in a longer perspective does not reward capability, gives *another*."

The remarks made show that "neutral" planning factors according to the principles of centrally planned economy are still applied in resource allocation and that customer focus has still not become a reality. In areas where road management is less successful, ineffective or for some reason more costly, road-users are forced to tolerate "bad" roads. The road manager has great faith in the allocation model. The allocation principle is considered to distribute available resources and reward capability within the SNRA correctly and "fairly" over consideration for road-users. Road-users already suffering from the effects of poor road management must therefore continue to pay higher costs for their transportation. We shall return to this problem in Chapter 9.

3.3 Summary

The culture that has long prevailed on the operative side in combination with incentives and inadequate follow-ups, checks and analyses had by the end of the 1980s led to a considerable potential for improvement. When the organisation was established in the 1940s, and for many years after, road-users and society were probably very satisfied with the road improvements that were made. The resources were in all probability used with a high level of productivity according to the circumstances of the day. Memories of the early 1960s might show some indications of commencing decline. We also know the authority the road engineer held in society and not merely with the road manager. At the same time, the road management organisation and its management team were focused on the investments in the road network.

In summary, we can say that the planned economy model ultimately led to strong incentives to keep within budget [150], instead of to satisfy customers in the operative upkeep of the function of existing roads. Minor deviations from budgets reinforced people's confidence in the standard values. Inadequate follow-ups, checks, analyses and cross-checks enabled the standard values to continue to be used in the executive management of the administration. Productivity fell, as did capital utilisation in both fixed and current assets.

[149] Jaro Potucek at the SNRA's technical division, has made a written comment in the working document to the SNRA's ongoing implementation project of the road capital model, 2008, Borlänge

[150] 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 Åtvidaberg was the leading light in this respect in the 1980s. In the road administration they worked with engineering and production development, capacity studies, analyses of materials and choice of plant etc, and a suggestion scheme along organised lines, and there were a great number of skilled engineers and economists. What is being referred to here are weaknesses in financial follow-ups, cost accounting, analyses, learning, reporting, internal control, planning systems, incentives and wage and salary systems, which all together during decades led to low development of productivity (cf. the X-inefficiency by Harvey Leibenstein).

4. Cost increases and follow up

4.1 General description of cost increases

Questions of cost increases in infrastructure investments, the client's lack of life cycle perspective in procurement decisions and the low productivity development in the construction sector are discussed in many contexts.

In order to be able to do good business in the long-term, price awareness in a life cycle perspective and an understanding of successively increasing efficiency in activities and operations even in minor aspects are essential. It is in any case easy to understand the opposite, viz. that insufficient knowledge of the products and their actual life cycle costs on the part of the buyer, can lead to wrong measures being chosen, resource wastage, and inefficiencies. It is just as easy to see in an overall perspective that contractors have substantial opportunities to make "exorbitant" profits out of an ignorant client. These are matters of course to which we will return later.

The Building-Living Dialogue [151] found that "information about costs for operation and management in different sources used in the sector is often inadequate. The information often comes directly from finance departments without any structural engineering and/or installation engineering assessment" and that "management, employees and suppliers lack sufficient knowledge of the relationships between investment and operating cost".

The dialogue's findings also apply to a high degree to road management according to experience at the SNRA. Road management lacks a relevant cost definition. Costs are equated to consumption of appropriations and the life cycle perspective is not an aspect considered in the accounting. The cost of the road management of the state-administered road network could therefore be reduced to zero merely by a political decision not to make any appropriations for road management. Experience shows that this shortcoming in the accounting has led and continues to lead to a communication problem that the road manager tries to compensate for with the concept of "maintenance backlog" (cf. Chapter 6 on maintenance backlog). In order to be able to improve control and monitoring in road management and achieve a more effective allocation of resources, better knowledge is needed of actual costs and prices.

One conclusion that has been drawn from effectiveness audits, other analyses and literature reviews is that the design of construction contracts in these contexts plays a central role together with the accounting itself. The contract concept to a large degree controls what happens in what is basically a creative industry.

Experiences and their consequences can be divided into four main consequences with regard to cost increases, "on account" invoicing, life cycle perspective and productivity development.

Performance-based construction contracts have long been the predominant form of contract (94% in 2002 with a long-term target of approximately 60%). In Sweden it was found in 1977

[151] The Building-Living Dialogue, The National Board of Housing, Building and Planning, The Swedish Energy Agency, municipalities, property administrators, contractors, consultants, suppliers, etc and secretariats from 2004 to 2009, www.byggabodialogen.se, Karlskrona

that the cost increase only in the construction process [152] was 27% on average in investment projects. The increase was calculated at a fixed price level from the first time the project was entered in the Construction department's three-year budget (construction start in year three) up to the total cost of the completed project. A large proportion of the projects were carried out "in house" with the help of subcontractors.

The Swedish National Audit Office [153] (SNAO) studied the cost trend in 15 major investment projects from the first time they appeared in a long-term plan until the time they were completed. The investment projects amounted to a total cost of 9.8 billion SEK in the original calculations. The SNAO found that the projects at Banverket (the National Rail Administration) and the SNRA had increased by 17% and 86% respectively. The average for both administrations was 33%.

The SNAO points out the seriousness of underestimating costs. The underestimation, the magnitude of which varies around the country and between different types of traffic, can among other things lead to the state making flawed overarching decisions regarding the allocation of funding for investments in roads and railways. A cost increase in a project affects possibilities to carry out subsequent project despite the later project in actual fact being more profitable.

The problem of unhealthy cost increases is international and is taken up in different studies and articles. For example, an independent study of traditionally procured state projects in Great Britain with public funding over the past 25 years shows an average extra cost over time of on average about 40%. In 70% of the cases, the projects in Great Britain also took longer than planned to complete. Flyvbjerg et al (2003) report similar results.[154]

Characteristic of performance-based contracts in road management is that contracts are based on priced bills of quantities and that invoicing is nowadays to a large extent "on account". The client regards cost increases during the construction phase as quality problems related to the calculations made and/or the project's planning documents. Price increases in investment projects are the result of orders relating to changes and additions, which would seem to indicate shortcomings in the planning of the project. One important experience, and to which we shall return, is that it is first and foremost the performance-based contracts' adjustable quantities that increase. On the other hand, the contracts' unit prices are seldom adjusted.

The client's procurement unit has in a calculation database built up a data bank with detailed price information for quantities according to the Bills of quantities (MF 95 and more recently AMA). Before procurement of a project, the client draws up his own calculations with the support of the calculation database's unit prices. Tenders received are claimed to be evaluated in respect of "most advantageous price". It is known within the client's organisation that this type of evaluation is theoretically impossible, since the client almost totally lacks knowledge of life cycle costs and Best Practice for what the project is about (cf. the Building-Living

[152] The SNRA's Construction department, analysis conducted in connection with drawing up the budget for 1977, Stockholm
[153] RRV 1994:23, Infrastructure investments – a comparison of costs between plan and outcome in 15 major projects at the National Road Administration and the National Rail Administration, ISBN: 91-7498-088-2, Stockholm
[154] Flyvbjerg, B, Skamris Holm, M K & Buhl, S.L. (2003), How common and how large are cost overruns in transport infrastructure projects? *Transport Reviews*, Vol 23, no 1, 71-88.

Dialogue). We shall return to this problem set also in the perspective of the internal control aspect (see Section 1.1.5 on internal control).

The results of the calculations affect the project's costs if "most advantageous price" is not "lowest price" and if it is realised that "lowest price" probably is a gross miscalculation and/or would ultimately end in bankruptcy or similar. Nor can discrepancies between actual final price and contract totals be explained to any appreciable degree with the support of calculations of one's own other than by price differences and orders relating to changes and additions. It also seems less than probable that project planning over more than 30 years would have contained systematic sources of error that would lead overall to systematic increases in quantity. On the contrary, random theory indicates that "quantity errors in planning ought to balance out overall".

Another, more improbable, explanation might be that consultants and contractors cooperate in such a way that the construction documents contain known, or even built-in, quantity errors and that this information is for example "sold" to the contractor. With this knowledge, the contractor would be able to adjust the unit prices to a low total price in the tender evaluation in the knowledge that in realty substantial increases in revenue would result. In order to find the causes of a project's more or less "compulsory" price increases, there are probably other phenomena to analyse than quality deficiencies in calculations and project planning or undetected irregularities over more than thirty years. It therefore seems less likely that shortcomings in calculations should have any significant effect as regards quantity increases and the setting up and maintenance of an extensive detailed calculation database can therefore also be questioned. In the continuation of the discussion, the issue of the detailed database will therefore not be analysed further.

It is a known fact that two negotiating parties' internal information has a bearing on the outcome [155]. The one with the best internal information can achieve the best deal, at least in the short term. Researchers are unanimous upon this point. This type of problem with parties' different information is regulated by legislation in certain situations. For example, there are laws against insider dealing (the Insider Act) and "hidden defects" in real estate deals in the Code of Land Laws. Other examples include the right to reverse a purchase within seven days in the Law on Distance Selling, more or less voluntary consumer warranties, etc. In all cases, the weaker of the parties is protected against too large a deficit in internal information.

The experience is that the contractors gain an advantage over the client's project manager as regards internal information soon after the contract has been signed. Another significant experience in the same context is that the client's and the contractor's representatives in a project have completely different incentives in a negotiation. Disputes can for example arise when contracts are interpreted in different ways. Below follow some examples of *incentives* and similar factors of importance for how the client's *project manager* can act.

1. A working day free of conflict makes life considerably more pleasant than one filled with conflict. If personal integrity is not affected too negatively, a conflict-free solution will be chosen over conflict when disputes occur. This applies in particular when an issue is judged to remain unknown to superiors in the organisation or when such a solution in any case would not upset any superior.

[155] Paul Milgrom, John Robert, Economics, Organization and Management, ISBN 0-13-223967-1, New Jersey, 1992, p. 129 (for example).

2. It is easier to choose the contractor's interpretation if it is known that a superior will reward people who create peace and harmony in the organisation with a salary increase and/or a better career over people who are "always" creating disputes. Reward aspects may apply in particular when disputes repeatedly create more work for superiors.
3. In negotiations with contractors, cost increases can be approved if one's experience is that road management superiors accept the explanations that are given. For example, quantity increases due to planning errors or new technical solutions that give the customer a better solution, "abnormal precipitation", frost, etc are often accepted.

The relationship between the client's project manager and site manager hired from outside (and who works for the project manager) follows the same pattern as that between the project manager and his or her superior. The fewer the problems that end up on the project manager's desk, the more the site engineer is appreciated. In this relationship, one issue of internal control concerns the site manager's loyalties towards his 'employer' and the contractor and the site manager's internal information.

For the contractor's *personnel*, other *incentives* apply than for the client's. In the case of the contractors, it is usual for good financial results to also be recognised and rewarded with salary increases and better career opportunities. The contractor's personnel have an obligation to maximise profits. If results are too unsatisfactory, there is even a risk that a person might lose his or her job. The contractor's personnel are expected to exploit all possibilities for orders relating to changes and additions and extra revenues from quantity increases to the greatest extent possible. The company's reputation in the industry must naturally not suffer any long-term damage. For reasons to do with negotiation and competition, the contractor therefore protects his internal information. With growing knowledge of details in the project comes a gradual knowledge advantage that is exploited to obtain extra payment when the opportunity arises. Below follow some examples of how the parties' different incentives can affect interaction between the contractor's people responsible for an assignment and the client's project manager.

1. Experience is that a project's quantities generally speaking increase. This is a phenomenon that is a basic belief or "expectation" on the part of the client's project manager from the outset and is a support for the contractor in the negotiations. With this knowledge, it is not difficult for the contractor's personnel to take up quantity changes for discussion – changes that are to the contractor's advantage (increase revenues or create trust if reductions are taken up).
2. The contractor will from experience open a negotiation with a high bid with a built-in "bargaining margin". The client, whose attitude is that an agreement reached with taxpayers' money must be serious, sound and fair, begins the negotiation with an offer that can be justified or judged to be neutral and reasonable if a check is made.
3. The contractor has an advantage as regards internal information. Since the incentive is to optimise results and his own bonuses, any advantage that arises is exploited to the full in the negotiations.
4. According to Swedish negotiating tradition, a negotiation always ends in some kind of compromise where both parties can feel satisfied on the basis of their respective opening bids. The client's project manager has no salary incentive that drives him to push hard in the negotiations. The incentive is to avoid "messy" situations or disputes. It is therefore important for the project manager to avid disputes being raised to a higher level in the organisation. A practised contractor realises and exploits this with his knowledge of the "compromise rule" and the client's situation.

Low quality in a supplied component increases the number of repair, maintenance or replacement contracts. In theory, low quality in a supplied component might therefore very well lead to increased pressure for more contract assignments in the future compared to high quality. As a group, the contractors might therefore have good incentives not to deliver higher quality than is required for the work to be approved, even if higher quality could be delivered at the same cost. The individual contractor must, however, be sure to maintain a good reputation in the marketplace. The contractors of course also know that the client does not follow up quality systematically with a life cycle perspective or similar actual cost calculations. Nor does the quality issue need to be considered in the contractors' bids. If the contractor has a sufficiently good reputation he can offer the lowest tender price.

On the basis of what has been said above, the question may be asked if negotiations are usual in projects. A closer analysis of the construction contracts reveals that the level of detail as regards adjustable quantities is very high and for this reason also the number of negotiations or agreements. For example the investment projects close to conurbations on National Road 50 between Ornäs and Tallen and between Tallen and Gruvan (totalling approximately 300 million SEK) together had just over 1,800 adjustable and 50 non-adjustable "MF 95" quantities in the contracts. The lowest adjustable figure in the contract was 68 SEK in respect of "Refuge cobblestone". The largest adjustable amount, 17,983,836 SEK, was for "Terracing including splicing".

This meant a total of more than 1,800 agreements in the projects merely with regard to quantities. Of these quantities, only a small proportion can be verified afterwards (an internal control issue). The cost increase on the contracted amounts was approximately 10%. An experienced project manager has assessed that the number of quantities would have increased to more than double if the AMA structure had been applied in the contract. Today it is the AMA structure that applies in all new performance-based construction contracts.

Another example is taken from the mountain areas. Road projects mainly run through terrain without any buildings. The investment had been taken up as a bearing capacity measure in the county plan for the 1998 – 2007 period. The project consists of a 37-kilometre section of road, shortening the existing road by approximately 3 kilometres. Construction was planned to begin in 2003 and be completed in 2007. The investment expenditure at the planning stage was estimated to be 95 million SEK. The sums contracted in the tenders totalled 110 million SEK, while the final price, when the whole section had been opened to traffic in autumn 2008, has been estimated at approximately 150 million SEK.

The total acquisition value including developer's costs has so far been estimated to amount to approximately 155 million SEK, which can be compared to the amount of 95 million SEK in the long-term plan for the 1998 – 2007 period. Some unresolved disputes remain to be settled in court so the final price is somewhat uncertain. Soon after the contract had been signed, disputes began between the contractor and the client and were already in full swing when the project manager took over responsibility for the project.

The project consisted of several contracts with a total of approximately 140 adjustable quantities and 80 orders relating to changes and additions. The smallest item in the contracts was 1,224 SEK in respect of "Dismantling of road signs" and the highest was 17,613,000 SEK for "Terracing". This means that in total for the different contracts, the client has negotiated or reached agreement with the contractor approximately 220 times merely in respect of quantities and other things that have affected the price. The Bills of quantities were a mixture of MF 95 and version 2004. Of the actual increase in construction cost of approximately 31% at fixed prices, the orders in respect of changes and additions accounted for 4%. Quantity changes accounted for approximately 27%, i.e. about 87% of the total increase in cost.

The project with a road through unspoilt mountain terrain is an example where the SNRA's project manager was strong and asserted her interpretation of the contract. She did not back down in the face of the threat of arbitration. The project manager sat alone in negotiations with between eight and ten male representatives from the contractors and asserted the client's arguments and interpretation of the contract documents - a dispute that now will be decided in court. As to be expected from the discussion of incentives above, the project manager has encountered problems in her own organisation. The strain has even led to personal ill-health, half-time sick-leave, poor salary development and at least a temporary halt in her career.

Events such as these may have a deterring effect in her continued work as a project manager but also on other project managers who to an even greater extent may choose conflict-free solutions. More detailed quantities in the contracts according to the AMA structure, more adjustable quantities, a greater internal information advantage, project managers who are less inclined to enter into disputes, and even poorer possibilities to check agreements, will give the contractors great advantages in future negotiations. With this development, it will hardly be possible to hold back cost increases in infrastructure projects if this experience and analysis are correct.

Incentives are central issues as regards efficiency in operation and for all who work in an organisation. The issues that are taken up in this context, concern management and the attitude to incentives but are seen in this context as major issues that are best handled in a separate field of research.

The SNRA has more experience of the difficulty of conducting negotiations on prices at a detailed level successfully under similar circumstances. During the 1970s and most of the 1980s, the operations organisation worked with central agreements called haulier agreements. The agreements were adjusted every year taking the price trends for each type of resource into consideration. The hauliers' representatives had a great internal information advantage in the negotiations and they also had powerful incentives to raise the prices for the haulage industry around the country for a full calendar year. The synergy effects could not be considered to a sufficient extent by the SNRA's personnel but were probably known to their counterparts. Eventually, the prices in the central agreements were so high that the agreements were abolished since no-one in the SNRA's organisation could afford to use them. The locally procured prices were considerably lower, despite the fact that competition in the local area was often very limited.

4.2 Consequences of price increases

The price of cost increases can be calculated in hundreds of millions of kronor every year. Prices often include both costs for necessary adjustments to the project and price increases in submitted tenders that is difficult to justify. An experienced contractor has also estimated that the administration of the extensive contracts according to the MF 95 structure costs between one and two percent of the tender.

With a procurement volume of 10 billion SEK annually, the contractor's administration alone costs the client between 100 and 200 million SEK a year. With more than double the number of items in the contracts in the AMA structure, the handling cost can be estimated at between 200 and 300 million SEK a year. Add to this the client's costs, which can plausibly be estimated at over 100 million. It is not improbable that the cost increases and administrative handling involved in the detailed contracts cost society over half a billion kronor every year,

Every performance-based contract guarantees the contractor a colossal number of opportunities for negotiations or agreements that have an impact on prices. In this context the contractor has to reach agreement with either the external site engineer or the client's project manager, who can also be played off against each other. If the site engineer has accepted a particular manoeuvre by the contractor, there is little probability that the project manager, who has less detailed knowledge, will reject it. If the site engineer nonetheless does not accept it, there is still a possibility that the project manager will accept it if it is presented again.

The benefit to the client of the detailed information is considered to be low risk costs in the tender prices. This is a dubious benefit, since it depends to a large degree on how the tender prices have been calculated. If the tender period is short, it is usual (according to an experienced contractor) for the tender price to be largely based on the unit prices at component level. If this is true, the benefit to the client of the extreme level of detail is that the calculation database receives the data for which it is designed and that is used in client calculations. The calculations unfortunately do not seem to have any great impact on the projects' actual cost increases or productivity development.

There is instead much to indicate that cost increases are not primarily a problem that has to do with the quality of the calculations or systematic errors in the planning documents. Nor can any support be found in the available material for claims that consultants, contractors and/or site engineers engaged from outside have consistently cooperated or acted fraudulently towards clients for more than thirty years. The reason for the cost increases can probably be found in highly detailed adjustable quantities in the contracts, in the parties' different incentives, in the unbalanced possession of internal information and in the poor possibilities to make checks after the event.

4.3 Follow-ups: general description

Another issue concerns the road manager's problems as regards the quality of the forecasts in the regular budget follow-ups. The quality problem has existed for a very long time and causes difficulties as regards financial control relative to appropriation (budget). The external and internal criticism that has been made has been largely directed at the economists. However, they have had only limited possibilities to improve quality themselves. The solution to the problem has been "on account" invoicing and "on account" payments. Since the aim is efficient financial control with efficient use of appropriations, the client's economists might have been expected to oppose these procedures.

With "on account" invoicing, deviations against budget can be minimised since invoicing can to a large extent be controlled against the project's budget. In principle, it is only unforeseen orders related to changes and additions and changes in quantities invoiced during the year that can cause deviations from the budget. This kind of invoiceable extra costs can easily be taken into account in forecasts or rolled over to the following year, by which time the client will have an, to the extra costs , appropriately adapted budget. The actual production rate will not reflect the reported outcome relative to the budget. With the “on account” procedure, however, there is a very great risk that substantial advance payments will be made to a contractor.

In theory, the periodisation requirement remains. However, it is likely to be the exception rather than the rule that a project manager will make an accurate periodisation relative to actual quantities and thus cause problems for himself and other concerned parties in the organisation. “Everyone” in the organisation has an interest in deviations being small. The project manager also knows that periodisations can hardly be verified at the level of detail in the contract and where actual production would have generated the real costs. The possibility to make inspections and control measurements of completed work is also small or non-existent. Competed work is to a large extent hidden.

4.4 Follow-ups: consequences

On account invoicing may hide substantial advance payments depending on how it is managed and controlled by the client. Experience is that relative to a budget with fixed amounts per day or month there is as a rule a substantial backlog in the successively accumulated costs for a long period after the start of a project. It is also known that the contractor’s control is to a large extent focused on liquidity in the assignment. If the on account invoicing concept is not managed professionally by the road manager, there is a risk of significant inefficiency in road management’s capital utilisation. It has also been pointed out many times that profitability in the construction industry is low while the contractors show good profitability.

The organisation has thus chosen a life without criticism, but with apparently good precision in budget follow-ups, over more efficient capital utilisation. The SNRA’s economists have probably not taken up the challenge of making financial control more efficient with a risk of being criticised for the quality of the forecasts and control of the finances.

5. Inadequate life cycle perspective

Within the Building-Living Dialogue it is felt that “greater knowledge of linkages between operating cost over the entire life cycle and value” and “the development of more effective components and systems that are more user-friendly and reliable” are needed. The client should “steer and influence manufacturers towards standardised measurement and reporting methods in order to obtain better and more comparable basic information for LCC calculations (cf standardisation in the eneu®-konceptet”.

It is clear that experience at the SNRA is exactly the same as the impression in the rest of the industry [156] as regards this issue.

Knowledge of road components’ actual life cycle costs is almost non-existent. The accounting system lacks a component structure and provides no support whatsoever for learning about life cycle costs. For this reason, among others, there is not much to suggest that the road manager in Sweden is better than in Great Britain. An independent evaluation showed that

[156] The National Board of Housing, Building and Planning, The Swedish Energy Agency, municipalities, property administrators, contractors, consultants, suppliers, etc who all participated in the Building-Living Dialogue.

studied projects had an average cost over-run over time of approximately 40%, which translated to the entire Swedish road network would indicate annual amounts in the billions regardless of how the costs are calculated.

At the SNRA the solution hitherto has been to construct special administration systems for a number of selected components. Unfortunately, the accounting system does not allow prices, expenditures and costs to be transferred automatically. The administration systems therefore have to use standard values to a great extent. Together with the use of standard values, the long lives of some, but far from all, of the components have been the main reason why life cycle costs have not been followed up.

Lack of knowledge of life cycle costs has had a high price. A large proportion of this inefficiency cost is attributable to deficiencies in accounting .

6. Productivity problems

6.1 General description

According to the Building-Living Dialogue, the industry has little interest in changing and developing systems, processes and business procedures (the premise “we’ve always done it this way before” seems to apply). In practice, no client has succeeded in creating sustainable incentives for a healthy development. For example, it is often claimed that innovations can not be protected to a sufficient extent, which among other things leads to an unwillingness on the part of individual contractors to finance development projects themselves.

The lack of productivity development in the construction industry has been observed in many contexts, not least by the Government. It is remarkable in itself that creative engineers and contractors should lack ability to rationalise or develop productivity to the same extent as in other industries – or consciously avoid doing so. One explanation for the industry’s problems might be found in the assignment descriptions as they are expressed in the detailed contracts with their emphasis on quantities.

It is claimed that the contractors have difficulty in protecting innovations. It is therefore logical that project results and short-term rewards for the individual engineer should be first in line for creative initiatives. The contracts are so designed that money can be earned if they for example have high excavating capacity (higher than in the offer) or if the volumes excavated can be increased (for instance without real production costs). In other words, the present contract structure might lead to the contractor’s focus being on raising the final price of items in the contract instead of on more effective products. Nor can more effective products be justified for products with a higher acquisition price since the client does not have a life cycle perspective.

If capacity in excavation activities increases compared to the offer, this will not result in a lower price for the client, at least not in the short-term. The contractor’s profitability in the individual project will improve but it is far from certain that this will have any effect on the contractor’s unit prices in the next tender. The high capacity may for example have been achieved by maintaining a lower finish in the work and this may not be a possible way to go in a subsequent assignment with a different project manager.

The only way to "earn money" is to increase the invoiceable excavated volumes, preferably more than the actually volumes excavated. The contractor's experience is probably that it is generally simpler to both think short-term and devote his creative abilities to achieving greater invoiceable excavated volumes.

The client's total price increases with greater volumes excavated, as do the number of hours worked if assessed on the basis of the total price for the excavation work. When productivity development is analysed using measures such as produced length of 7-metre road per 1,000 hours worked, the changes in volume can therefore give a misleading picture provided the working time is assessed on the basis of the volumes excavated. It is not easy to assess productivity development and extremely detailed underlying information, and lack of knowledge of quality development and quality deficiency costs do not make it any easier. The present contract concept might therefore partly contribute to a picture of poor productivity development in the industry. Another contribution to this negative picture might thus emanate from the deficient accounting that has no linkages to products' actual quality, consumption or life cycle aspects.

It is extremely doubtful whether it is at all possible to measure productivity correctly without knowledge of defined physical road products' prices, costs, values or quality. Regarding operation of roads, the picture is somewhat different.

6.2 Experiences

The concept applied for performance-based contracts, whose proportion is expected to fall to just over 60% in the long term, follows the model with priced bills of quantities. According to the concept, most of the quantities must be adjustable in order to minimise the contractors' risk costs during the tendering procedures. Any risk cost mark-up would first and foremost need to be made for quantities in the construction documents deviating from actual quantities – a mark-up that the contractor must cover himself if the quantities are not adjustable.

The adjustable quantities open the door for the contractor to make money. Unit prices are in practice impossible to adjust once the tender has been accepted. Quantities are to be measured and invoiced in respect of actual values. This means that the contractor can make a profit either by achieving higher productivity than that upon which the unit price is based or by for example being paid for a quantity that is higher than the actual quantity. Productivity can increase through, for example, lower machinery costs and higher machinery capacity than in the calculated unit price. The simplest way to impact profits, in addition to orders relating to changes and additions, is to increase the quantities as much as possible, preferably more than actual quantities.

The client's personnel have not had any sound incentive. There are examples of dedicated members of the client's staff who with great integrity have fought tough battles with the contractors but who have also created disputes. The very trying way of working has not been rewarded but on the contrary punished with a poorer salary development than might have been expected. The people in question have not only created work for their superiors but also disharmony in the interaction with the contractors. Career paths have therefore been closed. Many are the examples where superiors have "steamrollered" diligent members of staff who are prepared to fight. The reasons may very but a sufficient number of cases have concerned disputed quantities. Project managers learn very quickly which battles are worth fighting. The contractors generally have an advantage as regards internal information that they can exploit in negotiations and agreements. It is therefore no accident that quantities – and with them costs – increase in the projects, despite the fact that random theory indicates that increases and decreases should cancel each other out at a sufficiently high level.

The contractor's personnel are focused on generating the highest profit possible, in order to be rewarded personally – a natural and healthy incentive. In this contract concept, focus and creativity will therefore come to be directed towards lower quality and higher quantities. This is probably the most important reason for the usual cost increases and the low productivity increase in the sector.

Knowledge of components' life cycle costs is another problem that has to do with the contract concept. Today the contracts are based on the AMA structure and not on the components to which the life cycle costs can be linked and that are significant for road management's costs. If procurement, evaluation and contracts were instead based on components' life cycle costs, the contractors' focus would instead be directed towards developing better and/or cheaper components. Lower life cycle costs would also increase productivity in road management Maybe even better substantial advance payments could lead to an increased productivity depending on how it is measured.

7. Road management's internal control (IC)

7.1 General description

Internal control (IC) must be so designed that the goals of the operations and activities can be attained efficiently with reasonable certainty and resource input provided that laws and regulations are adhered to. In an analysis of IC, assessment is made of whether the organisation's activities are controlled so that the operations are efficient and suited to their purpose and the processes are in accordance with applicable regulatory frameworks and laws and that the reporting is correct.

IC is very much about principles and about the organisation's own established checks of systems and routines. In the auditors' report, we can say that the assessment of IC for the period audited is brought to head in a binary standpoint regarding condition (IC functions satisfactorily and is not commented upon or is unsatisfactory and is commented upon). Different auditors with different starting points can make different assessments of IC. In spite of this, two levels can certainly be found where "all" auditors would agree on the choice between satisfactory and unsatisfactory.

From the point of view of internal control, the contact concepts in the industry have weaknesses without their having led to qualified auditors' reports. The problems in internal accounting concern for example cost increases or losses in effectiveness that have been discussed for a long time.

7.2 Experiences (1)

A first experience concerning IC issues has existed at the SNRA for a long time. During the 1970s and some way into the 1980s, there was a requirement that the SNRA maintain a steady level of employment over the year. There were a high proportion of gravel roads around the country and road maintenance was extensive. There was a great need for friction materials, primarily for gravel wearing courses but also for base courses and reinforcement layers to improve existing roads. The Government would often provide extra resources through the county labour boards and the Labour Market Board's measures in the labour market to increase employment in the construction sector during the winter season. Such activities to create employment during the winter months included rock, gravel and moraine crushing. Most of the SNRA's operational areas still had at least one crusher. There was roughly one operational area per local government unit (282 in all) following the local government reform of 1962.

The SNRA handled current assets in friction materials in an accounting model developed within the finance department as one of the results of the "Gravel Survey" that was begun in 1968. The accounting model was called the "Stock Model". In the model, the SNRA's entire stock of gravel material was adjusted upwards against index to a replacement value using a standard price.

> "The standard price is calculated in connection with drawing up the budget for the next year of production. The price is calculated for the expected cost situation for purchasing, production and storage." [157]

The upward adjustment of the entire stock of gravel was reported with an equivalent increase in production capacity in the budget for operation and maintenance – the funds that were used to finance purchases of gravel. The upward-adjusted production capacity could be used for all kinds of operation and maintenance production. The idea was that when all stocks had one day been consumed, all transactions would have been corrected with a correct burdening of the appropriation.

> "The SNRA is given cost ceilings every year by the Government that include material supply costs. Where the authority had acquired materials in a preceding year when the prices were lower and placed part of them in storage, a price discrepancy arises provided prices increase between the materials in stock and the materials procured over coming years. This price difference benefits the authority, so the cost ceilings can be raised by corresponding amounts."

The standard price formed the foundation of the costs booked to the production account, with the same standard price regardless of whether the material had been acquired internally or from outside. The correction for price differences between actual price of material acquired from outside and the standard price was made against the cost ceiling for the following year.

IA's IC analysis [158] showed that there were shortcomings as regards control and effectiveness in road management's acquisition of friction materials and in the "Stock model's" accounting. The problems were largely due to the handling of the upward adjustment against index of stock values to a hypothetical replacement value.

Neither the adjustment nor the stock handling was under control. The model led to inappropriate incentives with substantial capital destruction of current assets. The IA's analysis showed that over the years between 1976 and 1981 the upward adjustment was

[157] The Stock model for operation, brief description of the model, National Directorate for Roads, DD, 1974-08
[158] Berth Jonsson, Alf Lundgren, Audit Report Materials Supply "Gravel", National Directorate for Roads, Audit Section, R 17 82:003, Borlänge, 1982

substantial, which meant that the SNRA's own friction material came to be perceived as expensive. The SNRA thus also came to contribute to push the price of friction material up. In the operational areas, people eventually decided that they could not "afford" to buy gravel from the SNRA's own stocks. Admittedly, in the short term, the cost of material purchased from outside was the same (standard price) as for material purchased internally regardless of price. It was known, however, that when the standard price is higher than the actual external price, the following year's budget was compensated with the difference.

7.3 Experiences (2)

In spring 1995, the IC issue came to a head at the SNRA. The Director-General had the full backing of politicians and the board to implement the rationalisation of the SNRA that among other things resulted in a rise in productivity of a billion SEK a year and led to a capital rationalisation of over 500 million SEK.

A short while after a public academic controversy between the Director-General and the new Minister for Communications, the Director-General began to be hounded intensively in the media. The chairman of the board publicly declared his full support for the Director-General, only to join in the criticism the very next day that the Minister for Communications had expressed. The external auditor, who worked for the Swedish National Audit Office (SNAO), told the IA department that the media would not be able to change his opinion that internal control at the SNRA was fully acceptable and that the observations made during the course of the review were within what is regarded as "normal" in large organisations. This statement was based on all audits performed over the year.

At the traditional meeting with the external auditors, this time between the SNRA's chairman and Director of Finance (acting Director-General) and the external auditors but without internal auditors (a decision that was not possible to change), the content of the auditors' report was approved. IA had, without any critical aspects of the performance, carried out 2,983 hours (54%) of the external audit's planned audit of the accounting for the year according to the agreement between the SNRA and the SNAO.

When the auditors' report was published, it was found that the external auditors expressed explicit criticism of the Director-General. The Annual Report for 1994 contained the following wording:

"Taking the accounting principles and other regulations that apply for the National Road Administration into consideration, in the SNAO's opinion the Annual Report is in all essentials correct. However, the SNAO has the following statement to make as regards administration:

In the process of change towards a more business-like state of affairs and greater competition that the SNRA is at present undergoing, internal control has not been strengthened to a sufficient extent. Nor has the regulatory framework in force been adhered to in all respects. The Director-General is therefore judged to have not fully fulfilled his obligations according to the Agency Administration Ordinance (1987:1100) §5. The shortcomings are discussed in greater detail in the SNAO's report (reg. no. 30-95-1276)."

Among other things, this report states:

"The SNAO does not direct the same criticism at the members of the board. The background to this is the board's formal status and limited possibilities for insight into the problem areas in question. The circumstances pointed out at the SNRA emphasise the importance of the board's actions as regards follow-ups and advice to the Director-General."

"In the SNAO's judgment, however, the Director-General has not acted sufficiently strongly to create a structure for internal control that might have prevented a number of inappropriate measures being taken at the SNRA. For example, the SNRA should have introduced instructions and routines to secure sufficient legal competence before entering into important agreements."

It should be noted that no losses relating to weakness in agreements had been identified. On the other hand, there were one or two examples of agreements whose content was difficult to understand for the external auditors. It was later found that unclear points concerning the payments made had explanations that were acceptable to the external auditors. The external auditors' review pointed out weaknesses in agreements that entailed risks of problems. The SNAO's comment is fairly general and could in all certainty apply to many organisations.

At the SNRA, however, there was a culture that meant that "all" organisational units at "all" levels "manage themselves" as regards "competence in all issues". Alarmingly often not even the expert is called in who might be sitting in an office adjacent to, for example, the project engineer responsible for the project in question. Examples exist where such important issues as geotechnics are concerned. The SNAO unconsciously points out an unfortunate cultural issue at the SNRA that has a long history.

The IA's report to the SNRA board concerning the events of spring 1995 and the auditors' report for 1994, states among other things that [159]

> "In 1994 the SNAO made its final report on the Government's assignment concerning the issue of strengthening internal control and other aspects at government authorities [160]. Appendix 6 of the SNAO report contains a summarised assessment of how internal control functions at five authorities: the Swedish Immigration Board, the National Labour Market Administration, the Swedish Customs Board, the National Police Board, and the National Road Administration. It has been stated that no concrete assessment of internal control is possible since "no explicit values exist upon to which to base such an assessment". The assessment is made in summary on the basis of a number of criteria without the real needs being evaluated. A scale from *strict* to *laissez-faire* is applied.
>
> In the opinion of the SNAO, internal control at the SNRA is generally *strict*, followed in descending order by the National Labour Market Administration, the National Police Board and the Customs Board, while at the Immigration Board it is judged to be mainly *laissez-faire*. The SNRA is therefore rated relatively highly among the authorities compared."
>
> "In IA's opinion, 1994's internal control is no worse at the regional divisions than previous years' but rather the contrary. The average number of remarks per visit has

[159] Berth Jonsson, IA's report to the board, Report 1, Appendix 7 on operations and control among other things takes up the need for accounting of road capital, 12 September1995, AL60 95:8914, Borlänge 1995
[160] Förbättrad intern kontroll, intern revision m m vid de statliga myndigheterna, RRV 1994:34 (Improved internal control, internal audits etc at government authorities, National Audit Ofice 1994:34

fallen by 28% since 1993. The figure is in itself not a fully appropriate measure. The 28%-reduction and IA's general opinion, however, give a uniform picture of improved internal control at the regional divisions."

The SNAO's own authorities were not slow to change the assessment of the quality of internal control at the SNRA from "best in group" to unsatisfactory. It is impossible to determine how far the SNAO were influenced by media pressure, knowledge of the Minister for Communications' expectations or the fact that that content of the auditors' report had been drawn up at the external auditors' meeting with the chairman of the SNRA board and the economy director. Nevertheless the discussions are important about the assessments of internal control that had been made on *the one hand* by the SNAO's specialized internal control investigators, IA's internal auditors and the SNAO's authorised auditors hired from outside and on *the other hand* the SNAO's responsible auditor.

Awareness of the importance of the internal control issue during the change process was one of the reasons why the independent technical analysis capacity in the IA was to be strengthened with two or three people with a focus on the greatest business risks and risk of financial losses. First and foremost, there existed well-founded risk assessments concerning pavement operations, for which the IA's special analytical model had been developed.

It was also in pavement operations that the lack of competition had been identified in the west of Sweden. The decision taken in 1994 to introduce the road capital model had to do with avoiding losses in connection with the allocation of resources and increasing transparency and improving communication with the politicians. Neither the new management nor the board has declared the same high ambitions as the previous management concerning strengthened analytical capacity and greater transparency. Neither internal nor external auditors have returned to demands for development of internal control of the same level of ambition as before 1995.

The series of events, however, teaches us more about the importance of having systems and routines that are self-controlling to the highest degree possible. Internal control is an area that must be constantly monitored and the ambitions from 1994 concerning internal control have been worked into the quality-related accounting presented in the following, which means that this extremely important experience is built-in in the quality-related accounting according to the TAM concept.

7.4 Experiences (3)

A third experience exists concerning IC aspects in the concepts applied by the SNRA with detailed performance-based contracts. First, there is a risk that the planning consultants and contractors might enter into a collaboration concerning quantity details in construction documents. Planning consultants might in theory possess information about probably incorrect or even consciously inaccurately stated quantities in underlying documents for tenders – information that might be worth paying for in collaboration with a contractor.

It can be mentioned in this context that rumours were widespread in the construction industry to the effect that the SNRA in its capacity as purchaser of a bridge design had obtained the second best solution from the bridge designer they had engaged, while a contractor bought the best one. The best solution was submitted by the contractor in a so-called alternative tender.

This may very well be a cock-and-bull story, but it proves nonetheless that deceitful or disloyal actions against a client were discussed in the industry.

The more adjustable quantities in a contract the greater the number of agreements on quantities, that have to be reached between the contractor and the project manager. The project manager will often have an external resource in the project in order to increase accessibility and, for example, avoid standstill costs. Therefore many measurements and value appraisals of quantities, in practice, will be made by the contractor and the project's site engineer. One important aspect of IC concerns the site engineer's – and also the project manager's – loyalty towards the contractor.

The detailed contracts contain a very large number of adjustable quantities that cannot be verified afterwards when the work has been completed or even when the next phase of the work has begun. Occurrences of incorrect quantity agreements will be extremely difficult or often even impossible to check after the event.

7.5 Some consequences

IC experience 1

The SNRA's own friction material remained piled up in heaps to far too large an extent. The consequence of this was that the heaps gradually became overgrown with pine trees, brushwood and grass to such an extent that the material was unusable. The heaps were sometimes regarded as abandoned and it was not unusual for material to disappear and come to be used for purposes other than state-administered road management. Their full value, however, remained in the accounts (the "Stock Model"), was adjusted upwards and led, falsely, to greater production capacity for operational measures.

Many heaps were very old and covered with pine trees that might be up to 15 years old. One was discovered partly sunk in marshland since it had been produced during the winter on an even surface that turned out to be a frozen marsh. In 1978 the total stock value was 226 million SEK and in 1981 this figure had increased to 342 million SEK. At 1981 price levels, a value of almost a hundred million SEK had been lost through the introduction of the "Stock Model".

For friction material purchased from outside and withdrawals from own stocks, cross-checks were made, as stated previously, between standard prices and actual prices when the books were closed. One "troublesome consequence" of the chosen method of reporting the adjustment against index was that the production capacity for other operation and maintenance production came to increase by amounts corresponding to the upward adjustment of the entire remaining stock. The total advance that had arisen "by utilisation of inflation gains on unrealised stock withdrawals" (IA report R 17 82:003), amounted to just over 100 million SEK at the end of 1981.

In 1982 the necessary correction began of the accounts with costs burdening the appropriation for operation and maintenance of the obsolescence that had been established. The total stock value fell by 150 million SEK between 1981 (342 million SEK) and 1988 (192 million SEK). There was little new production since the number of crushers had fallen dramatically to less than ten during the final year of operation. Withdrawals from stock were also small, relatively speaking. The appropriation for “Operation and maintenance” was burdened with the “advance” of over a hundred million SEK.

This dearly-bought experience has its origins in the consequences of a forecast index adjustment of current assets to a replacement value without sufficient strengthening of IC.

IC experience 2

The consequence of the statement made by the Minister for Communications after the academic polemics in January 1995 was that the Director-General elected to resign. When he no longer had the confidence of the Government and later the SNRA board chairman it would have been difficult for him to fulfil his duties. The end result of the extensive review of the SNRA and the legal consequences for the Director-General was that nothing of any significance could be found to support any criticism. He was acquitted on all counts. It was, however, clear that the accusations and insinuations of irregularities in the media had been untrue.[161]

After the SNAO’s “qualified auditors’ report”, substantial administrative cost increases arose without the board taking any action. The negative development instead attracted the attention of the next Minister for Communications who in 1999 issued a directive to save 400 million SEK in administration costs. A clear sign that internal control was deteriorating can be found in the asphalt cartel uncovered at the SNRA, whose Production division was one of the members of the cartel. The asphalt cartel would have in all certainty been discovered earlier by IA’s analysis function, according to the 1994 decision, than when the authorities were tipped off by an insider. Perhaps some billions of taxpayers’ money might have been saved. The experience here is that very large sums of money can be saved with well-considered, functioning internal control including independent analyses.

IC experience 3

Concerning the contracts that the SNRA uses, it is clear that not only IC issues but also risks relating to loyalties become important. The greater the actual number of unverifiable agreements reached between representatives of the contractor and the client the more important the IC issues become. In theory, it would for example be a simple matter to finance all possible extraneous expenditure items by approving increases in quantity that are impossible to verify.

Agreements on quantities can be predated and invoiced at times when it is certain that control measurements are impossible to make. If any questions are raised concerning a delayed invoice, the “on account” principle can be given as the reason – a principle that “the entire organisation accepts – in order to avoid problems with forecasts and budget overruns. Periodisation is a later task that may be done when the books are closed. An accounting auditor will hardly be able to manage to verify a periodisation at the technically detailed level where costs occur.

Quantity information may be incorrect already at the time of preparing the tender documents and may be included from the outset in the contractor’s internal information, which was

[161] This confirmed IA’s for the board awkward analyses and reports (1995-09-12, AL60 95:8914) on practically all matters.

obtained through collaboration with the planning consultant. Known quantity errors, in the form of both too large and too small quantities, may thus have been exploited already at the time of submitting the tender. All in all, substantial cost increases (profit for the contractor) can arise in a project, even if all measurements of quantities being completely correct in the project. Internal control in the SNRA's contract concepts is inadequate.

The contract concepts need to be examined from the point of view of internal control taking into account such factors as the number of agreements that impact prices, the parties' incentives, internal information, possibilities for verification, administrative costs and, for example, capital utilisation.

7.6 Summary

Two of the experiences of IC on the part of road managers will be commented upon in this section. They concern the use of indexes and standard values, the concept used with highly detailed adjustable quantities in performance-based construction contracts, and different auditors' assessments of IC.

Regarding the application of index adjustments to current price levels, it is particularly important that the indexes correctly represent the intended price trend and that continuous checks are made against actual price trends. It is also important to analyse what can happen in activities and operations and what practical consequences such as different index adjustments can lead to. It must also be established how the bases for control may be affected. Incentives can for example be changed by how indexes develop, the consequences of which must then be built into the checks and verifications that are made in order for internal control to be claimed to function. The experience in road management is that the same aspects must apply in order for internal control to also be acceptable for the application of standard values.

The concept with an enormous number of detailed adjustable quantities in the performance-based contracts requires effective internal control. The requirements are so great that this form of contract should be discussed from the standpoint of whether it can even be accepted. A very large number of agreements must be reached between the client's personnel (employed and in practice often hired) and the contractor's representative on the quantities upon which the invoices will be based. The risk of cost increases is obvious. The experience is also that cost increases generally occur in projects. There is no support for the cause being systematic errors in the planning documents – errors that would lead to these cost increases. The IC problem for the client is therefore to a great extent a matter of preventing or limiting acceptance of incorrect quantities.

It is essential that the client's contracts be so designed as to facilitate checks and the detection of irregularities. In the concept that is currently applied, this type of IC aspect has not had any great significance and on account invoicing is a model that is actively defended by the SNRA's own economists.

Appendix 2 How to measure condition: with examples from practice.

The purpose of this appendix is to give examples of how components' conditions can be measured.

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 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 cannot 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 risk of accident on the one hand and IRI and rut depth values on the other[162]. Requirements and limit values in respect of the lowest acceptable pavement condition for different types of roads expressed primarily in terms of IRI and rut depth, can therefore 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 using 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 BÄRUND, provides a basis that can be used to assess appropriate reinforcement measures and cost calculations.

[162] Reports from the SNRA, VTI and Gunnar Lannér, Chalmers University of Technology

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 example 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 important issue, because the component exists on approximately 21% /21,247 km)[163] 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 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 unevenness to occur of the "washboard" type. Potholes, dust, and camber problems are other 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 planning, 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, $CaCl_2$. 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, complementary

[163] SNRA's Sector Report 2003, Publication "004:29, ISSN 1401-9612, Borlänge, 2004

addition of gravel and gravel recycling (several methods are used to restore material to shoulders and ditches) followed by planning. 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 described in the SNRA’s Function and Standard Descriptions, FSB[164], 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”.

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.

[164] FSB http://www.vti.se/info/rapporter/detalj.asp?RecID=262

Appendix 3 Value change for various component types

The purpose of this appendix is to give some more details about the different models according to the component types assessed condition changes. In the SNRA's implementation project and according to the principles that here are applied, the component types in Table A3.1 should use model I. The table contains an assessed lowest degree of objectivity and forecast content.

Component type	Condition description model I		Remarks
	Degree of objectivity	Forecast content	
Prerequisite items	-	-	
1. Road zones	1	1	Possible contingency item
2. Physical plannings	1	1	
3 Archaeological surveys	1	1	Possible delayed final invoice
4. Preparatory work	1	1	Possible delayed final invoice
5. Traffic control devices	1	1	
6. Construction administration	1	1	
Road equipment	-	-	
66. Other road equipment	1	1	Maintenance booked as operation

Table A3.1 Component types according to model I.

Table A3.2 shows the assessment regarding lowest degree of objectivity and forecast content. In order for model IIb to be applied effectively, an administration system linked to the road and traffic data bank is needed. This need has been the subject of discussion in respect of the component types in the table since 1994. Among other things, the changes occurring in the climate that have resulted in increased precipitation have once again brought the question to the fore. By order of the Director-General the SNRA is now working to adapt the road maintenance administrative system (RMD) in order to be able to handle information about geotechnical constructions.

Component type	Condition description model II		Remarks
	Degree of objectivity	Forecast content	
Road constructions	-	-	
28. Embankment piles	2	2	Admin. system!
29. Lime columns	2	2	Admin. system!
30. Light-weight fillings	2	2	Admin. system!
31. Mass stabilisations	2	2	Admin. system!
32. Vertical drainages	2	2	Admin. system!
33. Excavations	2	2	Admin. system!
34. Insulation **B)**	2	2	Admin. system!
35. Terracing, surface run-offs, roadside areas	2	2	Admin. system!
36. Superstructures excl. wearing courses	2	2	Admin. system!

Table A3.2 Component types according to model IIb.

To be able to use model III in internal accounting, data is needed from the bridge and tunnel administration system (BaTMan), which is linked to the road and traffic data bank. In the SNRA's implementation project and according to the principles that are applied in the project, the component types in Table A3.3 will use model III. The table also shows the assessments' lowest degree of objectivity and forecast content.

Component type	Condition description model III		Remarks
	Degree of objectivity	Forecast content	
Structures	-	-	
39. Fixed bridges	2	2	Data from BaTMan
40. Tubular bridges **B)**	2	2	Data from BaTMan
41. Floating bridges **B)**	2	2	Data from BaTMan
42. Openable bridges	2	2	Data from BaTMan
43. Large culverts	2	2	Data from BaTMan
44. Tunnels excl. installations	2	2	Data from BaTMan
45. Pile foundations	2	2	Data from BaTMan
46. Troughs	2	2	Data from BaTMan
47. Support structures	2	2	Data from BaTMan
48. Ferry berths	2	2	Data from BaTMan
49. Jetties and quays	2	2	Data from BaTMan

Table A3.3 Component types according to model III.

To be able to use model IV, PMS data linked to the road and traffic data bank is needed. In the SNRA's implementation project and according to the principles that are applied in the project, the component types in Table A3.4 will use model IV. The table also shows the assessments' lowest degree of objectivity and forecast content.

Component type	Condition description model IV		Remarks
	Degree of objectivity	Forecast content	
Road constructions	-	-	
37. Bound wearing courses	3	2	Data from PMS

Table A3.4 Component types according to model IV

To be able to use model V, data from an administration system linked to the road and traffic data bank is needed. In the SNRA's implementation project and according to the principles that are applied in the project, the component types in Table A3.5 will use model V. The table also shows the assessments' degree of objectivity and forecast content.

Component type	Condition description model V		Remarks
	Degree of objectivity	Forecast content	
Road constructions	-	-	
38. Gravel wearing courses	1	3	Admin. system!

TableA3.5 Component types according to model V

In order for model VI to be able to applied, documentation must exist that verifies the lengths of life or the consumption speed chosen for the various component types (see table A3.6).

Component type	Condition description model VI		Remarks
	Degree of objectivity	Forecast content	
Roadside areas	-	-	
7. Rest areas	1	1	Focus on operation
8. Traffic control areas	1	1	Focus on operation
9. Park-and-ride car parks	1	1	Focus on operation
10. Toilets **B)**	1	1	Focus on operation
11. Depots and workshops **B)**	1	1	Focus on operation
12. Stations and administrative buildings	1	1	Focus on operation
13. Other buildings **B)**	1	1	Focus on operation
Special installations	-	-	
14. Protection water constructions	1	1	
15. Water cleaning installations **B)**	1	1	
16. Noise embankments	1	1	
17. Concrete/brick planking noise barriers	1	1	
18. Wood/plastic/steel/glass noise barriers	1	1	
19. Aesthetic installations	1	1	Focus on operation
20. Roundabout areas **B)**	1	1	Focus on operation
21. Passages for animals **B)**	1	1	
22. Foot and cycle path installations	1	1	
23. Electrical installations	1	1	Focus on operation
24. Ventilation systems	2	2	Data from BaTMan
25. Safety systems	2	2	Data from BaTMan
26. Water supply and sewer systems	1	1	Focus on operation
27. Pumps	1	1	Focus on operation
Road equipment	-	-	
50. Road markings	1	1	
51. Guard rails	1	1	
52. Central safety barriers	1	1	
53. Wildlife fences	1	1	
54. Protection for rockslides	1	1	
55. Protection for snowslides **B)**	1	1	
56. Road lighting	1	1	Focus on operation
57. High mast lighting	1	1	Focus on operation
58. Traffic signals	1	1	Focus on operation
59. Large sign installations **B)**	1	1	
60. Portals	1	1	
61. VMS equipment	2	2	Data from BaTMan
62. CTS equipment	2	2	Data from BaTMan
63. VVIS equipment	1	1	
64. ATK equipment	1	1	
65. Toll booth equipment	1	1	

Table A3.6 Component types according to model VI

The table A3.6 shows the assessments' lowest degree of objectivity and forecast content. This does not prevent higher levels of ambition in respect of a component type leading to another condition description model with an administration system possibly being used later.

Appendix 4 Limit values for condition

The aim of this appendix is to give more details about how the limit values for conditions can be determined.

1. Introduction

The limit values for condition that are the controlling factors for when a measure is to be carried out and for valuing the road capital, can be set on the basis of several criteria. The general rule is that the limits must not be affected by funding (shortage of capital). The quality criteria must instead be linked to the transport policy's requirements regarding socioeconomic effectiveness and customer satisfaction. Since the value of the road capital is appraised at component level, the transport policy's requirements must be applied at component level.

The limit values for "as constructed" and "worst acceptable condition" must be specified for each component type. Component types that use one of the consumption models II, III, IV and V may have several measures to describe condition deficiencies (wear, degradation, ageing, damage, etc). In models II and III different types of deficiencies are weighed together into a plan with a measure or multistage planned maintenance. For component types that use models IV and V, limit values must be set for each and every one of the measures used to describe condition.

In the case of component types that use models II, III and VI, consumption is distributed over a period of time. In models II and III, today's functioning routines are used to determine the period within which the deficiency must have been rectified (the action period) for each component individual in connection with inventorying. For component types that use model VI, their lives are set equal for all of a type's component occurrences, with some possible variation on the basis of fixed rules in the form of a "circumstance algorithm".

In line with good accounting practice, the first value reduction for a fixed asset is made the first year (the year of acquisition). In the quality-related internal accounting, the year before the deficiency was identified (models II and III) or the acquisition (model VI) would be recorded as the year corresponding to "as constructed". The year corresponding to "worst acceptable condition" is thus the "as constructed" year with the addition of the action period and length of life. The years for "worst acceptable condition" occur the year before a measure is carried out or the latest date for replacement. The whole of the planned depreciation will thus have been booked the year before a measure or replacement is carried out, which means that no residual item needs to be (scrapped) cost-accounted in connection with the measure. This corresponds in all essentials to good accounting practice.

In the case of the component types that use models IV and V, "as constructed" corresponds to the quality in respect of every measure used to describe condition that the client at least expects when a new component is delivered. "As constructed" condition is defined as the lowest quality of the contractor's delivery of a new component that the client can accept without demanding corrective measures or compensation.

The client determines actual quality relative to the contracted quality requirements in a final inspection before handover and "opening to traffic". In the case of deliveries where quality is judged to be less than "as constructed" the client requests that corrective measures be carried out, that the price be reduced, that a penalty be paid and/or that the warranty period be extended. Deficiencies that are already present at the time of delivery are already noted in the quality assurance system but they will now also be recorded in the quality-related accounting.

The "worst acceptable condition" limit value must also be described in detail for each type of deficiency and condition description parameter (models IV and V). "Worst acceptable condition" is the lowest quality that condition is allowed to have or be consumed up to before maintenance measures must be undertaken in order to satisfy the stipulated requirements. A component that has reached its "worst acceptable condition" may either have been fully consumed or need to be replaced. It may also have a substantial residual value and be the object of some form of rebuilding.

As was pointed out in the introduction to this section, the quality criteria must be based on the transport policy's requirements in respect of socioeconomic effectiveness and customer satisfaction. Five different aspects should be analysed per type of deficiency and description parameter when determining the "as constructed" and "worst acceptable condition" limit values. The five aspects concern socioeconomic effectiveness, society's and road-users' (people and freight) expectations, what is possible from a political point of view, and road management.

For some component types the limit values may vary with different factors (type of road, traffic flows, speed, etc). These variations must be described in the form of algorithms. When an algorithm is applied, the circumstances of the component in question must result in the control limits that will apply.

2. Road-users' costs

The commission given to the SNRA by Parliament is to conduct road management with a socioeconomic approach. Road-users' costs are first and foremost costs in respect of 1) the time that people and goods are transported (cost of travelling time and goods transportation time), 2) use of transportation vehicles (vehicle costs) and 3) willingness to pay for greater comfort and lower risk of future ill health (here called comfort and ill-health costs). The effects for road users correspond in all essentials to the effects taken into consideration in the SNRA's socioeconomic calculations[165].

A few component types have known relationships between functional condition and road-users' costs. In the case of the *Bound wearing course* component type, there are known relationships between the roughness of the road surface (the IRI value) in the road's longitudinal direction and the costs incurred by different groups of road users.

Vibration, shaking and the number of times the brakes are used increase as the quality of the road deteriorates. This leads to higher fuel consumption, greater tyre wear and higher costs for repairs. At the beginning, the increase in transportation costs is negligible but accelerates as the road surface deteriorates. The cost increases are different for different types of vehicle such as passenger cars, trucks with trailers and trucks without trailers. When a road has become really bad, it is understandable that travelling time costs (people and goods) also increase markedly.

[165] Cf Vägverkets samhällsekonomiska kalkylvärden, (The SNRA's socioeconomic calculation values), Vägverket 2008:67, ISSN 1401-9612, Borlänge July 2008

In the case of freight, transportation damage can also increase. Alternatively, packaging costs may increase. Comfort gradually decreases and may develop into whole body vibration, which may in turn cause serious physical injury. If experienced over an extended period, jolts and large body movements [166] may eventually lead to fatigue fractures in the skeleton, causing drivers discomfort and pain in the spine and lumbar region.

In the case of *bound wearing courses* there is an effect relationship between IRI and transportation costs. IRI has a seasonal dimension. Studies conducted by VTI have shown that the IRI value can increase by up to 30% in winter relative to values measured during the summer. Attention therefore needs to be paid to the fact that IRI values in winter may be considerably higher and that the relationship function increases progressively.

When calculating effects, it may be appropriate to classify transportation according to type of vehicle, such as passenger cars, trucks with trailers and trucks without trailers. The classification can be made even more detailed if the effect relationships are known. The relation is used to provide answers to questions such as what the "optimal time" for a maintenance effort is. We find that road-users' costs increase at the very beginning and that the rate of increase is higher for worse roads. Together with the relationship function for society's costs, a measure of guidance is obtained for determining limit values for roads' condition on the basis of a socioeconomic perspective.

Another possibility is to base the components' limit value algorithms for "worst acceptable condition" on the road-users' demands and expectations, which can be found in the road user surveys that the SNRA conducts every year. The road-users can for example be asked "assessment questions" about how they perceive a number of selected types of components on roads with which they are acquainted that are maintained as test sections with a stable component condition for a longish period of time before and during the survey. In this way, the road manager would gain knowledge of two perceptions of the condition of a number of components: the road manager's own assessment and in the road-users' judgment.

The results from cost analyses and subjective gradings and expectations are used to determine the "worst acceptable condition value" for some of the more significant component types. Other component types are not given any limit value at all from the road-user point of view since condition is less significant for the road user. Other controlling effects may apply for these.

3. Society's costs

The transport policy's socioeconomic effectiveness requirement assumes that the road manager also considers consequences for society. The first such consequence is the cost to society of serious injuries or fatalities resulting from road accidents. Another cost to society is willingness to pay to reduce emissions and particles. Pollution from traffic can be expected to be given increasing prominence in the transport policy. The consequences of the transport infrastructure for regional economies are often the subject of discussion. If transport prerequisites are poor, weak regions may lose revenues and need other types of subsidies or contributions from society. This third type of cost to society resulting from deficient transport

[166] Hälsorisker med dåligt underhållna vägar, Roadex III delprojekt B 3, (Health risks of badly maintained roads, Roadex 3, subproject B 3), Johan Granlund, Borlänge 2008

infrastructure is difficult to calculate. A general assumption, however, might be that trade and industry in weak regions can hardly be allowed to have worse traffic prerequisites than their competitors in the rest of the country in the long term.

As the road deteriorates, society’s costs increase. Initially, the increase is moderate and is caused by an increase in the number of accidents. When the road has reached a sufficiently substandard condition, the number of accidents decreases while emissions and negative effects on the region’s economy increase. If the road is too bad, traffic will if possible seek alternative routes. Society's total costs in respect of accidents and emissions may thus be higher and all in all will continue to increase as the road’s condition deteriorates. The rate of increase is probably higher for the substandard roads than for those in better condition. When the road is sufficient bad, all transportation ceases, at which point there are no more road accidents or emissions. The cost to the region’s economy on the other hand is enormous.

In addition to injuries and fatalities, emissions and effects on the region’s economy, there are also other effects that arise out of pollution of water catchments and noise. Other consequences that society should consider are measures to improve matters for people living close to roads and weak groups in society like children, old people and people with functional disabilities, and also measures to protect fauna and flora.

The quality of several component types can have an impact on the above mentioned effects for society. Examples of these include bound wearing courses, superstructures, terracing, surface run-offs, road-side areas, fences, guardrails, noise barriers, pollution of water catchments, rockslides and snowslides, and lighting, traffic sign, traffic signal and information installations. The dust problems experienced by people living close to gravel roads are largely a consequence of deficient quality as regards the *Gravel wearing course* component type (the condition of the gravel curve is deficient). A bound wearing course is often needed, however, to rectify the problem permanently.

CO_2 [167] emissions are proportional to vehicles’ fuel consumption. Known relationships exist between different types of vehicles’ fuel consumption and a road’s vertical profile. There are also relationships between fuel consumption and vehicles’ speeds, different types of wearing course and roads’ IRI values. Roads’ design, permitted speeds and types of wearing course are mainly issues related to road’s standard. IRI values on the other hand are measures of roads’ condition.

Society's need to reduce noise levels on existing roads have been identified and costed objectively. In-depth knowledge exists about noise, for example with regard to traffic, speeds, the bound wearing course component type and noise barriers. This knowledge can provide good guidance when deciding the two component types’ “worst acceptable condition” and determining the condition deficiency scale for “sound leakage” in noise barriers.

Since the consequences of many deficiencies may be substantial, in many cases no damage at all is allowed in respect of the component type. The decision situation may therefore be binary. For other deficiencies and component types, risk assessments constitute the basis for

[167] CO_2 emissions from petroleum products generally speaking have a negative effect for society. Theoretically, however, CO_2 is an important element in the growth of plants, and might therefore have a positive effect for parts of society, especially in the forest regions. A closer study, however, shows that trees’ and other plants’ ability to assimilate CO_2 from vehicle emissions is very small and no positive effects are to be expected.

decisions about measures. The highest acceptable vulnerability can then be expressed as "worst acceptable condition".

Proven relationships exist between the condition of bound wearing courses and the risk of being injured or killed. From the point of view of society's costs, a risk-based limit value is therefore needed for a pavement's "worst acceptable condition". As regards safe side areas in the *Terracing, surface run-offs, road-side areas* component type, systematic, well documented inventorying is carried out in so-called "road audits". The assessments, which are made by specialists, are subjective and based on the risk of serious personal injury as a result of running off the road. The cost of carrying out necessary measures is also assessed in the audits. The measures are often investments to raise the road's standard, for example by flattening slopes, replacing conduit ends, moving electricity and lighting masts, blasting rock, etc. Model IIb can be used for measures of condition such as clearing trees and undergrowth that attract game, where "worst acceptable condition" is linked to the year when the measure must at the latest be carried out.

In the case of constructional works there may be other types of functional relationships or consequences of constructions' unsatisfactory condition. These may be lower speeds, lower permitted loads, unloading and reloading, detours when roads are closed, etc – consequences with step-like functional relationships. All component types must be analysed systematically in respect of the effects and costs exemplified above in order to find support for a possible algorithm for the "worst acceptable condition" limit value.

Effects for road-users and society are usually called traffic effects and costs are called traffic costs.

4. The road manager's costs

Central issues in the TAM concept are: 1) How is the component to be maintained for it to have the lowest possible life cycle cost? 2) When are the "optimum" times for different maintenance measures when everything is considered? 3) Is the best measure to continue to maintain the existing component or invest in a new one? With the funding principles that apply today, road management's costs are a part of society's costs. With another funding principle, for example road pricing, road management's costs would be viewed in a business economics perspective together with road users' costs. This "ambiguity" is the reason for the separate accounting of the road manager's costs.

By negative effect for the road manager is meant, for example, that a component's condition deteriorates to the extent that the cost of restoring it become "unreasonably" high or that there is a significant risk that the road's intended function is jeopardised. If a component is severely damaged, another possible consequence might be that other components, for example, are also damaged. However, expenditures for maintenance measures do not normally increase to any appreciable extent if measures are postponed. From the viewpoint of business economics, carrying out measures as soon as the smallest deficiency is detected cannot be justified either, since the fixed costs and road-users' costs resulting from disruptions in traffic, for example, are relatively high. In general, therefore, for the road manager, the later measures are carried out the lower the total road management costs.

A general conception among researchers is that planned preventive maintenance measures reduce components' life cycle costs. Order, road user, efficiency, energy and environmental considerations in all essentials support carrying out maintenance measures on components at well-reasoned, defined condition limit values. It is also important from the point of view of knowledge accumulation and improvement efforts that the effectiveness of different measures, and in particular preventive measures, is followed up and checked systematically. In-depth knowledge is needed of how to "achieve" the lowest life cycle cost for all components in every situation, considering the demands that follow on from the five aspects listed above.

It is not uncommon today for a single road engineer's personal judgment to determine these limit values for several component types' condition. Only in the case of a few component types can it be claimed that a definite consensus exists as to when a maintenance measure should be undertaken. For most component types there are no known condition relationships with effects for road-users and society.

Component types that are intended to provide safety, security, guidance, information about traffic regulations etc for road users must be maintained in an acceptable condition. Maintaining their condition is first and foremost a task for the road manager. For component types without known effect relationships between a component's condition and costs to road-users or society, decisions about measures can be based on assessments of risks in the transport system or on aesthetic and legal aspects. The road manager's considerations can also be based on dimensioning technical lives, actual lives and principles like the "reversed prudence principle" (cf. the section in Chapter 4 about Model VI).

The road manager perspective is primarily a way of viewing all component types' deficiencies and measures from a business economics point of view. The road manager perspective is a cost minimisation problem, when relationships between condition and effects have been considered to a sufficient extent. In order to minimise components' life cycle costs in an acceptable manner, knowledge of the quality requirements is essential. Quality requirements affect issues relating to residual values, frequency of maintenance and business economic considerations between investment and continued maintenance.

5. Consequences of politics considerations

Political considerations in the present context primarily refer to a kind of fairness aspect – a politically assessed general "reasonableness and fairness" based on a social perspective. The political aspect concerns, for example, where the political "disgrace point" lies. The limit for what is "worst acceptable condition" often develops out of comparing a state-administered road in one region with equivalent roads in other regions followed by various groups lobbying the politicians. In general, politicians must be able to justify roads' standard and condition, including any differences compared to other roads in the eyes of their constituents. It is therefore common today, that *ad hoc*-like fairness and reasonableness become the determining factors as regards component types' standard but also for conditions' limits values.

It could probably be shown for example that financially challenged regions have a considerable regional economic handicap as a result of a relatively greater proportion of unsatisfactory roads. It can hardly be questioned that this might be a serious competitive disadvantage for the region's trade and industry. Among older citizens, financially challenged regions might theoretically also have a higher proportion of skeletal injuries (microcracks in the spinal column) and soft tissue injuries resulting from extensive whole body vibrations caused by travelling on poor roads over a long period of time. The financially challenged regions would in such cases theoretically also have higher municipal costs for the demanding care of elderly citizens indirectly caused by poorer roads than in the rest of the country. This example, which may be more than a little incisive, nonetheless illustrates a complex risk and fairness issue that would be impossible to elucidate in a socioeconomic calculation. Such questions and concerns can probably only be taken into consideration through political interest and decisions.

6. The transport policy's requirements regarding socioeconomic effectiveness

The overarching transport policy objective demands socioeconomic effectiveness in road management. Utility and sacrifices for road-users, society and road managers must in total give as "optimum" an outcome as possible. For a few component types such as the *Bound wearing courses* component type, a socioeconomic calculation will lead to quantified limit values being able to be set. Socioeconomic assessments together with information about road-users' expectations, political considerations and the business economics aspects of road management will therefore be able to form the foundation for the "worst acceptable condition" limit value according to "best available knowledge".

There could be known calculable socioeconomic relationships between roads' condition and effects such as traffic and road manager costs. In that case there would be possible to calculate how the total cost varies with the condition of the component and to find the point where the costs are minimized. It is then conceivable to find the limit value where the condition should be improved.

For one or a few component types (bound wearing courses and possibly road structures and constructional works) the socioeconomic sum function exists with an "optimum" condition for when a measure should be carried out. These relationships can for example represent bound wearing courses' roughness measured in IRI and costs to road-users and society.

However, there is a) a certain amount of uncertainty concerning the valuation of the factors included and b) a need to not exaggerate funding needs. It is also known that the curve's lowest point is indistinct. It is therefore reasonable to estimate the socioeconomic function's minimum slightly displaced in the "poor" direction relative to a strictly mathematical optimum. The *Terracing, surface run-offs, road-side areas* and *Superstructures* component types probably have sum curves with "elongated minima". Poor condition of constructional works can also give functions with socioeconomic minima. Roads with little traffic will probably not give socioeconomically calculated minimum values for any component type.

Other component types lack known relationships with effects for road-users and/or society. "Optimum condition" can therefore be as close to the limit value for "worst acceptable condition" as possible without exceeding the limit value for any length of time. Maintaining these component types in an acceptable state is first and foremost an assessment issue for the road manager. It is greatly expected that the assessments will be uniform. Limit values may be defined on the basis of knowledge of the component types' function and socioeconomic significance, road-users' expectations and risk assessments in respect of, for example, safety and the environment.

For reasons of efficiency, carrying out measures on a component may sometimes be coordinated with measures for a whole group of similar components, following the same pattern as when changing lamps. In such cases, the effectiveness of the measure is assessed for the whole group and not for individual components. Analyses can take this into consideration by summing components belonging to the same project.

7. Concluding comment

It is essential that politicians and the general public do not perceive limit values as arbitrary or tendentious. On the contrary, it would be desirable to obtain political acceptance for the limits that are ultimately established. For example, it would be possible for the Parliamentary Committee on Transport and Communications to present examples of condition according to the limit values that the analysis described results in and request some form of political acceptance.

In practice, there are a number of factors that have an impact on the component types' limit values for the different condition parameters. Examples of such factors that could be included in an algorithm for limit values are road category, road width, traffic density, posted speed, climate zone and bearing capacity. For reasons of credibility, the factors that influence component types' limit values and the "circumstance algorithm" that are used to determine "worst acceptable condition" must be adequately documented. Some limit values will need to be adjusted in line with vehicles' technical development as knowledge improves and customers' demands and expectations change.

It is important in this context that the road manager takes socioeconomically "optimum" limits for maintenance measures into consideration in those cases where they exist. The "worst acceptable condition" limit value for measures to be carried out is in this case synonymous with the "optimum condition" for maintenance measures. Henceforth the term "worst acceptable condition" will be used for "optimum condition".

In figure A4.1 the component types are divided into two groups where each group's limit value can be justified on the basis of either a socioeconomic perspective (Function type 1) or a more political perspective akin to plausibility (Function type 2). It is important to note that in theory one and the same component type can belong to both function types depending, for example, on traffic flow. Which curve is to apply is shown by the component type's "circumstance algorithm".

The way in which limit values are determined is another aspect of data quality. In order to certify the quality of data for different types of analyses, this type of aspect will also be quality certified for each individual component occurrence.

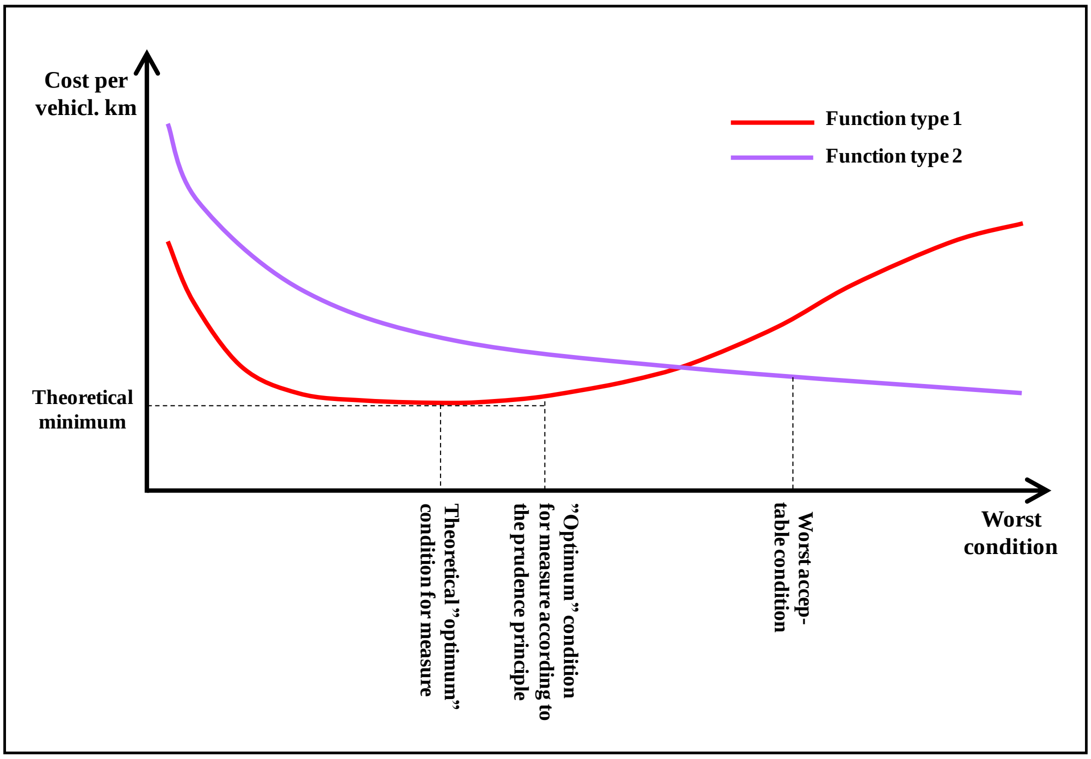

Figure A4.1 Two theoretical function types for components' limit values for condition

The limit value for "as constructed" condition (Q_B) is expressed in parameters that describe condition and using the "circumstance algorithms" that apply for the component type in question. The limit value for "worst acceptable condition" (Q_S) for the component type is expressed in the same way.

Appendix 5 Composite component types or planned preventive maintenance

1. General principles

Sometimes components' condition can best be described by combining models. An example of this is when a component has two types of deficiency where one can be maintained almost indefinitely while the second will eventually lead to replacement of the component. Such a development of a component's condition would be described by combining models IV and VI. Construction materials can fatigue and age to the extent that their necessary properties cease to exist and exceed the "worst acceptable" value. Ageing or fatigue can occur suddenly and unexpectedly. The entire component may need to be replaced within a certain time (e.g. 10 years) after the inspection. This can occur despite all regular maintenance being carried out according to all applicable requirements. At Banverket (the Swedish National Rail Administration), track is considered to be an example of a component type that follows this maintenance principle.

The *Track* component type is measured systematically using a method similar to that used for bound wearing courses. In the example, tracks' condition values are recorded using model IV up to "worst acceptable". They then have a substantial residual value. From the time the 'fatigue' deficiency is detected in the steel, which may be difficult to predict time-wise but always necessitates replacement, the residual value is gradually reduced to zero using model IIb. This takes place over a period that is reasonably judged to remain before replacement is necessary (e.g. 10 years), at which time the planned replacement takes place.

In the example above, all maintenance measures are adjusted in time and scope to the time of replacement. The ideal case and the planning challenge during the final ten-year period is that the entire component has been consumed and in the accounts has its lowest possible value (preferably equal to zero) when the time comes to replace it. If this is achieved, there will be no scrapping cost for the year when the replacement is made. Normally a calculation will be necessary in order to show the most advantageous time for replacement from an economic point of view in such a situation, when two deficiencies are to be adjusted to each other.

At other times there will be component types made up of different elements with different lengths of life or that consist of connected parts. For example, a lighting installation may consist of a pole with an electrical installation, lighting fittings and lamps with a technical life of 50 years, 15 years and 5 years, respectively. If lamp replacements are included in the operating cost while expenditures for poles, electrical installations and fittings replacements should be booked as assets, this maintenance will in practice also lead to accounting problems.

Maintenance in the form of fittings replacement could be booked in the same way as lamp replacement. It would then be possible to regard the lighting installation as a single entity for which it is known that a number of operational measures (fittings and lamp replacements) will need to be carried out over the life of the installation. If the expenditures for fitting replacements are substantial and the fittings have a life of 15 years, a case can be made for booking them as assets in order for the consumption costs to be correct. This is also an approach that is in agreement with the principles of quality-related accounting of road capital.

Since it is a strict requirement that consumption costs be as realistic and accurate as possible, it is essential to find relevant and appropriate principles for determining length of life and value reduction for "composite components" such as lighting installations. The principle and description of value reduction that follows from this can also be applied in the case of planned multistage preventive maintenance over a component type's life for models IIb, III and VI.

In the lighting installation example, one alternative might be to report the constructional elements individually as component types. However, this would not meet the plausibility requirements in the model's criteria for what might be a component type with its own condition value in the accounts. The complex of problems would then be able to be broken down into very small elements in a component's construction (e.g. replaceable parts in a ventilation system or bearings in a bridge construction.

Fittings that are replaced are not booked as assets in traditional accounting. When the original investment is booked as an asset in the external accounting, it is common for the lives of the parts to be weighted together in respect of their values. In the example, the life of the whole lighting installation would be between 15 and 50 years, e.g. 40 years. In the SNRA's external accounting, 40 years is used for the entire investment project with all its different component types and different lengths of life. The actual life of the individual component types varies from a few years in extreme cases to well over a hundred.

With the system used in the external accounting, the first fittings mounted with a life of 15 years would be depreciated over a further 25 years after its replacement. To some extent this compensates for the replacement of the fittings after 15 years not affecting value or consumption costs. Correspondingly, the pole and the electrical installation will be fully depreciated 10 years before their theoretical replacement date.

In quality-related accounting, the ambition is to arrive at realistic value appraisals and consumption costs. The possibilities that exist must therefore be exploited in order to improve the accounting principles for component types consisting of constructional elements with completely different lengths of life, particularly if it can be accomplished by computer.

Component types may be made up of more than two constructional elements with their own lengths of life. The principles discussed below can be applied for components with more than two constructional elements with completely different lengths of life. The accounting is considered to be difficult to overview if there are more than two parts. This increases the demands as regards pedagogics and understanding. Here, we will therefore confine ourselves to discussing the problem of two constructional elements. If there are more than two constructional elements, it may nonetheless be possible to sort the elements into two groups and then apply the principles below for the groups.

The basic idea is that a component's two constructional elements (or groups of constructional elements) will be depreciated in their entirety at the same time and as close to their actual scrapping date as possible. This means that the entire life of the component type can be adapted to both the shortest and the longest life. The total life will thus be an integer multiple of the life of the constructional element with the shortest life. In the lighting installation example, the total life is 15 + 15 + 15 = 45 years.

In order not to risk implying that the funding needs are exaggerated by using the dimensioning life of 45 years instead of the more probable 50 years, it is chosen, according to the reversed prudence principle, to make a further fittings replacement before the pole and installation are scrapped in their entirety. The total life of the component type is thereby judged to be able to be 60 years (or possibly 4 * 14 = 56 years) – a length of life that also occurs in practice.

Value-adding maintenance, that in the example is in the form of fittings replacements, is booked as an asset in the quality-related accounting. The total value booked as an asset that is thus to be consumed over 60 years is in the example the acquisition value plus the acquisition expenditures for three fittings replacements. The total amount can provide guidance for the calculation of the theoretical value reduction rate for composite component types but also for planned preventive maintenance. Only actual acquisition and maintenance expenditures may be accounted as assets. The booked consumption cost is therefore made up of periodised amounts based on actual expenditures but in proportions that in this case can take into consideration all planned measures over the entire forecast life.

In the example, four fittings replacements are planned over the life of the lighting installation. Expenditures for actual fittings replacements are not accounted as assets until they have actually been carried out. Accounting of composite component types that use models IIb, III and VI can be made easier by introducing a so-called *Linkage coefficient*.

4.8.2 Linkage coefficient, S

In principle, G values > 1 could be used for composite component types. Instead of using G > 1, a linkage coefficient (S9) is introduced. The purpose is to adjust the relative consumption (R) taking the knowledge that exists of maintenance of the component type's entire life cycle into consideration. The S coefficient can adapt the value reduction aspect in order to better reflect the whole component's annual consumption, provided that the intention is to carry out the planned maintenance. In this way, the residual value coefficient G and relative consumption R are still distinct and comprehensible. This should simplify the pedagogical description of the accounting model.

The constructional element with the shortest life (t years) has acquisition value B. The constructional element with acquisition value A has the longest life. T is an integer multiple of t (T = n * t, where n is an integer). A factor S can be derived with the support of the following relationships (cf. Figure 9):

Value reduction according to the standard formula after X years = RX * (A + B) = (X / n * t) * (A + B)

The value reduction after X years should have been = R_X * (A + n * B) = (X / n * t) * (A + n * B)

The value reduction is corrected using factor S according to: S * R_X * (A + B) = R_X * (A + n * B)

S = (A + n * B) / (A + B), where the remaining starting value for the continued value reduction and number of remaining replacements change after each replacement. In order to obtain a general expression for S after each replacement or planned maintenance measure, A and n must be changed. In a general expression for S, A is replaced by A – k * A / n and n by (n – k), where k is the number of replacements carried out. No replacement has been carried out at the time of acquisition n, which means that k = 0. After eliminations, the general formula is:

$$S_k = \frac{n * (A + n * B - k * B) - k * A}{n * (A + B) - k * A}$$

In the lighting installations example, the acquisition value of the fittings constitutes 20% and has the shortest life, 15 years. The pole and the electrical installation constitute 80% of the entire lighting installation's acquisition value and have a life of 60 years. The integer multiple n = T / t = 4. After 15 years, the first planned fittings replacement (k = 1) has been made and three replacements thus remain. The linkage coefficients in the example are:

$$S_0 = \frac{8}{5} \quad S_1 = \frac{3}{2} \quad S_2 = \frac{4}{3} \quad S_3 = \frac{1}{1} = 1$$

Corresponding R values are then calculated in turn with "as constructed year" from the year of acquisition, the year for the first, second and third replacements according to the rules that were presented earlier. In Figure A5.1, the lighting installation example has been sketched at fixed prices with three planned fittings replacements (every 15 years). According to the plan, the value reduction must be corrected to follow the purple line. The S values are calculated without considering index trends. One reason for this is that fittings and poles can have completely different price trends (indexes). The residual value of the lighting installation is zero (G = 1).

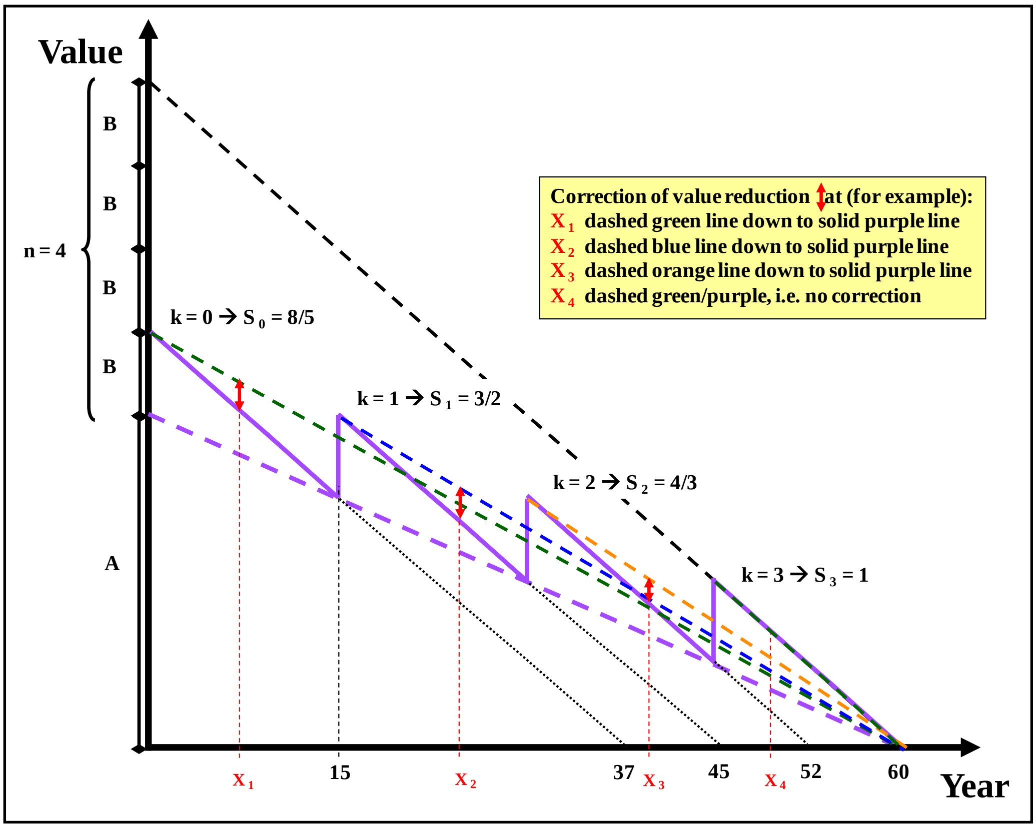

Figure A5.1 The lighting installation example as "composite component type" at fixed price.

In practice, replacements of constructional element B will probably not fully agree with the plan either in time or cost. The reduction in value can nonetheless be adjusted to actual measures and follow the “accounting principles” and “best available knowledge” upon which the plan is based. The intention is to give as realistic a consumption cost as possible while still following uniform, fixed and verifiable accounting principles.

The linkage coefficient is calculated on the basis of “best available knowledge” as regards the maintenance measures that the component is judged to need during its existence. The coefficient adjusts the value so that it is changed to fit the actual measures. If the measures are not carried out according to the assessments, the entire component’s life will be shortened. In the example, the life is 37 years if no replacements at all are carried out. With only one fittings replacement before year 37, the length of life is 45 years and with a further replacement before year 45, it is extended to 52 years and so on. The actual expenditures and replacement times can change these theoretical lengths of life while the total estimated life is 60 years.

For component types that are not composite or that do not have strictly preventive planned maintenance, the value of $S = 1$. $S < 1$ can in principle not occur since A is the constructional element with the longest life and other lives are integer proportions of it with faster rates of consumption. On the other hand, composite component types or types with planned maintenance occur for which $S \geq 1$.

Analyses should be carried out to determine whether the component types *Rest areas*, *Traffic control and information areas, Park-and-ride car parks*, *Protection for water catchments*, *Water supply and sewer systems*, *Concrete/brick noise barriers*, *Wood/plastic/steel/glass noise barriers*, *Road lighting*, *High-mast lighting*, *Traffic signals*, *Road information signs* and *Toll booth equipment* should be handled as composite component types.

Appendix 6 Calculation of Maintenance backlog - some more information

1. Calculation of Maintenance backlog (Mbl) as a total expenditure (I)

Restoring all the Mbl components to “healthy” components requires expenditure ΔV (unit price) as discussed in Chapter 6. For the components to then remain “healthy”, costs changed by a value of ΔK (unit prices) must be continuously funded. Each component type is reviewed in the same way. $AV^{healthy}$ includes only “healthy components”.

The condition values and value consumption for all component types that apply value change model VI are based on a standard cost of applying a measure and service life. Model VI is valid for the vast majority of all component types and components, whereas accounted growth values are based on actual expenditures.

According to alternative *I*, Mbl is calculated as the total expenditure for restoring all n component types’ Mbl components (k) from their unsatisfactory condition to “as constructed” The expenditure (Mbl^{expend}) for restoring a component’s condition is the component’s standard cost of applying a measure (= residual value coefficient G * the calculation value) adjusted by any cost-increase factor f ($f \geq 1$ in the case of Mbl).

2. Calculation of Mbl as expenditure according to a measure plan (II)

It may sometimes be necessary to compare groups of components within the same component type. Such a comparison gives rise to many questions that need to be analysed by means of measure planning in order to eliminate a Mbl. For example, all the high mast lighting poles in one region could be compared with the high mast lighting poles in another.

When comparing for example the regions’ and the average condition values and annual costs of e.g. high mast lighting poles, it is important to understand what a high or low condition value in combination with a high or low annual cost signifies. Four situations differing in principle can be distinguished in such a comparison:

1 High condition value and low consumption cost per unit
2 High condition value and high consumption cost per unit
3 Low condition value and low consumption cost per unit
4 Low condition value and high consumption cost per unit

Since the “healthy core” contains a great many components of varying age and use, it can probably be assumed that a low average annual cost also means a longer life cycle cost relative to a high average annual cost. A low annual cost should therefore be an advantage from the point of view of road management. Situations 1 and 3 should in principle thus be better than 2 or 4 for the “healthy core”. However, this only applies on condition that ”Function type 1” components are not compared with “Function type 2” components or that their proportions in the compared “cores” differ markedly from each other.

With the same average annual cost for the “component cores", situation 3 implies, in comparison with situation 1, that the components in 3 are for example older, that they have a relatively short service life, or that they may have had a low acquisition value. An older version of the same components should mean that it will not take as long to reach the point where new investment or maintenance is necessary for those components. At the same time there may be a risk that in a “healthy core” with predominantly younger components development over their remaining service life will lead to the appearance of components of better quality and with better characteristics, which could have a negative impact on the components’ economic life.

Different maintenance strategies give components different life cycle costs and thus different impacts on the condition values. Academic studies have shown that preventive maintenance often gives a lower total cost than emergency maintenance (*ad hoc* measures). Consistent preventive maintenance on all components probably also gives a relatively lower average condition value of the situation 3 type. If situation 3 is a consequence of functioning preventive maintenance, the cost can be expected to be low. Situation 3 might in this case then be preferable to situation 1.

If the risk of a shortened economic life is deemed possible and the interest rate used for costing is assumed to remain unchanged or fall over the “remaining life” comparison period, situation 3 might be preferable to situation 1 for a group of components. With good possibilities for funding, a clear risk of shortened economic life and/or an assessment that the real rate of interest will not come down but rather increase during a later comparison period, situation 3 might be preferable.

Regarding the level of the condition values in situations 2 and 4, the same applies as for situations 1 and 3. It is not however possible to find any advantages that mean that situation 2 or 4 would be preferable to situation 1 or 3. A low life cycle cost is always preferable to a high one, unless the effects for road-users and society are the same. The effects are taken into account through the applied limit values (”Function types 1 and 2”); otherwise, there are no known differences in effect between different occurrences of one and the same component type.

Too low a standard cost for carrying out a measure leads to relatively too low an accounted consumption cost and too high a condition value for the “healthy core”. Too high a standard cost for carrying out a measure, on the other hand, means relatively too high accounted consumption cost and too low a condition value for the “core”. Too low a standard cost for carrying out a measure leads to relatively too low an accounted consumption cost and too high a condition value for the “healthy core”. Too short a service life means relatively too high an accounted consumption cost and too low a condition value for the “core”.

In summary we can say that situation 3 is preferable to situations 1, 2 and 4, when a number of potential and “normally” probable risks are taken into account. If the condition is that the real interest rate can be expected to rise, i.e. that price development is low with continued maintenance rather than new investment, situation 1 (with a relatively speaking high condition value) may be preferable to situations 2, 3 and 4. Situations 1 and 3 are always preferable to 2 and 4. The relationship between situations 2 and 4 is the same as between 1 and 3.

Other strategies may aim to provide as good prerequisites as possible in order to affect or develop a weak construction market. It may in such cases be important to achieve an even age distribution of the components within an individual component type or together with another component type. Together they can create prerequisites for a specialised construction market focused on the upkeep of the types of components in question. A good prerequisite for a functioning construction market is for example a relatively constant volume of measures in SEK over a foreseeable period. The strategy of having constant volumes over the planning horizon requires a qualified forecast of the need for measures for the types of components in question.

The measures that need to be carried out over the coming years together with all the measures that should already have been carried out can be planned over for example a 10-year period, in such a way that the actual annual volume of measures is as consistent as possible. If the component type can be coordinated with another component type, this should give a greater possibility to achieve an even distribution of the total volume. With good planning of the volumes of measures, and if contract periods are sufficiently long, construction contracts might be able to be made so attractive that they stimulate development of both products and production to increase the contractor's competitive ability. In summary, it must nonetheless be argued that different strategies for actual planning of the measures should not have any effect on the actual "value item" in order to eliminate a Mbl.

3. Calculation of Mbl as an annual cost (III)

The condition valuation is cost-based at current price levels. Theoretically, this means that a decrease in value is equivalent to the cost of restoring the decrease. The decrease in value can only be calculated in respect of a standard price for carrying out the measure when the condition has reached its limit value (standard cost of applying the measure). The measure's actual cost only becomes known after it has been carried out.

With active control, sound economic prerequisites and healthy competition the maintenance cost per component and function type should develop towards a gradually falling price level. For components of both "Function types 1 and 2" the following will probably apply:

- More road maintenance leads to higher maintenance expenditure and a higher quality road network relative to the "optimum" level. In total, the socio-economic cost will be high with low traffic costs and a high average condition value of the components.
- Less road maintenance leads to lower maintenance expenditure and a road network of lower quality relative to the "optimum" level. In total, the socio-economic cost will be high with high traffic costs and a low average condition value of the components.

Both society's and the road manager's costs are reduced with lower levels of maintenance. There is therefore a considerable risk that the components' condition will fall below their "optimum" and "worst acceptable" limit values. By studying the "healthy core" of components it can be ensured that this will not be the case in the assessments that are made. Theoretical average replacement values and maintenance costs can be assessed on the basis of the "healthy core's" data for each component type. If regular checks and adjustments are made, cost levels should be relatively close to the replacement value of component types that have no residual value. For a component type *with* a residual value the corresponding cost level will be close to its replacement value minus its residual value.

The cost-based valuations in the quality-related accounts are regularly checked and adjusted against expenditure and actual consumption. According to the condition for the "healthy core's" components, the maintenance appropriations used have been in good balance with the decreases in value. This means that the figures should gradually become increasingly accurate.

A single average component's funding needs for maintenance vary over its service life. In the real estate sector, for example, annual allocations are made for the funding of maintenance measures. This is not possible in state-administered road management, where only minor deviations against annual appropriations are accepted. With a large number of components of varying age and with varying maintenance needs, it is probable that the total funding needs for maintenance measures will be fairly even over a number of years.

The average standard price of long-term maintenance of previous Mbl components with total quantity q can be assumed to be the same as for the components in the ”healthy core”. The annual cost (KMbl) of maintaining recently restored Mbl components will “normally” be low the first years. Viewed over the lives of the former Mbl components the standard prices can be expected to be on a par with the components in the “healthy core”.

It is assumed, as before, that steady funding of maintenance measures on a very large number of components of varying age can be planned time-wise so that no Mbl occurs again. With this prerequisite for all component types' Mbl components restored to “as constructed” the total annual cost KMbl can be used as a basis for assessing the amount of funding that will needed to continue maintenance.

The prerequisite is also based on the fact that only in exceptional cases is a measure not intended to achieve “as constructed” when the condition of an individual Mbl component is improved. For example, when a pavement with 20 mm deep ruts is to be repaired, there can be hardly anyone who would “buy” a new pavement with the requirement that it should have 8 mm deep ruts when repaired. On the contrary, the endeavour of “as constructed” is to achieve a completely even pavement surface or as rut-free a surface as possible. The demand that the contractor must meet is that 1.5 mm initial ruts can be approved, otherwise a penalty will be deducted from the payment for the work carried out.

One explanation why “as constructed” is required is that in most cases the fixed costs in respect of the measures relatively speaking constitute a considerable proportion of the total cost of carrying out the measure. Initial ruts tend to affect traffic so that the pavement develops ruts faster. Fixed costs also include, for example, procurement costs or call-offs of measures, administration, and inspection and, not least, the contractors' setting up and removal costs.

For certain types of components, it sometimes happens that a simple measure does not aim to achieve “as constructed” condition but only slow down an ongoing deterioration in condition temporarily. If in the case of such measures the deterioration does not accelerate, relatively speaking, the chosen measure may be more effective (more profitable) than the alternative, more expensive measure. The quality of the measure and the financial picture will be able to be determined from the quality-related accounts (LCC).

When components belonging to Mbl are combined with those in the “healthy core” the combined mean value of the components' condition value will probably deviate against that of the “healthy core”. The components that were previously part of the Mbl probably have a higher condition value after the measures have been carried out than the corresponding mean value in the “healthy core”.

To summarise, the expenditure that must be funded for the Mbl components' condition to be restored can be calculated. The rate at which the measures are to be carried out depends partly upon which strategy is chosen. KMbl is the long-term annual maintenance cost that needs to be funded to be able to maintain the condition of the components that were previously part of the Mbl in a similar fashion to the components in the "healthy core". The funding issue is woven in among issues that relate to the information about the maintenance backlog and should therefore also be discussed in this context.

Appendix 7 Improved data for long-term planning: An example

With a transparent accounting of the "best knowledge" on the shortcomings of the whole transport system the various stakeholders can plan for urgent efficiency measures. The following simple example can illustrate some of the problems described above that an interactive process could handle.

The example is a study of the possibility of establishing a multipurpose terminal at the surface 1 between the railway line J1 and J2 and road V1 and V2 (see Figure A7.1 below). A terminal would affect the heavier traffic destinations and itineraries. When the amount of heavy traffic increases it also affects other road users, to varying degrees depending on road function, and the road alternatives between different destinations. Special traffic analyses study the way traffic is likely to be redistributed throughout the road system if the multipurpose terminal becomes a reality.

Under the conditions in this example, the volume of traffic in the junction 2 will increase. Previously junction 2 is identified as a standard deficiency, where the economic impact is assessed according to a given algorithm. One factor in the algorithm is about traffic flows in the connecting roads and another one is the allowable speeds. Traffic analysis data on higher traffic flows in the junction 2 is used in the reanalysis of the standard deficiencies impact on road users and society.

One result of the analysis may be that an investment in a combined terminal should imply that the crossing must be addressed. Unless the deficiency of the crossing had been well documented it is likely that the analysis had not been made sufficiently thorough. The crossing is in the example near the terminal site. In reality, the distance to the intersection might be large and would still result in significant impacts to road users and society from a terminal.

If the junction 2 is not addressed in connection with the construction of the terminal then users and society will suffer from unwanted costs. With the documented information on the deficient standard of the crossing can traffic outcomes and effect be tested on a general level in a traffic analysis (in case the terminal is establised) with regard to the new traffic flow in the intersection. A large number of decisions could therefore be made with better knowledge of traffic-related indirect effects on other parts of the network provided that you have access to good models for traffic analysis.

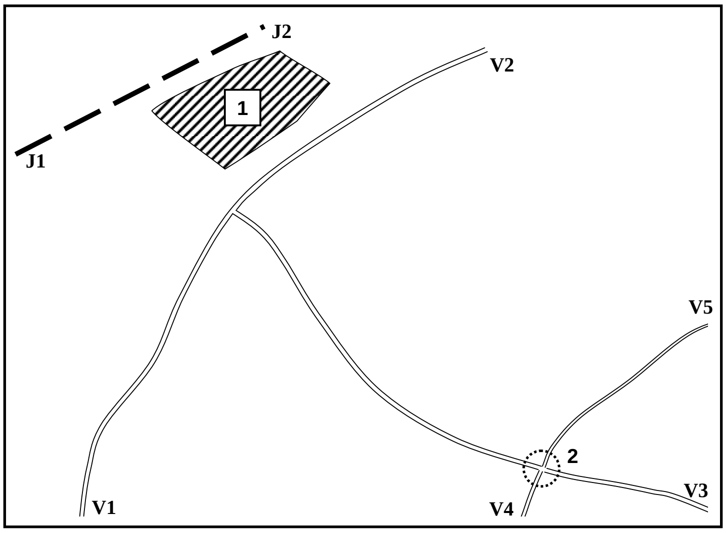

Figure A7.1 simple example of decision making based on a quality-related accounting

A non-rectified junction 2 will eventually be identified as a major standard deficiency, if the terminal has been built and the traffic flows have increased. Several years after the terminal is completed the crossing might still have been addressed but with negative social and traffic impacts during the interim period. Of course, other pressing needs have been funded over time but without the alternative costs and benefits being sufficiently illuminated. The important thing in this example is that the quality-related accounts contributed to the consequences being analyzed using a systems approach in a simple way even before the decision on the terminal (see Item "2" in Table A7.1 below). There is also a preliminary indication of the percentage by which the state may contribute, related to the estimated effects to society as a whole.

OBJECT	Type	STATUS	Effect in SEK							Total								
			Travelling time			Greenhouse effect					Utilities		Cost		Net Pres Value Ratio		Maximum grant	
			Rank	Utili-ty	Accu-mulated	Rank	Utili-ty	Accu-mulated		Rank	Total	Accu-mulated	Total	Accu-mulated	Obj	Acc	%	SEK
Object X – Y	2.1	**F**	6	8 987	8 987	**1**	10 532	10 352		4	27 665	27 665	11 565	11 565	1,84	1,84	100	11 565
- - -		**-**	--	--	--	--	--	--		-	--	--	--	--	--	--		
Object E – F	2.2	**V**	21	2 598	289 413	**34**	1 162	142 187		20	7 633	581 607	4 482	346 814	1,31	1,29	100	4 482
Object C – D	5.2	**S**	53	1 722	291 135	**35**	1 005	143 192		59	4 619	586 226	3 172	349 986	1,12	1,29	94	2 961
Object A – B	2.1	**A**	2	11 881	303 016	**36**	996	144 188		3	29 412	615 638	11 784	361 770	1,92	1,31	100	11 784
- - -																		
Object ”2”	4.1	**S**	237	316	1 809 332	**201**	62	285 794		17	528	3 085 267	293	2 197 384	1,39	1,09	**87**	**255**
- - -		**-**	--	--	--	--	--	--		-	--	--	--	--	--	--		

Table A7.1 With new traffic data objects "2" received a higher priority

Appendix 8 Details of the implementation process

For the administrative systems, the rule is that "When describing condition, the best possible technical knowledge" shall be used, i.e. not necessary create new information but use the knowledge and data that exists today. In the case of BaTMan and PMS, the system administrators expect TRAV to solve their desire that they have expressed for so long to be able to have financial information delivered directly from the accounts. Figure A8.1 shows how the different systems interact with each other. With some slight adjustments, the diagram has been used in the implementation project.

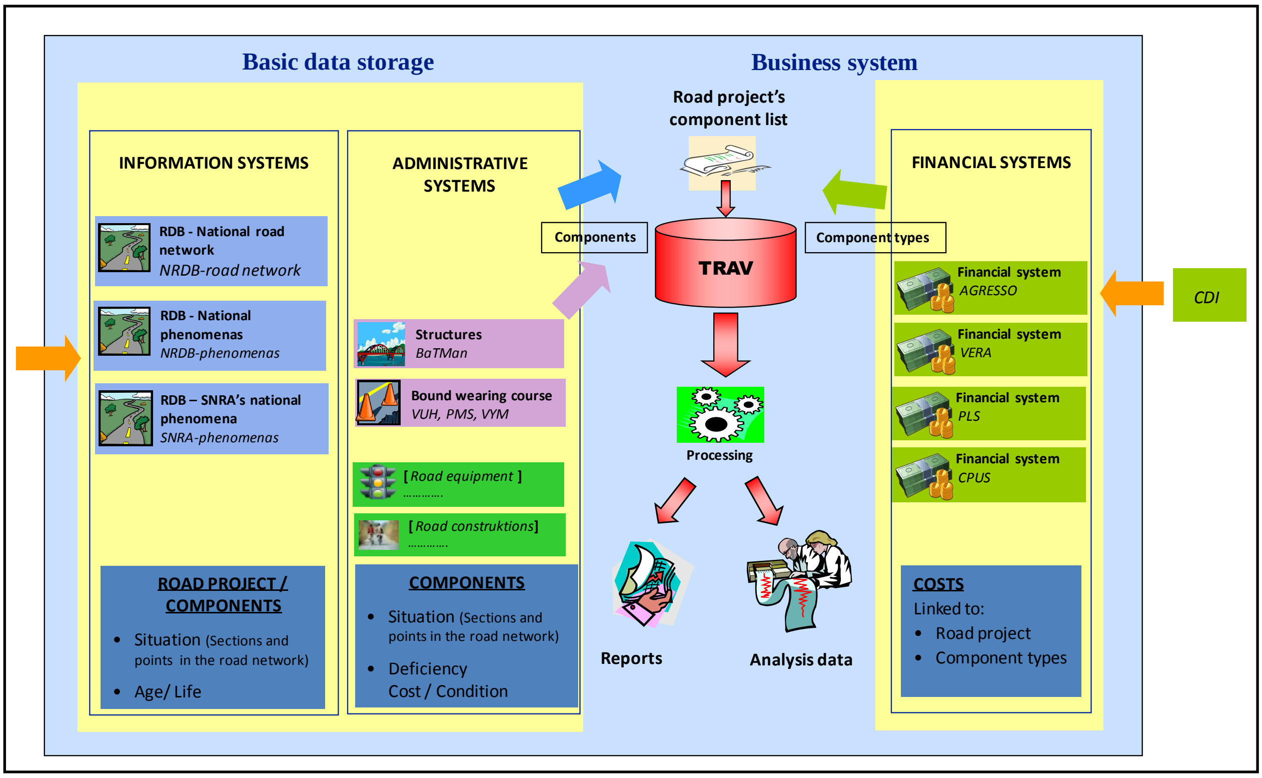

Figure A8.1 Illustration of how the different systems interact with each other

1. Preliminary study concerning component types in BaTMan

In the BaTMan preliminary study, the starting point was that "all financial information about actual costs comes from Agresso and can be linked to each component as described below. No details of actual costs are obtained from BaTMan.

> "The structures are inspected continuously at a maximum interval of six years And all damage as regards condition documented. A "fictitious cost of carrying out measures" is given for each structural element and totalling the cost of measures for each component type is thus not expected to present "any major problems". The "fictitious cost of carrying out measures" is not equivalent to the cost of restoring the structural element to its original condition. When BaTMan delivers data to the quality-related accounting the "fictitious cost of the measures" must therefore be adjusted to the corresponding value that is normally used in operational planning and budgets."

BaTMan provides data for the following component types, where some additional information has been added compared to the printed version of the preliminary study according to verbal agreements with the person responsible. Component type group 5 Structures comprises 5.1 Bridges, 5.2 Tubular bridges, 5.3 Openable bridges, 5.4 Large culverts, 5.5 Tunnels excl. installations, 5.6 Pile foundations, 5.7 Troughs, 5.8 Support structures, 5.9 Ferry berths and 5.10 Jetties and quays.

BaTMan also delivers data to TRAV for some component types in group 3 Special installations, when they are present in or on the structures listed above. This concerns the following component types: 3.10 Electrical installations, 3.11 Ventilation systems, 3.12 Safety systems, 3.13 Water supply and sewer systems and 3.14 Pumps.

The data to be delivered must also exist in BaTMan's database. This means that some adaptation is necessary so that the data packets are assembled correctly. The information about the total deficiency that BaTMan must deliver to TRAV is 1) the date of the deficiency, 2) the cost of the deficiency, and 3) the date of the measure(s). The strategy for the upkeep of a structure can also contain preventive measures, in which case they will have been documented in BaTMan. From the point of view of handling and value, preventive measures are equated with identified deficiencies. Subsequent life cycle cost analyses will show the profitability of any preventive measures carried out and will be included in follow-ups and the learning process. The date of a deficiency is the same as the date of analysis and planning based on data from inspections, the cost of a deficiency is calculated at the price level of the date the planning was done and is an adjusted "fictitious cost of carrying out a measure", and the date of the measure(s) is the date by which the deficiency must have been rectified at the latest (according to value reduction model III).

BaTMan also contains bridges that are not connected to the road network (approx. 130 in all, covering a total area of approx. 20.000 m^2. Examples of such bridges can be found on cycle paths and in rest areas and in the form of protected, beautiful old stone arch bridges. "Bridges of this type cannot be connected to a road network in the normal way in BaTMan because they are not allowed to affect the handling of dispensations etc. In order for these structures' needs to be satisfied in TRAV, some way of connecting them to the road network must be devised." It is proposed that the bridges be assigned "planned" status at the closest reference link. All structures will thus have a connection to the road network.

In the system administrator's opinion, the necessary adaptations in BaTMan are moderate. The work is estimated to take approximately 360 working hours and cost roughly 324,000 SEK. The database must also be supplemented at the regional units – something that is going to be done anyway, according to an earlier decision.

2. Preliminary study concerning component types in PMS

"The SNRA's Pavement Management System (PMS) is a system for handling, extracting and presenting data, primarily about road surface condition and pavement measures. The data in PMS comes from 3 sources:

- Data about the road network and a number of phenomena from TNE [168]

[168] 09-06-22, see Triona www.triona.se and http://www22.vv.se/nvdb_templates/Page2____24714.aspx . NVDB stands for Nationell vägdatabas (National Road Database).

- Data about executed pavement measures from the road and traffic data bank (RDB) [169]
- Data from road surface measurements from VYM [170]

PMS's databases are characterised by:

- Each region having its own database
- The databases being used only for extraction
- Updates normally being carried out once or twice per year and region, when new condition data has been received and at the end of the year
- The contents of the databases being recreated in their entirety when they are updated, by retrieving all information afresh from TNE, VYM and RMD
- The road network being described for a particular date and having no history
- Data from RMD containing all available history
- Data from VYM containing all available history
- Data about phenomena from NVDB and/or the RDB containing history from 1987"

Measurements of the surface condition of paved roads are taken using laser technology and measuring vehicles that carry out the measurements at the normal traffic rhythm. Measurement data is collected for several characteristics of the road surface. In principle, mean values are obtained over 20-metre sections. The SNRA preferably uses two measurements: maximum rut depth (mm) and IRI (mm/m). Maximum rut depth describes unevenness across the road and IRI unevenness along the road. There are also measurements of cross-fall, undulation, curvature and macrotexture (the road surface's "coarseness"). There are also a number of calculated measurements that on the basis of the measured cross section describe lateral unevenness in other ways. Whole body vibration is for example calculated using measurement values over slightly more than the entire lane width for each decimetre of road in its longitudinal direction. There is also a sway measurement for wrongly banked roads and edge slump. Common to all of these is that they are relatively new and no experience from using them exists.

In 1994, it cost approximately 25 million SEK to measure all the paved roads in the whole country. Measurements of the entire road network were also carried out for a number of years due to a decision having been taken to introduce quality-related accounting. Quality-related accounting was never introduced and measurements are no longer made of the entire paved road network every year, mainly for reasons of cost. With the measurement strategies used, the scope of the measurements has varied. The trend is that the total extent of measurements has decreased in recent years and that the "more 'important' road network is measured more frequently than the 'simpler' road network".

> "The current measurement strategy has been used since 2005 and means that the European highways, trunk roads and primary roads are measured at least every other year and the secondary and tertiary road networks at least every five years. In the preliminary study, "it is pointed out that forecast values of maximum rut depth and IRI are not absolute measurements that can give a completely "true" picture of how a wearing course is consumed but should be regarded as the best available knowledge."

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[169] 09-06-22, see http://www20.vv.se/fudinfoexternwebb/pages/ProjektVisaNy.aspx?ProjektId=1411. VUH stands for Väg- och underhållsdata (Road and maintenance data).
[170] 09-06-22, see http://www20.vv.se/fudinfoexternwebb/pages/ProjektVisaNy.aspx?ProjektId=1550. VYM stands for Vägytemätningar (Road surface measurements).

"Some problems with these measurements concern:

- Maximum rut depth and IRI do not describe all the circumstances that motivate pavement measures in practice.
- The accuracy of the forecast calculation is dependent upon access to condition data, which in its turn is dependent upon present and previous measurement strategies. The scope of the measurements has become smaller in recent years.
- The accuracy of the forecast calculation is also dependent upon access to up-to-date, complete information about pavement measures carried out and kept updated in the RMD. The quality of the data in the RMD is not always the best.
- There is a need to improve the forecast models in PMS, in particular as regards IRI."

One important question is how to separate the wearing course's individual components. "Two main principles are conceivable:

- A division based on pavement measures registered in the RMD.
- A division into road sections that have been defined in the RDB.

The division must be done such that paved roads can be distinguished from gravel roads."

Following a thorough review of the pros and cons of each of the two principles, it was proposed that "the division into wearing course components be defined and described in the road and traffic data bank (RDB). Every road is in some way divided into parts that constitute wearing course components. The division may be done freely in the way that is judged most appropriate for TRAV. Information about the division can be retrieved to PMS and forecast condition values can then be calculated for each respective component. This makes it possible to create components of a given length, e.g. 400 m.

The principle used for the division will mean stability over time and prerequisites for handling all components in TRAV uniformly in both the RDB and TRAV.

A major issue is how costs in respect of pavement maintenance – value-adding measures – are to be handled in the future. These costs are in principle handled in the road and maintenance data system today in such a way that costs might be able to be delivered to TRAV via PMS. One problem with this is that there is no connection between the road and maintenance data system and the financial and accounting system. What would be needed for the handling of costs in the road and maintenance data system to meet the demands made by TRAV should be investigated."

The preliminary study points out that completeness needs to be improved in the road and maintenance data system – something that has been desired for a long time. Description and rules also need to be drawn up for how registration is to be done and the regions must be required to adhere to them. One region has used a system developed in-house to follow up all work carried out in respect of pavement maintenance. Data can be transferred to the road and maintenance data system and from there to PMS. If this system were for example used by all regions from the time TRAV is implemented, data quality would improve. The list of measures below can be found in the preliminary study concerning how to adapt PMS to the needs of quality-related accounting:

- “Forecast models must be reviewed and improved.
- Routines must be developed for calculating forecast condition values for components on the basis of homogeneous sections in PMS.
- Possible development of routines for calculating relative consumption for components on the basis of homogeneous sections in PMS.
- Development of routines for transferring data to TRAV.
- Introduction of new measurements in the long term.”

3. Preliminary study concerning “Other component types” – and the prudence principle

> “In the tests carried out using the model, the total acquisition value of the component types “*Terracing, surface run-offs, road-side areas”, “Roadside areas*”, “*Superstructures excl. wearing courses*”, “*Bound wearing courses*” and “*Bridges*” varied between approx. 45% and 95% of the object’s total costs. In the case of roads with heavy traffic in major conurbations, the proportions are in the lower half of the interval, because major investments in for example Land, Safety equipment and Signalling equipment are required. The higher percentages are generally more common in the case of roads with little traffic in sparsely-populated areas. On average, for the whole country, these component types are estimated to account for approx. 80% of the total acquisition value of existing road installations. *Other component types’* acquisition value would in that case amount to approx. 20% of the total value”. This would be equivalent to a replacement value of between 150 and 200 billion SEK.”

A special preliminary study focused on how to TRAV could be provided with information about “Other component types”

For *Other component types*, in addition to the effects of road closure or when a road is taken out of general operation, there are no known calculable linkages between condition and effects in the form of costs and revenues for road-users and society.” For all practical purposes, the lives given in model VI under *Lack of financial resources* agree reasonably well with the technical life.

When roads are constructed, a dimensioning life is used. Knowledge of the actual lives of *Other components* is insufficient. Preliminary estimates of actual lives have, however, been made by experts at the SNRA’s central operation and maintenance function. Their estimates were based on the dimensioning lives. These contain a safety margin that in reality is judged to give the component an acceptable condition for a further period equivalent to approx. 30% of its dimensioning life, sometimes rounded to the closest fifty years. This assumption will be processed at the regional and local operation and maintenance units. If, for example, the dimensioning life is 30 years, the actual life from “As constructed” to “Worst acceptable condition” will be set to 40 years in model VI. In an accounting context, the so-called prudence concept will apply – a concept that should also be discussed in respect of this type of accounting.

In financial contexts Sweden applies a prudent concept, which among other things on the one hand means that costs are booked as early as possible, while on the other hand revenues are not booked until they have been realised. Expected costs whose magnitude or times of occurrence are uncertain are booked as provisions in the balance sheet.

Applying the prudence concept in the case of costs arising from reductions in value of *Other component types* would involve choosing the shortest life within the expected interval. The principle of a sufficiently short life ensures that costs are borne to the least required extent and that overvaluation is avoided. At the same time, this would, however, send signals of extensive maintenance needs – signals that financers might not perceive as credible.

The purpose of condition-related accounting is to deliver the road capital's value and cost data with as "correct" as possible information according to the "best available knowledge". For the road manager, in most cases where *Other component types* are concerned, it is advantageous from a business economics point of view to delay carrying out maintenance measures and replacements. *Other component types* have no known linkages between condition and effects for society and road-users, but can nonetheless affect the fulfilment of the road manager's environmental and safety goals. Sometimes however, poor condition can be more clearly related to issues concerning the road manager's responsibilities, failure to carry out measures and a risk of having to pay compensation. All in all, demands for credibility towards the owner/financer and an endeavour to increase productivity indicate that the valuation of the road capital should, for reasons of prudence, show as long lives and low annual costs as possible. The proposal in the preliminary study is therefore that the longer life be chosen within a conceivable interval when value reduction model VI is used.

The report also discuss some further aspects related to "other component types":

> "*Prerequisite items*, as the name implies, are prerequisites for a road's being able to be constructed at all. The prerequisites are:
>
> - access to land through right of way being granted,
> - project/planning documents that after consultation are put on public display and concluded with the establishment of a work plan in accordance with the formalised process,
> - archaeological surveys where such are judged to be in the public interest,
> - preparatory work in the form of power lines, telephone lines, fibre cables, water and sewage conduits, redirection of watercourses, intersections with private and municipal roads, transportation routes etc,
> - traffic control devices with detours, traffic regulation and signs in general during the construction period,
> - the road manager's construction administration and overheads.
>
> It may take a long time before the actual expenditure is known for some of the items. Typical items that are usually subject to considerable delay are Land, Archaeological surveys and Preparatory work. Since they are accounted separately as component types in their own right, this does not affect any of the other types. This means that the object can also be held open in the condition-related accounting for as long as in the external accounting (five years). It is proposed that the items not be subject to any value reduction and allowed to have forecast values until the actual values are known without any great detrimental effect on the analyses that will be made shortly after the road is opened to traffic."
>
> "During the preliminary study it became clear that effective control and monitoring of road management requires structured, relevant, well documented and easily accessible

information about different deficiencies and conditions in the road network and about measures that have been carried out and costs. It has also been found that a target-oriented development of productivity and systematised learning can for example be based on benchmarking, analyses and knowledge of best practice, cost drivers and LCC. In the discussions that have taken place concerning the *Other component types* group it came out that the Government, for reasons to do with the risk of climate change, requires that the priority order gradually be raised for, for example, the component types *Geotechnical constructions*, "*Terracing, surface run-offs, road-side areas*" and *Superstructures*. Control and monitoring of road management operations for the component type group *Road equipment* can be expected to lead to similar requirements regarding development.

Both road lighting and road markings have annual costs in the order of SEK 175-200 million without us having any clear picture of whether the figures are reasonable or if the costs will increase due a substantial delayed need, or even decrease. The SNRA needs to clarify how large an annual cost a component type is allowed to have before explicit control of the cost development for a component type is needed. When costs in different parts of the country cannot be compared, there is a lack of natural driving force to improve effectiveness.

Excavations and sections with pressure banks and overloading are classified in the "*Terracing, surface run-offs, road-side areas*" component type group. There is great agreement that value reduction model II b be applied (no value reduction before a deficiency has been established and documented) in the case of component types *Geotechnical constructions*, "*Terracing, surface run-offs, road-side areas*" and *Superstructures*. A general administrative system therefore needs to be developed for these component types. A closer study should be made of whether the system for road and maintenance data (RMD) can be used as it stands for registering deficiencies, condition and measures for these component types."

"In theory, a developed road and maintenance data system (RMD) should also be able to function as an administrative system for component type *Gravel wearing courses* and the other component types being studied. "By way of suggestion, the component type *Other road equipment* can follow consumption model I (non value reduction)." The component types in the *Prerequisite items* group and the *Other road equipment* component type are considered to follow value reduction model I (no value reduction). They are called "'Model I' component types. The study points out the need to monitor and document the condition of some components better. Condition and other data are considered to be able to be handled in already existing road and maintenance data systems. Here the component types are called "road and maintenance component types". The remaining component types, for which no systematic inventorying will probably be carried out in the foreseeable future, are called "'Model VI' component types".

In the implementation studies detailed lists of components belonging to different types were made and it was decided how they should be measured and what the "worst acceptable condition" was. The preliminary study looked at how TRAV could be provided with information about the details R, G, S, "*As constructed*", and *"Worst acceptable" condition*. Factors S and G are linked to the component type while R concerns the individual component.

__4. Preliminary study of the interaction with the road and traffic data bank (RDB)__

The first approach was to test the possibility to have “road objects” as a common concept and linkage between respective components’ information in the accounting system the RDB. The financial information would then be able to be linked to the components’ situations and other information in the RDB. The reasons behind this approach are for example:

- that new road objects are registered with their extents in the road network in the *Road object* phenomenon in the RDB.
- that new components (belonging to different component types) are linked to the road network and registered as phenomena in the RDB. The components are also given a *Road object ID* and *“Opened to traffic - /Date of measure*.
- that in the case of a value-adding measure carried out on a single component, the component is identified by means of its situation in the RDB and linked to the accounting via its *Road object ID*. Financial transactions can then be handled for the right component in TRAV.
- that changes in the RDB of a component’s situation, discontinuation of a component and changes in the road network are transferred to TRAV as transactions for delivery of the cost and change in value to the accounting system.

In other respects, the following also applies in this particular approach:

- that a 1:1 relationship will exist between component types and phenomenon types in the RDB.
- that existing phenomenon types in the RDB that are in agreement with component types in TRAV will keep their existing attributes even if these are not used in TRAV.
- that components in the RDB will be handled as both section and point phenomena.
- that regional RDB phenomena exist today that are not fully in agreement with component types in TRAV. For example, *Traffic signal* (point phenomenon) will be replaced with the phenomenon type *Traffic signals* (section phenomena).
- that the RDB phenomena’s attribute *Date of measure/Opened to traffic* will for the time being be used as the basis for determining the acquisition year, when the information (the attribute) is given in connection with the retroactive booking of the component.
- that those phenomena that are created automatically in the retroactive booking take the information about the year they came into being (Construction year or Reinforcement year) of the closest existing all-inclusive phenomenon.

The preliminary study emphasises the importance of stating who will be responsible for the different links in the chain early on in the process, i.e. who will be responsible for:

- all the different types of data and decisions concerning description, content, classification, quality requirements, etc.
- keeping the types of data updated from the time of the retroactive booking until TRAV is commissioned.
- keeping the data up-to-date.
- managing the operative handling of the data in the RDB.

It must also be clarified how the interaction is to be accomplished between the RDB, TRAV, Agresso, administrative systems in updating situations and when corrections are made. The risk analysis that was conducted pointed out the risk of "insufficient quality of data in the RDB". This risk can be practically eliminated by:

- establishing unambiguous quality requirements,
- providing education and training,
- drawing up good users' guides,
- continuously following up data that has been kept up-to-date.

5. Preliminary study of the interaction with the AGRESSO accounting system

> "The roads are an asset in the state's/SNRA's balance sheet and accounting is therefore done according to the models and rules that apply for government authorities and agencies and that are used in traditional business accounting. This form of accounting has certain weaknesses when it comes to highlighting the actual value, a condition value or a market value of an asset. In traditional accounting of road installations, a road object has a life of 40 years. Additional investments, maintenance measures or changes in condition of other kinds do not affect the object's financial value. From a financial point of view, this means that the road has no value after the 40 years have passed but may in reality be in the same condition as when it was constructed."

The preliminary study of the interaction with the accounting system was conducted by the working group's financial accountants. The study reported interviews with a total of twelve people[171], of whom two were among the accountants responsible at the SNRA during the 1992 – 1996 period, one was a representative of the implementation project's client, two are auditors and three are experienced purchasers. Among other things, all interviews took up the issue of booking costs at component level. It transpired that all the interviewees considered it unrealistic to book items at component level before the final invoice. They were all also agreed that the Agresso accounting system should not have accounting at component level. The standard accounting system would continue parallel with the road capital model.

Condition-related value determination and booking of the individual components in the road network in the external accounting has never been an option. So far as can be judged from the preliminary study the interviews have centred around complex solutions for routines. From a list of at least ten main topics and eighteen sub-topics, a number of uncertainties, demands for defined prerequisites and allocations of various cost items etc have been discussed. The focus of the interviews appears to have been to analyse how diffuse values of individual components in external accounting risk affecting or being compared or equated with the "certain values" in the external accounting. Also discussed was an approach involving the use of standard unit prices from the SNRA's calculation database, which would entirely eliminate the need to allocate by component type in connection with the final invoice.

This preliminary study was considered by the project's working group to be "a mobilisation of the heavy resistance brigade" to the project including, among others, the economists previously responsible at the SNRA.

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[171] Mentioned by name are Kurt Johansson (Swedish National Financial Management Authority), Leif Hansson (National Rail Administration), Bengt Jäderholm (consultant), Ulf Niregård (SNRA), Lars Jacobsson (SNRA), Hans Kvarnlöf (SNRA), Timo Agåker (SNRA), Anders Rainer (SNRA), Mats Johannesson (SNRA), Lars Örnfelt (SNRA), Lars Sundström (SNRA), Lars Klarby (SNRA).

The project manager did not accept the preliminary study but instead arranged for representatives of the personnel directly concerned (project managers for road measures and financial administrators) to discuss the concept proposed in the project in more detail. Three experienced people with long track records in their roles took part in this discussion, one as project manager, one as external site engineer, and one as regional financial administrator. The discussion focused on difficulties, problems and possibilities to handle invoices and accounting, according to the road capital accounting concept.

It was unanimously decided that there would be no problem or any unreasonable effort involved in allocating the actual total expenditure for a project to the occurring component types on the basis of settled, priced quantities at hand-over time, The revised as-built drawing, that the contractor already today is obliged to provide when the project is handed over to the client, contains most of the information about the project's definitive component occurrences. It will therefore not be difficult to allocate a road project's total expenditure to the component types and then to the component occurrences in a road object module linked to invoice processing and the accounting system.

A routine for this module was also sketched. All component types undisputed at hand-over time are signed by both the contractor and the client in an official record of what was ready for final invoicing. For all occurrences of signed component types the acquisition value and acquisition date (e.g. the time it was "opened to traffic") are thus ready for registration in the condition-related internal accounting. As soon as the revised digital as-built drawing has been delivered and the final invoice is to be paid, the components' details are registered in the internal accounting. Component types that are the subject of dispute can be registered as agreements are signed and the invoices accepted.

The implementation project's ambition is to make project control more effective, reduce contract handling costs, and reduce cost increases in projects and make data capture more efficient. This naturally affects present routines, roles and systems. The preliminary study had been expected to give a general picture of the consequences for accounting, routines and internal control.

The indisputably highest accuracy as regards components' acquisition values is obtained, provided that the priced bills of quantities in the contract contain the component types' unit prices and that it is the components' quantities that are adjustable. This solution would also give the best internal monitoring and control. Allocation of the project's total acquisition expenditure to component types would be eliminated at the same time as the component types' unit prices would reflect a market price. Component occurrences with details of acquisition expenditure should be stored in an internal accounting system. The total of all component types' acquisition expenditure would be accounted in the external accounting's asset accounting of road installations as a total acquisition expense for the investment project.

For as long as can be seen, performance-based contracts have been the predominant form of contract. It is also in performance-based contracts that the greatest improvement potential can be found. For reasons of analysis, learning, knowledge and accounting, the client should ensure that the same information can be obtained irrespective of the form of contract.

Today, the booking of a road object in the external accounting is held open for up to five years after the object is "opened to traffic". In the internal accounting the same need will arise with the difference that it will only apply for some individual component type in the project but not for the others. More often than not this need to be able to book late expenses will primarily concern *Prerequisite items* (e.g. costs relating to relocating pipes and cables and purchasing land).

For most component types, follow-ups, analyses and learning can therefore begin immediately after hand-over. Analyses and learning in respect of project control can be conducted during the entire project period based on automatic reports of causes of deviations from the contract as regards unit prices, quantities and time.

The introduction of the attribute *Road object* in the components will make it possible to total all components' condition values in the internal accounting and verify or make a plausibility check of this total figure against the booked value of the same road object in the external accounting. Differences can be analysed and understood, since index and value reduction items are booked separately in a similar way to accumulated depreciations in the external accounting.

6. Preliminary study of component types' unit prices when booked retroactively

This preliminary study is intended to describe how unit prices for the acquisition value should be obtained. Unit prices are to be used in order to be able to give components on the 98,000-kilometre state road network a historical value in the retroactive value determination and booking. This requires unit prices at a specified price level with a good index for conversion to the year of acquisition. The component's value at the price level in question represents the replacement value. The value is equivalent to the expense that the SNRA would have for acquiring the same kind of component with today's requirements regarding design, quality and manufacturing process. Prices must be obtained for components on motorways and "2+1", 13 metre, 9 metre, 7-9 metre, 6-7 metre and < 6 metre roads. Two alternative methods are discussed in the preliminary study.

6.1 Alternative 1

For 100 road objects constructed after 1998 and accounted as assets, the total acquisition value is accounted to each respective object's different component types. The road objects must be new construction projects in rural areas with a suitable distribution of the types of road listed above. They must be "as free as possible from costs in respect of parts that may be difficult to differentiate, e.g. roadside installations, connecting roads and ramps where quantities and costs may be included in the principal road". The component types' total values in respect of the road object are divided by the respective component occurrences' combined quantities at a unit price. The unit of quantity for the component type must be the same unit that the corresponding phenomenon type has in the RDB. Most are section phenomena and are expressed in metres but some will be point phenomena and be expressed as units.

> "The work will be carried out by the regions, which means that each region will calculate approx. 15 objects. The work is expected to take approx. 2 man-days per object for the object's project manager and site engineer (consultant). Costs are estimated to total approx. SEK 800,000 (110 x 2,500 SEK/day + 100 x 5,000 SEK/day)."

Some component types will need to be calculated separately since there will not be a sufficient number of occurrences among the 100 objects in the material to give representative mean values. Unit prices and values of the pavement, bridge and tunnel components in the entire road network will be retrieved from PMS and BaTMan.

Type of road, geographical location and type of terrain must also be stated for the 100 objects in order for the unit prices to be divided into different price-affecting classes (algorithms). During the retroactive value determination and booking, information about the type of road, location and terrain will be able to be retrieved from the RDB and the unit price chosen automatically by the system via the algorithm that applies for the respective component type.

6.2 Alternative 2

In this alternative the unit prices will be able to be taken directly from information in the calculation database or similar data sources. The remaining unit prices will be calculated in the same way as in planning contexts, when the road object's costs are estimated. In alternative 2, "typical" component types will be "designed" and costed on the basis of the prices in the calculation database or similar data sources. The work will be carried out by engineering consultants and some of the SNRA's calculation specialists. In the preliminary study this is estimated to cost roughly 100,000 SEK.

At a subsequent stage, the unit prices obtained in alternative 1 or 2 can be verified in a test by applying them on 100 other newly constructed objects with a similar distribution of the different types of road. These objects should also have been constructed after 1998. The objects' total costs are calculated using the algorithm-controlled unit prices and the component occurrences' actual quantities (metres or number) compared with the index-adjusted acquisition value for the road object in the accounting system.

One quality requirement that has been discussed for the test is that the relative deviation (Δ) for the total of all road objects per type of road should satisfy the condition $-10\ \% \leq \Delta \leq +10\ \%$. For individual road objects the corresponding condition is $-20\ \% \leq \Delta \leq +20\ \%$. The unit prices obtained in step 1 (in both alternatives) should be adjusted iteratively so that the stipulated tolerance conditions are met. In the retroactive computerised value determination the definitively corrected or verified unit prices are used.

Some of the drawbacks of alternative 1 mentioned in the preliminary study are that:

- it is estimated to be more expensive than alternative 2,
- more involvement is required on the part of the objects' project manager and/or site engineer,
- it might be difficult to remember important details,
- it may be difficult to find 100 + 100 suitable road objects, and
- statistics-wise, sufficiently good information may not be available for many component types.

In alternative 1 the advantage is considered to be that all costs will be included and that actual unit prices are used. In alternative 2, on the other hand, there is a risk that not all costs will be included. Alternative 2 was nonetheless considered to have great advantages in the preliminary study. It was for example considered to be an advantage that:

- each component type can be calculated individually without affecting the prices of the other types,
- the calculation process is transparent,
- the total work effort is cheaper than in alternative 1,
- the work does not require the involvement of the entire organisation,
- conventional calculation models can be used, which increases credibility,
- an assessment must be made of what a “normal” road design comprises.

That the spread of some component types’ unit prices will be substantial when several road objects are analysed has been known for a long time in road management. This is partly why there are component types such as Road zones, Projects, Archaeological surveys, Preparatory work, Traffic control devices, Embankment piles, Lime columns, Light-weight filling, Mass stabilisation, Vertical drainage, Separations and Rockslide barriers. These types of components can vary widely, from not occurring at all to in some cases accounting for most of the cost of the object.

It is important to have a general understanding of cost variations between road objects and a qualified idea of what variations can be accepted for the individual road object. It is therefore not appropriate, for example, to try to distribute the costs relating to these types of components proportionally over other occurring types. This “accuracy problem” that the sections of the preliminary study quoted above indicate, also leads to the question of the construction price index. Each component type shall as far as possible only bear “its costs” and each type shall only be adjusted in line with the development of “its resource prices”.

7. Preliminary study of component types’ construction price index

The SNRA uses a number of index combinations, partly on a monthly basis and partly on an annual basis. On a monthly basis a road index, pavement index and a bridge index (with a number of sub indexes) are calculated. On a yearly basis there are for example indexes for salaries, transportation and for various materials.

In the preliminary study all component types were analysed, including sensitivity analysis about divergences between indexes and finally a proposal for each component.

The work done on choosing an index was based on simple assessments/interpretations of the component types’ content. A more detailed analysis of the component types’ content of goods and services would give a better foundation for the choice of index, but was not considered feasible from the point of view of the work involved.

Statistics Sweden called attention to the risks involved in handling indexes over long periods of time and the uncertainty that this engenders.

> “With the clear wording that we have in TRAV regarding the importance of separate indexes for each component type, we have here chosen as many as 17 different indexes. And even more indexes and/or index combinations are conceivable, which would then require a thorough analysis effort to secure greater accuracy.”

One question that follows on from the compilations in the preliminary study is whether the great differences between different indexes can be explained. The preliminary study also highlights the importance of using a "correct" index. The rationales should form frameworks for a more detailed review of indexes. The preliminary study of unit prices proposes a detailed calculation of unit prices on the basis of the structure in alternative 2 based on the General Material and Workmanship Recommendations (AMA). The assessment is that the index issue for the component types is best handled in parallel with the work on unit prices. In this context, it should also be rational to assess what resource types affect the unit prices and what the proportion of each respective resources type is of the total unit price.

With high quality work on indexes and regular cross-checks between applied index and actual price development per component type, the price development should be able to be explained. Computerised analyses can be made of road management's cost drivers. Good quality as regards the proportions of the types of resources for different unit prices will also constitute good support for analyses of how the construction contract market functions competition-wise. It also gives a good idea of real interest levels when decisions are to be made about investment or continued maintenance.

8. Preliminary study of the IT solution for TRAV

This preliminary study analyses the IT solution that is to be designed for condition-related accounting of road capital (TRAV). None of the preliminary study's many flow charts or figures have been copied to this description of the ongoing implementation.

The preliminary study begins by outlining a vision of how the peripheral systems and activities/operations are intended to function according to the following quotes from the study.

- "A financial system/new business system that can directly or indirectly contribute to booking followed-up costs at component level through differentiation between new construction, improvements or value-adding maintenance at the time of registration.
- A uniform road object register that can be linked to a road network and associated lists of ordered components will be drawn up.
- BaTMan that reports the condition of existing components.
- PMS that reports the condition of existing components.
- RDB that reports all components (new, concluded, handed over, changed with regard to their distribution) with full transaction handling.
- Value determination and booking for TRAV is handled by the RDB with information provided from the same source."

> "One fundamental principle is that each operational object is created only once in a system, but is supplemented with information from other systems when operational events occur and that one system is responsible for concluding an operational object. Other systems will have access to data through well defined interfaces to shared registers where they can see their operational view of the objects. This requires that the concepts (the operational objects) and their linkages (relations) be well-defined in a common cross-system information model."

The functional requirements regarding TRAV's surrounding environment were formulated in the preliminary study with a few general requirements and prerequisites in the form of a list of points.

On the basis of these functional prerequisites usage case modelling is done where user representatives must be involved in the continuation of the work of specifying requirements. The preliminary study contains rough functional requirements regarding TRAV applications in the form of the 35-point list.

The possibilities for producing data output that should exist were described divided into four points:

1. "Possibilities to ask questions and produce reports using a "Cube" according to certain fixed concepts
2. Report extraction using a selection of concepts in a "report generator"
3. Selection of sections of road in a map interface for presentation in the form of a report, chart or map.
4. Selection for processing in a specific analysis system, possibly with local data storage."

The preliminary study also contains a section where risks, problems and possibilities are listed on the basis of a number of factors, some of which are generally applicable to new systems that are to be integrated in old environments while others are more specifically related to TRAV. Among the point mentioned is the planned reorganisation of SNRA, insufficient used participation, that the need for the system to survive in the long term renders it sensitive to changes in surrounding systems and that organisation and way of working must be developed and adapted.

9. Initiative for a pilot study to improve the data capture

In the discussions about data capture in the implementing project the researcher gave the following external example as an initiative for a pilot study in the SNRA:

Good example of data capture in industry
It is a difficult and resource-intensive task using present routines to accomplish internal accounting using the TAM concept. The routines for capturing road capital data therefore need to be improved in a well-considered manner and new technology needs to be introduced. In this improvement effort, solutions that have existed in trade and industry for more than 20 years may provide some inspiration. The following episode, that many of us will recognise, took place in the late 1980s.

A roughly ten-year-old Cylinda refrigerator stopped working. A service technician from ASEA-SKANDIA was called. After about 30 minutes' work the refrigerator had been repaired (new compressor) at a cost of approximately 1,000 kronor.

When his work was done, the technician took out a small "data stack" of a type similar to one that an SNRA employee [172] was involved in developing for geodetic measurement during the '70s and '80s. The technician also took out a barcode reader, a small printer and a binder of laminated pages containing tables of service jobs and spare parts. He scanned in the barcodes for the job and the parts used and printed out two copies of the repair documentation. The

[172] Eliz Lundin, Civil Engineer at SNRA

customer signed one, which the technician kept, and was given the other one with the warranty details. This administration took the technician five minutes.

When the technician arrived back at the office he transferred the contents of the data stack to a computer in exactly the same way as the SNRA's measurement engineers transferred their data stack data to an HP computer. This data provided sufficient relevant information to

- immediately invoice the customer,
- update the central warehouse's stock of compressors for the type of refrigerator in question (automatically registered against the reorder point for automatic ordering and stock replenishment),
- deliver data to the quality system for follow up of the type of refrigerator that had been repaired,
- deliver customer and white goods data to the marketing department,
- deliver data about the technician's performance to the personnel administration (PA) system.

The data had been collected at source, data administration was the least possible, and the information had also been quality assured by the customer. This was the picture at one of Sweden's largest service companies in the white goods sector at the end of the 1980s.

Today, data capture has been developed still further. Since 1997 the company has been called ELEKTRO-SKANDIA. According to a central representative of the company, the routine for an equivalent repair today (2007) is as follows:

In the company's register, a customer's telephone number is their customer number. For most customers the service technician can obtain directions to the customer by means of information that is easily accessible on the Internet. Through the customer's telephone number, the company can access all details about that customer. What did we do when we last visited the customer and when was it? What did it cost? Were there any problems with the customer? How was the payment? On the customer's premises, the actual repair work takes roughly as long as at the end of the 1980s, i.e. half an hour at most.

The data stack and the binder of laminated lists are not used today. They have been superseded by 3G phones. If the technician encounters a tough problem, he or she takes a photo and sends it to an expert at head office in Stockholm. They then try to solve the problem together by phone.

All Cylinda brand white goods have factory-affixed barcodes today, which means that supplier and delivery information can be accessed for all a product's components. The date the product was assembled and by whom is also known. Information also exists about any technical problems or similar and any adjustments that were needed before or in connection with delivery. The product's entire logistics chain is thus known, together with the date it was delivered to the customer and any service hitherto carried out.

The 3G phone contains all the information that was previously carried in the binders of laminated lists. Jobs, error types, spare parts etc all have 2-digit codes. Options for the job in question are called up at the touch of a finger. The repair documents are still printed out on paper in duplicate. The technician keeps the one that the customer has signed and the customer keeps the other one. The data is sent to the company’s IT function using the 3G phone.

In principle, the invoice for the job can be sent as the technician closes the door behind him when he leaves the customer’s home. To a very great extent the company uses fixed prices for private customers, at least for the most common types of repair. These can then be followed up and analysed effectively by computer.

In addition to the information for the invoice, the technique also provides data for stock logistics – nowadays the stock exists for the most part only in the technician’s service van. The reorder points in the stock management system mean that the technician automatically receives consignments of spares from the manufacturer so that his “in-vehicle stock” can be replenished and the parts available for the next service job.

High quality data is also delivered to the PA system for analysis and dimensioning of resources for the company’s service undertakings. The already quite substantial amount of quality data linked to each individual white goods product is extended with information for life cycle analyses. Competition in the white goods sector is tough, so products are developed continuously – an improvement effort that is an absolute necessity if the company is not to disappear from the market.

By also monitoring the products, that the customers have over their entire life cycle and the customers' next purchase in the form of a new Cylinda product or not, important analyses can also be made of the actual outcome of prices, quality and CSI.

For every type of product, the company can make important analyses of the quality of suppliers’ components, the company’s market shares and selling prices in relation to quality, service undertaking and profitability, linked to the aftermarket. The company gathers its data as close to the source as possible. Data capture has been made more efficient and quality-assured in a well thought out manner and the number of errors minimised. The data has a properly adapted, relevant content for control, monitoring and analysis. HM is another company whose success is largely due to smart data capture, fast analyses and flexible suppliers.

The SNRA’s problem is lack of confidence, which is why the development focus should set stringent requirements regarding security and internal control in systems and routines and regarding the verifiability of information. The SNRA’s development is moving in the direction of decreasing volumes of autonomous production and increasing dependence on relevant, quality-assured data for analyses. The volumes, values and costs that are administered on behalf of the taxpayer are considerably larger than their equivalents in the white goods sector. This fact should support significant ambitions in the areas of data capture and efficient interaction with contracted consultants and contractors and an interest in development.