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ASSET MANAGEMENT
TECHNICAL INPUT FOR DECISION-MAKING

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ABSTRACT

Transportation Asset Management (TAM) is a method for the administration and improvement of assets in the transport system. In Sweden, demands and ambitions in society are expressed through the goals in transport policy – goals that among other things result in the performance quality of road constructions. There is, however, a lack of satisfactory indicators for the efficient administration, supervision, monitoring and reporting of road management in several of the target areas.

« The best knowledge » about the deficiencies in road components and their effect varies from road to road. In some cases a deficiency in standard might have newly been discovered and appraised in a standardised manner. In other cases more in-depth knowledge might have been acquired about deficiencies, remedial action costs and ensuing effects during the physical planning analyses (feasibility study, preliminary design plan and final design plan). Deficiencies can also be attended to, for example, through solid knowledge about remedial action costs. In the TAM model proposed, the target standard value of the components is calculated through using current « best knowledge ». This knowledge about deficiencies in standard, their effect and remedial action costs is then further systematised and applied.

Deficiencies in the condition of key road components like bridges, tunnels and surface wearing courses are discovered mostly through regular, systematic audits. Deficiencies in other components are discovered more by chance, or not at all. The model describes six different procedures to establish road component condition. One or more of these is applied to each component, as pre-decided. Based on the physical condition, the component-related construction price index developed by Statistic Sweden and knowledge about remedial action costs, the model calculates a quality and cost-related condition value per component.

Quality-related accounting presents true road management costs that reflect the wear and deterioration of the road network. Occasionally the condition value for a component will have been improved through maintenance measures during the period, in which case the closing condition value exceeds the opening condition value. To learn more about the efficiency of the road management processes, the model contains current calculations about the road management effects for road users and society per homogeneous road stretch/link. Quality-related values and costs along with the opening and closing value of the effects during the time period (including police-reported road accidents) are recorded in the road database. Quality defect costs, road management inefficiency, maintenance backlogs and funding needs can, for example, be computed mechanically based on information in the quality-related accounting.

All economic details from the quality-related accounting can be checked against external accounting – the « economic truth ». This means it is mostly technical information that is used to explain, in economic terms, what is happening within the framework of the « economic truth » based on « best knowledge ». Similarly, the effects accounting, based on « best knowledge », follows the principles and values that can be interpreted from research, physical planning and transport policy and that also are applied in road management investment calculations. True information about the cost and effects of road management, road capital deficiencies and values for the standard and condition can therefore be effective indicators for the administration, supervision, monitoring and reporting of road management. This can also be used as a basis for making decisions on fair road charges in road pricing systems.

TRANSPORTATION ASSET MANAGEMENT (TAM)

1. BACKGROUND

In practice, the administration and supervision of road management in Sweden followed planned economy principles until the end of the 1980's. Little interest was paid to the expectations of road users or the community. The national administration of road management focused more on ensuring access to statistics for the planning system. Standard prices were used for most resources consumed, without reconciling this with reality. Furthermore, there were several centralised contracts for the purchase and leasing of vehicles and machinery. Operations analyses were based on poor quality data. Proposals for organisational change that would have a regional economic impact resulted in long, drawn-out political discussions. As time progressed, this resulted in a lack of knowledge about the real cost of road management, in uneconomical use of the inherent possibilities in a planable volume of production, and in low productivity trends. To cite a typical example; rationalisation of production often meant a decrease in resources the following year, since increased productivity results in lower draft estimates (well-known as the « ratchet effect »). Resources were instead transferred to work sites where no rationalisation had taken place, where the need was therefore considered to be greater. In other words, there was a major incentive to oppose rationalisation, to manufacture for stock and to purchase towards the end of the year so as not to fall short of budget – things that were not apparent in the accounting.

The Internal Audit Department of the Swedish Road Administration (SRA) conducted a thorough and objective analysis of the real operational costs in three maintenance and operations districts over a year. In the conclusions, it pointed out the possibility of increasing productivity by at least 20% (SEK 1 billion/year in 1986 prices), a capital rationalisation of at least 40% (SEK 500 million in 1986 prices) and better cash management of at least SEK 10 million/year (in 1986 prices). Further, it was maintained that administration aimed at achieving the overall road management goals in traffic policy could be improved. As a contribution to the debate, the Internal Audit Department prepared a proposal at the end of the 1980's for an alternative management model using internal accounting, where « road capital » related to the standard and condition of roads would have a key role in management, supervision and reporting.

In preparation for the reorganisation of the SRA in 1992, a determined endeavour to develop human resources, organisational culture, management and processes was initiated based on a visionary and strategic document (entitled « Vägvisaren ») as well as eight designated focus areas, which in practice entailed such things as focusing on customers and results and on creating conditions for further learning within the organisation. Part of this cultural and organisational development was the idea of process-management for the operations and a clear division of road management into products and services. In the autumn of 1992, SRA top management requested better input for the administration, supervision and monitoring of real changes in the standard and condition of the road network. In December, the Internal Audit Department presented a quality and cost-related accounting model for road capital as commissioned by the Director-General. In 1994, after extensive external examination of the model, SRA top management decided that road management would be developed so as to be based on the goals in traffic policy, customer expectations and the model for quality-related accounting of road capital. Only the first stage of more improved accounting has been implemented. Since 1994 road constructions are set up as an asset in the balance sheet and depreciated according to plan.

In the Financial Department's cost account of the financial effects of the reorganisation in 1992 an annual increase in productivity of at least SEK one billion was found.

1.1 Academic view on traditional accounting

An academic article written by Sherrie Koechling, 2004 discusses different arguments to convince those in charge of accounting to abandon the method of planned depreciation. One argument is that asset management focuses on the administration of the value of assets, including the effect of continuous maintenance during their entire life cycle. In the depreciation according to plan method information is given about the continuous deterioration of the asset without taking into consideration the increased value resulting from maintenance. This means that the asset is undervalued. Another argument points out that the primary objective of all accounting systems is to provide users with appropriate information; i.e., information that is relevant and reliable. It is usually a requirement that a construction be preserved in an efficient way – a requirement that must be accompanied by relevant information about how maintenance endeavours are being carried out. The value of assets is of significance when discussing infrastructure and the expected cost of maintenance in the budget; e.g., it is in principle more difficult (according to Koechling) to motivate an annual maintenance expense of SEK 30 000 for a car worth SEK 40 000 (book-value) than for a car worth SEK 400 000 (according to market value) even though it is the same car. Another argument is that the government, through better assets accounting, can obtain better terms and conditions on the financial market, resulting in lower capital costs. It is further claimed that there is no better "music » in the ears of a financial manager than that something « saves money ». It has been repeatedly shown that effective, preventive maintenance reduces life cycle costs for infrastructure six to tenfold compared to the « worst first strategy ». However, many financial managers defend the depreciation according to plan method, despite its misleading presentation of road capital, because it is administratively easy and inexpensive.

2. ROAD CAPITAL

Suitable information is needed for better knowledge about road management processes, for analyses and effective benchmarking of life cycle costs and effects, for controlling road management « cost drivers » and for a business-like approach. Today there is a lack of established practice and principles for quality-related and cost-based accounting of road capital. Such a model must be simple in structure, be able to be checked by external, independent staff without requiring extensive assistance from technical experts, and fulfill strict requirements on accounting principles. As knowledge about the standard, condition, quality defects, valuation, principles and systems gradually improves, the development and adjustments necessary is not to result in historical data becoming unusable. From this point of view, the design of the model must be stable.

Road investments are largely financed through appropriations settled in the national budget. However, to an increasing extent this is occurring through loans that are amortised over a period of less than 40 years. Studies (VTI-notat, 1996) have shown that the actual life span of road investments varies widely (between less than 20 years in the vicinity of larger built-up areas to over 100 years in sparsely populated areas). With a view to road components, the life span can vary between a few years for certain road surfaces to over a hundred years for bridges and tunnels, for example. When politicians speak about maintaining road capital they are not normally referring to the value of the road construction entered in the books. « Maintenance of the road capital » usually has a more practical meaning. It is expected that the SRA will carry out maintenance measures in order to ensure that the intended physical function of roads will be maintained through preventive action. Occasionally this concept even means achieving a higher standard, as needs in society change. The socio-economic benefits ensuing from the extension of the transport infrastructure are very large. If the aim is to manage and operate a publicly financed road transport system as a community service, it would be reasonable to link the road capital concept to the socio-economic aspect as well.

Further, it does happen that politicians use the term « road capital » to refer to the socio-economic marginal effects of traffic and the road network and thereby disregard capital costs and the local environmental impact in connection with road construction – "what happens, happens ». While the socio-economic basis for a definition of road capital is relevant, this can hardly lead via complex relationships to « almost anything » in society to a clear, controllable and reliable capital value for the purposes of administration and supervision. It can be ascertained that there is no generally accepted definition of the term "road capital », despite the fact that it has been used for more than twenty years in many different contexts. It would be reasonable to presume that an appropriate accounting of road capital and deficiencies in road capital should primarily support the administration, supervision, monitoring and reporting of road management according to transport policy within the « protection » that the road user, social and political perspective provides. The definition of *road capital* used in this model is as follows:

> Road capital consists of the quality-adjusted replacement cost of physical road components. Quality and deficiency are related to the requirements on standard and condition derived from transport policy. The capital assets value of road constructions, road stretches/links, roads within an area, road systems and road networks is the sum of the value of the components concerned.
>
> Deficiencies in the standard and condition of road components are appraised on the basis of information about the relative deficiency from a technical and performance viewpoint and the cost of remedial action. The relative deficiency is determined as the current condition in relation to the best and « worst acceptable « condition – limits set with regard to the effect on society, road users, road managers and what is politically possible.

2.1 Economic terms for types of action

In this paper, types of action have been divided into investments and service (Figure 1).

Investment is a socio-economically defensible measure intended to raise the standard of a road or surrounding environment in the long-term. Investments are divided as follows:

- *New construction* refers to building new roads, and normally provides a lasting effect for society, road users and/or road management.
- *Improvements* refer to betterments in the existing road construction in a way that normally provides a lasting effect for society, road users and/or road management.

Service is economically defensible planned and/or emergency measures the purpose of which is to maintain the actual intended and expected functioning of the existing road construction. Service is divided as follows:

- *Maintenance* has a positive effect on the road construction with the aim to preserve or restore the intended functioning and/or condition of the existing construction. It is often possible to plan the time and scope of maintenance measures, which are effective more than a year. Inclement weather, landslides or other similar occurrences can make planning difficult.

- *Operation measures* are short-term measures aimed at maintaining the expected and intended functioning of the existing road construction for the benefit of road users primarily as concerns road safety, access and mobility. The aim is also to rectify critical situations that threaten the durability of the construction and/or have a negative impact on the surroundings. Operation measures are characteristically supervisory and consist of immediate troubleshooting actions. Such measures with a short-term effect (less than a year) are often difficult to plan time-wise.

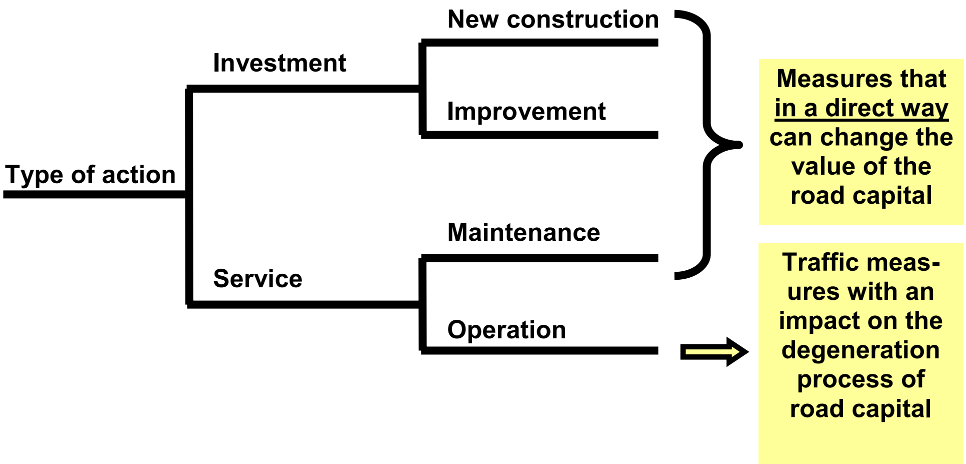

Figure 1 - Relationship between types of action and road capital

Action is principally undertaken on road components. From a management perspective, the accounting is based on the conviction that the greatest detailed information is required at the lowest operative levels, and that superordinate information needs can principally consist of accumulated data and analyses of detailed underlying information. The principles and definitions in the quality-related accounting model are discussed in the following.

2.2 Road components

A road component is a clearly identifiable physical part of the construction and is serviced, maintained and replaced individually. Each has its own function, its own technical life span of at least three years and a material value. The effective administration, supervision and monitoring of road management demands knowledge about the components, which are the natural cost units in the accounting. Table 1 shows a gross list of components that are considered to be appropriate. These have been sub-divided into *eight main categories* and a total of 43 sub-categories, of which seven are miscellaneous.

Table 1 - Gross list of road construction components

Real estate for roads and traffic	***Road constructions***	***Road safety structures***
Ground and physical planning	Road structure	Structures for canalisation and separation
Buildings and premises	Wearing course	Paths for pedestrians and bicycles
Off-road facilities	Retaining walls	Lateral reserves
Rest and parking areas	Erosion barrier and side slope reinforcements	Fences
Rest and parking area equipment	Ground insulation	Guard rails
Machinery and equipment for roads and traffic	Geotechnical construction	Glare shields
Other off-road facilities	Draining system arrangements	Shelters against land-and snowslides
Environmental structures	Other road constructions	Lighting
Cultural, faunal and floral protection structures	***Road structures***	Other safety structures
Water protection structures	Fixed bridges	***Facilities for traffic routing***
Noise barriers	Tubular bridges	Road sign facilities
Aesthetic arrangements	Drawbridges	Traffic signal installations
Other environmental structures	Tunnels	Facilities for traffic information
Special installations	Ferry berths	Other facilities for traffic informatics
Special arrangements for accessibility	Public piers	Road markings
Special arrangements for gender equality	Other structures	Other facilities for traffic routing

2.3 Terminology in quality-related accounting

This section describes the acquisition value, the construction price index, the replacement cost, condition deficiency, condition value, the deficiency in standard and the target standard value. The value, deficiency and cost of the components share in common the fact that they are registered in the road database in terms of attributes, either stretch/link or fixed point attributes. Information can be combined for road stretches, roads, road networks or geographical areas of roads. Comparisons can be made, for example, of how the value, deficiencies and costs change over time for the selected roads and geographical areas in relation to traffic and the action taken. The value of a specific component, which is appraised at current price levels, does not take into consideration such financial factors as interest, alternative use or return on capital. Although interest expenses during the construction stage as part of the acquisition value are taken into consideration.

The acquisition value consists either of the real cost of acquisition cost, if this is known, or otherwise of a calculated value. In the case of roads that have evolved over a long period of time through gradual improvements (gravelling, ditching, spot reinforcements, etc) and not through new construction, standard calculations are the only possible way to obtain a fair acquisition value, indexed for example to when the road was nationalised. *The construction price index* includes both changes in technology as well as production. Indexation using official construction price indices (per type of component with regard to the kind of resource) provides an acquisition value that corresponds approximately to the current acquisition price on a sound contract market. Such a “new condition value », *replacement cost*, is calculated continuously in the quality-related accounting model.

Based on the replacement cost of the component, the value can be adjusted for established wear/deterioration of the condition (*condition deficiency*). Such an adjusted value in reference to the actual condition is defined *condition value*. Alternatively, the condition value can be adjusted to reflect an improvement. An existing road can also have deficiencies that have been identified and recorded in relation to the target standard. The physical standard adjusted to the target standard without *deficiencies in the standard* corresponds to a *target standard value*. The fundamental principles in the model for quality and cost-related accounting can be summed up in five points.

1. The basis for the evaluation is the real acquisition value of a component according to external accounting, or if this is unknown, an established standard calculation of the acquisition value.
2. Continuous indexation of the acquisition value up to the current price level (replacement cost) using the construction price index per type of component. The indexed prices are regularly checked against real prices. The replacement cost of a road construction corresponds to a « new condition value » of the construction at the existing standard in the same way as the actual cost is provided and expected to function.
3. The quality-adjusted value of components is calculated from what is known about the cost to remedy identified deficiencies to reach the target standard or « new condition ». The established target standard is based on socio-economic analyses, risk assessments and/or on generally accepted traffic engineering knowledge. The « new condition » of a road construction refers to the state a newly built road construction should have in compliance with regulations applicable to the standard at hand.
4. A deficiency in the standard is the deviation between the target standard and the actual standard of the construction. The target standard value is obtained by adding the investment costs incurred through measures taken to reach the target standard for the existing road stretch/link to the replacement cost of the construction at the same price level. The value for the deficiency in standard is the difference between the target standard value and the replacement cost.
5. Condition deficiency is the deviation in the condition (through wear, deterioration, age, damage) of a construction compared to its « new condition ». The value for the condition deficiency is the difference between the replacement cost and the condition value.

2.4 Component condition

Systematic inspection methods, sometimes using technical systems, to objectively determine road condition have been developed for the types of component that either are of considerable value, need extensive service, or are of major significance to safety in the road transport system. However, technical systems are lacking for many types of component. While some of these are highly common, their total value is relatively quite low. Based on documented experience regarding developments in component condition it would then be reasonable to use a simple model to describe condition – a model based on prognoses (cf. planned depreciation in traditional accounting). In practice descriptions are available through a combination of surveys, sampling, ocular inspections and prognoses. The current condition can be seen as relative wear on a scale from « new condition » to « worst acceptable condition ». Six different models to describe condition have been identified (Figure 2) – descriptions based on principles established for each individual type of component.

Model I

Model I is used when there is no change in condition that affects the value of the component; e.g., no depreciation deduction is made for land in the road reserve. The acquisition value is the basis for indexation. The market value should in principle be used for land that is owned. Figure 2 shows the change in condition value (indexation) over time.

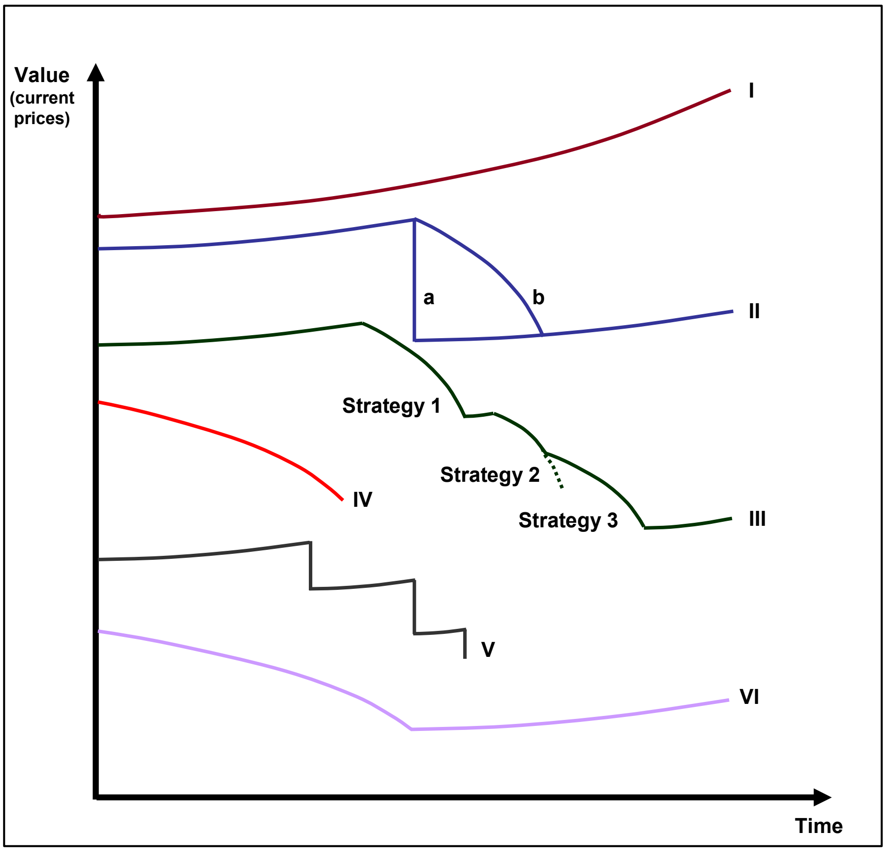

Figure 2 - Alternative models to describe the condition of components

Model II
It is not considered that any change in condition affecting the value has occurred before a deficiency has been ascertained (and documented). A decrease in value is only recorded once the deficiency has been determined. There are two different ways to handle depreciation.

a. If the deficiency is basically total when discovered and cannot essentially become worse, a lump-sum depreciation equivalent to the total remedial action cost is entered.
b. If the deficiency is such that it will gradually develop to such an extent that remedial action must be taken later on (set at a certain year in the future, based on experience), an annual deduction is entered up to that year so that the sum of all the deductions is equal to the total indexed remedial action cost.

To some extent, objective surveys of the road structure condition are conducted to study the bearing capacity using ground penetrating radar, laser technology, deflectometers and sampling supplemented by a manual analysis (BÄRUND). The condition is described systematically. This procedure is represented by model II (normally II b).

Model III
A change in condition that affects the value is considered to have occurred once a deficiency has been ascertained in conformity with the principles in model II. No depreciation of the value is entered before the deficiency has been confirmed. When a deficiency demanding action and the cost of this remedial action have been documented there are basically two alternative rules on how to handle the depreciation (cf. II a and II b). A strate-

gic procedure is formulated in model III through a maintenance plan over a set period of time. Alternative b (according to II b) is most common in model III.

If remedial action is not taken in time, as per maintenance strategy 1, this could increase the extent of the deficiency or damage and demand a more expensive maintenance measure. This means that a second maintenance strategy must be drawn up. Once the change in strategy has been decided, the depreciation is accounted in relation to the new cost of remedial action and over the number of years on which strategy 2 is based. In the event that this maintenance strategy is not implemented either, the deficiency can deteriorate further and a third maintenance strategy be drawn up with a new time plan and measures. In this way new premises for the calculation of the continued depreciation are obtained. Maintenance strategy 3 can be drawn up ahead of the year for initiating strategy 2 if it is known that the limit for the deficiency according to strategy 2 has passed or if it is not the intention to implement strategy 2. Condition descriptions for bridges correspond to model III as they are inspected systematically (ocular, x-ray, analysis of samples, strength calculations, test loads, etc) and maintenance strategies are set as needed. There is a corresponding programme for the tunnels component.

Model IV
The SRA pavement management system (PMS) contains objective condition values obtained using vehicles equipped with laser technology for the wearing course component. The values are calculated as an average value for 20 and 200 meter stretches and for homogeneous stretches (usually from about 1 to 10 km). The values measured are stored for every decimeter. The intention is to calculate an indicator for whole body vibrations. The condition description for the road surface component corresponds to model IV.

Model V
A four-stage scale of change in condition can be applied, first and foremost in connection with ocular inspections, supported by sketches, photographs, and/or films as follows:

1 corresponds to a component in « new condition ». No depreciation is calculated here.
2 corresponds to a worn component that has a functionally acceptable condition. It is about half worn out. The depreciation is 50% of the estimated cost of remedial action.
3 corresponds to a construction that is worn down to the worst acceptable functional condition. The depreciation is 100% of the estimated cost of remedial action. If the worn out component is to be replaced by a new one, the entire value of the component is written off so that there is no residual value.
4 corresponds to a component that has deteriorated past the worst acceptable condition and must be attended to immediately. If the component has not been completely written off, the condition can result in a higher cost of remedial action and an even lower value.

For some components there are exact requirements stipulated in the construction contract as regards service – requirements that are more or less systematically monitored. Several components are already being inspected ocularly today in line with the principles in models II and V.

Model VI
A depreciation according to plan can be applied for components where the condition or change in condition is not surveyed, but where there is good knowledge about the technical life span. The depreciation can be complete or an estimated residual value.

Combinations of condition descriptions
In practice the condition of a component is often best presented through a combination of description models. In those cases where the component has two types of deficiency, a combination of models IV and VI could be suitable. One of these deficiencies could possibly be continuously maintained to reduce inconvenience while the other could be attended to some time in the future without this preventing having to replace the component (fatigue/aging of the material with a risk of total breakdown). If the maintenance measures for the deficiency represented by model IV as regards time and scope can be adjusted to the point in time of the replacement, there will be no debit in the annual profit/loss for any scrap value.

2.5 Limit values for condition and « relative wear »

Road capital is evaluated at the component level, which means that the limit values for « new condition » and « worst acceptable condition » are specified for each component. In connection with the evaluation, the relative condition is essential, while factors like financing (shortage of capital) and interest do not affect the value. A component could have several kinds of condition deficiencies. « The best condition » is decided for prevalent types of deficiency, such as the condition that the industry considers free from defect and that can be expected for a newly produced component under optimal conditions with the best possible technology. When a component has reached the « worst acceptable condition » it could be completely worn out and need replacement. It could also have a residual value and be subject to repair. Hence, the cost of remedial action and the amount of the residual value are also assessed for the type of deficiency in connection with the « worst acceptable condition ». Before the « worst acceptable condition » is set for each type of deficiency, the impact of the worst condition value is appraised from four separate aspects.

1. *Aspects concerning the effect on road users*
   This refers to costs in relation to travel time, goods, vehicles, comfort and ill-health for road users (private individuals/trade and industry). The effects can be assessed based on known cause and effect relationships for the condition of bridges, tunnels, ferry berths, road structures and wearing courses.
2. *Aspects concerning the effect on society*
   This refers to emissions, pollution of water sources, noise, road deaths and injuries. Examples of components where the condition can be related to this type of effect are wearing courses, safe roadside areas, guard rails and safety barriers, anti-glare shields, protection against rock or snow landslides, lighting, road signs, traffic signals and information boards as well as noise and water pollution protection.
3. *Aspects concerning the effect on the road manager*
   This refers to the fact that the condition of components can deteriorate to such an extent that the restoration cost becomes economically prohibitive or that there is too great a risk that the performance of the road will be jeopardised. Where the deficiency is serious it could mean damage to other components as well. The road manager perspective is a cost minimisation problem.
4. *Aspects concerning what is politically possible*

This refers to a kind of social-economical holistic perspective based in part on a total economic perspective and partially on general political « fairness and reasonability » with political « shame limits »; e.g., taxes can be eliminated in aspects 1-3.

The worst acceptable condition with regard to all aspects
When all the limits for « the worst acceptable condition » have been decided systematically per component and type of deficiency for the four aspects, a compilation is made to find the « worst acceptable value » that satisfies all aspects. The condition deficiency is calculated as the product of the cost of remedial action (standard cost to restore the condition from the « worst acceptable » to « new condition ») and the « relative wear » (quality index for « new condition » minus the actual condition through the entire difference between « new condition » and the « worst acceptable condition ». See Figure 3).

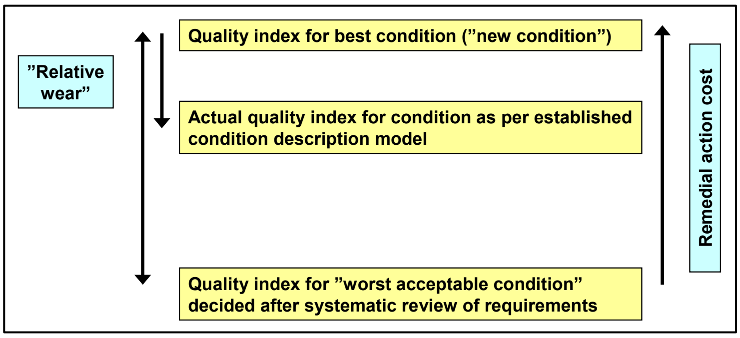

Figure 3 - Principles for determining « relative wear » and actual condition value

2.6 Value of a road construction according to two principles

The following shows how quality-related assets accounting compares to traditional accounting (Figure 4).

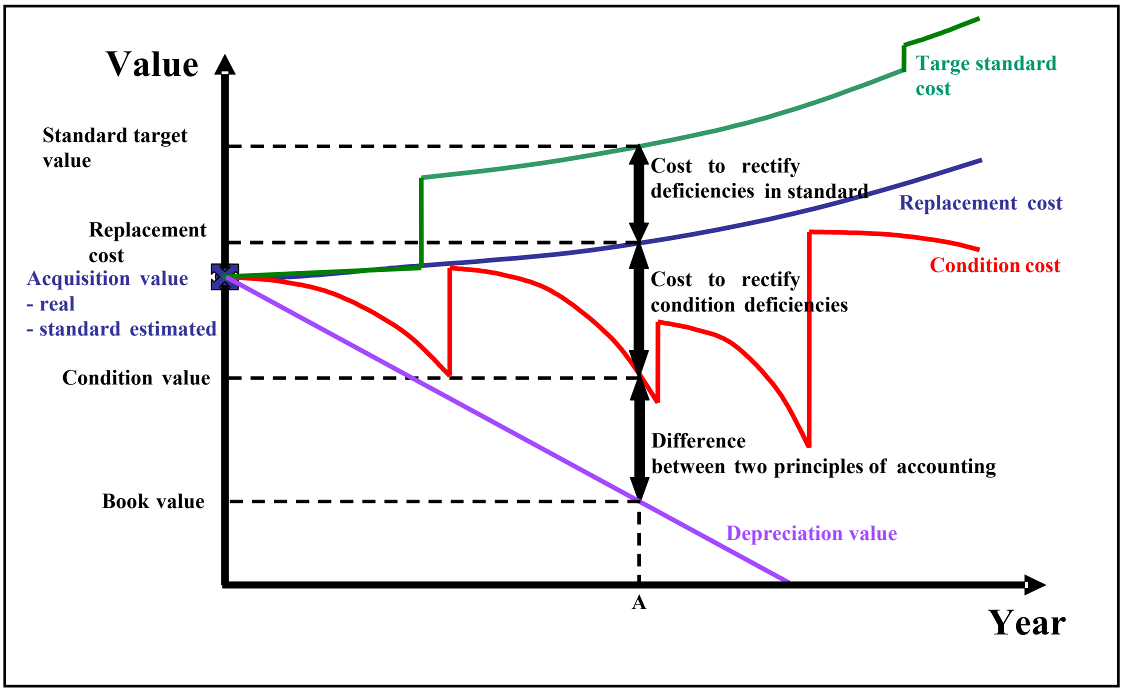

Figure 4 - Principle relation between the book value and quality-related values

Figure 4 shows how the value calculated according to the one principle can theoretically be explained and reconciliated with the value calculated according to the other. The replacement cost (blue curve) corresponds to the acquisition value adjusted to current price levels using a construction price index adapted to the component. The actual value of a construction consists of the quality-adjusted condition value (**red curve**). The figure shows periodic improvements in the condition through maintenance measures, which is shown through the steadily falling curve for the book value (**purple curve**) without any investments. The curve for the target standard value of the component (**green curve**) corresponds to the desired value of a construction or link in « new condition » according to the target standard.

2.7 Example: road surface component and inefficiency

The condition of the right lane (K1) on a stretch of motorway that is 7 554 meters long improved between July 1, 2003 and June 30 2004. This improvement is explained by surface maintenance measures undertaken in the autumn of 2003. The survey was conducted in the autumn immediately after the completion of the works. The old surface had been milled away and transferred to a depot for re-use on a lower traffic volume road. At this point in time, the condition value of the road surface was reduced to zero – a reduction in value that was debited to the profit and loss for the period. A new surface was laid on the “milled box » at a cost of SEK 5 282 000, which is the new replacement cost for the stretch of traffic lane. The change in value for the period is shown in Figure 5.

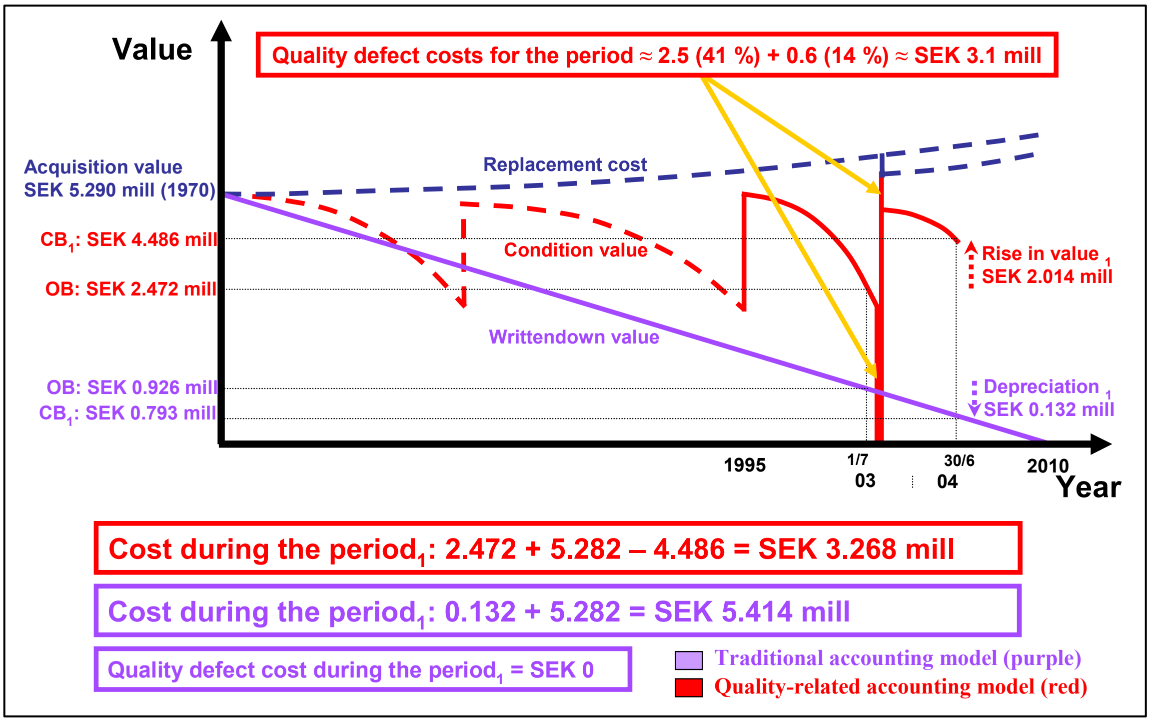

Figure 5 - Comparison of the information from two accounting models

The two accounting methods provide extremely different information for the period.

- In a very misleading way, traditional accounting uses depreciation to emphasise that the value of the surface had decreased, despite the fact that it was newly re-surfaced. The cost of this remedial action during the period is SEK 5.4 million (5.282 + 0.132) and no quality defect cost can be seen.

- The quality-related accounting shows a positive increase in value (SEK 2.0 million net) from SEK 2.5 million to SEK 4.5 million due to maintenance amounting to SEK 5.282 million. It shows a cost for wear and tear of ca SEK 0.3 million (the total cost of SEK 3.3 million for the period minus the quality defect cost of SEK 3 million) including that the quality defect cost comprises both the cost of the quality deficiency at the time it was decided to replace the surface (SEK 2.4 million, as 41% of the old surface still remained for use as per rule) and the cost of the defective quality of the new surface (cost of SEK 0.6 million since 14% of the surfacing had already been worn out as a result of poor execution at the time it was taken over from the contractor). Without quality defects the cost of the pavement wear on K1 for the period would have been about SEK 0.3 million.

After a mechanical statistical selection of the cost of components in the quality-related accounting, an analysis can be made of the inefficient service of the components. It is also possible to mechanically compute the cost of the combined inefficiency of road management operations as well as the cost of different types of quality defects. (This will be described in Jonsson’s doctoral thesis now being written). These analyses would be impossible through traditional accounting without an enormous and completely economically indefensible amount of work.

2.8 Overall financing and reliability of road management

An « optimal » balance and distribution between investment and maintenance can be difficult to make in the national budget. External factors such as the utilisation of capacity within the construction industry, the current regional market situation and the real rate of interest affect the effectiveness of the distribution. During times of high interest rates, there should theoretically be an increase in the volume of maintenance while on the other hand investments should increase when interest rates are low. Further, relatively low prices should apply in combination with a low use of capacity within the industry, even if the utilisation of capacity depends on national investment volumes. Figure 6 shows development curves for the period between 1978 and 2006.

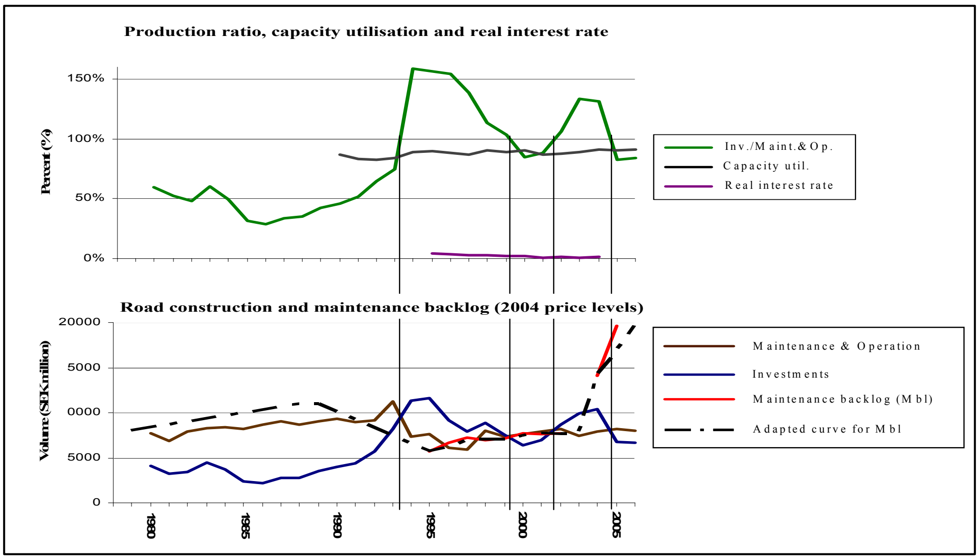

Figure 6 Contemporary outside factors, production volume and development in maintenance backlog

Between 1993 and 1999 it was found that when real interest rates were highest, investments (new construction) were relatively the highest, but when interest rates fell between 1999 and 2002 maintenance works increased. When interest rates continued to fall between 2002 and 2005 there was a relative increase in construction investments. It is difficult to see that the rate of real interest affects the political distribution between the appropriation for construction investments and maintenance and operation works. Neither is it possible to see that capacity utilisation within the private sector is a considerable factor when deciding the production volume within road management.

If instead one looks at maintenance backlog within road management it becomes clear that this task does not affect the actual appropriation of funds at all. In fact it is quite the opposite: the greater the amount of maintenance backlog the lower the appropriation. This was particularly apparent in 2006 ahead of the national election. Since the unemployment level was high at that time it can be assumed that, for tactical reasons, public funds were transferred to measures stimulating employment– something that did not promote efficient road management.

A significant inefficiency in road management could be avoided through an adjusted distribution of responsibility between the road manager and politicians when financing road management.

2.9 Example: Maintenance backlog

With a view to the reasons given above it would be easy to draw the conclusion that the SRA has lost credibility when it comes to maintenance backlog (Mbl). The Mbl is in part a result of the fact that traditional accounting is incapable of providing the necessary information for a discussion first and foremost between the road manager and political decision-makers. When the Mbl is substantial, a heavy financial burden for the accumulated insufficient road maintenance is dumped on future generations. The road manager claims that the reason for the Mbl is that there is too little funding – an opinion that national economists (politicians) would like to have presented in a convincing way. To be able to do this, it is necessary to be able to show that the condition of the road network is unacceptable and that appropriated funds have been used efficiently. Both of these matters can be shown through quality-related accounting. Figure 7 provides a summary of how the Mbl can be defined and computed mechanically. The computed values a, b, c, d and P illustrate different starting points.

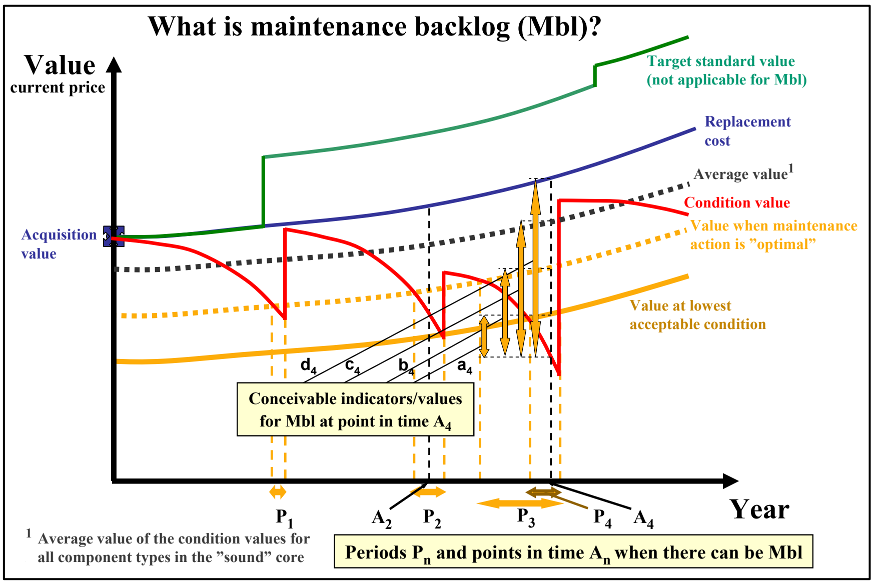

Figure 7 - Conceivable indicators or values to describe Mbl at point in time, A_4.

A review of the figures a – d results in a proposal on how Mbl can be determined mechanically. When calculating the Mbl, the type of component where the condition has been unacceptable for a sufficiently long time, P, (« unacceptable core ») is removed both from all the components as well as from the components that have quality defect costs and/or inefficient service (« core with quality defect costs and inefficient service »). After having removed these « a sound core » of components is left. An average value of the condition values for the components in the « sound core » is determined. The annual cost of this « sound core » is compared to the average condition value of the « core » over a number of years. The cost per component unit and year to keep the average value in balance (« balanced cost »/unit) is determined. The Mbl for the type of component

= « balanced cost »/unit * the number of component units in the « unacceptable core » + ∑ higher restoration cost in addition to the standard cost for conditions that have passed the limit.

In order to gradually eliminate the Mbl for the type of component, an « extra appropriation » theoretically is needed

= Mbl + « balanced cost »/unit * the number of component units in the « core of quality defect costs and inefficient service » – ∑ cost incurred during the year for components in (« the unacceptable core » + « core of quality defect costs and inefficient service »).

The adjusted appropriation that is needed to gradually eliminate the Mbl for all types of component is the sum of the “extra appropriation » for all the component types. If it is to be possible to gradually eliminate the backlog through this total supplementary appropriation, all inefficient use of appropriations must cease and the number of components in the Mbl must be relatively limited. This attempt can be continuously monitored through mechanical analyses of the quality-related accounting.

3. EFFECTS OF THE TRANSPORT SYSTEM

A key question regarding the administration and supervision of road management in society is the way in which the substantial assets in action within the road network are taken into consideration. Section 2.5 shows that the « worst acceptable condition » has been determined subsequent to a systematic review and analysis of the « best knowledge » about the effect on the private sector, society, road users and national economy. In this way the effects have an influence on the value of the components in quality-related accounting. Using information about the quality-adjusted values for the physical road network is therefore an efficient way within the administration of road management to achieve the goals in transport policy.

Another way to consider the substantial assets in action within the road network can be to listen to the needs, expectations and desires of road users, the business community and society at large. It is, however, difficult to use this type of information uncritically as it can be interpreted that all action taken on the road network is « free » or that it has already been paid for, perhaps even at too high a price. The needs can be extensive and result in social-economic inefficiency. However, the opinion of stakeholders are included in the long-term planning process. In the TAM model it is considered positive that road users are paying more and more for the services they use. The relation between the desire to pay and the quality of the road system then becomes clearer.

A third way to consider the substantial assets in action in the road network is to continuously monitor the sacrifices and benefits of road users and society. It is, however, not possible to monitor all sacrifices and benefits, and not the real ones either. This forces one to select a few of the most significant effects and to use standard models. Benefits in the road transport system often concern minor sacrifices, for example, when an old road is compared to a new one and shorter travel times and a reduction in emissions and accidents is found. The TAM model that has been presented uses all three ways to consider the substantial assets in action within the road network. The third way is illustrated by the following.

3.1 Model for effects accounting

The foregoing shows that it is possible to study road management costs and changes in quality for components, road stretches, roads, road networks and roads within a chosen area. For the effective administration, supervision, monitoring and reporting of road management what remains is information about the effects on different categories of road user and on society. This can be achieved through being able to link information about attributes and attribute terms for appreciable effects of road management in the road database. Knowledge about the relationship between transport costs and the road surface condition (IRI = International Roughness Index) must be used systematically and continuously. There are, for example, relationship algorithms for higher transport costs for three types of vehicle caused by increasing IRI values (Figure 8) as well as for other cause and effect relationships (e.g. road accidents and emissions) in the SRA cause and effect catalogue – relationships that can be used systematically and continuously for computerised calculations of effects.

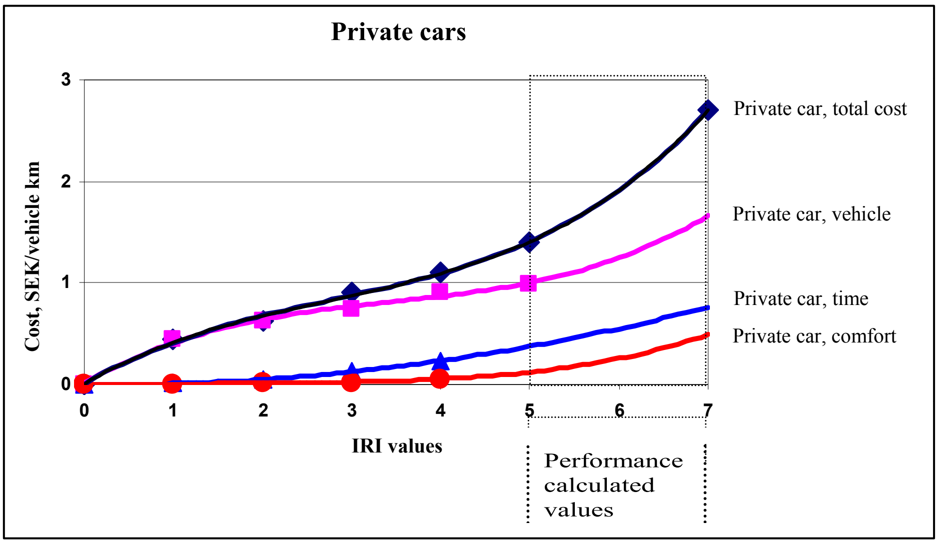

Figure 8 - Increase in transport costs for private cars as a function of IRI (Leif Fäldner)

3.2 Example: Effects on the stretch between Nås and Björbo on Highway 71

The proposed effects model was tested on a stretch of road between Nås and Björbo along Highway 71. This runs a distance of 15.088 kilometres and consists of three sub-stretches of about the same length but of different origin. The stretch farthest to the west is « unconstructed »; i.e., there is no known road investment details. The middle stretch and the eastern stretch originated through road construction investments and were opened to traffic in 1963 and 1998 respectively. All the calculations of the effects that were made in the example were based on mathematical algorithms for known relationships. A « computerised calculation » of the effects on the entire road network using the existing program would be a minor computer technology problem. The data calculated is stored as stretch/link and fixed point attributes and as attribute terms linked to the road network in the road database using existing automatic data processing support. In the TAM model it is suggested that the output generator and information is made available to external stakeholders. The transport costs for the three vehicle types – private cars, lorries without a trailer and lorries with a trailer – were calculated in the example using Fäldner's relationships supplemented with estimated input values for IRI = 0 applied to real measured IRI values. The effects on society (« cost » of traffic accidents and the desire in society to pay to reduce the amount of emissions) was evaluated according to the given conditions for long-term planning. Information about the actual number of accidents reported to the police was used. There is no information available regarding property damage accidents and their cost to society from the year 2000. In 2001, at the time of the study there were two minor injuries reported along this stretch of road. The prognosis for 2002 – 2005 was set at zero road deaths and injuries, serious or minor.

A « ready reckoner » (by Jan Berglöf) was used to determine the air pollution from the different types of vehicle, expressed in quantity per vehicle kilometre. Local staff estimated the maintenance costs per kilometer at different points in time. Traditional depreciation was adapted to each type of component. This information was used for the purpose of the example. In order to improve the basic input for administering road management, quality-related accounting should be used instead. « The costs » were expressed as 1/100th of a Swedish crown per vehicle kilometer at 2001 price levels using the consumer price index. Figure 9 shows the accumulated step by step effects on road management, society and transports without taking into consideration taxes, co-variations or the effects of multiplication. It also shows the « costs » before and after remedial action had been taken to rectify the deficiencies in standard on the stretch. Figure 10 shows an account of the effects on Highway 71. Trend curves are important when studying entire roads, road networks, areas of road or when making comparisons between roads.

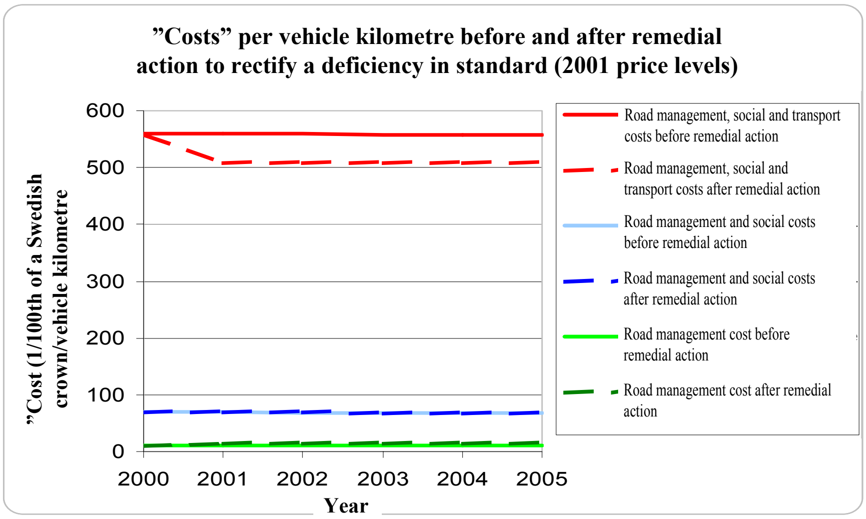

Figure 9 - Road management, socio-economic and transport costs on the stretch/vehicle kilometer

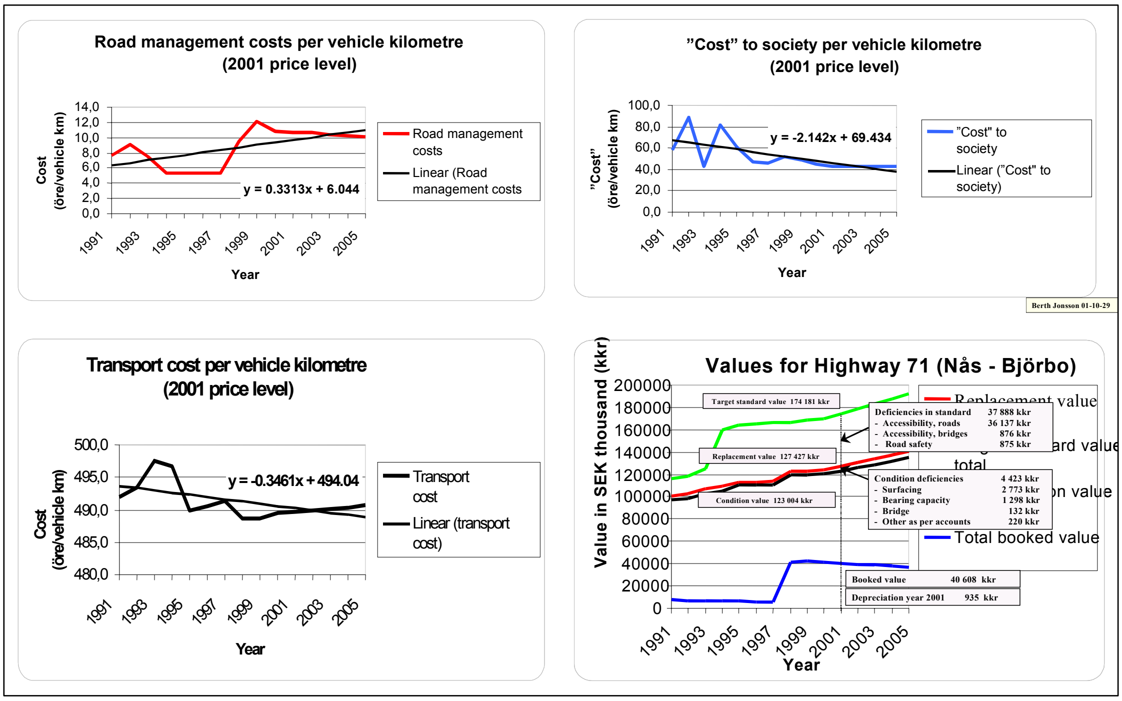

Figure 10 - Development of road capital, costs and effects on a stretch of Highway 71

Through using existing SRA automatic data processing tools, the proposed TAM model for any chosen component, road stretch, road, road network or geographical area can mechanically select, sum up and analyse information about such things as traffic, quality-related capital assets as well as costs and effects for road users and society. Details can also be obtained about road projects and project components.

4. CONCLUSIONS

Present-day traditional accounting does not provide management or politicians with guidance for the administration and supervision of road management. Instead, decision-makers have to rely on more or less isolated assessments by engineers – assessments that are either accepted or rejected since they cannot be completely understood or checked. At the beginning of this paper mention was made of the major increase in productivity amounting to SEK one billion that was achieved through organisational changes at the SRA in 1992. At that time, the low productivity of road management could be attributed, amongst other things, to a lack of information in the accounting. This paper describes a proposal for internal accounting based on technical input – accounting tailored to needs and providing top management with economic data and information about effects. A very large improvement potential has been shown.

The value of the road reserve, road superstructure, bridges, tunnels and road surfaces is equal to at least 75% of the entire road capital. Input to enable mechanical calculations of this road capital according to quality-related accounting principles is already documented to a large extent in existing systems. The quality of information about the condition varies for other components, which account for roughly less than 25% (ca SEK 200 billion in replacement cost) of the total value of road capital. If the condition of all the remaining components were described according to model VI above, a considerable improvement would anyway be achieved compared to the quality in present-day accounting, since the depreciation is adjusted to the life cycle of the different types of component. In the road surfacing example, the decisions regarding milling and accepting a new surfacing were the result of the judgement and action of engineers – decisions that would never be apparent to decision-makers in traditional accounting. Quality-related internal accounting is based on technical information and provides true, easily comprehensible economic information that clearly shows actual costs and results.

The question can be asked whether technical information is better through being transformed into cost-related terms – a question that deserves to be analysed and discussed. This paper maintains that such is the case, due to the fact that technical information is treated according to strictly set rules and principles that can be checked by independent auditors. The accounting model has good internal control with regard to simplicity, transparency and controllability. It has been shown to serve the purpose (relevancy and reliability) and be able to provide key information for learning and improvements through the opportunity to check and analyse. This ought to improve the allocation of resources and make road management more efficient.

All economic details from the quality-related accounting can be checked against external accounting – the « economic truth ». This means it is mostly technical information that is used to explain, in economic terms, what is happening within the framework of the « economic truth » based on « best knowledge ». Similarly, the effects accounting, based on « best knowledge », follows the principles and values that can be interpreted from research, physical planning and transport policy and that also are applied in road management investment calculations. True information about the cost and effects of road management, road capital deficiencies and values for the standard and condition can therefore be effective indicators for the administration, supervision, monitoring and reporting of road management. This can also be used as a basis for making decisions on fair road charges in road pricing systems.

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