WHOLE LIFE MANAGEMENT FOR OPTIMISATION OF ASSETS

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ABSTRACT

There are very few people who understand that roads are big business (Robinson, Danielson and Snaith, 1996). This is evidenced through road Agencies such as the French Roads Administration who manage assets similar in size to General Motors, while the Japan Road Improvement Special Account generates roughly the same revenues as Nippon Steel and Pepsico (Robinson, Danielson and Snaith, 1996).

This paper identifies a process for the design, use and implementation of a Pavement Management System (PMS), Maintenance Management System (MMS), Bridge Management System (BMS) and other components to form a single integrated Whole Life Management System (WLMS).

Such a system, if correctly implemented, can provide significant benefits on networks such as Public Private Partnerships (PPP) and the traditional Government Road Agency (Jordan, 2004). The benefits of integration and descriptions of business processes to carry this out are identified in addition to functional requirement considerations for a true WLMS System.

These requirements are just as applicable for Private Enterprise as they are for Road Agency's departments requiring access to varying parts of the system for their requirements. This process to develop a WLMS system identifies requirements from the initial stage of asset creation through to maintaining the asset over the concession period / Road Agency "Permanent Moving Window".

The context of this paper is to present a WLMS System process, associated methodologies and elements to be considered when developing and compiling a WLMS system. This new process provides PPP operators and Road Agency's potential multiple scenarios to assist in enabling greater control and performance of their networks which will benefit stakeholders, shareholders and the community.

A contribution to the field of Asset Management is provided through the areas of cash flow analysis for road infrastructure monitoring and future prediction for Government Road Agency's. Use of this process is highly beneficial in Annual Refinancing Reports which provide indicators to shareholders of their investments, current 'health' and projected 'health'.

It also provides a platform for Performance based road maintenance contracts and brings into view the community considerations that road network managers should now be taking into account. Such considerations include the socio–economic impact of the strategic decisions being made and efficiency impacts on the network through disruptions to road users.

1. INTRODUCTION

The purpose of this paper is to identify a refined process for development of the Whole Life Cost process that reflects the evolving requirements of PPP projects and emerging business attitudes of Road Agencies. Road Agencies are increasing capacities to their networks where possible but it is a costly and politically difficult situation. Optimisation of the assets will deliver as efficiently as possible the level of service being provided to the road users. This includes the efficiency in managing congestion.

This refined process provides PPP operators and Road Agencies potential multiple scenarios to assist in enabling greater control and performance of their networks which will benefit both stakeholders and shareholders. This is across the spectrum of design, construction, maintenance and disposal alternatives across both the strategic, tactical and operational levels.

Use of such a process is highly beneficial in producing Annual Refinancing Reports as it provides indicators to shareholders of their investments' current 'health' and projected 'health'. Also of relevant significance is the use of such a system as the primary software platform from which performance based maintenance contracts can be delivered.

Such software should never replace the business processes in asset management. It can however provide significant sources of information to the Road Agency. That information could range from monitoring the network in a 'Traditional' role, detailed monitoring of partly or fully outsourced maintenance contracts and providing strategic evaluations through scenario analysis. This includes impacts on the community residents, Road Users and stakeholders.

The optimisation of assets can be best achieved by a uniform robust framework that incorporates not only assets themselves but the strategic and operational business processes driving the management of those assets.

2. BACKGROUND

Optimising of assets can be defined as providing an improvement that increases the overall efficiency in 'real terms' to the maximum extent plausible. There is a recognised need that Road Agencies and their respective networks are under significant pressure from a rapid growth in demand over the past 30 years. This demand has reached a point in most western countries whereby the increased capacity has accelerated the deterioration of some assets beyond traditional expectations.

Significant financial resources are committed to road network development and maintenance (Robinson et al, 1996). Due to funding being unable to keep pace with demand, the requirement to extract the optimal life out of assets has never been greater. A focus has now been placed on Road Agencies to explore methods that have been previously associated with private enterprise such as PPP's.

It's not just the assets that need to be optimised on the network, but the restructuring of Road Agencies to become more efficient and optimised in the way that they run their businesses. These attitudes are now becoming more predominant throughout the industry to optimise the life of the asset, the Road Agency requirements and balancing the benefits / costs to the community.

PMS, MMS and investment models such as Highway Development and Management (HDM) have been around for many years in varying formats (Robinson et al, 1996). While each of these tools (decision support and operational) will independently provide the road manager with the ability to manage, monitor and predict asset lives, no truly integrated infrastructure process has yet been developed that incorporates the whole life of any asset from the planning stage through to the disposal stage (Jordan, 2004). This process must include the internal operating costs (business framework costs) of the Road Agencies to deliver the service.

The combining of all these costs (planning, design, construction, administration, maintenance, disposal etc), from each phase of the whole life assessment of the asset from the respective tools has rarely been considered. It is seen in some quarters as the ultimate goal for any organisation to be achieved as it can potentially deliver an optimised efficient strategic / operations combination. It would also take account of benefits / costs not only to the Road Manager but also to the Road User and Residents alike.

The overall objective or goal of the process must be to work safer, smarter and more cost effectively to provide the optimal outcome for the public who pays through their taxes to maintain the transportation networks. Although the Road Agency plays a pivotal role, they are certainly not the only ones who play a part. Stakeholders such as the construction industry, government officials, emergency services and the car industry also play a significant role.

3. DEVELOPING WHOLE LIFE MANAGEMENT METHODOLOGY

3.1. Overview

It is the role of a true road management system to provide both a knowledge base and decision support basis to assist in the generation and evaluation of management strategies (Robinson, et al, 1996). The potential shortcoming of not combining all of the alternatives at each stage in the life of the network is more clearly highlighted in experience with PPP type road networks (Jordan, 2004).

One component that has been carried out in isolation when constructing new parts of the network is the initial multiple design alternatives that should be investigated (green field and major upgrade). The impact of each design is not necessarily reviewed and validated through its' long term maintenance strategy associated with that design under current asset management approaches and methods (Jordan, 2004).

This design isolation occurs in many cases and can potentially result in a less than optimum design alternative being delivered over the life of the network once maintenance and upgrade investment strategies are taken into consideration in the overall context for whole life evaluation.

Is the design appropriate in the overall context of the network? Will it optimise, increase or decrease the ongoing maintenance costs? What about longer term congestion impacts? These questions and many more cannot be answered under traditional evaluation processes when each component is viewed in isolation. It is important to note that when dealing with maintenance of a network not all components are necessarily considered in the evaluation.

A brief definition of Life Cycle Costing can be summarised as the complete costs associated with an asset. This includes the planning, design, acquisition, administration, construction, operation, maintenance, rehabilitation/replacement, salvage and/or disposal costs.

Whole life costing provides a rationale for objectively comparing alternate means of achieving the desired result, where the alternatives differ not only in their capital expenditure (CAPEX), but also in their subsequent operational expenditure (OPEX) costs and disposal costs.

It also determines whether a higher initial construction cost is justified by reduction in future maintenance costs when considering alternatives. From a strategic perspective it may be more beneficial for low CAPEX and a follow on high OPEX based on the original design and potential funding restrictions (Jordan, 2004) to truly optimise the network.

Whole life Costing is the summation of all the various components that provide the total overall cost of an asset throughout its life cycle. An overview of the Whole Life Management Process is identified in the diagram below and shows the varying components that should be considered at a high level.

Vehicle operating costs on the network are also an important cost, albeit to the road user and not the Road Agency. The increase in population, economic growth and international trade has increased the number of vehicle miles travelled on road networks. This corresponds to an increase in the numbers of vehicles such as passenger vehicles, heavy vehicles (trucks) which causes delays (congestion). This in turn increases the cost of delivering goods and services to the national as an entity. These costs should ideally be optimised. For example, modelling the introduction of electronic tags for a tollway can show an increase in the average speed and therefore provide a reduction in vehicle operating costs.

The overall evaluation of the Whole Life Management Process takes in all levels of the network ranging from the strategic through to the man on the ground carrying out the operational works. It also takes into account the varying phases of the network ranging from the planning, administration, design, disposal etc, not just operational (Figure 1). All costs for each of these phases should be incorporated into the overall cost of managing and operating any given network.

3.2. Context of System Delivery

It is important that the context in which the system is to be delivered is taken into account when developed. Alternatively the system should be flexible enough to take account of changing business needs within an organisation. An example of typical types of context that should be considered when utilising this approach or indeed anything to do with Asset Management include:

- Private Enterprise (PPP Approach);
- Government Organisations (Performance based contracts);
- Stakeholders (including residents);
- Government legislation; and

- Other country specific requirements.

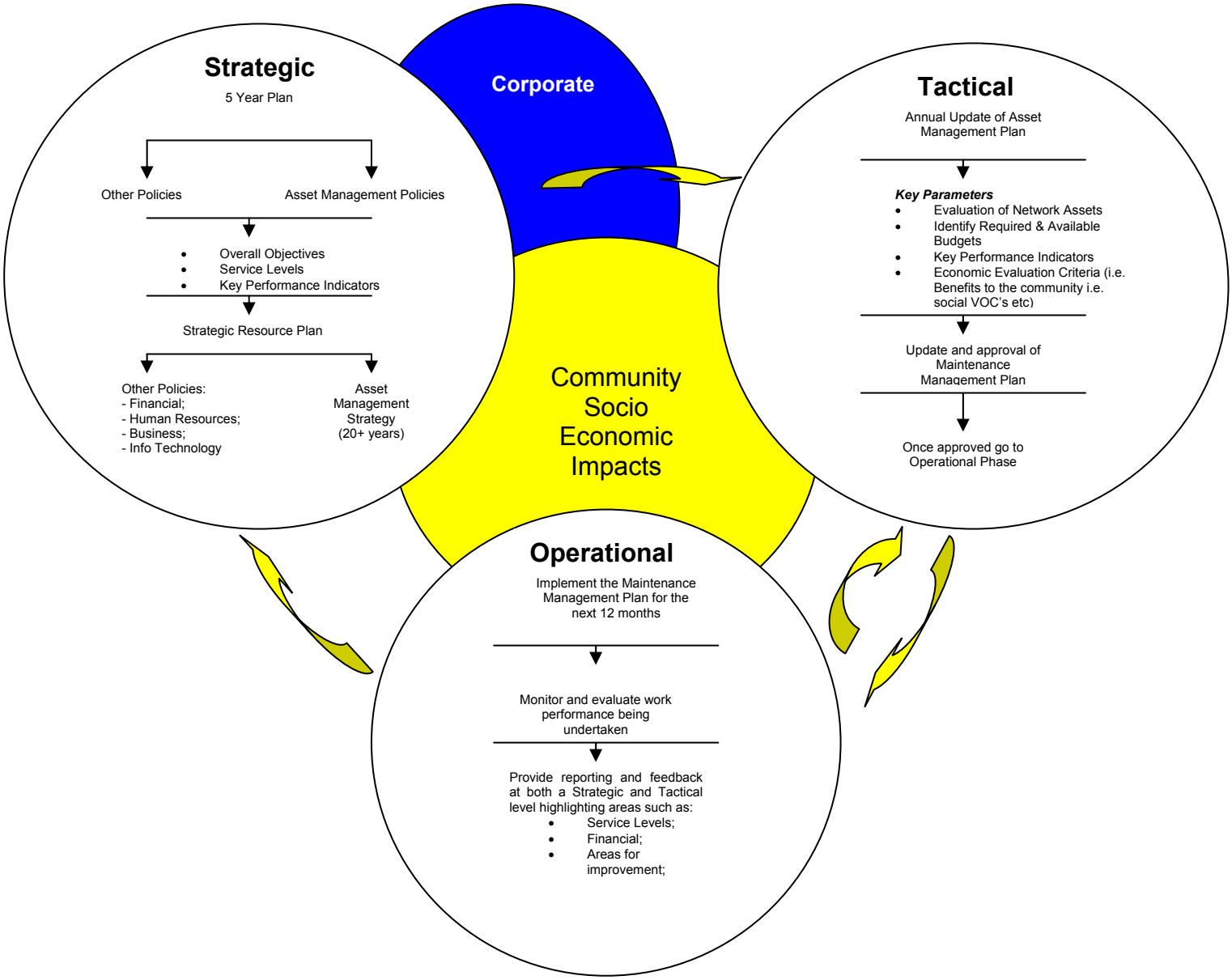


Figure 1 - An overview of the Whole Life Management System Process

4. BUSINESS IMPACTS AND ACCOUNTABILITY

The identification and implementation of an appropriate WLMS should be undertaken in a number of stages to develop and maintain the required business processes and strategy focus surrounding the network and its objectives. The methodology applied should be wholly appropriate for the function for which it is to be utilised.

To put it more simplistically, it should not only meet the contractual requirements but also provide benefits to the Road Manager, for example allowing continual updates to their business plan (refinancing document) on an annual basis and identify any implications changing network strategies will have in an overall financial impact sense.

4.1. Business Strategy Considerations

A number of inputs that may be included within the Business strategy are:

- ***Policy and Strategies***, Understanding the Road Agency policies and strategies.

- ***Data***, Understanding what the data requirements are and how each element of data interrelates within the overall policies and strategies. Is there for example a performance based maintenance contract? This will require more accurate data to develop the financial model within a defined level of confidence.

- ***Benchmarking***, of Business Key Performance indicators and condition performance criteria which is relevant to the regulatory role of the Network Agency/Concessionaire

- ***Establishment of a set of performance criteria***, and performance indicators generated from reviews of developments in Road Agency/PPP/toll road operations

- ***Models***, the most appropriate models that are best suited to the management and operational criteria of the network and the environment of that network

- ***Interoperability***, with other Regions / Countries or PPP networks that can provide economies of scale for developing such systems

- ***Risk Management,*** current strategies and methodologies used by the Road Agency must be taken in context and appropriately utilised within the system.

- ***Institutional capability***, to set processes in place enabling effective monitoring of these business KPI's in potential future KPI's not currently envisaged

- ***Identification of users***, and the level of access those users should be provided

- ***Deliverables required by the system***, Not only in the context of contractual requirements but the varying levels of management and in the case of a PPP operator the annual refinancing documentation requirements that can be dropped straight into an annual report

When evaluating whole life costing alternatives there are a number of important elements which must be considered such as discount rates. If set too high the costs may appear to be insignificant whereas if the rate is too low the investment may be discouraged.

Other factors to be considered should include:

- ***Inflation***, is difficult to pinpoint and may lead to less favourable or inappropriate selections

- ***Fluctuation***, of maintenance and running costs over the life of the concession

- ***Taxation*** rates and allowances for staff

- ***Probability*** associated with risk, over the concession period

- ***Obsolescence***, for economic, functional, physical, social and legal reasons

All these considerations and many others should be taken into account when conducting whole life costing and they should span the plausible range of outcomes based on the available information at the time of the analysis (Robinson et al, 1996).

A brief summary of some considerations when setting up a Whole Life Management System are:

- *Strategic and Tactical Objectives;*
- *Whole Life Performance Framework Objectives;*
- *Trade off Analysis and Investment Strategy Objectives;*
- *Whole Life Business Strategy;*
- *IT Strategy Framework;*
- *Objectives of the WLMS IT Strategy;*
- *Business Process Modelling;*
- *Activity Based Modelling;*
- *Whole Life Management Plan;*
- *Investment Criteria;*
- *Whole Life Key Performance Indicators; and*
- *Modelling Framework.*

4.2. Asset Management Plan

The Asset Management cycle and how it fits into it. i.e. the system should cover primarily the tactical and operational stuff but be able to evaluate the strategy and potential policies
A Whole Life Cost Plan for the Network or Concession should ideally be produced for the assets and reviewed annually as further information such as survey data and revised traffic forecasts are produced.

Recommendations from the review of anticipated OPEX over the following twelve months and the ensuing period of the Concession should be incorporated. Current performance against anticipated performance should also be presented in the form of Key Performance Indicators (KPI's) against standardised benchmark figures.

Surveys and other information should be collected with the annual review of the highway, its components' performance and recommendations for a 5-year rolling maintenance programme incorporating any updated condition data.

A further longer term view should be taken of the performance of assets such as comparison with the predicted design lives and maintenance requirements identified within the Whole Life Plan. This can identify at an early stage any potential departures from the planned maintenance regime and will allow the concessionaire or Road Agency an opportunity to recommend action whereby necessary replacements or amendments to maintenance cycles to optimise the life of individual components can be carried out. This information is vital and should be incorporated within the financial budgeting and forecasting of the system.

Ideally the Concessionaire/Road Agencies will provide a network that minimises maintenance works requiring lane closures and disruption to the Road User. This can be through mechanisms such as optimising timing and increasing efficiency of multiple asset type rehabilitation/replacement works in localised areas. In the eyes of the Concessionaire it is minimising cost and maximising the potential revenue through tolls whereas in the eyes of the Road Agency it is minimising the Road User costs

5. DEVELOPING MULTIPLE SCENARIOS

Developing potential overall scenarios through combining the outcomes from decision support tools and fixed costs, permit a true investigation of scenario permutations with their respective combination overall total combined costs. This process can be considered a step forward as optimisation of the network in an overall context from planning to disposal is truly delivered. Traditionally only components have been evaluated in isolation.

An example of the comparative relative costs of each component for each scenario is presented in Table 1. In the case of PPP's whereby 'green' field engineering is carried out, it can result in over 100 scenarios. Many of these 100 plus scenarios can be quickly dismissed through Engineering Experience.

Cost Component	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Planning	$A	$2A	$A	$3A
Design	$2B	$B	$B	$2B
Construction	$3C	$2C	$4C	$3C
Aquisition	$D	$D	$D	$D
Operation	$3E	$2E	$E	$2E
Administration	$F	$F	$F	$F
Maintenance	$G	$2G	$G	$G
Disposal	$H	$3H	$H	$H
Road User Benefits	$3T	$4T	$T	$2T
Stakeholder Benefits	$3S	$4S	$S	$2S
Overall Whole Life Management System Result *(Cost and benefits overall Ranking)*	***3***	***4***	***1***	***2***

Table 1 - Example Comparison of Alternatives from each cost Tool

The concept behind the WLMS process is to allow the appropriate selection of the preferred 'optimum' scenario based on the current available information at the time of evaluation. The selection of each independent systems "optimum" alternative may not necessarily reflect the overall preferred 'optimum' whole life cost scenario.

In fact, in some situations the preferred 'optimum' whole life cost scenario may result in a particular tools' "optimum" alternative (i.e. maintenance strategy), as the most expensive alternative identified by that individual assessment tool. As shown in table 1, the most expensive construction option is in highest ranking scenario (Scenario 3).

6. CONTINUOUS CYCLE OF IMPROVEMENT

As the project or network continues to evolve over time, operational/business needs may dictate a change in requirements. The WLMS model should be the focal point for the measurement and evaluation of proposed changes and provide direct feedback to shareholders or stakeholders with the financial implications.

By monitoring project data throughout the operational phase of the project, Whole Life Cost models are maintained and refreshed through annual refinancing reports. The performance of the Contractor in relation to budget/cost control, service delivery and other related outputs can be measured in a transparent way.

At the core of the continuous improvement process (within the annual refinancing report), there is usually a risk management component in place to deal with the following types of manageable issues that can allow ongoing improvement to occur and be monitored in the form of KPI's:

- Asset does not function as required;
- Asset does not meet business case;
- Health and Safety;
- Overspecified (CAPEX too high);
- Underspecified (Opex too high);
- Access problems (macro and micro - non availability);
- Quality of detailing affecting performance;
- Quality of workmanship affecting performance; and
- Quality of maintenance affecting performance.

Using the increasing store of data related to an asset over time, planned maintenance and replacement schedules for assets can be continually refined to:

- reflect changes to specification during construction works;
- reflect asset condition to monitor original assumptions;
- reflect actual performance of asset components throughout the life cycle; and
- take account of responsive/non responsive maintenance activities and update the schedules.

The whole life performance and associated replacement schedules should be sufficiently detailed to identify the precise nature of any planned repair or replacement and flexible enough to obtain a simple overview of the works.

Throughout the life-cycle, the Concessionaire or Road Agency can maintain a register of all responsive repair items. On an annual basis the whole life performance maintenance and associated replacement schedule should be updated to take account of these repairs. A maintenance register should be prepared encompassing each asset type at service commencement identifying the anticipated planned maintenance programme.

Thereafter, full condition surveys should be undertaken at appropriate and agreed intervals to:

- Verify the data generally;
- Identify components which are degrading faster than predicted;
- Identify components which are wearing better than expected;
- Identify areas where maintenance regimes should be adjusted;
- Identify unreported damage to components ; and
- Update the through life maintenance and replacement schedules as required.

Appropriate survey regimes should be undertaken to ensure planned maintenance programmes are available and relevant for each asset type. After updating the schedules, the maintenance work for the coming year should be extracted and summarised in an annual maintenance register and then inserted into the relevant annual refinancing document section for that asset types future works programmes.

7. MODELLING METHODS FOR THE WLMS

A number of modelling methods currently exist within the industry to model the varying asset types and these can be divided into two general categories:

- *Probabilistic Models*, that predict the distribution of the independent variable by recognising the stochastic nature of most general asset performances; and
- *Deterministic Models*, that predict a single value and adjust the performance based on past experience.

There is a third modelling method which is a Hybridised version of the two general categories (Jordan, 2006) and is evaluated in two phases. Phase 1 identifies a single value that is of a high level of confidence based on past experience. Phase 2 involves the creation of a reverse risk profile of the asset in a probabilistic manner.

Within each categorised modelling method there are a number of themes and sub themes as shown in the figure below. Road Agencies and Private Road operators can collect significant amounts of raw data. The obvious questions are then raised are we collecting the correct data, what is the right form for the data, what to do with this data and what is the level of uncertainty associated with the data.

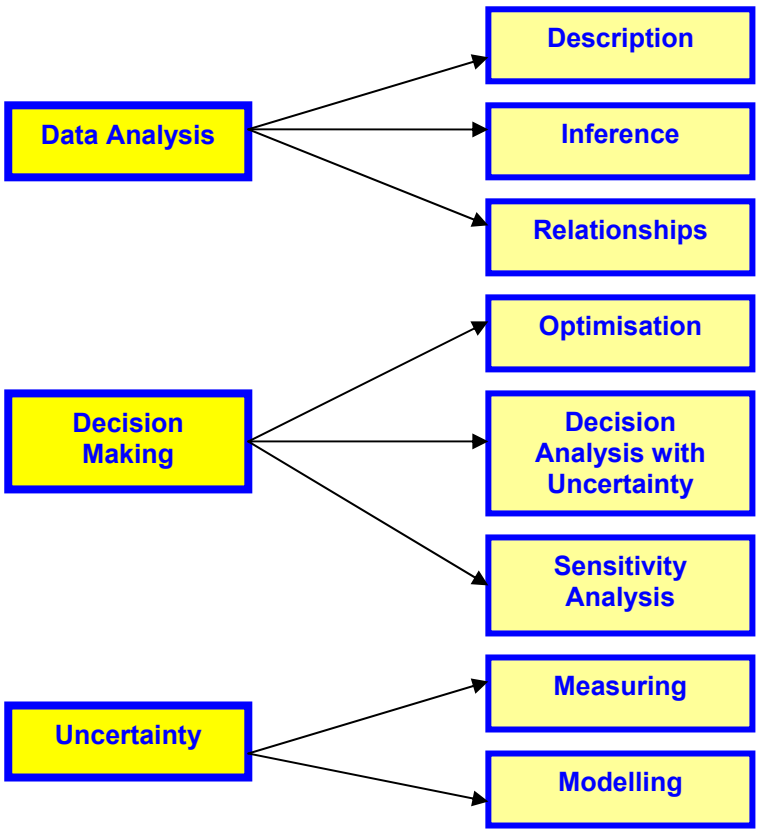


Figure 2 - Typical Model Themes and Sub Themes (Albright et al, 2003)

8. OPTIMAL TIMING OF INVESTMENT

Assets within any network are considered to be economically adequate at a point in time if additional investment is not economically justified. Justification can only be met through two mechanisms:

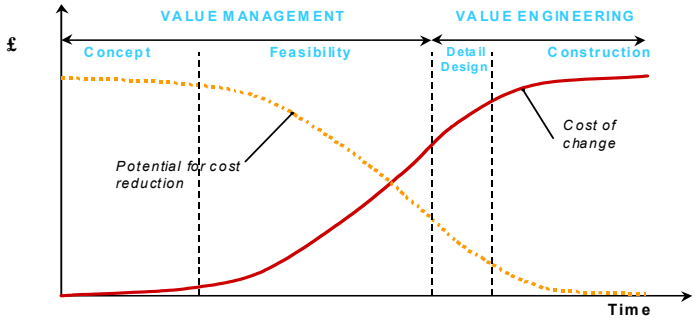
- The present value of benefits exceeds the present value of costs (NPV > 0); and
- There is no net welfare gain from delaying the investment (delaying does not increase NPV).

The first criteria will ensure net benefits will earn what they could elsewhere within the economy (opportunity cost) and the second ensures that the investment occurs at the optimal time.

To reach the point of optimal investment within the Asset Network, both over and under capacity of the assets and maintenance regimes should be identified by a series of levels and through economic justification to ensure greater or lower investment is not being applied than is warranted.

An example of optimal timing through cost potential and impact is shown below.

Cost potential and impact



Source: BAA

9. RISK MANAGEMENT

Risk Management is an integral component of any existing network or PPP bidding structure and a balance must be found on the allowable risk within a project and funds set aside to cater for the elements associated with that risk. Most Road Agencies contemplating a Concession project are looking to off load considerable risk onto the private sector and at the same time try to minimise their cash outgoings.

The definition of the term 'Risk Management' can still be misunderstand in some areas of the industry. A simple definition is 'Risk Management provides the basis for judging the relative merits of alternatives to support robust Management Decisions and Conclusions (Robinson, Danielson, Snaith, 1996).

This can be simply explained as Identification of Probability for premature failure of an asset, political changes, policies and a number of influences that must be taken into account. These risks directly impact on direct costs (budgets) that are allocated towards maintaining an Infrastructure Network. Uncertainties always exist and it is ideal to minimise exposure to the level of risk where possible through risk identification and management.

Conducting a risk analysis will not diminish the risk, but simply aid in identifying the risk and allows appropriate decisions that can be made based on the Road Agency/PPP companies policies whether it be engineering or financial constraint orientated. Risk is usually identified, estimated and continually updated within a "Risk Register" noted in the annual refinancing report in the PPP Concession.

10. CONGESTION MANAGEMENT

Congestion is an element that requires an increase in road capacity, the alternatives are costly delays to the road user which can also make driving congestions more difficult as it can lead to accidents. The issue of course is that it is virtually impossible to maintain a level of congestion through constant road construction.

Traffic management centres provide the tools such as CCTV, speed monitoring devices, co-ordination of reports from police to optimise where possible:

- Traffic incidents;
- Adverse weather conditions;
- Maintenance works; and
- Management of congestion through Intelligent Transport Systems (ITS) etc.

Actions to minimise congestion provide Network operators the ability to provide optimal traffic conditions. This may be through identifying and clearing incidents, adjusting signal timings, ITS billboards to motorists or simply opening and closing lanes.

11. APPLICATIONS OF THE WLMS

11.1. Network Wide based Applications

Whole life costing for network based applications may be used by either a Road Agency or private enterprise concern that is or intends on operating a network (either on behalf of the agency or through a concession mechanism).

The main benefit for a Road Agency to produce a financial model that utilises a WLMS approach is that the investigation of alternative procurement strategies can be conducted as shown in the figure on the following page. The outcome of any review utilising such a model can identify the following fundamental elements to be outsourced;

- Financial feasibility of outsourcing an area (i.e. region) or component of the network (i.e. PPP to be outsourced);
- Regional size and associated scope of works;
- Upper financial levels of work to be outsourced before becoming a major works project;
- Asset Management impacts to the network including business and condition based Key Performance Indicators;
- Anticipated value for money return to the Road Agency;
- Funding arrangements and mechanisms appropriate;
- Identifying road work impacts to the network and identifying the most appropriate mechanism for payment (i.e. lane unavailability, shadow tolling, visible tolling or other methods);
- Assess the likely risk and impact to the Road Agency for unexpected events such as inclement weather type situations;
- Identification of the appropriate legal framework based on the financial model outcomes for risk and value for money considerations;
- Identification of which elements to appropriately monitor through KPI's and be linked back through the legal framework (some KPI's would not be linked but to provide an overview of the companies performance); and

- Other forms found to be beneficial to the individual agency.

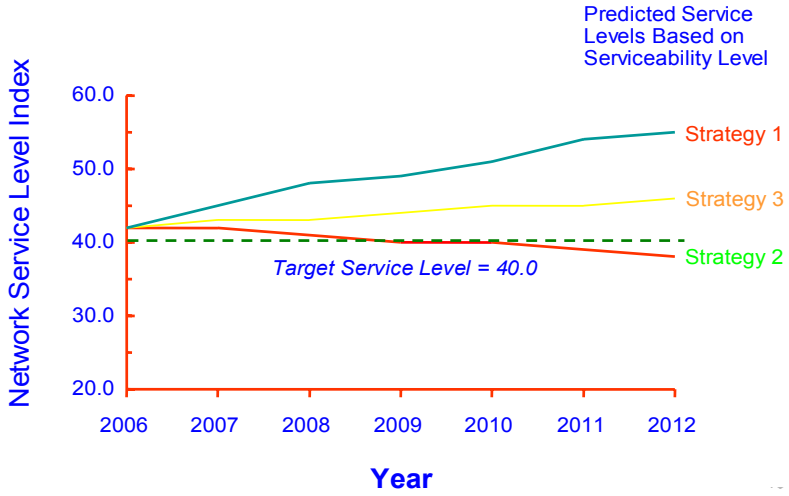


Figure 3 – Example Predicted Levels of Service for a Network based on Budget

In addition to Service Level monitoring of the network as identified in the figure above, an overall financial strategic perspective relating to the operational efficiency of the Road Agency can be monitored and certain predefined financial criteria can be set in place. This predefined criteria may be linked to indicators such as a Public Sector Comparator (PSC) that if met, may trigger a series of events whereby an area or component of that network is identified to be suitable for outsourcing.

11.2. Project Specific Application

The project specific application of Whole Life Costing is primarily a subset of the Network Wide application from the Road Agencies perspective. A potential project may occur when a realistic outsourcing candidate (area or region), is triggered identifying a potential PPP or PFI project that is suitable for outsourcing. This may be through mechanisms such as a Public Service Comparator (PSC).

An example of a benefit for outsourcing in a PPP format is the known cost over the life of the concession. This is opposed to the annual ups and downs and increasing levels of funding restrictions placed on Road Agencies. The funding can therefore be set aside and justified to Government. A stable and financially sound Government must however be in place from the PPP concessionaire perspective to ensure they are paid or it nullifies the point in investing in such a business venture.

The road agency may primarily use the system to identify projects within the short and long term works programmes. This may be either in the form of rehabilitation/replacement works or alternatively identification of major works programmes that are upgrading existing components of the network or creation of new roads. A significant advantage with WLMS systems is the ability to deal with multi criteria considerations such as environmental, traffic, social, political and others to achieve a robust solution.

From a consortium perspective, a project specific application may involve the bidding or operational monitoring of a PPP or PFI project. This would involve modelling the concession at bidding, monitoring the ongoing condition and financial operations, and highlighting potential areas for concern for the handover requirements. The system would also highlight areas that are most at risk of not meeting the required standards and the level of confidence associated with each item at risk.

11.3. Other Applications

Although this thesis is not identifying an appropriate procurement process, WLMS is an ideal tool to provide sound solutions with strong economic justification. Identification of a preferred procurement method can be identified and justified. This justification can be identified through the economic indicators such as BCR, NPV, EIRR, PSC and many others.

12. CONCLUSION

The purpose of this paper was to identify a new stage in the development of the Whole Life Cost process to reflect the requirements of PPP projects and the changing business attitudes of traditionally operated Road Agencies.

The expectations of road network managers, users and residents have all changed significantly over the past 30 years. Residents and Road Users now expect value for money from their taxes. This may be in the form of reduction in noise to community areas from motorways through to minimising the maintenance cost of their vehicles from the roads they use. It's a balance that the road network manager must achieve with the available funds.

With funding constraints becoming more common it requires new thought processes that enable the network to be operated smarter, more efficiently and effectively. Non traditional elements such as economic development within a community and the strengthening of local industry must now been taken into account to identify impacts of decisions. Such elements must now form part of the overall business considerations and strategies for the Road Agency.

The ability to monitor and provide detailed or high level strategic advice on a number of levels identifies this approach to Whole Life Costing as setting a new benchmark within industry. It is this new benchmark that Road Agencies should aspire to when developing a system that is measuring their true costs. Not just the costs of maintaining or upgrading the network but the costs attributable to administering, identifying the potential risks associated with that network, community impacts and identifying more cost effective contract procurement methods.

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