SAFE ROAD NETWORKS – INTEGRATING SAFETY INTO ASSET MANAGEMENT

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Abstract
Managing road assets has become a well established practice in the last decade. Current practice in road asset management focuses primarily on the physical deterioration or consumption of assets. However, beside the deterioration due to wear and tear, there are other aspects of road management that are related to the safety and well being of the community. Road safety assessments and formal road safety audits are carried out to assess the risk potential of roads and road elements. The result of safety audits usually carries financial consequences – pavement condition, signage and other safety related aspects all need to be improved to reduce risk and/or improve safety outcomes.

The paper describes the integration of these important road management areas into an asset management decision support tool to coordinate investments in pavement condition with investments in safety measures to assist achieving good road management outcomes. The resulting short and long term forecast is based on an optimised balance of asset preservation and risk management associated with safety measures.

Key Words: Pavement Management System, budget allocation, works program, asset condition, road management, safety, risk, skid resistance, roughness, and optimisation

Introduction

The parallel developments of road asset and risk management techniques are concerned with the same asset though approach its creation and renewal from quite different directions. Asset managers traditionally aim at maximalise service level and life at minimum cost, whilst safety managers concentrate on saving lives and reducing the human casualty cost of road transport. Conventional organisational structures treat safety and asset management separately, though they compete for funding from the same source. The coordination and rational distribution of funds is usually a hotly contested process leaving sometimes both parties dissatisfied. An obvious solution to the rational allocation of funds is integrating the competing demands for the limited funding pool.

Managing road safety

The safe system approach (Figure 1) shows road safety management in the context of overall travel safety. Focussing on just one element of the safe system model, Safer Roads and Roadsides, road safety, from an engineering perspective, is primarily concerned with the physical road pavement condition and roadside environment. Effective management requires (a) the knowledge of *what* is managed (b) the relevant properties and (c) the funding requirements. ARRB Group has developed the NetRisk road network safety assessment method and Road Safety Risk Manager (RSRM) for managing road safety engineering elements. (McInnerney, 2003)

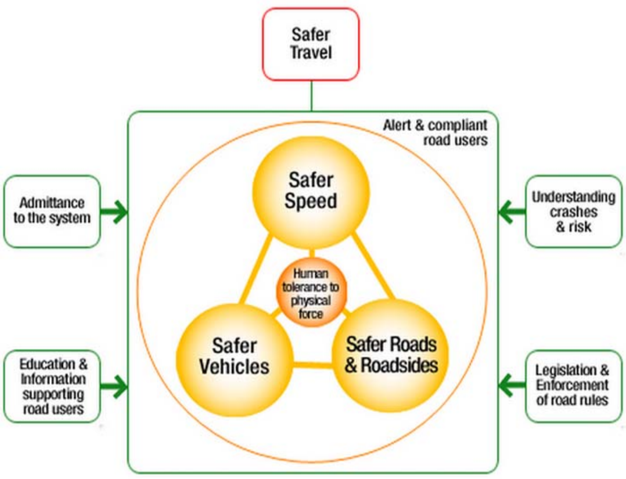


Figure 1: Safe system approach

The NetRisk process entails a systematic approach to establish the key engineering safety risk factors. The process includes data collection and evaluation of the risk related to a set of safety parameters.

NetRisk
Utilising high resolution digital images taken at 10 metre intervals along a road network, ARRB's NetRisk software, developed in conjunction with the Queensland Roads Alliance, allows a road authority to assign a relative risk score to specific road features that contribute to the cause and severity of motor vehicle crashes. These include features such as the type of road – rural/urban, divided/undivided etc. – roadside condition, i.e. width of available clearzone,
The output from a NetRisk assessment allows road managers to quickly and easily identify road safety issues and determine the priority of investment to address those issues, through say a mass treatment program, or to conduct more detailed site assessments, such as road safety audits.
The value of adopting a NetRisk approach is that road segments across an entire network can be evaluated as high, medium or low risk to a road user, independent of traffic volume. Hence the safety risk that may be present at a small rural road may be compared to the level of risk on an urban arterial road. This permits strategic decisions to be made that address safety priorities across a network rather than allocating road safety funds at the busiest roads.
Road Safety Risk Manager is a software analysis tool that permits a road manager to determine the optimum expenditure of road safety funds. Using the same crash risk data as NetRisk, RSRM considers the reduction in risk that alternative treatment options may provide at a location and between locations across an entire road network.
Both NetRisk and RSRM are powerful management tools for road safety, but they do not consider traditional asset management parameters in their analysis engines. The actions to address / reduce risk fall into two broad categories, namely they either require capital investment i.e. creating new assets, such as new signage, widening etc., or coincide with asset renewal, such as e.g. resurfacing. The distinction between the two is critical from asset management's point of view, as asset managers typically deal with asset renewal and not asset creation.

Managing assets
The goal of infrastructure asset management is to meet a required level of service in the most cost effective manner. (IIMM 2006).
The asset management process may be used to determine the budgetary requirements or to allocate work according to the available funding.
The closer inspection of the asset management cycle (Figure 2) reveals the realities and opportunities to integrate safety management with asset management. At each station of the asset management cycle all assets and asset components must be considered, as there is no free entry point into the cycle. Consequently safety considerations must be integrated into all phases of the cycle.

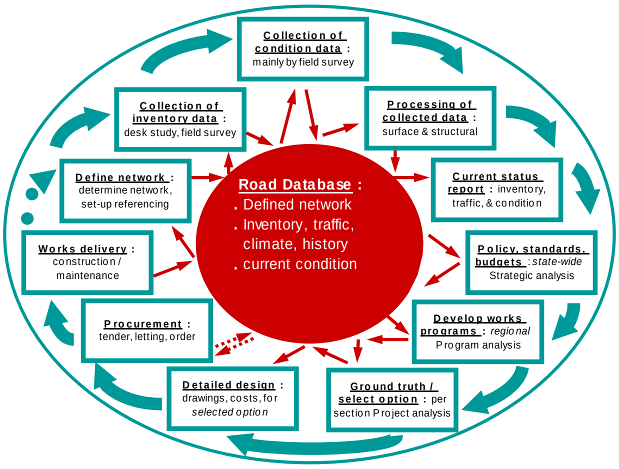


Figure 2: The asset management cycle

Data collection (including updating the asset register) is the first opportunity to introduce safety into the cycle. The asset management process can only contemplate existing information; hence it is paramount that safety related information becomes part of the system as soon as possible. The NetRisk system provides the data and the appropriate data processing and interpretation tools as discussed previously.

Policies and standards reflect the asset owner's priorities and desires. The objectives and results of the asset management cycle are defined through policies and standards translated into specific performance targets and measures. Whilst policies may contain broad statements and objectives, key performance measures and targets are expressed numerically, i.e. in very specific terms. These play a critical role in the works program development and treatment selection process as discussed later. Safety measures must be incorporated in the policy and key performance measures. If safety remains at policy statement level, without translation into specific target parameters, it cannot be incorporated into the asset management cycle.

Developing works program entails generating options and selecting the optimum combination of treatments – work items – in such a manner that the combination of work items (the works program) (a) fits into the budget and (b) achieves or best approximates the target parameters. This step involves the analysis of the data, life cycle cost analysis and treatment selection. The conventional road asset management approach takes into account pavement condition, deterioration and user costs. The remedial options – treatments – all aim at rectifying the defective conditions. The obvious opportunity for safety considerations to enter the calculations is there by including safety in the definition of defective or unsatisfactory conditions. Once safety aspects are part of the defective conditions, then by selecting the appropriate remedial treatment, benefits can be assigned to rectifying the safety defects.

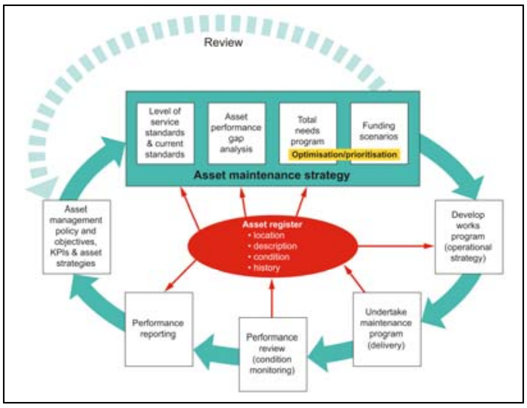
Defects or defective conditions and their modelling are a vital part of the works program development. Whilst pavement deterioration modelling has a rich history and ample examples, the availability of safety related models is limited. The two main avenues explored cover the modelling of safety related pavement properties, such as roughness, skid resistance, texture depth and rutting. (Cairney et al 2005) These models are immediately useable as demonstrated in the case study presented in this paper. A more direct approach to safety management is to take safety related risks into account. This way the circle of remedial treatments can be broadened significantly. Pavement condition related safety defects can be rectified only with pavement improvements, consequently signage, shoulder sealing and similar non-pavement condition related treatments would not have benefits that could be included in the treatment selection.

The existence of remedial treatments does not necessarily guarantee that the treatment will be selected. The treatment selection, i.e. the process of selecting the most effective combination of treatments, involves either prioritisation or optimisation. Prioritisation is a simple ranking process, where a ranking parameter - typically benefit cost ratio - is calculated, and all treatments are sorted according to the priority order. The priority list is cut off when the available budget is exhausted. This process has several pitfalls, such as the definition of benefits (priority ranking) and the incapability of taking into account the total impact on the network. It is also likely that the cost of the selected projects will be either less or more but rarely exactly the available budget.

A more advanced treatment selection method is optimisation. The definition of optimum, the most critical point of the process, is given by means of the objective function. The objective function is the target performance measure(s). The objective function may include one or more parameters; in the latter case the opportunity is clearly given to weight these parameters according to the asset manager's requirements. For example, the target objective function may include the weighted average of roughness, rutting, surfacing age and skid resistance. Without including safety in the objective function, safety aspects cannot be part of the asset management cycle.

Project level design presents the next opportunity to consider safety related measures. Road asset management is concerned primarily with the maintenance of existing assets, so the works program will primarily contain treatments for existing conditions and defects. Though creation of new assets falls outside the routine asset management tasks, new ancillary assets that complement existing ones can be accrued through this process – as long as (a) these are on the list of available treatments and (b) benefits can be associated with them. The underlying requirement therefore is to incorporate these ancillary safety treatments in the design standard, i.e. to make their implementation compulsory.

The central point of the asset management process is the **asset register** (Figure 3). It is paramount that the newly created ancillary safety related assets find their way in to the asset register and become part of the asset management cycle. Being included in the road asset register ensures that they remain part of the asset management cycle and their maintenance and renewal can be planned.



Source: Austroads (2006).

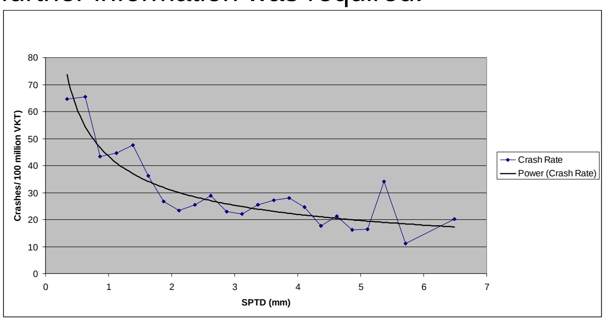
Figure 3: Central role of information in the asset management process

Case study

The challenges facing the integration of asset management and safety processes were explored by embedding safety aspects into an existing PMS system. For this purpose a rural network of 3000 km was selected. The network consists of mostly two-lane two-way rural sealed and asphalt roads.

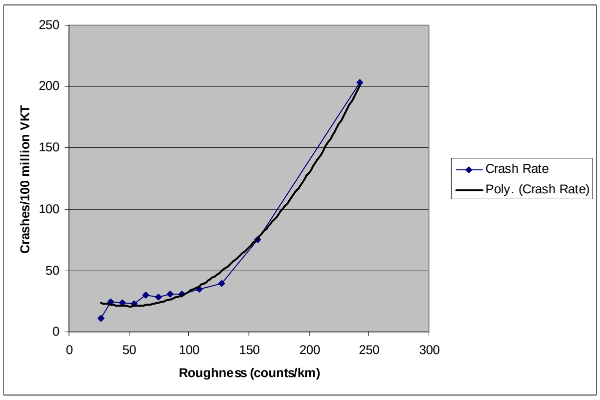
Models

The deterioration of the pavement was modelled with appropriately adjusted and calibrated HDM models that have been used for over seven years in the dTIMS asset management software (Deighton 2009) for the given network. The existing deterioration models were complemented with crash rate models for roughness and texture depth. (Figure 4 and Figure 5) These models were developed for Australian rural network and were considered representative and valid for the network analysed in this case. The need for behavioural changes is reflected by the fact that the crash rate cannot be reduced to zero with roughness and/or texture depth improvements only. Roughness and texture depth data was readily available, so no further information was required.



Source: Cairney and Bennett (2008)

Figure 4: Relationship between macrotexture and crash rate for rural high speed roads



Source: Cairney and Bennett (2008)

Figure 5: Relationship between roughness and crash rate

No changes were required to the remedial treatments – appropriate treatments for roughness and texture depth defects were already implemented in the system. In order to maintain direct comparability the triggers, costs and works effects were left unchanged.

Objective function

The two functions (roughness and texture) may yield benefits concurrently, when both roughness and texture is improved. The coincidence and overlap of the two independent variables necessitates establishing an objective function that incorporates benefits originating from the improvement in both parameters. This may be achieved either by introducing a risk factor or an aggregate index. For the current case an aggregate index was used incorporating crash rates from both roughness and texture depth. The objective functions also included a traffic weighting, i.e. the benefit associated with a treatment and location was weighted by the AADT. This method introduced an added priority to heavily trafficked roads.

Discussion

A budget allocation of $10 Million p.a. was explored by using the conventional – performance based – objective function and the safety oriented objective function. The results of the modelling confirmed that the linking of the condition parameters to crash rate will yield only limited change in the overall condition as the condition and safety functions show quite similar trends. However, the different objective functions, i.e. moving away from the condition based objectives towards safety based targets result in structural differences in the composition of the works program.

The performance oriented objective function allocated most of the budget to resealing. The asset owner's primary objective was to maintain a reasonably low seal age, hence the resulting reseal program. (Figure 6)

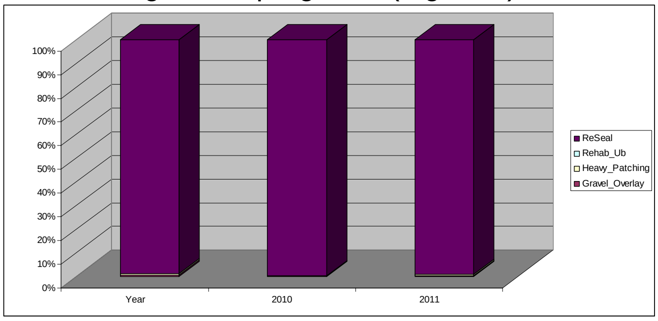


Figure 6: budget allocation – performance oriented objective function

The safety oriented analysis had the same triggers and budget constraints, so the pool of treatment options (strategies) to choose from for the works program was the same. However, the work was distributed significantly differently. The safety oriented objective function assisted in generating a more balanced works program that had a significant proportion of treatments addressing high roughness. (Figure 7) This result highlights the paramount importance of selecting the most appropriate objective function to get the anticipated results.

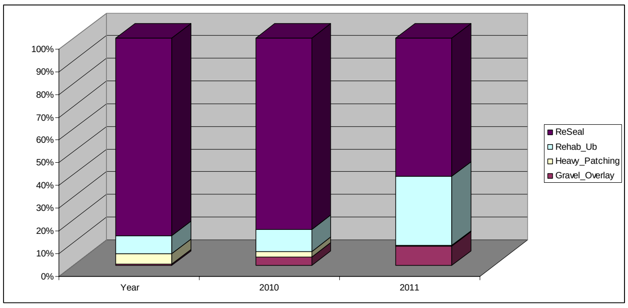


Figure 7: budget allocation – safety oriented objective function

The $10 M budget constraint was not sufficient to significantly reduce the crash rate – this remained practically unchanged. To achieve material improvement in the crash rate, a significantly larger annual budget would be required.

The current case study intended to explore the allocation of road maintenance funding according to safety rather than condition. This approach excluded the option of introducing treatments that aim improving safety without affecting pavement condition. This may be considered a shortcoming as added safety features demand increased funding. However, the objective of the current work was to illustrate that existing funding levels may be distributed in such a manner that safety aspects are taken in to account. Specific safety measures - i.e. treatments serving primarily safety improvement without condition improvements – require additional treatments and hence increased budget. These can be easily incorporated into existing PMS systems.

Conclusions

The analytical work to date confirmed that safety aspects can be incorporated into an existing PMS system. Safety can be taken into account by either condition related functions as demonstrated here or by including safety specific measures, such as signage, widening etc. By limiting the safety measures to condition related issues, it is possible to re-distribute the available funding in such a manner that these are taken into account. However, for a broader approach, safety measures must be considered as a separate asset class that may or may not contribute to condition improvement but will contribute to overall safety.

The definition of the term overall safety is critical for the analysis. The current example showed that improvement to texture depth and roughness improved the crash rate; however, the collective impact had to be defined through the optimisation target, i.e. the objective function. The concept of overall risk would be more suitable for this purpose and would express the ultimate objective – i.e. to reduce risk to the road users – much more effectively. This can be achieved by taking the results of NetRisk (McInnerney 2003) and incorporating into the asset management system.

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Peter Kadar

Peter Kadar has been involved with the road construction industry for over 35 years. He was project manager of managed major freeway constructions, conducted pavement research with the Australian Road Research Board and managed pavement and materials testing facilities. His interests include the asphalt industry and recycling and most recently asset management. Most recently he focused on the financial side of the pavement industry through asset management and assisting road agencies in short and long term planning and work scheduling. After a long carrier in consulting he has returned to ARRB as a principal consultant in pavement materials and asset management.

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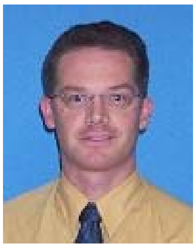

David has over 18 years experience working in road design, traffic management and road safety, 16 years in NSW Local Government.
As Team Leader Safe Systems at ARRB Group's NSW/ACT office, David has been involved in a number research and consulting projects for Austroads. He has managed a number of NetRisk projects for state and local road authorities and has long held the view that asset management and road safety should be combined to achieve optimum road management outcomes.