Case Study

Strategic Decision Making Tool for Renewals

Initiative number 2014_07

August 2014
<table>
<thead>
<tr>
<th>Version No</th>
<th>Date</th>
<th>Item Affected</th>
<th>Description of Change</th>
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<td>1</td>
<td>01/08/2014</td>
<td>1st</td>
<td>Draft of Report Completed</td>
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<tr>
<td>2</td>
<td>20/10/2014</td>
<td>Final Draft</td>
<td>– Feedback incorporated</td>
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<td>3</td>
<td>09/12/2014</td>
<td>Final Report</td>
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Executive Summary

Auckland Transport (AT) manages a large portfolio of Transport assets ranging from buses and wharves to roads, street lighting and footpaths.

AT’s asset renewal programme is a significant investment that consumes about 20% of its annual budget.

Exploring different options that may be considered for asset renewals and understanding the consequences of these options are important for investment decisions. Conveying this message to the governing body will ensure that decisions are made with the knowledge of asset consequences.

To facilitate this process AT has developed a “Strategic Decision Making Tool for Asset Renewals”. Initial outputs from this tool are being used, with other considerations, to develop the 2015 Long Term Plan (LTP).

The outputs from this tool can also be used to communicate with the governing body to demonstrate consequences of different investment options for asset renewals.
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1 Introduction

1.1 Project Outline

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Auckland Transport _ Auckland Region</th>
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<tr>
<td>Project Location:</td>
<td>Auckland Transport _ Auckland Region</td>
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<td>Project Objectives:</td>
<td>To develop renewal investment options for transport assets</td>
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<td>Length:</td>
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<td>Traffic Volume:</td>
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<td>Supplier(s):</td>
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<td>Project Stage:</td>
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<td>Value: (cost savings)</td>
<td>This approach will develop investment options for asset renewals</td>
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<td>Scope of Work:</td>
<td>Develop investment options for asset renewals based on portfolio condition and risk policies</td>
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<td>Constraints:</td>
<td>Time and resources</td>
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<tr>
<td>Project commenced:</td>
<td>Yes</td>
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<tr>
<td>Key Issues:</td>
<td>Confidence of asset condition information and selection of appropriate deterioration curves</td>
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1.2 Project Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation / Role</th>
<th>Contact Details (Email and Telephone)</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
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</table>
2 Case Study

2.1 Background

Auckland Transport (AT) has been developing a strategic renewals forecasting tool to help optimise the condition profile of its portfolio and provide a common approach to balancing levels of service, cost and risk across all asset classes.

In this three-way relationship, asset condition provides a first proxy for levels of service. While condition is not the only driver of renewals investment, it does underpin many of the levels of service and risk factors on the network. Condition, as ‘loss of service potential’, is also a primary variable in setting the value of the current investment and state of the network.

The model is part of an optimised decision-making methodology that provides a robust, consistent and equitable approach to the management of transport assets and levels of service across the region. It enables AT to analyse renewal needs resulting from the following asset management policies, based on the specific requirements of each asset class:

- condition profile to be achieved in the long term
- condition-based level of service required
- level of acceptance of backlog risk

It also provides the reverse process i.e. the condition and backlog consequences that result from specific annual budgets. This provides for direct testing of trade-offs across the portfolio between:

- funding availability
- level of service required
- level of backlog that can be be accepted based on risk criteria such as criticality, movement and public perception considerations

The amalgamated portfolio of AT assets has significant local variations in levels of service and asset condition and performance across the region. Analysis of current asset condition has identified long-term investment issues, needs, costs and risks. These include:
• current renewals investment deficit - historical deferred renewals with associated potential for increased whole of life costs
• renewals liabilities - increased expenditure within the planning period if levels of service are to be maintained
• areas of high risk - assets that represent unacceptable risk to the network and attract increased maintenance and whole of life costs.

The renewals model is designed to provide an investment path that addresses these issues over the long term.

3 The Strategic Decision Making Tool for Renewals

The modelling of asset renewals uses asset management policies and inputs based on the specific requirements of each of the asset classes and include:
• condition profile – Current and preferred future profiles
• Intervention Triggers based on level of service (using condition as a proxy)
• Level of tolerance for backlog risk
• Base life
• Renewal cost rate
• Annual growth
• Deterioration profile

The following sections describe the use of these asset management policy settings and inputs in the renewal model. They are:

• condition and deterioration
• levels of service
• changing the condition profile
• risk and backlog management
• trade-offs
• maintenance
• outputs.
3.1 Condition and deterioration

Assets are assessed against a 5 point condition grade scale from 1 (very good) through to 5 (very poor).

Asset types such as road pavements, buildings, bridges and drainage all have different base lives and deteriorate at different rates. Several factors influence their rates of deterioration and useful lives including built specification, loading and environmental conditions. Examples of these are illustrated in Figure 1.

![Nominal deterioration curves - condition vs. age](image)

**FIGURE 1** Condition grades, deterioration rates and condition-based levels of service.

The model uses the above deterioration curves and asset base lives to calculate the annual deterioration of each asset. These curves are initial estimations for planning purposes and are based on earlier work done within the New Zealand infrastructure asset management sector.

3.2 Levels of service

The predominant driver of renewals investment is the condition of network assets, although other factors must be considered to address specific levels of service or risk. This renewals model uses condition as a proxy for levels of service.

Figure 1 shows the general approach taken to renewals intervention, using three levels of service options for the management of asset condition. Each asset type has been assigned a condition-based level of service based on this approach as highlighted in Figure 2 below.
<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Levels of Service Intervention Triggers</th>
<th>Asset Classes</th>
<th>Risk Profile Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Risk Assets</td>
<td>LOS 1 - No assets in poor or very poor</td>
<td>Rail stations, Traffic systems, Wharves, Busway stations, Rolling stock, Bridges, AIFS</td>
<td>Front-of-house assets with significant public perception implications.</td>
</tr>
<tr>
<td></td>
<td>condition</td>
<td></td>
<td>Assets with significant safety risks and/or traffic movement implications.</td>
</tr>
<tr>
<td>Moderate Risk Assets</td>
<td>LOS 2 - No assets in very poor condition</td>
<td>Pavement base, Pavement surface AC, Pavement surface chip seal, Footpaths, Kerb &amp; channel, Drainage pipes, Catchpits, Cycleways, Corridor structures, Streetlight poles, Streetlight luminaires, Streetlight brackets, Corridor structures, Signs, Retaining walls, Parking buildings and equipment, Off street Car parks, Sea walls, Bus shelters</td>
<td>Assets having medium to low public perception and safety implications</td>
</tr>
<tr>
<td>Low Risk Assets</td>
<td>LOS 3 - Assets allowed to fall into very poor condition with risk of failure</td>
<td>None assigned</td>
<td>Non-critical assets with no public perception or safety implications</td>
</tr>
</tbody>
</table>

Figure 2 – Levels of Service Intervention Triggers based on Risk profile

Assets below condition grade 5 are deemed to have failed and generally carry too much health and safety risk for public use.

### 3.3 Changing the condition profile

The condition profile is the amount of the asset in each condition grade (1 to 5) at any one time. The model identifies the investment required to change the current condition profile of each asset class to a more cost-efficient state over time while having regard for growth, funding constraints, levels of service, risk and whole of life cost.

Figure 3 shows an example existing condition profile (yellow columns) as the current measure of the asset within each condition grade. It shows:

- the condition-based level of service i.e. the renewals intervention point for this asset class
- the level of existing backlog i.e. the amount of asset below the intervention point in condition grades 4 and 5
- the level of future backlog liability i.e. the higher than optimal renewals expected at the intervention point within the next 12 years (from condition grades 3 and 2)
- a low level of asset in condition grade 1 means that more of the asset is either currently in backlog, or will need to be renewed soon.

**FIGURE 3 Condition profiles**

The target condition profile (green columns) is based on the nominal deterioration profile and represents the most cost efficient condition state for the asset class (i.e. results in the least whole of life renewals cost). This is the condition profile that the model works towards over time.

Figure 3 also identifies the time the asset spends in each condition grade. This shows that for some assets, the fast rate of deterioration near the end of their lives is a key risk consideration when setting condition-based levels of service and managing backlog.

Figure 4 is an example of output from the model showing how the condition profile is changed over time from its current profile to its more optimal state. For this example (bridges) the level of service is 1 (no assets worse than condition grade 3) therefore all orange is backlog. The policy settings in this test data allow a small but reducing percentage of backlog in the long term.

The model identifies the annual renewals cost and the annual average for each decade. In this example the model indicates a reducing renewals cost as the asset moves...
towards a more cost-efficient condition profile. Note that the examples in this paper reflect growth in the asset base which has been input into the model.

![Condition profile change over time](image)

**FIGURE 2** Condition profile change over time

### 3.4 Risk and backlog management

Risk is incorporated into the model in two ways:

- by setting the condition-based level of service (the renewals intervention point). This is a first response to risk and reflects the tolerance for risk for each asset and was discussed earlier.
- by setting the time to address backlog. This reflects the tolerance for backlog risk over time for each asset. This has an impact on cost and condition.

The model incorporates a 'years to address backlog' variable that reduces backlog to zero over a set number of years and maintains it at zero thereafter. Backlog in this context is anything that falls below the level of service intervention point in any year. The examples shown in figures 4 to 7 identify the cost and condition impacts of setting different amounts of time to address the existing backlog.

### 3.5 Trade-offs

The model enables setting of asset management policies based on the specific requirements of each asset class such as:

- condition profile to be achieved in the long term
- condition-based level of service required (renewals intervention point)
- number of years allowed to address backlog i.e. achieve desired levels of service (level of acceptance of backlog risk)

The model uses these policies to identify the annual renewal needs for each asset class. However, it also provides the reverse process i.e. the input of annual budgets for each asset class to identify the condition and backlog consequences that result. This provides for direct testing of trade-offs between:
• funding availability
• level of service required
• level of backlog that can be accepted based on risk criteria such as criticality, movement and public perception considerations.

This function can provide decision-makers with a better understanding of the relationship between cost, level of service and risk for each asset class and across the portfolio as whole.

An example of the input of specific annual budgets and the consequential cost and condition is shown in Figure 8.

3.6 Maintenance
Renewals interventions are timed to minimise reactive maintenance costs and the risk associated with very poor condition assets. There is a strong link between renewals and maintenance but this is not yet quantified and used in this version of the model. It will be incorporated in future development.

3.7 Outputs
Typical outputs from the model are shown in figures 4 to 8. These show condition and renewals cost outputs and are used to inform decision making on policy settings at the asset level. These outputs are used by decision makers in several ways:

• to understand the cost of condition-based levels of service
• to understand future renewals liability
• to assess the risks associated with current and future backlog
• to test the condition and risk consequences of specific budget scenarios
• to provide a consistent basis for trade-offs of cost, condition and risk across the asset portfolio
• To inform decision-makers of condition and risk consequences of different budget scenarios.

4 Further improvements
The renewals model has been reviewed by Auckland University for its general approach and has received a very positive assessment. Their report states that 'significant value has already been achieved by the development of the renewal model, and this approach could well become best practice not only in New Zealand but also internationally'.

The model has also been tested for its detailed functioning by an external specialist. Nevertheless it is still a work in progress and a programme of refinements and improvements is on-going. Planned improvements include:

• Refinement of current and future condition profiles including stochastic analysis
• Refinement of the deterioration modelling process
• Increased granularity of analysis
• Maintenance impacts upon deterioration profile and useful life
• Multi-criteria analysis of broader asset significance to levels of service rather than just condition to inform renewals intervention. This includes additional factors against each asset type such as loading, risk, criticality, location and customer satisfaction.

The model is currently maintained as an Excel spread sheet but it is intended that it be developed as a stand-alone application on another platform.

5 Conclusion

The Auckland Transport portfolio renewals model is an integrated approach to understanding the relationship between condition-based levels of service, cost and condition-based risk across all classes of assets in the transport portfolio. It provides a long-term baseline of renewals needs and a consistent basis for renewals decision-making.

It is not intended to replicate other detailed and specialised analyses undertaken for individual assets in the network. What it does provide is:

• an investment path for changing the condition of the assets to a lower cost steady state condition profile over the long-term. This normalises existing variations in condition-based levels of service and backlog across the network.
• an understanding of long-term renewals cost pressures between asset classes across the portfolio
• visibility of condition-based risk resulting from existing and future backlog
• a mechanism for direct testing of trade-offs between funding, level of service and level of backlog risk.

The asset management assumptions and policy settings used in the model are set by consensus among Auckland Transport asset specialists and local managers. These will continue to be improved to give decision-makers confidence that the underlying asset management assumptions and policies reflect the high level long term behaviour and requirements of the network.

The model is currently providing executive decision makers with the long term baseline costs of managing renewals on the Auckland Transport network.
## 6 Recommendations

<table>
<thead>
<tr>
<th>Specific Recommendations</th>
<th>Suggested Action to be Taken</th>
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<tr>
<td>Its recommended that options for asset renewals be developed using an approach based on asset condition, risk profile and acceptable level of backlog.</td>
<td>AT's renewal model to be made available for wider RCA use in the future.</td>
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<tr>
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<td>RCA's may consider implementing similar approach for establishing options for asset renewals</td>
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7 Feedback

1) Consideration of Economic Justification

The model outputs are performance based outputs – Using condition based Levels of Service as an intervention point for renewals.

Economic justification of the decision to renew is also to be justified through the model.

Increased maintenance and targeted repairs may be an alternative to full renewal to rectify the levels of service and it can be economically more attractive.

This aspect will be considered in the model improvements planned for 2014/15.

2) Selection of the Levels of Service intervention triggers

It has been pointed out that the levels of service intervention points of LOS 1 and LOS 2 are too high and networks will struggle to afford that level of investment needs.

What was demonstrated in the model is current approach of Auckland Transport and is subject to change. The advantage of this model is that these intervention points can be changed and the impact on investment needs can be seen instantaneously

3) Definition of Backlog

Backlog is defined as the portion of assets that lie outside the levels of service intervention point.

One of the key model outputs is the distribution of backlog over time for different funding scenarios.

Backlog distribution has been found to be useful to highlight the consequences of different options.

4) Consistency of Condition Grading Systems and Methodologies

Accuracy of model outputs depend heavily on the availability of robust condition information based on the 1-5 grading system recommended by the NAMS IIMM manual.

Having accurate and up to date condition data is vital for the success of the model outputs.

Auckland transport is developing standardised guidelines for the survey, capture and storage of condition data for all asset groups.
5) Optimisation of Renewals

Renewal activities that minimise the risk of unexpected asset failure, maintain assets at an acceptable condition and enhance safety and performance are regarded as optimised renewal activities for Auckland Transport.

The model outputs can satisfy this requirement for the development of renewal activities as the methodology incorporated these optimisation principles.

Also the levels of service based outputs (performance outputs)) are regarded as optimised renewal programmes because they provide an asset condition profile close to the optimal distribution after the “Backlog clearance period”

6) Aligning with ONRC requirements

This renewal tool can be used to model the impact of ONRC requirements. More work will need to be done to facilitate this ability.

7) Web Based Application

AT intends to transform this renewal tool to a web based application in the near future.
8 Appendices

Renewal Model Outputs
FIGURE 3 Setting 1 year to address backlog

FIGURE 4 Setting 5 years to address backlog
FIGURE 5 Setting 30 years to address backlog

FIGURE 6 Setting 50 years to address backlog
### FIGURE 7 Constrained budget trade-off - showing cost vs. condition

| Headings          | 2016 result | 2017 result | 2018 result | 2019 result | 2020 result | 2021 result | 2022 result | 2023 result | 2024 result | 2025 result | 2026 result | 2027 result | 2028 result | 2029 result | 2030 result | 2031 result | 2032 result | 2033 result |
|-------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Renewals cost     | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $6,000,000  | $6,000,000  | $6,000,000  | $5,000,000  | $5,000,000  | $4,495,712  | $1,734,561  | $1,641,390  |
| Percentage outside LOS | 21.90% | 24.87% | 26.54% | 27.12% | 25.69% | 21.82% | 16.86% | 12.49% | 8.72% | 6.78% | 4.49% | 2.09% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Renewals actual   | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $7,000,000  | $6,000,000  | $6,000,000  | $5,000,000  | $5,000,000  | $5,000,000  | $5,000,000  | $5,000,000  |

FIGURE 7 Constrained budget trade-off - showing cost vs. condition