Impact of various maintenance strategies on unsealed road deterioration to achieve an acceptable maintenance budget & road performance

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Outline

• Introduction
• Unsealed road models
• Network & detailed data
• System setup – models, LOS, PCI, etc
• Results
• Summary
• Recommendations
Introduction - NT

NT Pop = 0.25 mill  
NT area = 1.42 mill sq km

Texas Pop = 27 mill  
Texas area = 0.7 mill
Introduction

• NTDoT wanted a PMS for their unsealed road network to
  ▪ establish a long-term stable budget
  ▪ have a sustainable road network
  ▪ develop maintenance strategies to achieve above

• Existing PMS platform dTIMS
Unsealed road models

• Unsealed road models based on a local road deterioration study (LRDS) provided:
  ▪ roughness (IRI) model (m/km)
  ▪ gravel loss (GL) model (mm)
  ▪ shape loss (SL) model (% change in X-fall)

• Above fit to data \( (r^2 = 0.09 \text{ to } 0.59) \)

• Independent variables statistically significant
## Network and detailed data

<table>
<thead>
<tr>
<th><code>Road Class</code></th>
<th>Flat bladed (km)</th>
<th>Formed (km)</th>
<th>Gravel (km)</th>
<th>Total (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural - Local</td>
<td>516.60</td>
<td>869.69</td>
<td>535.31</td>
<td>1921.59</td>
</tr>
<tr>
<td>Rural - Secondary</td>
<td>1069.33</td>
<td>2400.26</td>
<td>2345.62</td>
<td>5815.22</td>
</tr>
<tr>
<td>Rural - State Arterial</td>
<td>5.87</td>
<td>361.12</td>
<td>595.03</td>
<td>962.03</td>
</tr>
<tr>
<td>Urban - Local</td>
<td>6.34</td>
<td>3.20</td>
<td>0.82</td>
<td>10.36</td>
</tr>
<tr>
<td>Urban - Primary Arterial</td>
<td>2.28</td>
<td></td>
<td></td>
<td>2.28</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1598.14</strong></td>
<td><strong>3636.55</strong></td>
<td><strong>3476.78</strong></td>
<td><strong>8711.48</strong></td>
</tr>
</tbody>
</table>
## Network and detailed data

<table>
<thead>
<tr>
<th>Inventory data provided</th>
<th>Condition and traffic data provided</th>
<th>Presumptive values to initiate analysis (when no data supplied)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Road Number</strong></td>
<td>Gravel depth</td>
<td>110 mm</td>
</tr>
<tr>
<td>From</td>
<td>P075</td>
<td>-</td>
</tr>
<tr>
<td>To</td>
<td>MMP</td>
<td>70 mm</td>
</tr>
<tr>
<td><strong>Region</strong></td>
<td>ADT</td>
<td>500</td>
</tr>
<tr>
<td><strong>Width</strong></td>
<td>ADL</td>
<td>-</td>
</tr>
<tr>
<td><strong>Road Class</strong></td>
<td>PCT_COMM (% commercial vehicles)</td>
<td>30</td>
</tr>
<tr>
<td><strong>Surface type</strong></td>
<td>IRI</td>
<td>3</td>
</tr>
<tr>
<td><strong>Width</strong></td>
<td></td>
<td>7.5 m</td>
</tr>
<tr>
<td><strong>Growth</strong></td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td><strong>Crossfall</strong></td>
<td></td>
<td>3%</td>
</tr>
<tr>
<td><strong>Pct Shape Loss</strong></td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>
System setup – Models and CI

- Models – GL, IRI and SL used to predict future conditions
- Condition Index (CI) produced by transformation of:
  - GD, IRI & SL to Index values, e.g. for IRI
System setup – Level of Service (LOS) settings

• Expressed as Index range from very good (0-1) to very poor (4-5) for GD, SL & IRI

• Use of Index for LOS connects community acceptability with condition measures

• Further refinement of Index range possible to match community’s acceptance
### System setup – LOS levels for Index values & Road Types

#### INDX_CI_Gdepth

<table>
<thead>
<tr>
<th>Index description</th>
<th>INDX value</th>
<th>Rural State Arterial</th>
<th>Rural Secondary</th>
<th>Rural Local</th>
<th>Urban Primary</th>
<th>Urban Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>0-1</td>
<td>200-150</td>
<td>200-150</td>
<td>200-150</td>
<td>200-150</td>
<td>200-150</td>
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<tr>
<td>Good</td>
<td>1-2</td>
<td>150-125</td>
<td>150-125</td>
<td>150-125</td>
<td>150-125</td>
<td>150-125</td>
</tr>
<tr>
<td>Fair</td>
<td>2-3</td>
<td>125-100</td>
<td>125-100</td>
<td>125-100</td>
<td>125-100</td>
<td>125-100</td>
</tr>
<tr>
<td>Poor</td>
<td>3-4</td>
<td>100-50</td>
<td>100-50</td>
<td>100-50</td>
<td>100-50</td>
<td>100-50</td>
</tr>
<tr>
<td>Very poor</td>
<td>4-5</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
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</tbody>
</table>

#### INDX_CI_SL

<table>
<thead>
<tr>
<th>Index description</th>
<th>INDX value</th>
<th>Rural State Arterial</th>
<th>Rural Secondary</th>
<th>Rural Local</th>
<th>Urban Primary</th>
<th>Urban Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>0-1</td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
<td>0-5</td>
</tr>
<tr>
<td>Good</td>
<td>1-2</td>
<td>5-7</td>
<td>5-7</td>
<td>5-7</td>
<td>5-7</td>
<td>5-7</td>
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<tr>
<td>Fair</td>
<td>2-3</td>
<td>7-10</td>
<td>7-10</td>
<td>7-10</td>
<td>7-10</td>
<td>7-10</td>
</tr>
<tr>
<td>Poor</td>
<td>3-4</td>
<td>10-20</td>
<td>10-20</td>
<td>10-20</td>
<td>10-20</td>
<td>10-20</td>
</tr>
<tr>
<td>Very poor</td>
<td>4-5</td>
<td>&gt;20</td>
<td>&gt;20</td>
<td>&gt;20</td>
<td>&gt;20</td>
<td>&gt;20</td>
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</table>

#### INDX_CI_IRI

<table>
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<tr>
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<th>Rural Secondary</th>
<th>Rural Local</th>
<th>Urban Primary</th>
<th>Urban Local</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
<td>0-1</td>
<td>0-3</td>
<td>0-3</td>
<td>0-3</td>
<td>0-3</td>
<td>0-3</td>
</tr>
<tr>
<td>Good</td>
<td>1-2</td>
<td>3-5</td>
<td>3-5</td>
<td>3-5</td>
<td>3-5</td>
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<tr>
<td>Fair</td>
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<td>5-10</td>
<td>5-10</td>
<td>5-10</td>
<td>5-10</td>
<td>5-10</td>
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<tr>
<td>Poor</td>
<td>3-4</td>
<td>10-15</td>
<td>10-15</td>
<td>10-15</td>
<td>10-15</td>
<td>10-15</td>
</tr>
<tr>
<td>Very poor</td>
<td>4-5</td>
<td>&gt;15</td>
<td>&gt;15</td>
<td>&gt;15</td>
<td>&gt;15</td>
<td>&gt;15</td>
</tr>
</tbody>
</table>
System setup – PCI Index

• Is a composite index by aggregating condition indicators (CI) Index value

• CIs used for gravel depth, roughness & shape loss
PCI setup – PCI Index

PCI = \( \text{MAX}(w_i \times Index_i) + \rho \left( \frac{\text{SUM}(w_i \times Index_i) - \text{MAX}(w_i \times Index_i)}{\Sigma(w_i) - \text{Avg}(w_i)} \right) \)

\( w_i \) = weight for individual condition criteria
  = 1 or 0 (where surface type is not gravel) for gravel depth
  = 1 for roughness
  = 1 for shape loss

\( Index_i \) = Index value for individual condition criteria for roughness, gravel & shape loss

\( \rho \) = condition factor (= 0.1)
System setup - treatments

- Rural State Arterial
  - 1 × full maintenance grade (FMG)
  - 1 × between batters (Half Maintenance Grade, HMG)
  - 2 × carriageway (Running Surface Grade, RSG)

- Rural Secondary
  - 1 × full maintenance grade (FMG)
  - 2 × carriageway (Running Surface Grade, RSG)

- Rural Local
  - 1 × between batters (Half Maintenance Grade, HMG)
  - 1 × carriageway (Running Surface Grade, RSG)
System setup - treatment triggers

- Annual composite re-gravelling: FMG to HMG and 1 – 2 RSG when gravel depth (GD) is < 100 mm
- Annual composite reshape treatments: FMG to HMG and 1 – 2 RSG when total shape loss (SL) is > 10%
- Annual grading: combination of varying frequencies of FMG to HMG and RSG applied yearly except when re-gravelling and reshaping triggered
System setup – works effects

- Works effects (WE) – impact on conditions from treatments
- Impact of WE improvement is area between ‘do-nothing’ and new performance due to treatment
Results – budget scenarios

- Treatment options varied with road class – each class analysed separately with separate budget scenarios
- Large number of treatment options limited analysis period to 5 years
- Unrestricted annual budget used showed existing annual budget did not meet required LOS on all road classes
- Annual $20 m network budget with optimised scenarios showed not all sections were treated annually
Results – network condition

• Some input data was assumed – actual funding needs could vary

• Network condition can change between condition data collection and analysis

• Results are indicative of potential achievements

• Examination of conditions (PCI) over analysis shows distribution of conditions with time
Results - network PCI distribution

PCI distribution for defined $20 m annual budget
Results - network PCI distribution

PCI distribution for unrestricted annual budget
Results – network funding

- Defined budget annual $20 m - most treatments were grading with different types and frequencies

- Unrestricted annual budget – more renewal and re-gravelling work

- Unrestricted annual budget $60 m – may have over-estimated unit rates or treatment regimes were not fully executed (annualised composite treatments)
Summary

- PMS developed for NTDoT unsealed road network
- Further PMS refinements recommended
Recommendations

- Review network database to combine short sections (< 100 m)
- Review annual composite treatments to make a wider range of choices for annual budget
- Adopt different treatments for different regions
- Refine calibration of models to reflect ‘wet’ and ‘dry’ regions
- Review unit cost rates to reflect regional differences
- Review triggers to closely reflect current practice
- Provide separate budgets for each region