OPTIMIZED PAVEMENT CAPITAL PLANNING

Presented by:
Roozbeh Rashedi, Ph.D.
Karolina Konarski, MASc., P.Eng.
Infrastructure Solutions Inc. (ISI)

Ontario-based, “ACCOUNTINEERING” company

Optimization Software

Road Network Capital Planning

Asset Management Planning

Asset Condition Assessment

Water/Wastewater Rate Studies
ISI’s Road Maintenance Survey

The most comprehensive survey of road maintenance practices ever undertaken in Canada, with 171 municipalities participating.

* Number of municipalities participated
Road Preventive Maintenance State-of-Practice

- In general, 98% of Canadian municipalities perceive preventive maintenance as an important and cost-effective approach to extending the service life of their pavement assets.
- Municipalities expect considerable cost savings, improved pavement condition and safety with preventive maintenance programs.
- While the survey demonstrates a clear appreciation for the importance of preventive maintenance, a majority of the municipalities do not sufficiently apply preventive maintenance treatments.
- Municipalities report that only 20% or less of their road network is currently maintained based on what respondents perceive to be best practices for preventive maintenance.
Observations and Comments

- Municipalities are being overly influenced by voter requests.
- Councils are following the advice of Road Needs Studies, where engineering companies recommend repairing worst roads for safety and other reasons, assuming an unlimited municipal budget.
- Simplistic pavement management systems or limited resources are used for analysis that prioritize capital projects based on poorest asset condition first.
- More education is critical. Public Works officials and municipal engineers need to communicate to municipal councils, finance officers, and the public the need to refocus on preventive maintenance.
- Better analytical tools are needed. Smaller municipalities need proper pavement maintenance programs and capital planning tools that can consider all aspects of preservation strategies including engineering, finance, and life cycle performance.
The Search for Better Capital Planning Tools

In 2014, ISI undertook a global search (Australia, UK, the United States) for capital planning software and interviewed 40+ companies.

- **University of Waterloo** is a leader in infrastructure and pavement management research.
- **More than two decades of research** on capital renewal optimization.
- Advanced optimization technology that is **patent pending** in US & Canada.
- True and powerful optimization technology with **multi-year** and **multi-constraint** analysis.
- Is capable of handling **very large-scale networks**.
- **Successfully tested** on variety of asset types (e.g., buildings, bridges, and roads).
- Can result in **7% to 17% cost saving** and **added performance**.
Why Optimization?

**Simple Ranking**
- Interventions are determined by current asset condition (worst-first).
- Sections are ranked based on their condition and budget is used until it is fully exhausted.

- **X** Multiple Criteria Decision Making
- **X** Maximize Long-Term Performance
- **X** Setting targets for the model
- **X** Multi-Constraint Analysis
- **X** Effect of investment timing

**Multi-Criteria Prioritization**
- Sections are prioritized using a variety of performance, economic, and safety factors. The analysis is performed on a year-by-year basis to identify the highest priority projects at each year.

- **✓** Multiple Criteria Decision Making
- **✓** Maximize Long-Term Performance
- **✓** Setting targets for the model
- **✓** Multi-Constraint Analysis
- **✓** Effect of investment timing

**Optimization**
- Multiple constraints are applied, with lowest life cycle cost and/or maximum performance as the objective. Ability to consider interventions across time that gives the ultimate investment efficiency.

- **✓** Multiple Criteria Decision Making
- **✓** Maximize Long-Term Performance
- **✓** Setting targets for the model
- **✓** Multi-Constraint Analysis
- **✓** Effect of investment timing

---

**Decreasing Model Complexity**

**Increasing Solution Quality**
Optimized Capital Planning Process

- **Database**
  - Pavilion Condition
  - Traffic
  - Pavilion Structure
  - Geospatial Data
  - Inventory Data

- **Data Verification**
  - **Macro-Prioritization Policies:**
    - Functional Class
    - Roadside Environment
    - Surface Type
    - MMS Class
    - Service Type

- **Micro-Prioritization**
  - Asset-by-Asset

- **Optimization**
  - Capital Plan Network Performance Scenario Comparison

- **Engineering Models:**
  - Performance Models
  - Decision Rules
  - Cost Data
  - Etc.
A Municipal Case Study

- Population: approx. 30,000
- Pavement Network: 360 Km
- Requires a 10-year pavement management and capital renewal plan
- Annual Budget approx. $2,000,000
- Infrastructure Deficit approx. $23,500,000
Network Performance: Optimization vs. Ranking

- 15% to 30% improvement over ranking solutions
- Millions of dollars in cost savings over the planning horizon
Scenario Comparison

Budget Scenarios

Macro Settings

<table>
<thead>
<tr>
<th>Function Class</th>
<th>Relative Importance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>100</td>
</tr>
<tr>
<td>Expressway</td>
<td>90</td>
</tr>
<tr>
<td>Major Arterial</td>
<td>80</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>70</td>
</tr>
<tr>
<td>Collector</td>
<td>60</td>
</tr>
<tr>
<td>Local</td>
<td>50</td>
</tr>
</tbody>
</table>

Socio-Economic

Optimization Results
Applied Treatments: Optimization vs. Worst-First

Extensive use of major rehab and reconstruction

Balanced allocation of fund across all sections with a focus on preventive treatments
Golder Associates Limited – Company Background

- We have been providing services for Canada’s road network since 1960
- Today we are more than 6,500 people in 165 offices on 6 continents, employee owned
- Consulting, design, environmental and construction services
- Sectors include:
  - Infrastructure
  - Mining
  - Manufacturing
  - Power
  - Oil and Gas
- Golder is built around technical excellence, commitment to our clients and employee ownership
**ISI – Golder Strategic Alliance**

- Utilize Golder’s road engineering and construction expertise to provide valuable inputs to the programming and implementation

- Tool needs to incorporate advanced mathematics and be based on sound engineering principles and real-world road construction expertise

- Golder’s technical inputs to include analyses of various pavement deterioration behaviors, development and refining of decision trees in treatment selection and pavement deterioration after treatment
Pavement Preservation: Cost Savings and Increased LOS

- Worst-first vs. Preventative Maintenance
- Example

![Graph showing cost comparison between Worst-first and Preventive Maintenance, with a $350K savings milestone.](image-url)
- $350,000 in savings over 20 years, and a much higher level of service over its life
- Need better Capital Planning Tool which recognizes the vast array of treatments available
Not possible to use one simplified curve for all roads in a network, results in poor analysis.

Important in budgeting; need accurate deterioration prediction capability from applying pavement deterioration curves to suit a particular road type, subgrade, traffic conditions, etc.

Select the most appropriate treatments at the best time, estimate improvement in pavement condition of the selected treatments and subsequent deterioration following treatments.

Optimized plan is verified through rigorous engineering analysis to confirm practicality and adequacy of selected treatment.
Pavement deterioration curves covering a wide spectrum of road classifications based on traffic, surface type, subgrade, etc.
Performance Models, Decision Trees & Cost Data

- Identifying available treatments and their associated cost taking into consideration locational variance and roadside environment
Significantly different treatments based on existing condition of road

Important that rehabilitation strategy is based on distresses observed, not only PCI value

PCI is not enough to rate the road condition, the program screens unsuitable treatments

Leads to more consistency between asset management and project specific road rehabilitation strategy
## Viable Options for Rehabilitation

### Example

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Road A</th>
<th>Road B</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCI</td>
<td>60 - Severe rutting, slight cracking</td>
<td>60 – no rutting, severe transverse cracking</td>
</tr>
<tr>
<td>40 mm Overlay</td>
<td>Yes (7 years)</td>
<td>Yes (5 years)</td>
</tr>
<tr>
<td>Mill &amp; Overlay</td>
<td>Yes (10 years)</td>
<td>Yes (9 years)</td>
</tr>
<tr>
<td>Slurry Seal</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Microsurfacing</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Microsurfacing with rut filling</td>
<td>Yes (9 years)</td>
<td>No</td>
</tr>
<tr>
<td>FDR and 90 mm HMA</td>
<td>Yes (20 years)</td>
<td>Yes (20 years)</td>
</tr>
</tbody>
</table>
Key Takeaways

- The need for raising awareness about the importance of preventive maintenance with a focus on both public and councils.

- Optimized Pavement Programming can save municipalities millions of dollars and provide a higher level of service to the community.

- Engineering modeling and rigorous verification of inputs and outputs is at the heart of a robust capital planning tool.

- Reliable performance and cost models need to incorporate critical factors affecting physical performance and life cycle cost.

- Municipalities’ support as beta clients or advisory board members is a key to our success.