A Multi-Objective Asset Management Approach to Evaluate Maintenance Strategies for Funding Allocation

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Outline

• **Transportation Asset Management (TAM)**
  - TAM Challenges
  - Traditional and Modern Approach

• **Metropolitan Transportation Commission in California**
  - TAM and Metropolitan Transportation Commission

• **Enhanced StreetSaver Process with Sustainability Objectives**
  - Target Objectives and Performance Measures
  - Pavement Life-Cycle
  - Estimation of CO₂ Emissions from Vehicle Use Phase
  - Social Cost of CO₂

• **Case Study**

• **Conclusions**
Transportation Asset Management (TAM)

“Strategic and systematic process of operating, maintaining, upgrading and expanding physical assets effectively throughout their life cycle. It focuses on business and engineering practices for resource allocation and utilization with the objective of better decision making based upon quality information and well defined objectives.”

AASHTO Transportation Asset Management Guide, 2011
TAM Challenges

Physical
• Asset deterioration over time

Economic
• Funding gap

Social
• Growing population
• Increasing needs
• Maintain quality of life
• Human health
• Safety

Environmental
• Air pollution
• Depletion of non-renewable resources

Decision-Making
• Interdependency of Assets
• Multidimensional problem
• Different perspectives
• Uncertainty about future
Traditional and Modern Approach

- Performance-based
- Agency costs
  - More cost-effective to maintain pavements in good condition than to let them deteriorate (Witczak 1987)
  - Rehabilitation or reconstruction can be 6 to 10 times more expensive than timely preventive maintenance (Galehouse et al. 2006)

- Include environmental and social costs
- Environmental sustainability
  - Air
  - Natural resources
- Social sustainability
- Accommodate of all road users
Metropolitan Transportation Commission (MTC)

- Transportation planning, coordinating and financing agency
- San Francisco Bay Area, CA

- http://mtc.ca.gov/

StreetSaver®

- Computer-assisted decision-making program
- Designed to help cities and counties prevent pavement problems through judicious maintenance and
to diagnose and repair those that exist in a timely, cost-effective manner

- http://www.mtcpms.org/
TAM and MTC

- Pavement Section Inventory
- Needs Analysis
- Budget Scenario
- Target Driven Scenario
- Reporting
Enhanced StreetSaver Process with Sustainability Objectives

Pavement Section Inventory

Needs Analysis:
- Unlimited budget

Min. emissions and fuel consumption

Budget Scenario:
- Limited budget

Target Driven Scenario:
- Min. network avg. PCI
- Min. network avg. RSL
- Min. % in very good condition
- Max. % in poor condition

Sustainability Targets

Exceed emissions of the optimal maintenance program (Needs) by not more than __ %

Min. PCI for sections that carry mass transit lines, bikeways or in proximity of hospitals, schools, parks and commercial centers

Report to user sections with accident statistics above threshold

Report to user sections with livability rating below threshold

Current StreetSaver Process

Sustainability Objectives
- Reduce Vehicle Emissions
- Improve Safety
- Foster Livability

Reporting:
- Cost
- PCI
- RSL

On-road vehicle emissions and fuel consumption for each maintenance plan

Sections with accident statistics above threshold

Sections with livability rating below threshold
Enhanced StreetSaver Process with Sustainability Objectives

Sustainability Objectives
- Reduce Vehicle Emissions
- Improve Safety
- Foster Livability

Sustainability Targets
- Exceed emissions of the optimal maintenance program (Needs) by not more than ___ %
- Min. PCI for sections that carry mass transit lines, bikeways or in proximity of hospitals, schools, parks and commercial centers
- Report to user sections with accident statistics above threshold
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Target Objectives and Performance Measures

Economic
• Agency cost of pavement maintenance.

Social
• Change in condition of sections carrying mass transportation lines / bikeways.
• Social cost of CO$_2$

Environmental
• On-road vehicle fuel consumption estimated from pavement roughness.
• Emission (CO$_2$) reduction from on-road vehicles estimated from pavement.
Pavement Life-Cycle

- Materials Acquisition and Production
- Construction
- Vehicle Use

Emissions

- Maintenance & Rehabilitation
- End-of-Life / Recycling
Estimation of CO$_2$ Emissions from Vehicle Use Phase

- **Pavement Condition**
  - Convert to roughness
  - Estimate fuel consumption
  - Estimate emissions
  - Emissions from on road vehicles

- **Maintenance**
  - Cost of maintenance activity
  - User fuel cost
    - Benefits
      - social cost of CO2
      - user fuel savings
  - Agency cost
    - Costs
      - agency cost of maintenance
CO₂ Estimation using IPCC Emissions Factors

- **Pavement condition**
  - Convert to **International Roughness Index (IRI)**

- **Effect of roughness on fuel consumption**
  - HDM-4 fuel consumption adjustment factors for IRI levels
  - Source: Chatti and Zaabar 2010

- **Fuel consumed** [L/km]
  - Multiply by **Length of section**
  - Multiply by **Lower heating value** [gigajoule per liter]
  - Source: American Petroleum Institute

- **Carbon emission factor** [kilogram CO₂ per gigajoule]
  - Source: IPCC 2006

- **Estimate of CO₂ emissions based on pavement condition**

5/19/2015  9th International Conference on Managing Pavement Assets | May 18-21, 2015
Social Cost of CO₂ Emissions

Purpose

• “To incorporate the social benefits of reducing carbon dioxide (CO2) emissions into cost-benefit analyses.”

Interagency Working Group on Social Cost of Carbon, United States Government 2013

Definition

• “An estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year”

• “Net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.”
Case Study

Pavement Network

- 940 miles
- Asphalt concrete (AC)
- AADT 20,000 vehicles

Scenarios

- Optimal Scenario (unlimited funding)
- Do-Nothing Scenario
- No Preventive Maintenance (PCI 99-70, IRI 0.9-1.4)
Enhanced TAM with economic, environmental and social objectives will result in:

- Better balanced funding allocation decisions when developing maintenance strategies.
- Positive impact on air quality.
- Drivers benefit with expected fuel savings and safer roads.
- Incorporate accident statistics and livability rating in the funding allocation process when prioritizing investments.
- Address the needs of not only motorized vehicles but also cyclists and pedestrians.
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