Pavement Management Implementation: Success Stories for Maryland Counties

September 25, 2015

Aaron D. Gerber, P.E.

KERCHER ENGINEERING INC.
How Does Your Organization Manage Pavement Assets?
WE CANNOT SOLVE OUR PROBLEMS WITH THE SAME THINKING WE USED WHEN WE CREATED THEM

- Albert Einstein
By Customer Complaint?
Do You Know What You Own?
Do You Know the Network Condition?
What Defines a “Good” vs. a “Bad” Road?
Do You Know the Current Network Budget Need?
Can You Reasonably Predict the Future Network Condition and Budgetary Needs?

WHERE WE’RE GOING, WE DON’T NEED ROADS.
In Determining Projects, Do You Apply the 3R’s?

- Right Treatment
- Right Place
- Right Time
In Determining Paving Projects, Are You Proactive or Reactive?

Reacting to a problem after it arises

Preventing problems before they arise
Why Implement Pavement Management?

Identify the Long-Term Consequences of Today’s Funding Decisions

Show the Best Use of Limited Tax Dollars for Maintaining County Road Infrastructure
Why Implement Pavement Management?

Preserve Today That Which Will Cost More to Rehabilitate Tomorrow

Maximize User Benefit and Level of Service
Cost of Delaying Pavement Repairs

Age in Years

Excellent
Monitor
Preservation $26,500/mile

Good
Preservation
Minor Rehab $155,000/mile

Fair
Minor Rehabilitation
Major Rehab $264,000/mile

Poor
Major Rehabilitation

Very Poor
Reconstruction
Rebuild $500,000/mile

Condition

Costs:
- Minor Rehabilitation: $155,000/mile
- Preservation: $26,500/mile
- Major Rehabilitation: $264,000/mile
- Rebuild: $500,000/mile
Types of Management Methods

- **Worst First** – Sort the Network from worst condition to best condition, and start picking off the top of the list.

- **Prioritization** – Develop a weighting scheme to take into consideration additional elements into treatment selection. Create a list and start picking from the highest weighted road to the lowest.

- **Optimization** – Achieve an objective (maximize condition) given a set of constraints (budgets) to make best/optimal use of funds.
Power of Pavement Preservation
Comparisons of Optimization vs. Worst First
Analysis Results

- Scenario: $10 Million/Year for 10 Years
- Data Source: Carroll County
- Metric 1: Average Network Condition (PCI)
- Metric 2: % of Network Treated
- Metric 3: Backlog Cost of Untreated Network
Average Network Condition (PCI)

6 Point Drop in PCI by Year 10
User Benefit – % of Network Treated

Total Network Length = 903 Miles

Optimized 10 Year Treated Length = 704 Miles

Worst First 10 Year Treated Length = 325 Miles
Backlog Cost of Untreated Network

Diff in Backlog Cost in Year 10 = $54 Million
Maryland Counties Who Can Answer These Questions Effectively
Background

- County has implemented Pavement Management since mid-90’s
- Utilized a simplified Pavement Management System (PMS) to track pavement condition and repair costs
- Limited Functionality
  - No Predictive Modeling
  - No Budget Analysis Capability
  - Not Customizable to County needs
Background

- In 2011, County acquired state-of-the-art PMS software and consulting services through competitive bid
- Provides budget optimization capabilities and pavement performance prediction
- Provides vastly improved decision making capabilities within the department
Inventory Management

- County Maintains a Pavement Inventory Database
  - Network Mileage: Approx. 903 Centerline Miles of Paved Roads
- Many Attributes are stored:
  - Road Name
  - Geometric Info: Length, Width, etc.
  - Commissioner District
  - Maintenance District
  - Subdivision
Pavement Condition Surveys

- Windshield Survey – County Has Performed Pavement Condition Surveys Since the mid-90’s
- Improved Processes adopted in 2012
- Collecting Pavement Surface Distresses on Each Road in the Network
  - Distress Severity (How Bad)
  - Distress Extent (How Much)
  - Structural Distresses – Cracking, Rutting, Patches/Potholes
  - Functional Distresses – Cracking, Raveling, Weathering
Pavement Condition Index

- Pavement Condition Index (PCI) Calculated from Distresses
- 0 to 100 Scale
  - 100 = Perfect/New Condition
  - 71-85 = Satisfactory Condition Range
  - 0 = Not Passable
- Used for Performance Modeling
- Used for Repair Decision Making
- Used for Reporting Network Condition
Treatments

- Preservation
  - Micro-Surfacing
  - Ultra-Thin Overlay (Subdivision Streets)

- Rehabilitation
  - Thin Overlays: Mill & Fill, Patching & Overlay (< 2”)
  - Thick Overlays: Deep Patching & Thick Overlays (>2”)

- Reconstruction
  - Full Depth Reclamation
  - Remove & Replace
Decision Trees

Carroll County Decision Tree

- Pavement Condition Index < 20 → Treatment = Full Depth Reclamation (FDR)
- 20 ≤ Pavement Condition Index < 45
  - Classification = 3, 4, or 5 → Treatment = Rehab-Thick
  - Classification = 6 → Treatment = FDR
- 45 ≤ Pavement Condition Index < 65 → Treatment = Rehab-Thin
- 65 ≤ Pavement Condition Index < 80
  - Subdivision = Yes → Treatment = Ultra-Thin Overlay
  - Subdivision = No → Treatment = Microsurface
- Pavement Condition Index ≥ 80 → Treatment = Monitor
Pavement Performance Concept
Pavement Structure Review
Distressed Pavement Section
Pavement Structure Review
Treatment: Rehab-Thin
Pavement Structure Review
Treatment: Rehab-Thick

[Diagram of pavement structure with layers labeled Surface, New Wearing Course, New Binder Course, and Base Course]
Pavement Structure Review
Treatment: Removal and Replacement / FDR
Treatment Performance Relationship

- Initial Construction
- Rehabilitation - Thick
- Rehabilitation - Thin

Condition Index vs. Age graph.
2014 Network Statistics

- Total Network Length = 903 Miles
- Average Network PCI = 76.5
- Approx. Network Cost Backlog = $60 Million
- $/Mile = $67,000/mi
Multi-Constraint Optimization Analysis
Performance Model – Benefit Concept

Decision Tree Threshold Line

Original Performance Model Defined in Network Master By Model Category

CONDITION

Age or Traffic
Performance Model – Benefit Concept

- Decision Tree Threshold Line
- Original Performance Model Defined in Network Master
- Functional Rehab Model Thin Overlay Treatment Benefit = Area Under Curve (Yellow Area)
Performance Model – Benefit Concept

- **Decision Tree Threshold Line**
- **Original Performance Model**
  Defined in Network Master
- **Structural Rehab Model**
  Thick Overlay Treatment
  Benefit = Area Under Curve (Green Area)
Performance Model – Benefit Concept

- Thin Overlay = Less Benefit Area But Less Cost
- Thick Overlay = More Benefit Area But More Cost

- Original Performance Model Defined in Network Master
Optimization Goals

- Obtain the Best Set of Projects
  - The projects meet a set of constraints
  - Maximizes or minimizes an Objective (maximize condition, minimize budget, etc.)
- The desired OUTPUT of the analysis is a WORKPLAN, that is:
  - Which sections to fix (WHERE)
  - Using which treatments (WHAT)
  - In which year (WHEN)
Performance Monitoring Process

- DPW Goal – Maintain Network Average PCI between 71 and 85 (Satisfactory Level)
- Run Various Optimization Analyses to Test Funding Needs to Meet Goal
- Compare to CIP Budgeting Scenario to determine Funding Needs
- Determine the Best Funding Scenario to Minimize Backlog Cost while Maintaining PCI Goal
Performance Monitoring Process

- Specific Requests from Budget Office
  - What happens to the network if we cut your budget in half?
  - What happens to the network if we give you additional $2 Million?
  - How much money would you need to achieve a PCI of 80 during the CIP period?
Budget Comparisons – Network Condition

Satisfactory Condition
PCI Goal Range 71 to 85
Budget Comparisons – Network Cost Backlog

- Cut Budget $5 Million/Year and Incur Additional $84 Million Backlog
- Cut Budget $10 Million/Year and Incur Additional $171 Million Backlog
Backlog Mileage - $15 Million/Year Budget

Most Expensive Treatments
Minimal Mileage

Reconstruction  Rehab (Major)  Rehab (Minor)  Preservation
Backlog Mileage - $10 Million/Year Budget

Most Expensive Treatments:
Half of Mileage

- Reconstruction
- Rehab (Major)
- Rehab (Minor)
- Preservation
Backlog Mileage - $5 Million/Year Budget

Most Expensive Treatments
Majority of Mileage
Carroll County Summary

- Making good treatment choices – Using the 3Rs
- Justifying and maintaining appropriate funding levels
- Educating public officials on processes
- Staff dedicated to the success of the program
Background

- In the past, the County utilized a spreadsheet to track inventory and construction history of pavement network
- This didn’t provide forecasting capability or budget analysis
- In 2013, County acquired software and consulting services through bridge contracting
Pavement Condition Surveys

- Windshield Survey – Performed Pavement Condition Surveys in 2014
- Collecting Pavement Surface Distresses on Each Road in the Network
  - Distress Severity (How Bad)
  - Distress Extent (How Much)
  - Structural Distresses – Cracking, Rutting, Patches/Potholes
  - Functional Distresses – Cracking, Raveling, Weathering
Treatments

- Preservation
  - Micro-Surfacing
  - Slurry Seals
  - Chip Seals
  - Cape Seals

- Rehabilitation
  - Thin Overlays: Mill & Fill, Patching & Overlay (< 2”)
  - Thick Overlays: Deep Patching & Thick Overlays (>2”)

- Reconstruction
  - FDR/CIR
Wicomico County Decision Tree

Pavement Type = Asphalt

Pavement Condition Index < 35 → Treatment = Reconstruction
35 ≤ Pavement Condition Index < 50 → Treatment = Rehab-Thick
50 ≤ Pavement Condition Index < 65 → Treatment = Rehab-Thin
65 ≤ Pavement Condition Index < 85 → Treatment = Surface Coat
Pavement Condition Index ≥ 85 → Treatment = Monitor

Pavement Type = Tar & Chip

Pavement Condition Index < 40 → Treatment = Tar&Chip + FDR
40 ≤ Pavement Condition Index < 55 → Treatment = Tar&Chip + Asphalt Level
55 ≤ Pavement Condition Index < 65 → Treatment = Tar&Chip + Asphalt Patch
65 ≤ Pavement Condition Index < 85 → Treatment = Tar&Chip
Pavement Condition Index ≥ 85 → Treatment = Monitor
Performance Models

- Initial Construction
- Rehabilitation – Thick
- Rehabilitation – Thin

Condition Index vs. Age
2014 Network Statistics

- Total Network Length = 623 Miles
- Average Network PCI = 72.3
- Approx. Network Cost Backlog = $44 Million
- $/Mile = $71,000/mi
Performance Monitoring Process

- Compare various Budget Scenario Results
- Plot PCI for analysis period
- Identify Backlog Cost and Length
- Determine Budget Requests Based on Results
Integration with Local Towns and Cities

- Inventory includes towns and cities within County limits
  - 8 Towns and Cities included
- Allows for collaboration with other local agencies
- Provides agencies with ability to take advantage of powerful analytics
- Reduces local government costs for implementation
  - Potential for cost sharing
Wicomico County Summary

- Just getting started in the process
- Now has understanding of network condition and budgetary needs
- Ready to move to the next stage of development of the program
- Integrating towns and cities into the County processes a plus
Background

- County has implemented Pavement Management since mid-90’s
- Utilized a simplified Pavement Management System (PMS) to track pavement condition and repair costs
- In 2011, County acquired software and consulting services through bridge contracting
Inventory Management

- County Maintains a Pavement Inventory Database
  - Network Mileage: Approx. 1,208 Centerline Miles of Paved Roads (Asphalt + Tar & Chip)

- Many Attributes are stored:
  - Geometric Info: Length, Width, Shoulders, etc.
  - Jurisdiction, Functional Classification, AADT
  - Maintenance District, Subdivisions
  - Culverts, Guardrails
Pavement Condition Surveys

- Windshield Survey – Performed Pavement Condition Surveys Since the mid-90’s
- Improved Processes adopted in 2012
- Collecting Pavement Surface Distresses on Each Road in the Network
  - Distress Severity (How Bad)
  - Distress Extent (How Much)
  - Structural Distresses – Cracking, Rutting, Patches/Potholes
  - Functional Distresses – Cracking, Raveling, Weathering
Pavement Condition Index

- Pavement Condition Index (PCI) Calculated from Distresses
- 0 to 100 Scale
  - 100 = Perfect/New Condition
  - 70 = Threshold for Deficient
  - 0 = Not Passable
- Used for Performance Modeling
- Used for Repair Decision Making
- Used for Reporting Network Condition
Treatments

- Preservation
  - Micro-Surfacing
  - Slurry Seals
  - Chip Seals

- Rehabilitation
  - Thin Overlays: Mill & Fill, Patching & Overlay (< 2”)
  - Thick Overlays: Deep Patching & Thick Overlays (>2”)

- Reconstruction
  - Full Depth Reclamation
  - Remove & Replace
Parking Facilities Management

- Integration of parking lots owned and maintained by the County into PMP
- Includes condition assessment of each site
- Specific treatment configurations
- Specific decision trees and models
- Analysis and Reporting for facility managers based on facility maintenance budgets
**Decision Trees**

**Frederick County Decision Tree**

1. **Pavement Type = Asphalt**
   - **Pavement Condition Index < 35**: Treatment = Full Depth Reclamation (FDR)
   - **35 <= Pavement Condition Index < 50**: Treatment = Rehab-Thick
   - **50 <= Pavement Condition Index < 65**: Treatment = Rehab-Thin
   - **65 <= Pavement Condition Index < 85**: Treatment = Surface Coat
   - **Pavement Condition Index >= 85**: Treatment = Monitor

2. **Pavement Type = Tar & Chip**
   - **Pavement Condition Index < 40**: Treatment = Tar&Chip + FDR
   - **40 <= Pavement Condition Index < 55**: Treatment = Tar&Chip + Asphalt Level
   - **55 <= Pavement Condition Index < 65**: Treatment = Tar&Chip + Asphalt Patch
   - **Pavement Condition Index >= 85**: Treatment = Monitor

3. **Pavement Type = Parking Facilities**
   - **Pavement Condition Index < 25**: Treatment = Reconstruction
   - **25 <= Pavement Condition Index < 45**: Treatment = Rehab-Thick
   - **45 <= Pavement Condition Index < 70**: Treatment = Rehab-Thin
   - **70 <= Pavement Condition Index < 85**: Treatment = Surface Coat
   - **Pavement Condition Index >= 85**: Treatment = Monitor

© 2015 Kercher Engineering, Inc.
2014-2015 Network Statistics

- Total Network Length = 1,208 Miles
- Average Network PCI = 76.4
- Approx. Network Cost Backlog = $80 Million
- $/Mile = $66,000/mi
Performance Monitoring Process

- CIP Budgeting Scenario to determine Funding Needs
  - Bond Funds vs. Cash Funds
- Plot PCI condition over CIP Budget Period
  - Asphalt and Tar & Chip are Separate
- Identify Backlog Cost related to CIP Budget
- DPW Goal – Maintain 85% of Network above 70 PCI
- Determine Adjustments to Budget Requests Based on Results
Network Condition – by Pavement Type

Pavement Condition Index Trends by Pavement Type

Year

PCI


Asphalt  Tar & Chip  Total Network
Network Cost Backlog – Asphalt Network

Cost Backlog of Untreated Asphalt Network

Year
- 2016
- 2017
- 2018
- 2019
- 2020
- 2021

Backlog Cost
- $70,000,000
- $60,000,000
- $50,000,000
- $40,000,000
- $30,000,000
- $20,000,000
- $10,000,000
- $0

Surface Coat
Rehab-Thin
Rehab-Thick
Reconstruct
Network Cost Backlog – Tar & Chip Network

Cost Backlog of Untreated Tar & Chip Network

Year

2016
2017
2018
2019
2020
2021

Backlog Cost

$0
$2,000,000
$4,000,000
$6,000,000
$8,000,000
$10,000,000
$12,000,000
$14,000,000
$16,000,000
$18,000,000

TC+Patch
TC+Level
TC+FDR
Performance Goal Monitoring

Asphalt Network - 85% in Fair or Better Condition Performance Goal

<table>
<thead>
<tr>
<th>Year</th>
<th>Budget</th>
<th>% Acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>$11,862,700</td>
<td>79%</td>
</tr>
<tr>
<td>2017</td>
<td>$6,427,700</td>
<td>75%</td>
</tr>
<tr>
<td>2018</td>
<td>$9,977,700</td>
<td>74%</td>
</tr>
<tr>
<td>2019</td>
<td>$13,455,200</td>
<td>76%</td>
</tr>
<tr>
<td>2020</td>
<td>$14,223,600</td>
<td>76%</td>
</tr>
<tr>
<td>2021</td>
<td>$13,611,600</td>
<td>75%</td>
</tr>
</tbody>
</table>
Performance Goal Monitoring

Asphalt Network - 85% in Fair or Better Condition Performance Goal
Comparison Budget Results for FY15-21

<table>
<thead>
<tr>
<th>Year</th>
<th>Accounting Budget</th>
<th>Requested Budget</th>
<th>Goal Setting Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>$12,483,726</td>
<td>$12,861,581</td>
<td>$12,483,726</td>
</tr>
<tr>
<td>2016</td>
<td>$12,861,581</td>
<td>$13,205,920.00</td>
<td>$13,018,720.00</td>
</tr>
<tr>
<td>2017</td>
<td>$7,529,660</td>
<td>$13,018,720.00</td>
<td>$13,959,938.00</td>
</tr>
<tr>
<td>2018</td>
<td>$12,861,581</td>
<td>$13,972,400.00</td>
<td>$13,959,938.00</td>
</tr>
<tr>
<td>2019</td>
<td>$13,920,644</td>
<td>$13,982,800.00</td>
<td>$13,959,938.00</td>
</tr>
<tr>
<td>2020</td>
<td>$13,745,995</td>
<td>$13,982,800.00</td>
<td>$14,500,000.00</td>
</tr>
<tr>
<td>2021</td>
<td>$13,745,995</td>
<td>$13,982,800.00</td>
<td>$14,500,000.00</td>
</tr>
</tbody>
</table>

- Accounting Budget % Acceptable: 83% 82% 78% 79% 80% 79% 79%
- Requested Budget % Acceptable: 83% 82% 81% 81% 83% 83% 83%
- Goal Setting Budget % Acceptable: 83% 83% 82% 83% 84% 85% 85%
Frederick County Summary

- Making good treatment choices – Using the 3Rs
- Justifying and maintaining appropriate funding levels
- Staff dedicated to the success of the program at all levels
- Taking advantage of software flexibility with parking facilities integration
How Did These Counties Succeed Where Many Fail?
By Adopting Powerful Software Solutions

- Pavement Management can be a Complex Process
- Maintain quality software to Ease the Burden
- Use the Software to Identify Budgetary Needs and Make Objective Decisions
- Fund the Network Properly to Save Money in the Long Run
- Choose the Treatment 3R approach
- Integrate Other Assets into the PMS Software to Manage Broader Infrastructure Funding Needs
By Adopting Sound Engineering Processes

- PMS Software is only part of the Process
  - It is a tool to manage DPW’s policies and practices

- Comprehensive Pavement Management Program:
  - Field Testing
  - Pavement Design
  - Quality Contract Documents and Administration
  - Quality Construction Specifications
  - Thorough Construction Inspection
  - Continuous Pavement Health Monitoring
Now We’re Waiting on the Rest of You!
Thank You!

Aaron D. Gerber, P.E.

KERCHER ENGINEERING INC.

adg@kercherei.com