City of Cleveland
Pavement Management Data Collection & Lessons Learned

Road Profiler User’s Group
October 27, 2008
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Presentation Overview

• Project Requirements & Results
  – Scope
  – Schedule
  – Quality
• Lessons Learned
• Q&A
City of Cleveland

Project Description and Requirements
City of Cleveland Project Scope

- 1250 centerline miles of roadway, with a breakdown of:
  - 64 centerline miles of Principal Arterial
  - 137 centerline miles of Major Arterial
  - 110 centerline miles of Collector Roadways
  - 1,009 centerline miles of Local Roadways
  - The most current GIS files are available from the City

- “Data collection shall be highly automated using highest technology available”
City of Cleveland Project Scope

- Gather and provide pavement condition information
  - Define street sectioning
  - Perform surface condition survey using GPS, lasers and video to measure roughness, rutting, cracking, texture and distress
  - Provide PCR per ODOT specs
  - Measure and record pavement width
  - Provide visual condition rating (1-5) for curbs & sidewalks
  - FWD testing to assess structural properties, including analysis and structural indices
City of Cleveland Project Scope

- Gather and provide digital images of ROW
  - Three views
  - Collection interval of 25 feet (maximum)
  - Geo-coded for use in GIS/RoadManager
  - Complete coverage of the ROW assets:
    - Travel lanes
    - Signs & Supports
    - Curbs
    - Sidewalks
    - Manholes
    - Hydrants
    - Storm Inlets
    - Curb & Gutters
    - Light Poles
    - ADA Ramps
    - Guardrails
    - Driveway Aprons
    - Pave. Markings
    - Trees
    - Traffic Signals
City of Cleveland Project Scope

• **Software and systems related**
  – Provide turn-key solution with RoadManager RPMS and ArcGIS data model
  – Provide RoadManager system training
  – Provide software for asset extraction using digital images

• **Business Process Change**
  – Mayor Jackson wanted to change roadway budget process from population based to needs based.
  – Perform an unbiased assessment of needs using third party and automated rating techniques
Project Scope – In Summary

- To include all 1250 centerline miles of roadway
- To gather and provide:
  - Pavement condition information
  - Digital images of ROW
  - Information on roadway assets
- To provide integrated solution using RoadManager RPMS
- To provide software for asset extraction using digital images
City of Cleveland

Project Approach
Data Collection: RT 3000

- All data collected at posted speed
- Testing does not impede flow of traffic
- 100% of roadways tested, no sampling
- Automation and real-time processing used to the maximum extent
Surface Distress Evaluation
Line Scan Images

- Distress rating of both severity and extent by image analysis
- Distress quantities precisely measured
## Data Collection: RT 3000 Data Attributes

<table>
<thead>
<tr>
<th>Data Element</th>
<th>System Used</th>
<th>Reporting Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roughness</td>
<td>Class I profiler (ASTM E950)</td>
<td>IRI in inches/mile in each wheelpath and Average IRI in inches/mile.</td>
</tr>
<tr>
<td>Rutting</td>
<td>Transverse profile using 5 lasers</td>
<td>Rut depth in inches. Report will be average rut or rut for each wheelpath depending upon option requested.</td>
</tr>
<tr>
<td>Right-of-Way Digital Images</td>
<td>Geo-3D Kronos using 3 ROW Cameras angled at customers preference</td>
<td>Filename reference within database deliverable. Images to be saved as jpeg format.</td>
</tr>
<tr>
<td>Pavement Digital Images</td>
<td>Line Scan Camera</td>
<td>Filename reference within database deliverable. Images to be saved as jpeg format.</td>
</tr>
<tr>
<td>Faulting and Raveling/Texture</td>
<td>32 kHz Laser</td>
<td>Mean Profile Depth (MPD) in millimeters. Equivalent to Mean Texture Depth (MTD).</td>
</tr>
<tr>
<td>Geometrics (optional)</td>
<td>POS/LV Inertial Positioning and orientation system</td>
<td>Heading in degrees. Grade and crossfall in percent slope.</td>
</tr>
<tr>
<td>GPS (advanced technology)</td>
<td>POS/LV Inertial Positioning and orientation system</td>
<td>X, Y, and Z coordinates. Coordinate system to be determined based on Department’s requirements.</td>
</tr>
</tbody>
</table>
Sample ROW Images
Geo-3D (Trimble) Trident Analyst

Attribute Data/Relationships

Lon, Lat, Alt
Stantec’s RT Viewer

![RT Viewer Interface]

- ID: 30680
- Name: HAMILTON AVE
- Street From: 17TH ST
- Street To: 10TH ST
- Image Location: \2.jpg\dayah11\dayah11\_00545.JPG

The interface includes a start button, continue button, and an image location field. The images displayed are related to the road conditions on HAMILTON AVE between 17TH ST and 10TH ST.
Environments Encountered
Project Management Challenge

Scope

Quality

Schedule

Cost

Risk
City of Cleveland

Project Schedule
City of Cleveland Project Schedule

• Advertised requirements:
  – Consultant selection July 5, 2007
  – NTP on August 24, 2007
  – Substantially complete in December

• In actuality:
  – Consultant selection in August 2007
  – NTP on September 5, 2007
  – Signed contract in December
  – Data delivery.....longer than expected
City of Cleveland Project Schedule

- Concerns with starting in October
  - Limited amount of daylight in Nov & Dec
  - Leaves
  - Weather
  - Impending snow season
City of Cleveland Project Schedule

PERT Technique for Estimating Schedules

- The technique and its procedures were developed in the late 1950s jointly by the Special Projects Office of the U.S. Navy (Polaris Program) and Booz-Allen-Hamilton in conjunction with the Lockheed Missiles System Division.

- A probabilistic approach is used to calculate the critical path and other parameters — based on a scheme of making three time estimates for each task.

- Expresses uncertainty in activity duration
  - Beta distribution assumed for activities
  - Assume normally distributed project duration
  - Project duration tends to be Normally Distributed (approx. sum of random variables)
  - Assumes independent Activity Durations (not always the case)
PERT Technique (continued)

\[ t_o = \text{Optimistic time to complete an activity} \]
\[ t_p = \text{Pessimistic time to complete an activity} \]
\[ t_m = \text{Most probable time to complete an activity} \]

Then the “expected” time, \( T_i \), to complete an activity is

\[ T_i = \frac{t_o + 4t_m + t_p}{6} \]

and the standard deviation, \( S_i \) is

\[ S_i = \frac{t_p - t_o}{6} \]

and the variance, \( V_i = S_i^2 \)
PERT Technique (continued)

(a) calculate the expected time $T_i$ for each activity
(b) calculate the standard deviation for each activity
(c) determine the ratio

$$Z = \frac{D - T_E}{S_T}$$

- where $T_E = \sum_{i=A}^{J} T_i$ is the total expected time to complete
- the project, and

$$V_T = \sum_{i=1}^{J} S_i^2$$

is the total variance in total project completion time.

(d) using the z-table, determine the number of days $d$ needed to complete the project with a given probability (say, 90%).
Beta Distribution

- **Optimistic Time** = $t_o$
- **Expected Time** = $T_i$
- **Most likely Time** = $t_m$
- **Pessimistic Time** = $t_p$
- **Probability density function**
  - **Completion time of task** $t_i$
# Normal Z-distribution Table

<table>
<thead>
<tr>
<th>$Z$</th>
<th>Probability of meeting completion date</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>.999</td>
</tr>
<tr>
<td>2.8</td>
<td>.997</td>
</tr>
<tr>
<td>2.6</td>
<td>.995</td>
</tr>
<tr>
<td>2.4</td>
<td>.992</td>
</tr>
<tr>
<td>2.2</td>
<td>.986</td>
</tr>
<tr>
<td>2.0</td>
<td>.977</td>
</tr>
<tr>
<td>1.8</td>
<td>.964</td>
</tr>
<tr>
<td>1.6</td>
<td>.945</td>
</tr>
<tr>
<td>1.4</td>
<td>.919</td>
</tr>
<tr>
<td>1.2</td>
<td>.885</td>
</tr>
<tr>
<td>1.0</td>
<td>.841</td>
</tr>
<tr>
<td>1.0</td>
<td>.841</td>
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<tr>
<td>1.0</td>
<td>.841</td>
</tr>
<tr>
<td>1.0</td>
<td>.841</td>
</tr>
<tr>
<td>1.0</td>
<td>.841</td>
</tr>
</tbody>
</table>
City of Cleveland Project Schedule

- **Estimate for 2500 miles of roadway collection**
  - 128 miles of Principal Arterial
  - 274 miles of Major Arterial
  - 220 miles of Collector Roadways
  - 2018 miles of Local Roadways

- **Principal Arterial**
  - $t_o$ = Optimistic time to complete activity = 2
  - $t_p$ = Pessimistic time to complete activity = 6
  - $t_m$ = Most probable time to complete activity = 3

Expected time = $T_{PA} = \frac{2 + 4(3) + 6}{6} = 3.3$ days

$S_{PA} = \frac{6 - 2}{6} = 0.67$

Do same for other roadways
## City of Cleveland Project Schedule

<table>
<thead>
<tr>
<th>Activity</th>
<th>Expected Time</th>
<th>Variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Arterial</td>
<td>3.3 days</td>
<td>0.45</td>
</tr>
<tr>
<td>Major Arterial</td>
<td>6.8 days</td>
<td>1.36</td>
</tr>
<tr>
<td>Collector Roads</td>
<td>6.2 days</td>
<td>1.36</td>
</tr>
<tr>
<td>Local Road</td>
<td>69 days</td>
<td>87.1</td>
</tr>
</tbody>
</table>
# City of Cleveland Project Schedule

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<td>1.36</td>
</tr>
<tr>
<td>Local Road</td>
<td>69 days</td>
<td>87.1</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>85.6 days</strong></td>
<td><strong>90.3</strong></td>
</tr>
</tbody>
</table>

\[ T_E = 86 \text{ d} \]

\[ S = (V)^{1/2} \]

\[ S = 9.5 \]
City of Cleveland Project Schedule

- Actual roadway collection
  \[ T_{Actual} = 154 \text{ calendar days} \]
  (not including winter shutdown)

What happened?

\[ T_{Actual} = T_{collecting} + T_{bad\ wx} + T_{equipment\ down} + T_{no\ crew} \]

- \[ T_{collecting} = 94 \text{ days} \]
- \[ T_{bad\ wx} = 39 \text{ days or 26\%} \] (not including winter shutdown)
- \[ T_{equipment\ down} = 17 \text{ days or 11\%} \]
Roadway Mileage Collected by Week

- Miles/week
- Cum. Miles

Winter Shutdown:
- 10/1
- 10/2
- 11/1
- 11/2
- 12/1
- 12/2
- 1/1
- 1/2
- 1/3
- 2/1
- 2/2
- 2/3
- 3/1
- 3/2
- 3/3
- 4/1
- 4/2
- 4/3
- 5/1
- 5/2
- 5/3
- 6/1
- 6/2
- 6/3
- 7/1
- 7/2
- 7/3
- 8/1
- 8/2
- 8/3
- 8/4
City of Cleveland
Pavement Management Demonstration Project

Project Quality
Data Quality Assurance Program

- **Overall quality monitoring process**
  - Used QES to perform independent rating on a 10% random sample
  - Rating and scoring procedures were verified using Cleveland requirements
  - Identified control sites for each pavement type and determined expected variability (City, Stantec & QES raters)
  - Established 95% confidence level
  - Different statistics for different data sets
- **Unacceptable data would be reprocessed (if needed)**
- **Prepared summary of QA results**
Ashpalt Pavement Samples
PCR Quality Assurance Plot

Sample Number

QES-Stantec PCR
Jointed Concrete Pavement Samples
PCR Quality Assurance Plot

Sample Number

QES-Stantec PCR

1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53
Brick Pavement Samples
PCR Quality Assurance Plot

Sample Number

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15

QES-Stantec PCR

-10 -8 -6 -4 -2  0  2  4  6  8  10
## Summary of QA Results

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th># Samples Compared</th>
<th>% Passing PCR Check</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick</td>
<td>19</td>
<td>100</td>
</tr>
<tr>
<td>Flexible</td>
<td>701</td>
<td>96.4</td>
</tr>
<tr>
<td>Rigid</td>
<td>70</td>
<td>95.7</td>
</tr>
</tbody>
</table>
IV&V Charts for VDOT District 4
Asphalt Interstate Pavements
City of Cleveland
Pavement Management Demonstration Project

Lessons Learned
Lessons Learned

• **Scope**
  – Network of 1250 centerline miles had large quantities of distressed pavement

• **Schedule**
  – Late/early season work is challenge (snow, daylight, etc)
  – Equipment breakdowns were exacerbated by slow speeds & short sections
  – Delays impacted client and we worked proactively

• **Quality**
  – Quality Management processes used successfully
  – High quality data delivered and documented
Questions and Answers