City of Cleveland Pavement Management Data Collection & Lessons Learned

Road Profiler User's Group
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One Team. Infinite Solutions.

Stantec

VHB QES

Presentation Overview

- **Project Requirements & Results**
  - Scope
  - Schedule
  - Quality
- **Lessons Learned**
- **Q&A**

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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	**Light Poles**
Signs & Supports	**ADA Ramps**
Curbs	**Guardrails**
Sidewalks	**Driveway Aprons**
Manholes	**Pave. Markings**
Hydrants	**Trees**
Storm Inlets	**Traffic Signals**
Curb & Gutters	

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**

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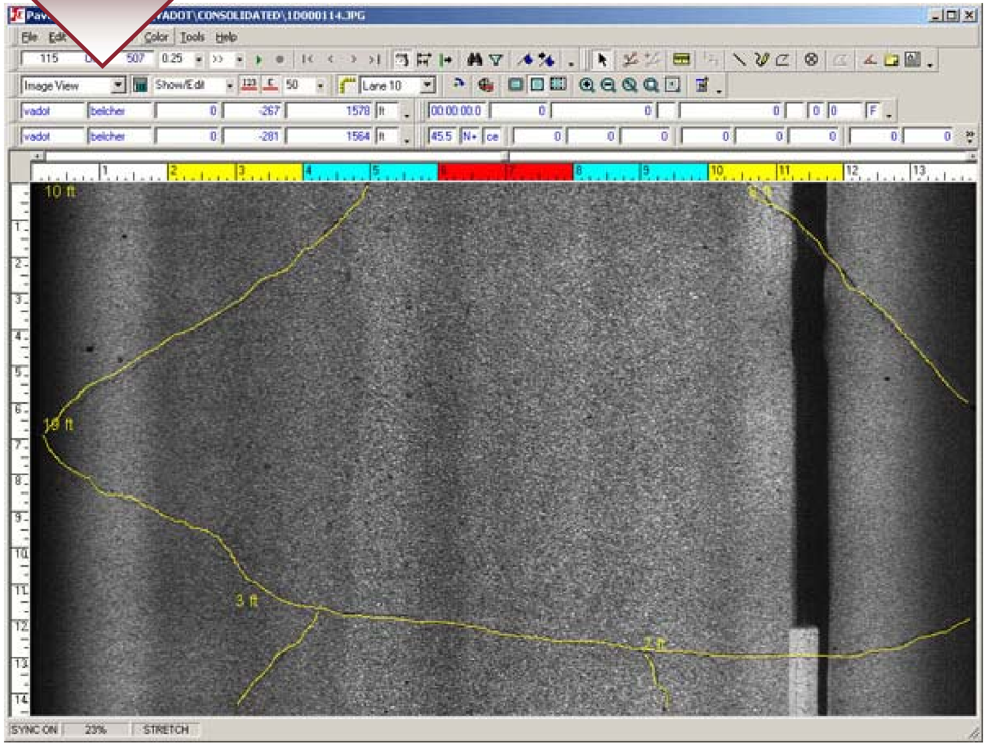
Project Approach

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



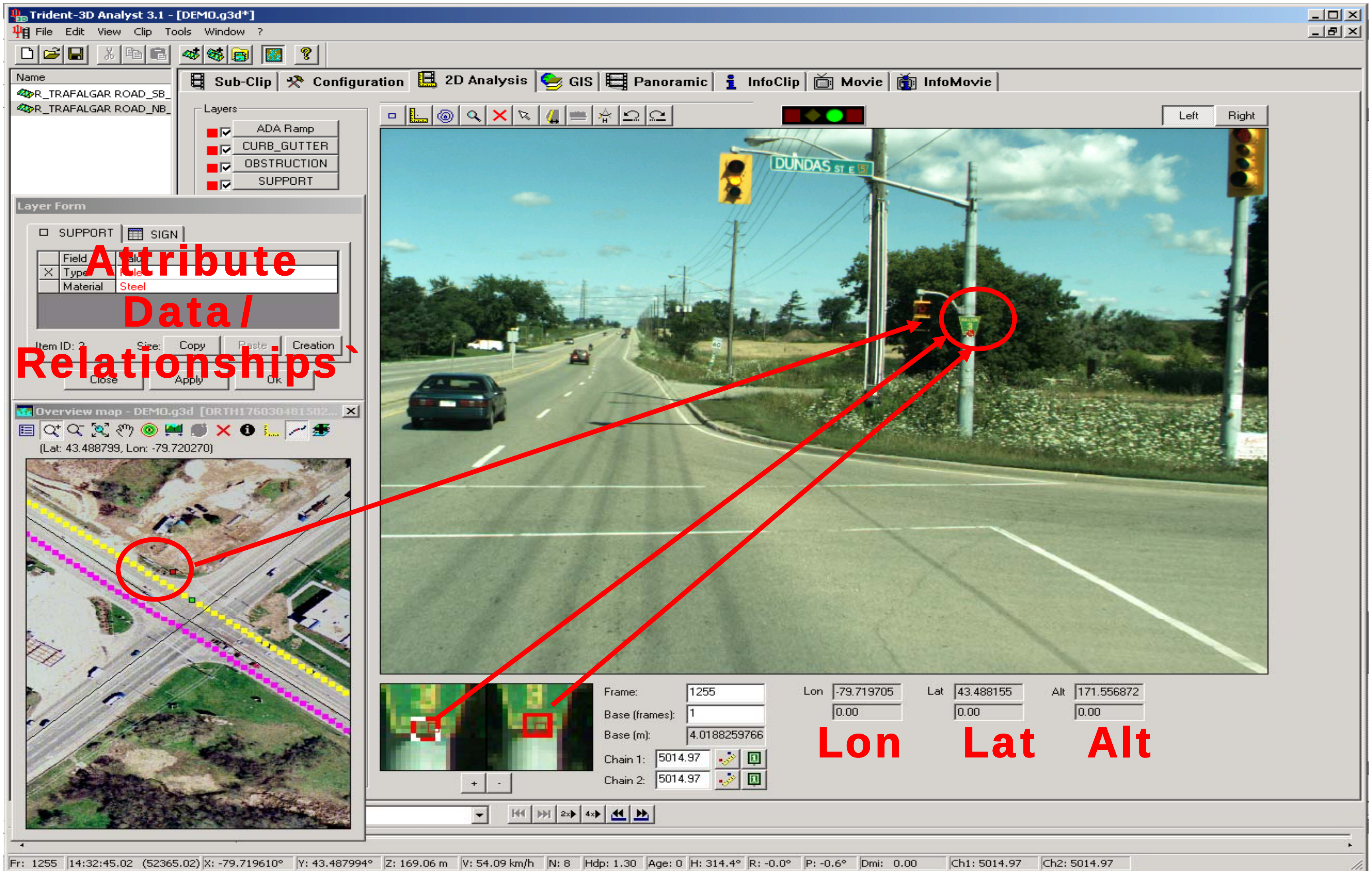
- Distress rating of both severity and extent by image analysis
- Distress quantities precisely measured

Data Collection: RT 3000 Data Attributes

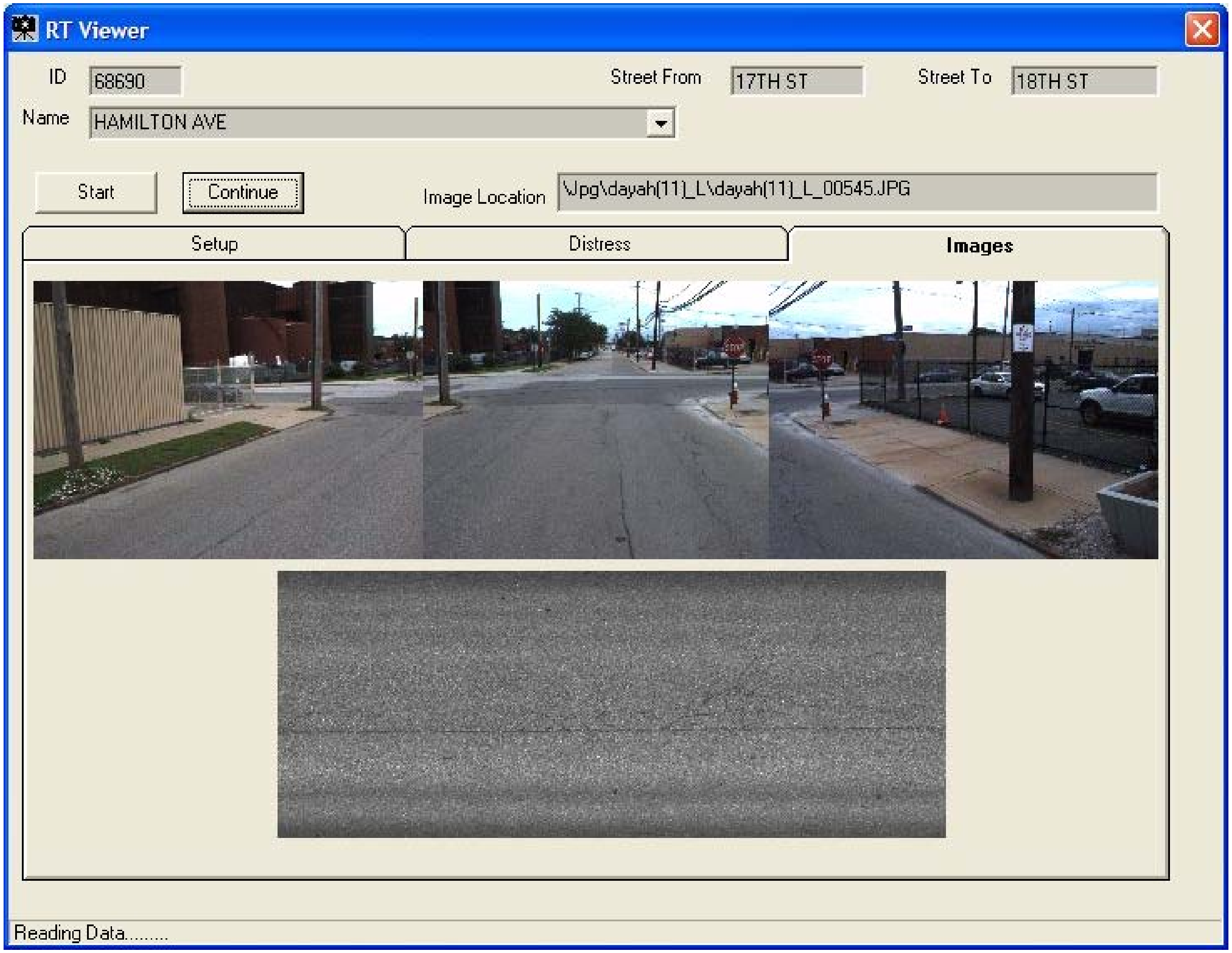
Data Element	System Used	Reporting Format
Roughness	Class I profiler (ASTM E950)	IRI in inches/mile in each wheelpath and Average IRI in inches/mile.
Rutting	Transverse profile using 5 lasers	Rut depth in inches. Report will be average rut or rut for each wheelpath depending upon option requested.
Right-of-Way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

Sample ROW Images

Geo-3D (Trimble) Trident Analyst



Stantec’s RT Viewer



Environments Encountered

Project Management Challenge

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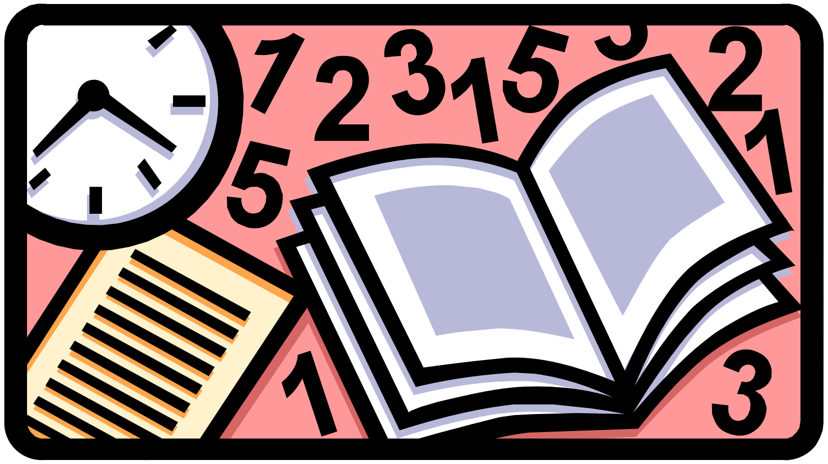
Project Schedule

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)

City of Cleveland Project Schedule

PERT Technique (continued)

t_o = Optimistic time to complete an activity

t_p = Pessimistic time to complete an activity

t_m = 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, $V_i = S_i^2$

City of Cleveland Project Schedule

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

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

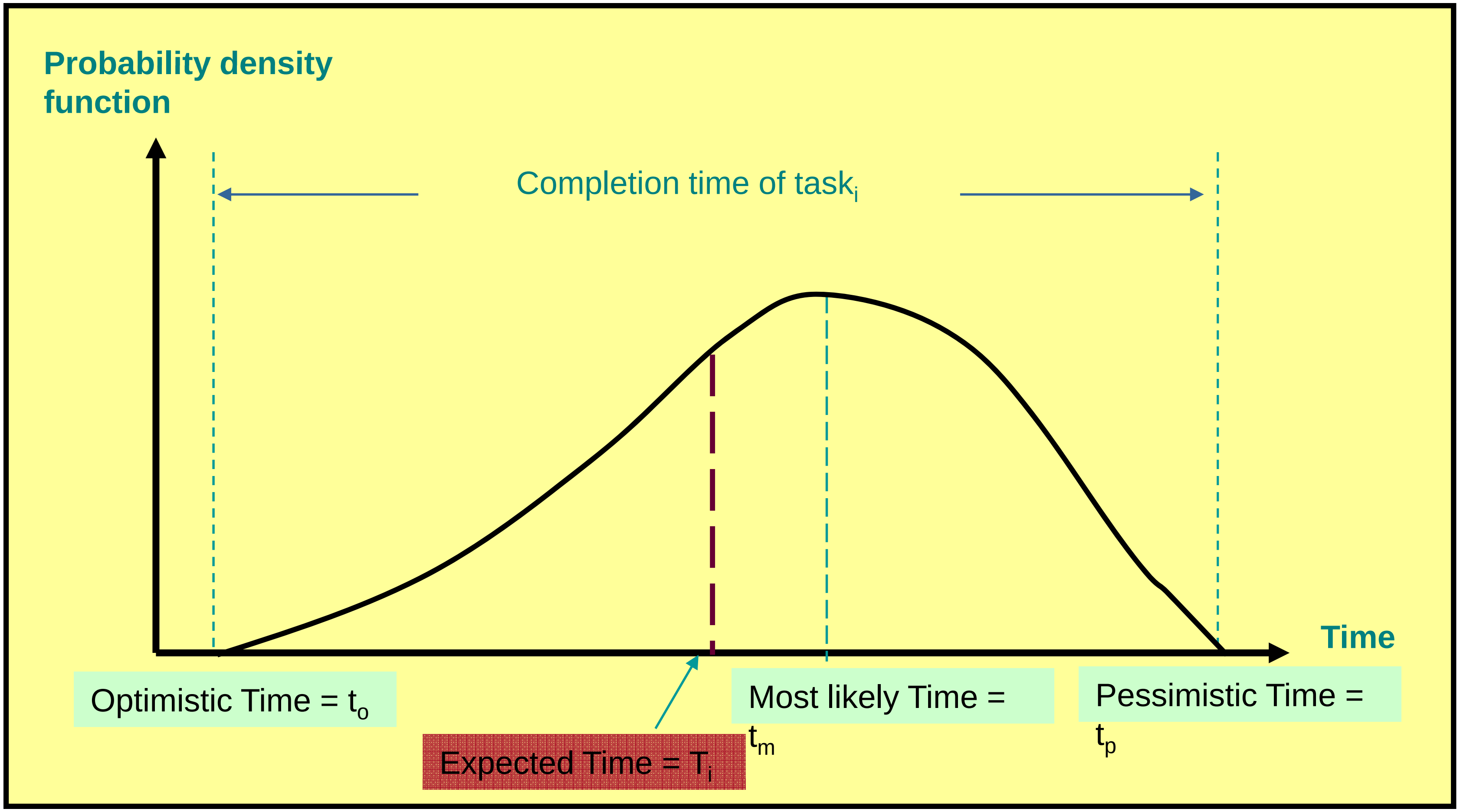
- where $T_E = \sum_{i=A}^{J} T_i$ is the total expected time to complete
- the project, and

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

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



Normal Z-distribution Table

Z	Probability of meeting completion date
3.0	.999
2.8	.997
2.6	.995
2.4	.992
2.2	.986
2.0	.977
1.8	.964
1.6	.945
1.4	.919
1.2	.885
1.0	.841

.8	.788
.6	.726
.4	.655
.2	.579
0	.5
-.2	.421
-.4	.345
-.6	.274
-.8	.212
-1.0	.159
-1.2	.115
-1.4	.081
-1.6	.055
-1.8	.036
-2.0	.023

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

$$S_i = \frac{t_p - t_o}{6}$$

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

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} = [2 + 4(3) + 6] / 6 = 3.3 days

S_{PA} = [6 - 2] / 6 = 0.67

Do same for other roadways

City of Cleveland Project Schedule

Activity	Expected Time	Variance
Principal Arterial	3.3 days	0.45
Major Arterial	6.8 days	1.36
Collector Roads	6.2 days	1.36
Local Road	69 days	87.1

City of Cleveland Project Schedule

Activity	Expected Time	Variance
Principal Arterial	3.3 days	0.45
Major Arterial	6.8 days	1.36
Collector Roads	6.2 days	1.36
Local Road	69 days	87.1
Sum	85.6 days	90.3

$T_E = 86$ d

$S = (V)^{1/2}$

$S = 9.5$

City of Cleveland Project Schedule

- **Actual roadway collection**

  T_{Actual} = 154 calendar days
  (not including winter shutdown)

What happened?

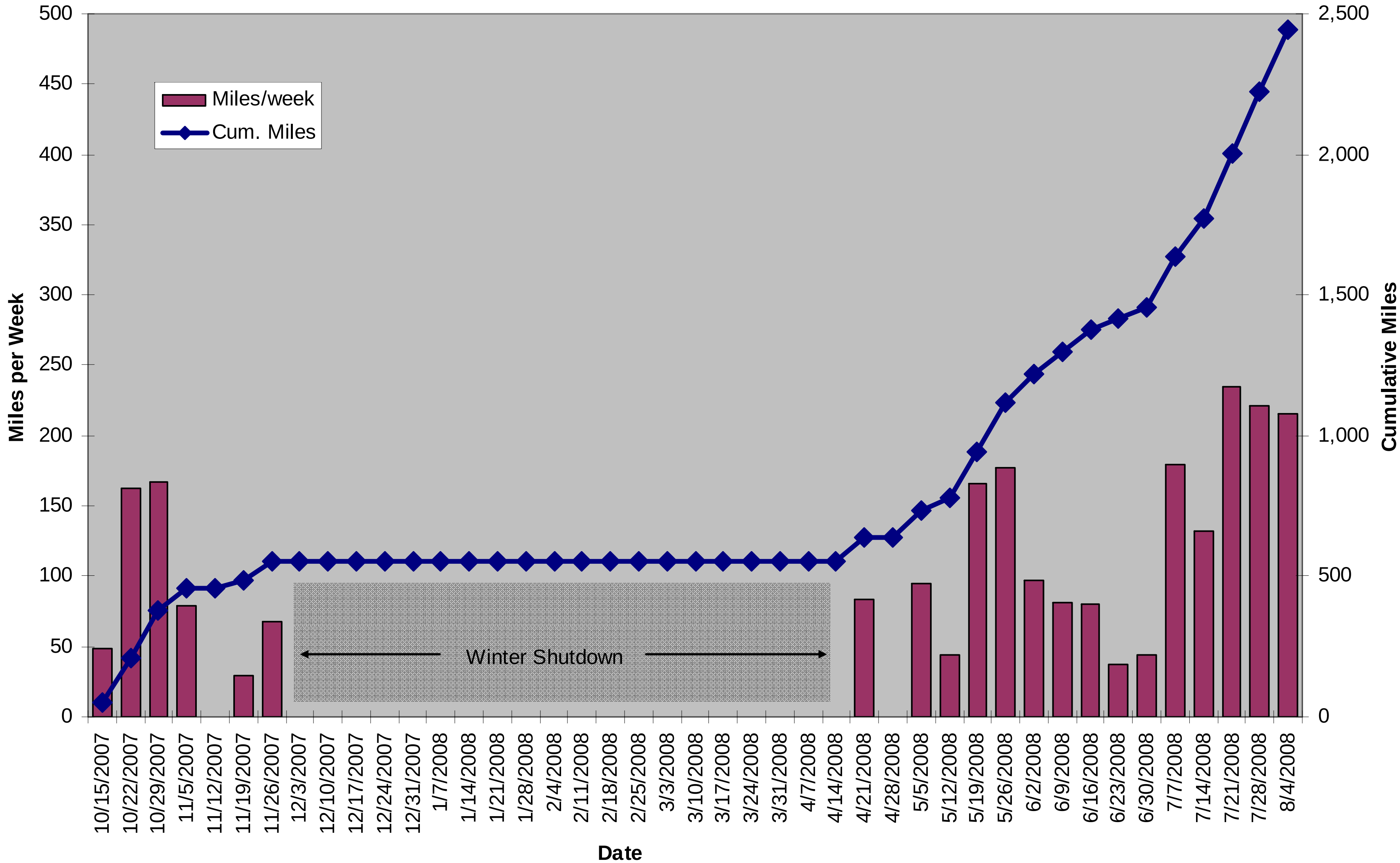
$T_{Actual} = T_{collecting} + T_{bad\ wx} + T_{equipment\ down} + T_{no\ crew}$

$T_{collecting}$ = 94 days

$T_{bad\ wx}$ = 39 days or 26% (not including winter shutdown)

$T_{equipment\ down}$ = 17 days or 11%

Roadway Mileage Collected by Week



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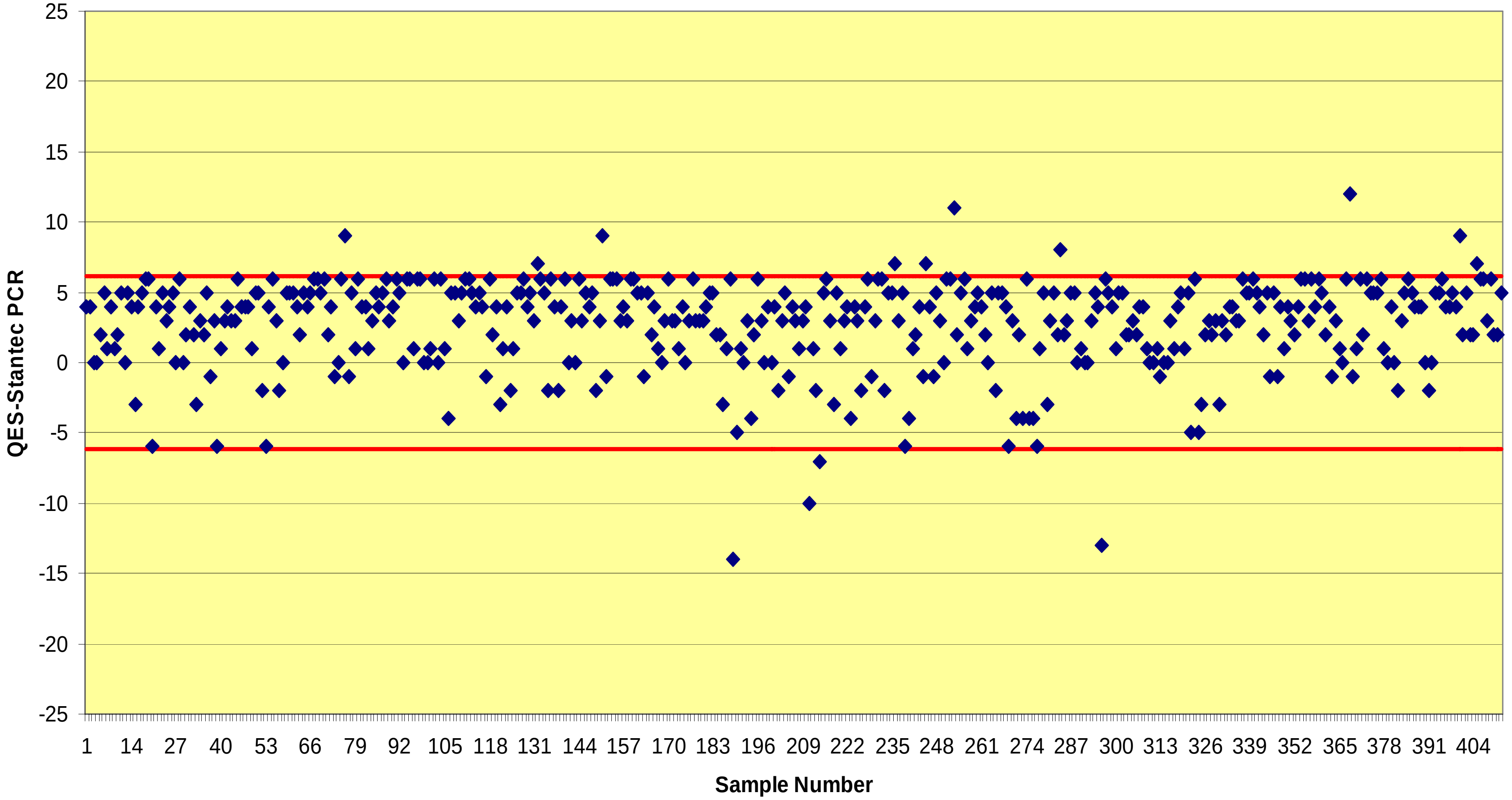
Pavement Management Demonstration Project

Project Quality

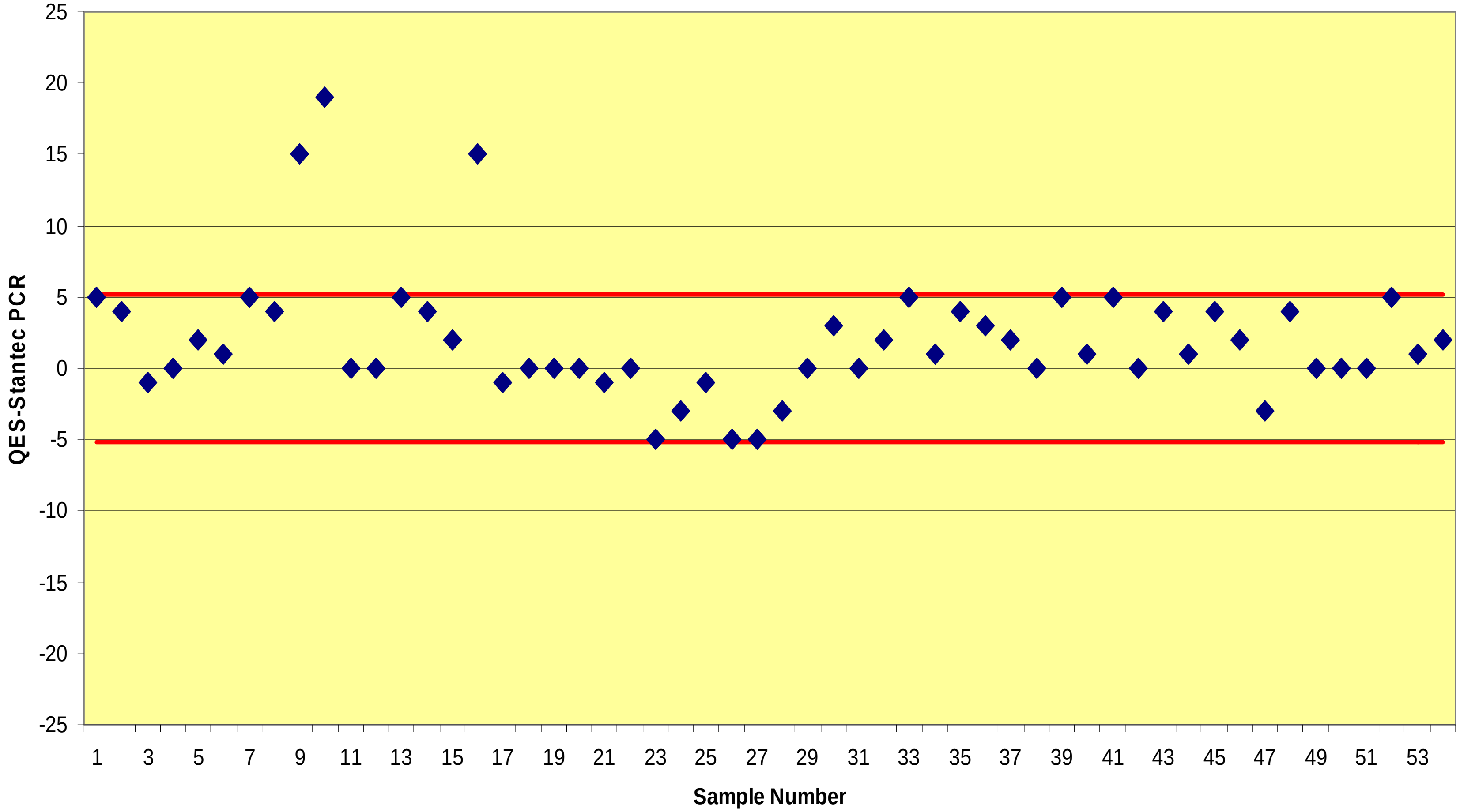
Data Quality Assurance Program

- **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**

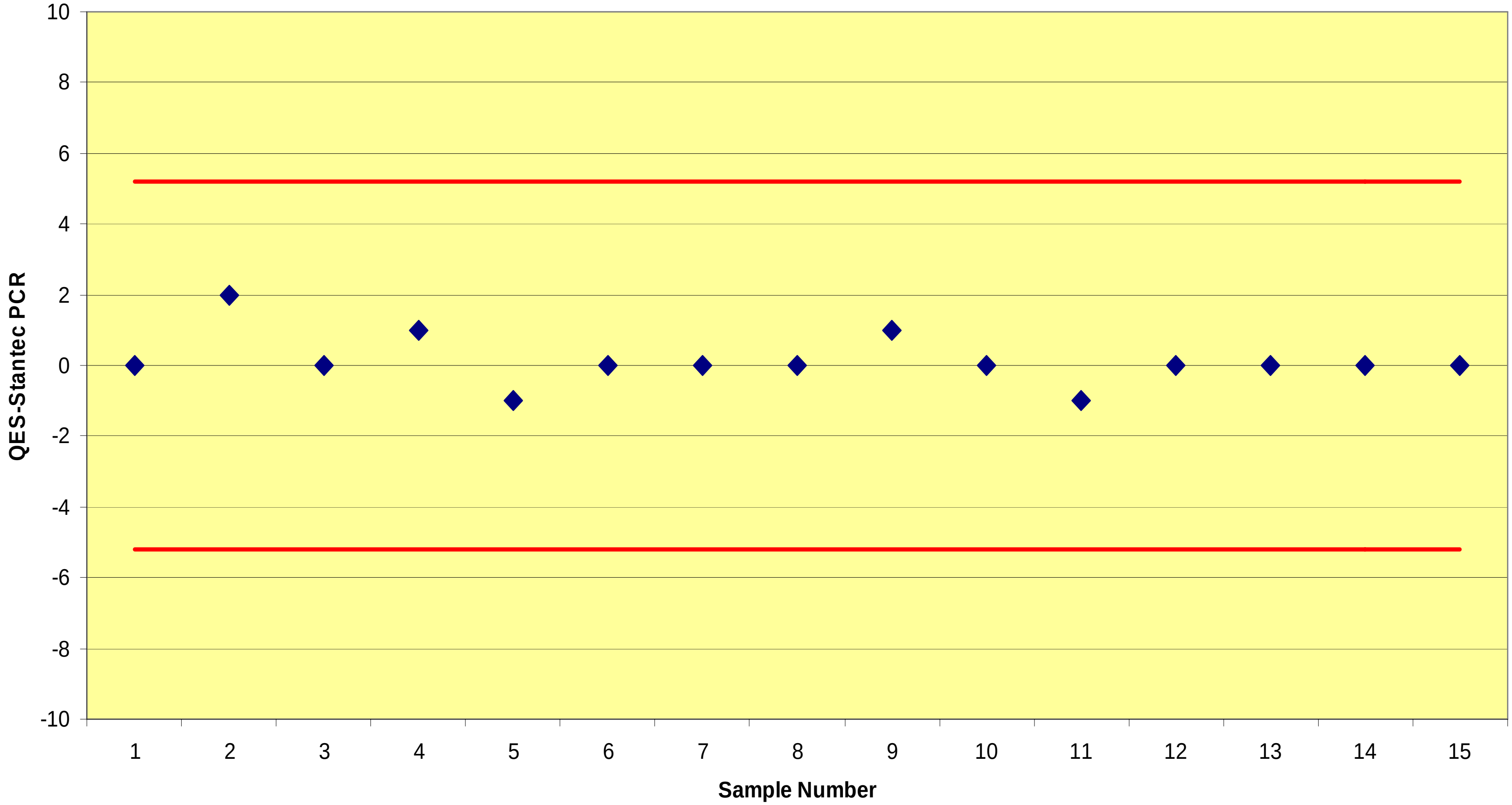
Ashpalt Pavement Samples
PCR Quality Assurance Plot



Jointed Concrete Pavement Samples
PCR Quality Assurance Plot

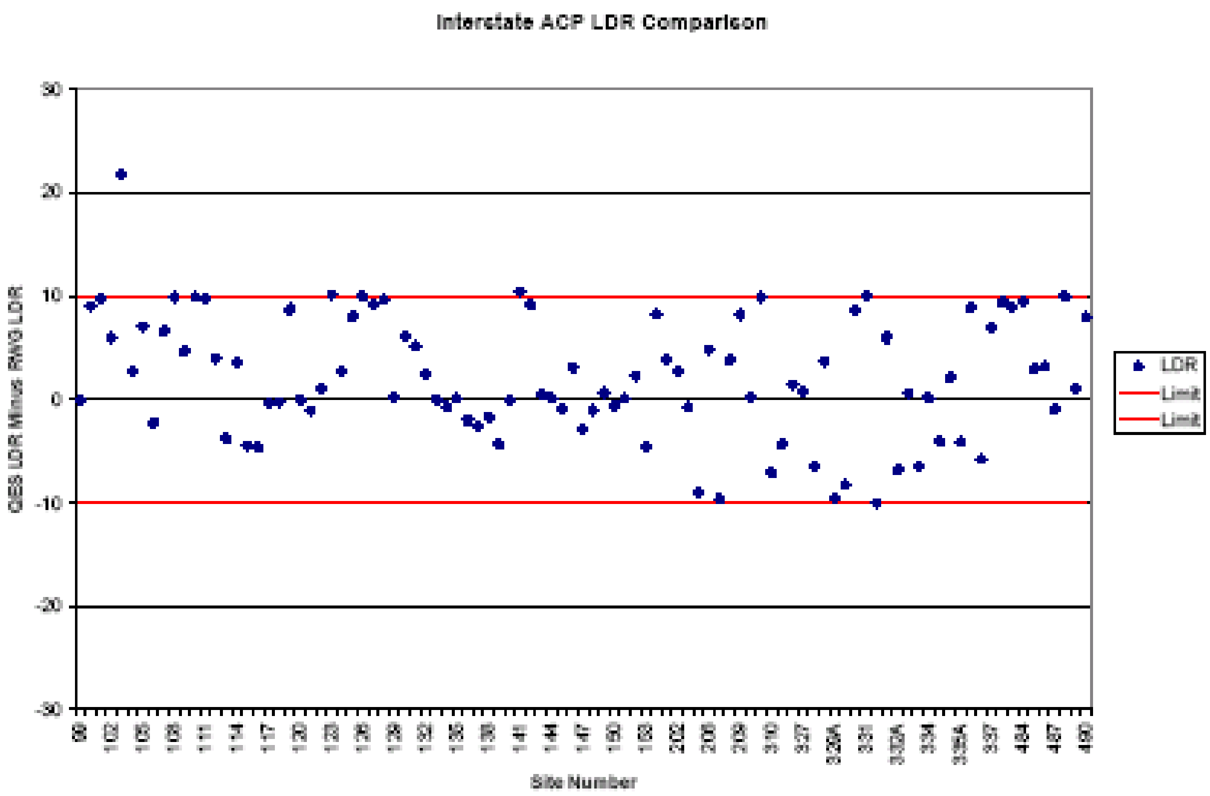


Brick Pavement Samples
PCR Quality Assurance Plot



Summary of QA Results

Pavement Type	# Samples Compared	% Passing PCR Check
Brick	19	100
Flexible	701	96.4
Rigid	70	95.7



IV&V Charts for
VDOT District 4
Asphalt Interstate Pavements

City of Cleveland

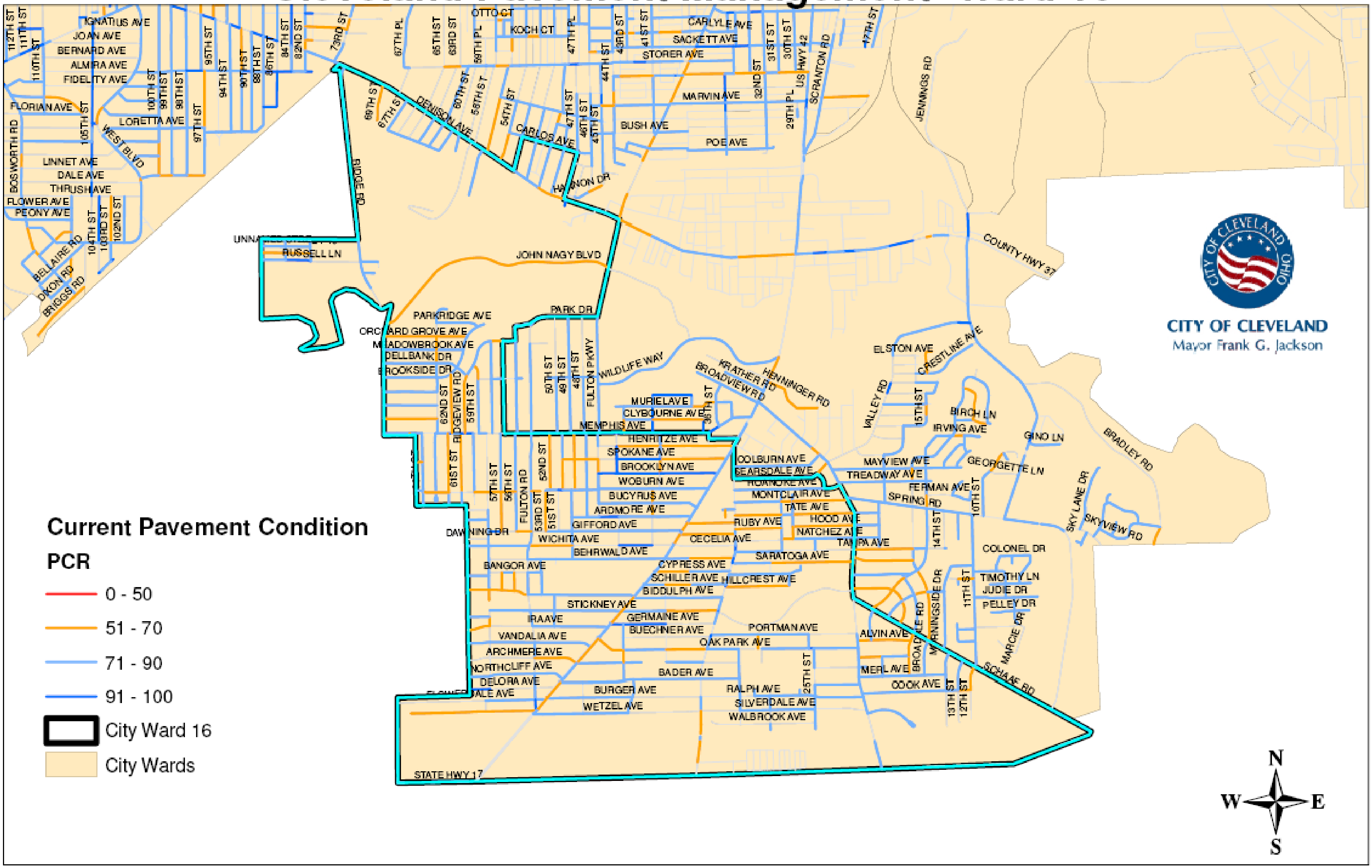
Pavement Management Demonstration Project

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

Cleveland Pavement Management- Ward 16



Data Collection Findings Through February 2008

Questions and Answers