Network-Level Automated Pavement Condition Assessment Using 3D-Laser Imaging (LCMS) Data: New Jersey Case Study

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Abstract

Pavement Management Systems (PMS) rely on accurate and consistent pavement condition data to support effective maintenance and rehabilitation (M&R) planning. Typical pavement condition data includes: Roughness Data (International Roughness Index –IRI-) and obtained using a full-inertial profiler; Rut Data, expressed as the depth of pavement surface depression in the wheel path, and, Surface Distress Data, rated in terms of distress type, severity, and quantity in accordance with certain standards and converted into a composite distress index. Traditionally, surface distress assessments were based on windshield surveys done by raters in a survey vehicle. As imaging and pattern recognition technologies have evolved, transportation agencies have been moving away towards automating the collection and compilation of crack/distress data. The Laser Crack Measurement System (LCMS) is one such technology – a 3D-laser system – capable of obtaining automated cracks, rutting and other surface distresses.

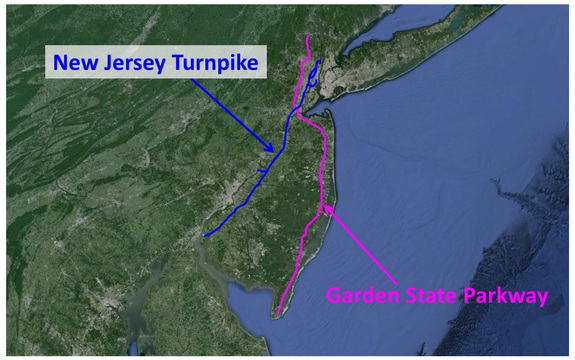
Introduction

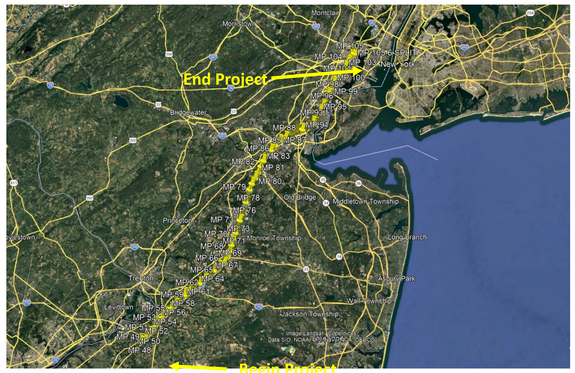
This study evaluates and compares three (3) years of pavement condition data collected on a fifty-seven (57) mile segment of the New Jersey Turnpike. LCMS imagery and inertial profiler data were obtained on the most traveled lane. Also, an in-house developed algorithm was used to categorize and quantify crack type, severity, and percentage automatically according to the New Jersey Department of Transportation's (NJDOT's) Surface Distress Index (SDI) distress definitions and the resulting SDI values were calculated. The SDI uses a 0-5 scale and is akin to the Federal Highway Administration's (FHWA's) Present Serviceability Rating (PSR).

Overall, it was found that IRI slightly increased and SDI decreased on pavement sections where no M&R was done over the 3-year data collection period. The SDI index was more sensitive to identify pavement deterioration over time. Based on these findings, the LCMS and complementary in-house developed algorithm proved to be successful tools for the automated collection and analysis of network pavement condition.

Field Testing

Project Limits





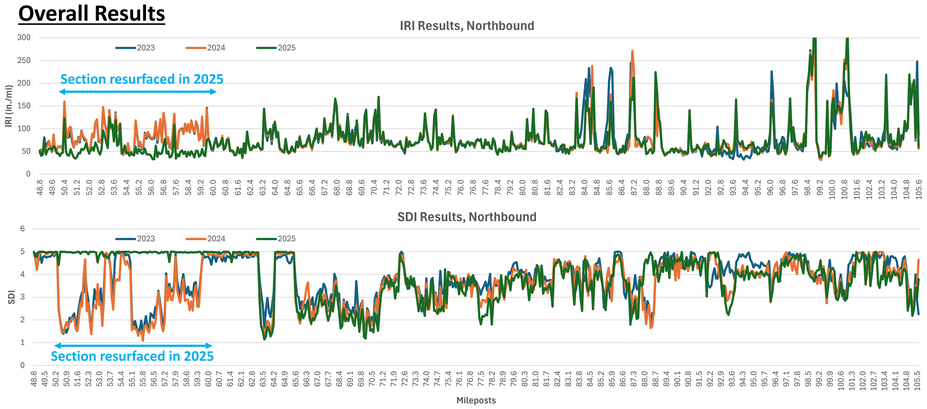
Integrated Testing Vehicle

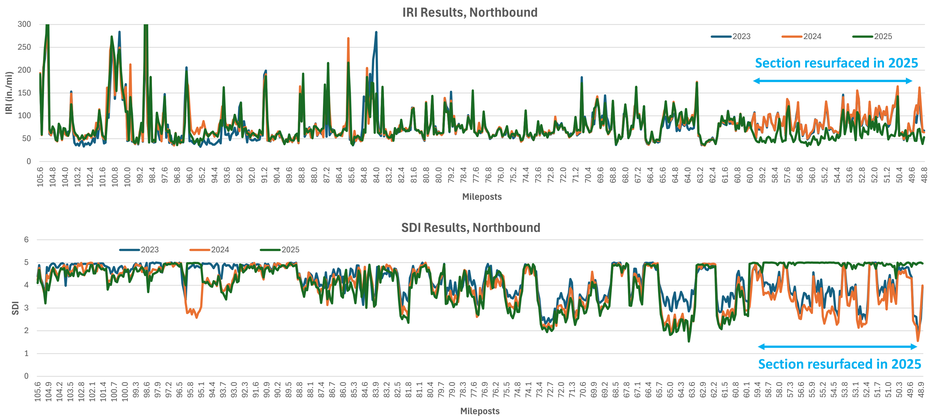
Results

Summary Tables

Rte	Dir	MPFrom	MPTo	GPSFrom	GPSTo	LaneDes	ProfilerDate	LiRI	RiRI	AiRI	NDI	LDI	SDI	ACTrSl	ACTrMod	ACTrSev	ACLngSl	ACLngMod	ACLngSev	ACLdMulSl	ACLdMulMod	ACLdMulSev	ACLdLngSl	ACLdLngMod	ACLdLngSev	PatchSl	PatchMod	PatchSev	LRut	RRut	ARut
NJTPK	SNO	48.8	48.9	40.07268 -74.75774	40.07369 -74.75638	2	4/1/2025	59.5	44.0	51.7	5.0	5.0	5.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.13	0.09	0.11
NJTPK	SNO	48.9	49.0	40.07369 -74.75638	40.07469 -74.75503	2	4/1/2025	42.3	38.4	40.4	4.8	5.0	4.8	0%	0%	0%	11%	4%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.11	0.11	0.11
NJTPK	SNO	49.0	49.1	40.07469 -74.75503	40.07568 -74.75365	2	4/1/2025	39.2	46.4	42.8	5.0	4.9	4.8	0%	0%	0%	1%	1%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0.15	0.08	0.11
NJTPK	SNO	49.1	49.2	40.07568 -74.75365	40.07669 -74.75230	2	4/1/2025	80.5	81.4	80.9	5.0	5.0	5.0	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.18	0.08	0.13
NJTPK	SNO	49.2	49.3	40.07669 -74.75230	40.07770 -74.75094	2	4/1/2025	43.6	42.6	43.1	5.0	5.0	5.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.16	0.05	0.10
NJTPK	SNO	49.3	49.4	40.07770 -74.75094	40.07870 -74.74958	2	4/1/2025	52.8	52.3	52.6	5.0	5.0	5.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.17	0.04	0.11
NJTPK	SNO	49.4	49.5	40.07870 -74.74958	40.07971 -74.74823	2	4/1/2025	52.8	59.4	56.1	5.0	5.0	5.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.22	0.05	0.14
NJTPK	SNO	49.5	49.6	40.07971 -74.74823	40.08073 -74.74688	2	4/1/2025	59.5	54.7	57.1	5.0	5.0	5.0	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.20	0.06	0.13
NJTPK	SNO	49.6	49.7	40.08073 -74.74688	40.08176 -74.74555	2	4/1/2025	48.8	55.8	52.3	4.9	5.0	4.9	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.17	0.05	0.11
NJTPK	SNO	49.7	49.8	40.08176 -74.74555	40.08281 -74.74425	2	4/1/2025	53.7	69.4	61.5	5.0	5.0	5.0	0%	0%	0%	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.14	0.05	0.09
NJTPK	SNO	49.8	49.9	40.08281 -74.74425	40.08389 -74.74298	2	4/1/2025	57.2	60.0	58.6	5.0	5.0	5.0	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.18	0.05	0.11
NJTPK	SNO	49.9	50.0	40.08389 -74.74298	40.08497 -74.74173	2	4/1/2025	45.4	45.6	45.5	5.0	5.0	5.0	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.17	0.05	0.11
NJTPK	SNO	50.0	50.1	40.08497 -74.74173	40.08607 -74.74050	2	4/1/2025	43.2	49.3	46.2	5.0	5.0	4.9	0%	0%	0%	5%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.17	0.05	0.11
NJTPK	SNO	50.1	50.2	40.08607 -74.74050	40.08718 -74.73928	2	4/1/2025	37.3	42.4	39.8	5.0	5.0	5.0	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.16	0.05	0.11
NJTPK	SNO	50.2	50.3	40.08718 -74.73928	40.08830 -74.73807	2	4/1/2025	45.1	46.9	46.0	5.0	5.0	5.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.20	0.05	0.12
NJTPK	SNO	50.3	50.4	40.08830 -74.73807	40.08942 -74.73688	2	4/1/2025	47.0	47.6	47.3	5.0	5.0	5.0	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.19	0.06	0.12
NJTPK	SNO	50.4	50.5	40.08942 -74.73688	40.09056 -74.73570	2	4/1/2025	115.3	130.0	122.7	4.8	4.6	4.4	6%	1%	1%	2%	3%	5%	2%	1%	0%	11%	1%	2%	0%	0%	0%	0.13	0.10	0.11
NJTPK	SNO	50.5	50.6	40.09056 -74.73570	40.09170 -74.73453	2	4/1/2025	54.2	44.1	49.1	5.0	5.0	5.0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.14	0.07	0.10
NJTPK	SNO	50.6	50.7	40.09170 -74.73453	40.09284 -74.73336	2	4/1/2025	48.3	34.6	41.4	5.0	5.0	5.0	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.13	0.07	0.10
NJTPK	SNO	50.7	50.8	40.09284 -74.73336	40.09398 -74.73218	2	4/1/2025	44.5	37.3	40.9	5.0	5.0	5.0	0%	0%	0%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.13	0.07	0.10

Overall Results





Northbound

Avg. IRI (in./mi)	2023	2024	2025
Overall Project Limits	79.5	79.0	75.0
Resurfaced Area	81.9	83.0	54.2
Areas w/o Maintenance	78.9	78.0	79.9

Avg. SDI	2023	2024	2025
Overall Project Limits	3.79	3.62	3.91
Resurfaced Area	3.30	3.07	4.95
Areas w/o Maintenance	3.91	3.76	3.66

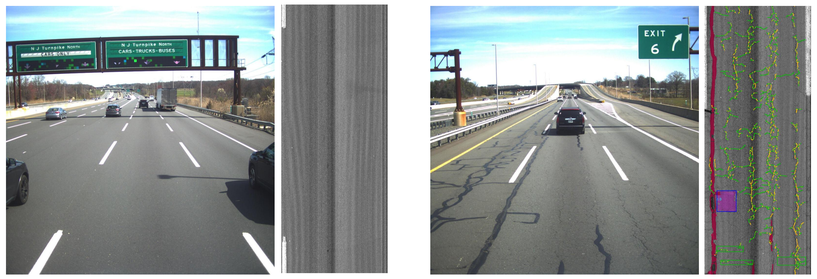
Southbound

Avg. IRI (in./mi)	2023	2024	2025
Overall Project Limits	79.1	81.9	77.5
Resurfaced Area	87.6	89.4	61.4
Areas w/o Maintenance	77.0	80.1	81.5

Avg. SDI	2023	2024	2025
Overall Project Limits	4.21	3.93	4.15
Resurfaced Area	3.84	3.53	4.94
Areas w/o Maintenance	4.30	4.03	3.96

Analysis

3D Laser Image + ROW Image



Distress Classification

In house developed algorithm to categorize and quantify crack type, severity, and percentage automatically:

- Longitudinal
- Transverse
- Fatigue (Alligator)

Distress Index

New Jersey Department of Transportation's (NJDOT's) Surface Distress Index (SDI). The SDI uses a 0-5 scale and is akin to the Federal Highway Administration's (FHWA's) Present Serviceability Rating (PSR).

Conclusions

- IRI slightly increased and SDI decreased on pavement sections where no M&R was done over the 3-year data collection period.
- The SDI index was more sensitive to identify pavement deterioration over time.
- LCMS and complementary in-house developed algorithm proved to be successful tools for the automated collection and analysis of network pavement condition.

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