NJDOT Pavement Support Program (PSP): Goals, Deliverables and the Future

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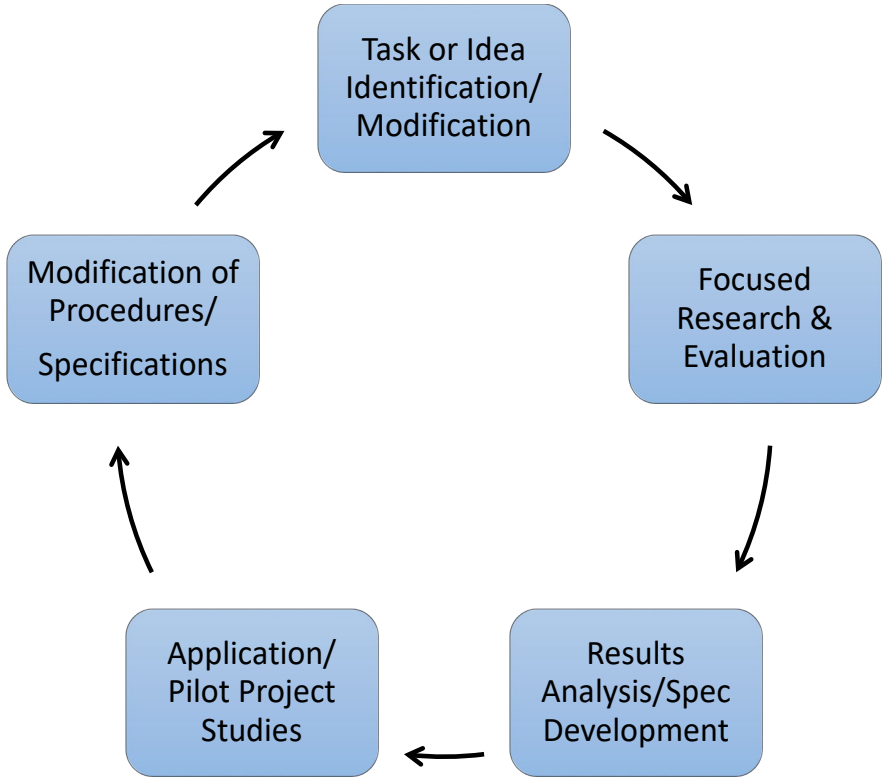
Pavement Support Program (PSP)

- State Planning and Research (SP&R) Program
  - Helene Roberts (FHWA)
- Main Goal: Support the activities of the Pavement & Drainage Management and Technology Unit
  - Manager: Susan Gresavage
- Prior to 2016, the PSP was a yearly contract
  - 2016 (3 years with 2 years added)
  - 2020 (5 years)
  - Center for Advanced Infrastructure and Transportation (CAIT) at Rutgers University has been awarded PSP since inception (2006)

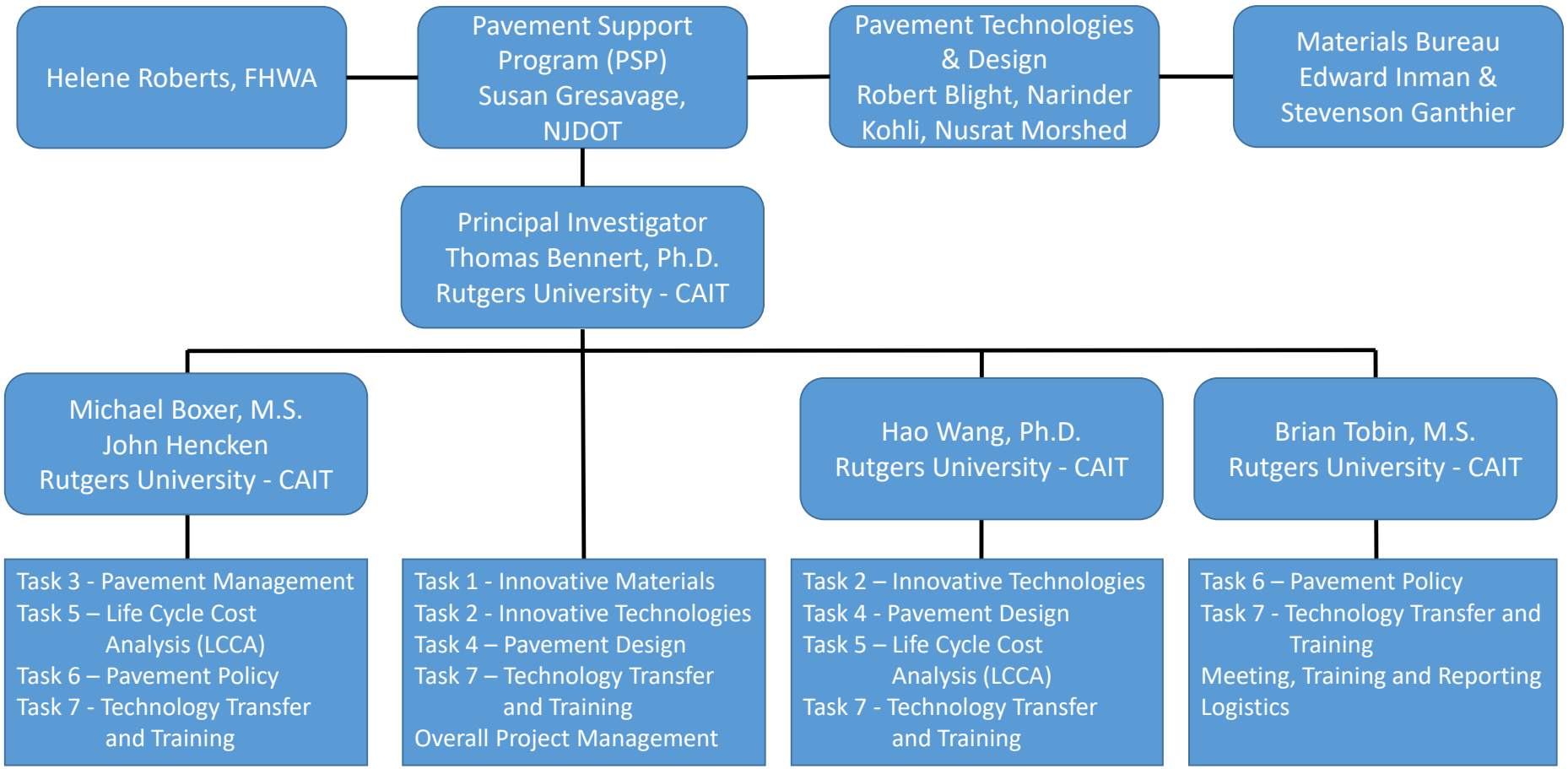
Pavement Support Program (PSP)

- "Extension of NJDOT Services"
  - Meet formally each quarter to discuss progress
  - Technical memorandums provided upon subtask completion
- Focuses on 7 major support tasks
  1. Innovative Materials
  2. Innovative Technologies
  3. Pavement Management System Development
  4. Pavement Design Procedures
  5. Life Cycle Cost Analysis/Cost Benefit Analysis
  6. Pavement Policy Decisions
  7. Technology Transfer & Training

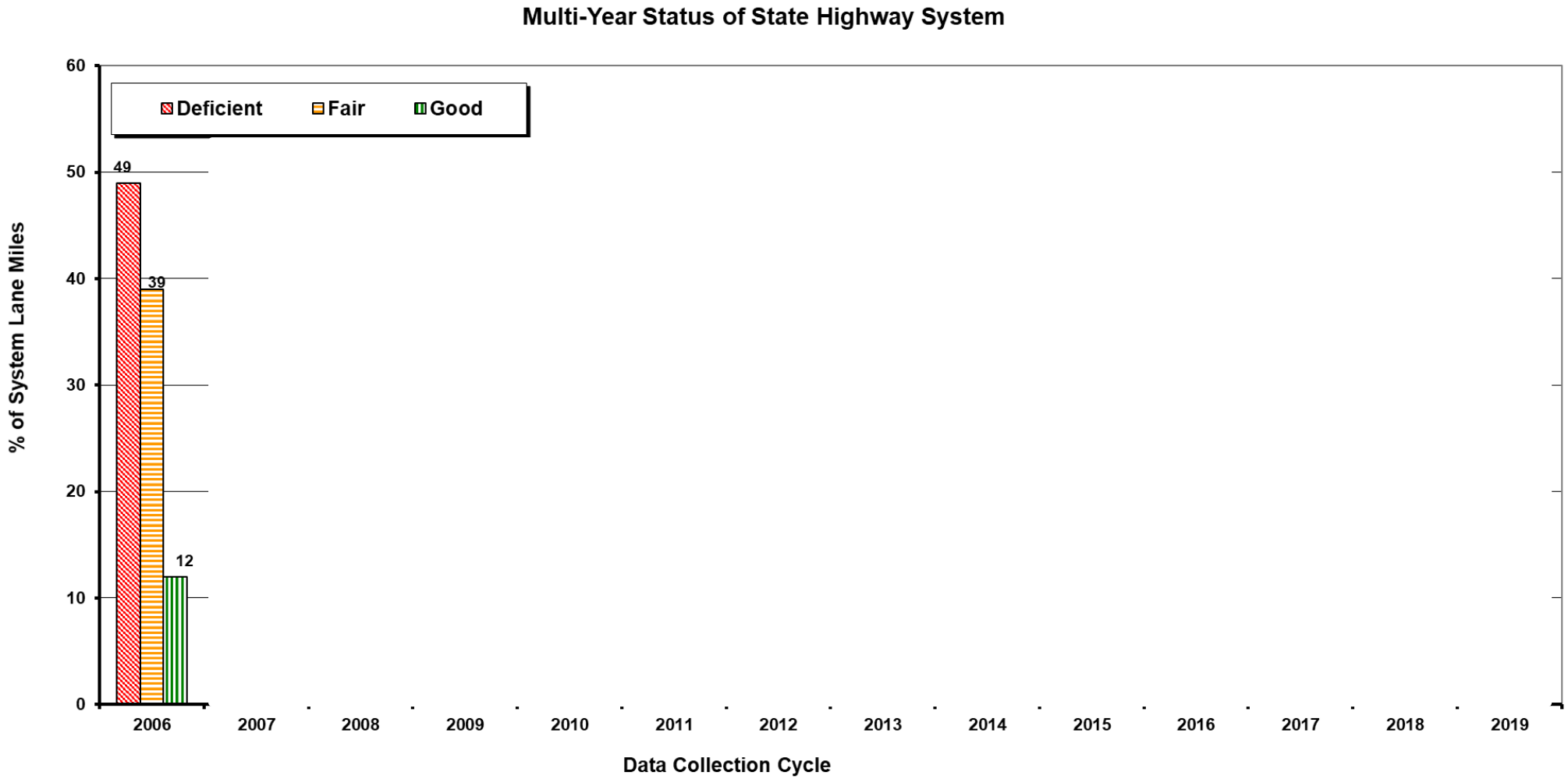


Pavement Support Program (PSP)

- Work effort conducted using support of 10+ full time staff, graduate students and undergraduate students

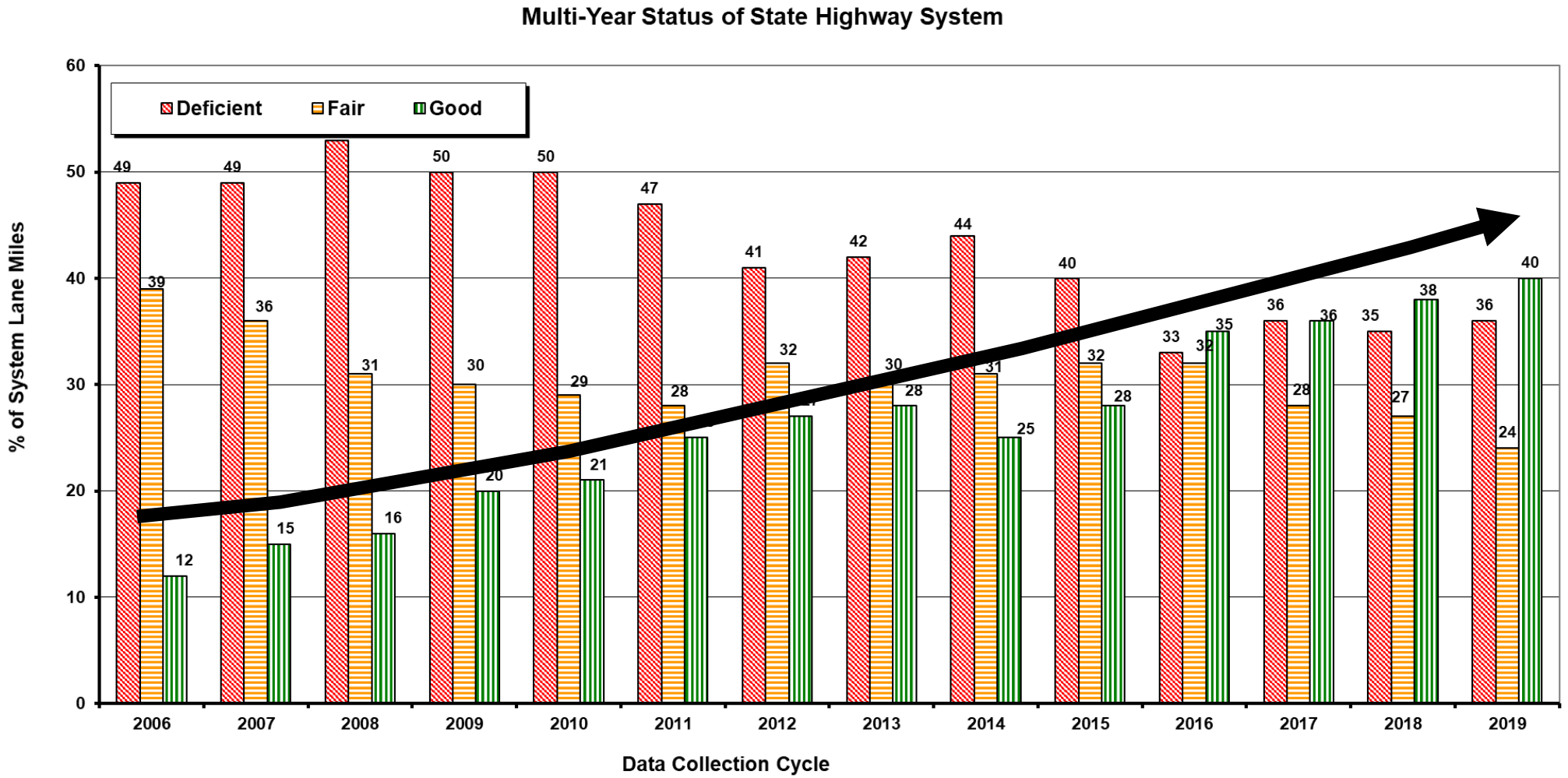


NJDOT Pavement System – How it started



Source: NJDOT Pavement Management System

NJDOT Pavement System – How it's going

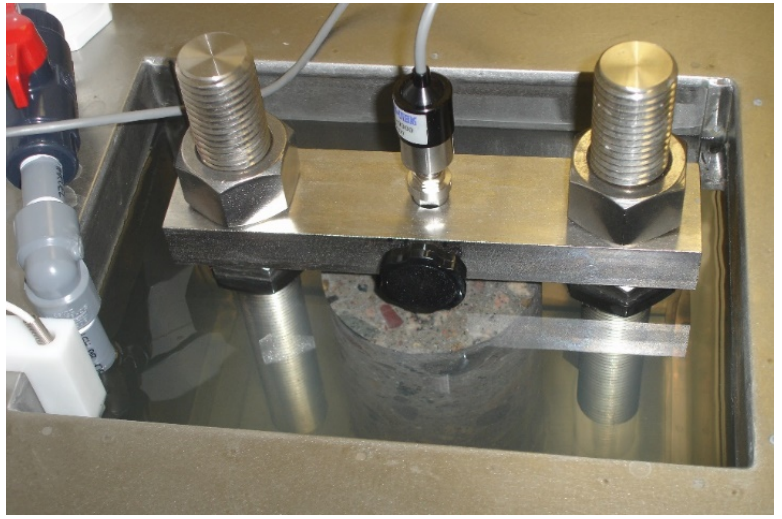


Source: NJDOT Pavement Management System

Examples of Activities
Task 1 – Innovative Materials

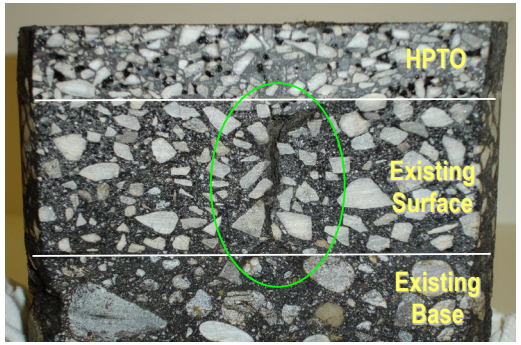
Task 1 – Innovative Materials

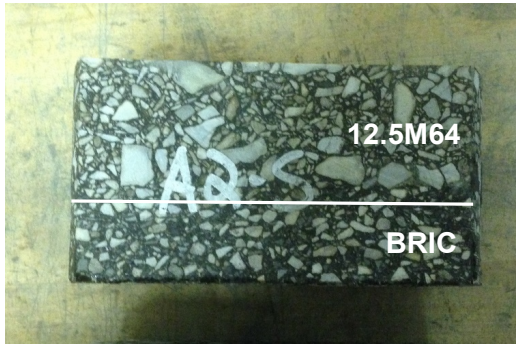
- PSP Innovative Materials looks at:
  - Developing new specifications for "new" construction materials
  - Updating and improving current specifications
    - New and improved test methods
  - Recycled materials
  - Materials targeting specific applications
    - Composite pavements
    - Pavement Preservation
    - Safety

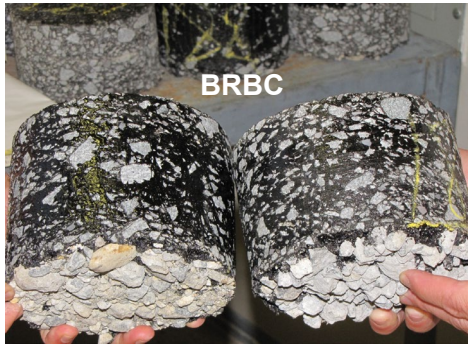


Task 1 – HPTO and BRIC

- NJDOT utilizes a series of "Specialty Mixes" that includes Performance Related Specifications to balance rutting and cracking
- Application specific for specific need
- Performance modeled using PMS data



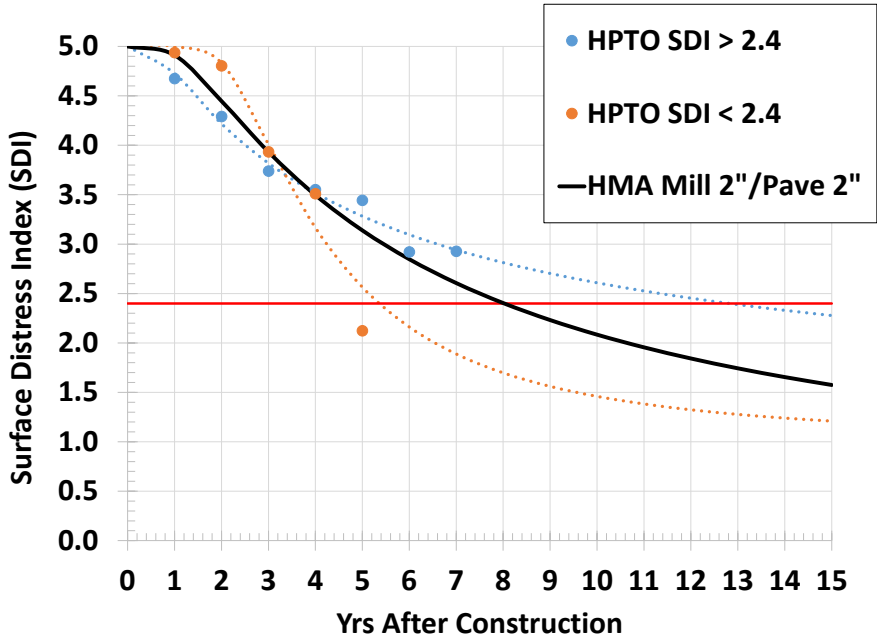




$$SDI = SDI_0 - e^{\left(A - B \cdot C^{\ln\left(\frac{1}{Age}\right)}\right)}$$

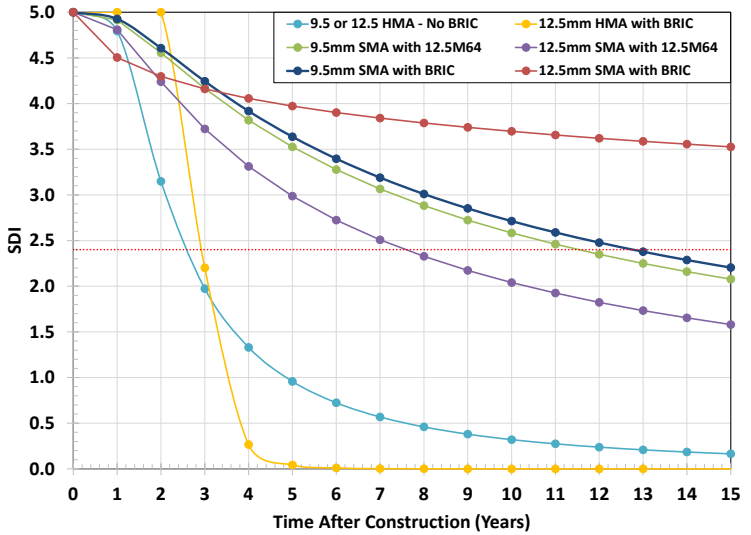
Task 1 – HPTO and BRIC

- HPTO used for pavement preservation
  - When applied to pavements in "Pavement Preservation" category, HPTO increases life 5+ years
  - Factors to watch for;
    - Binder content & grade
    - Aggregate selection
    - Diesel contamination from truck beds



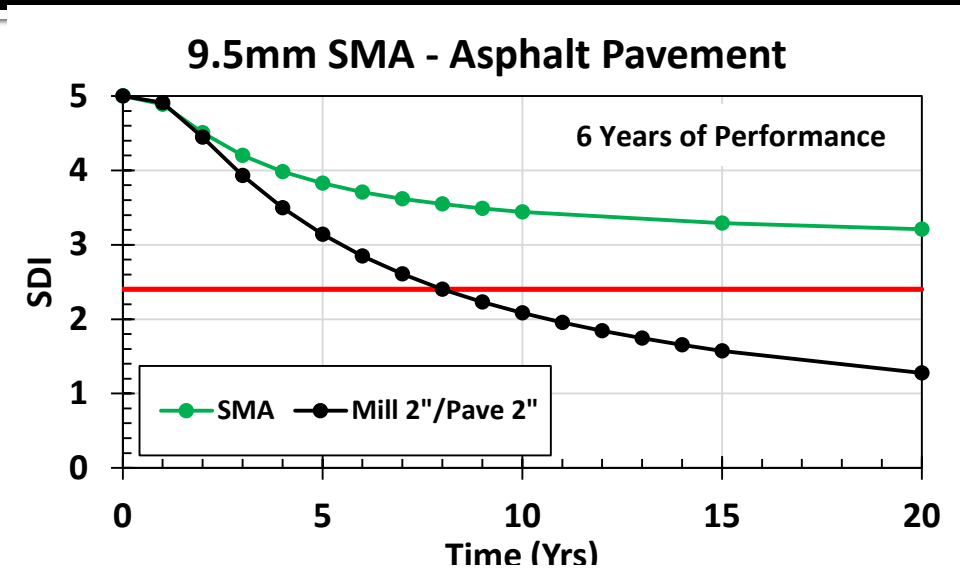
Task 1 – HPTO and BRIC

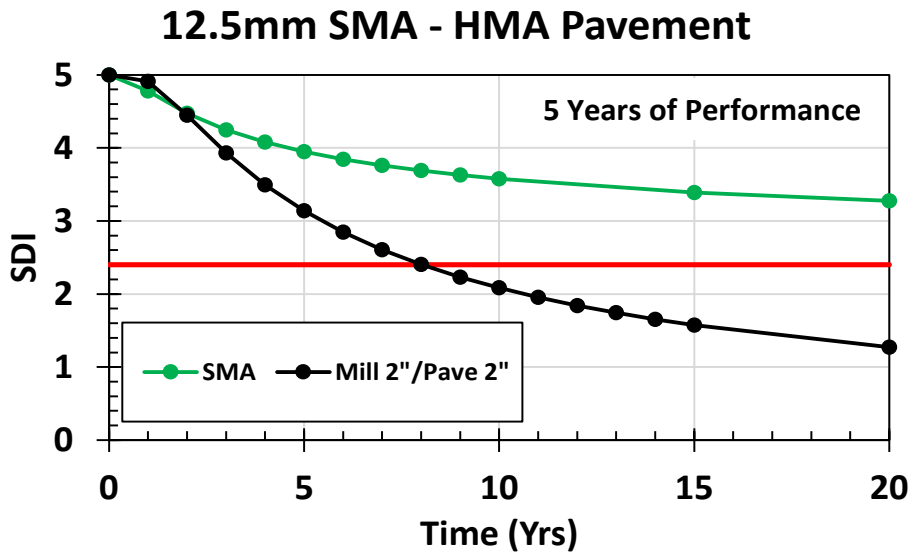
- BRIC improves asphalt overlay in mitigating reflective cracking in composite pavements
  - "System Approach"
    - BRIC reduces reflective cracking from horizontal deflection at joint
    - SMA reduces reflective cracking from vertical deflection at joint



Task 1 – SMA Performance

- Industry somewhat opposed to use of SMA
  - Costs higher than conventional asphalt
  - No RAP
  - No attention to details required
- SMA used in both flexible and composite pavements in NJ
  - Used sporadically until 2012
- Both 9.5 mm and 12.5 mm have been used
  - Currently only 12.5 mm



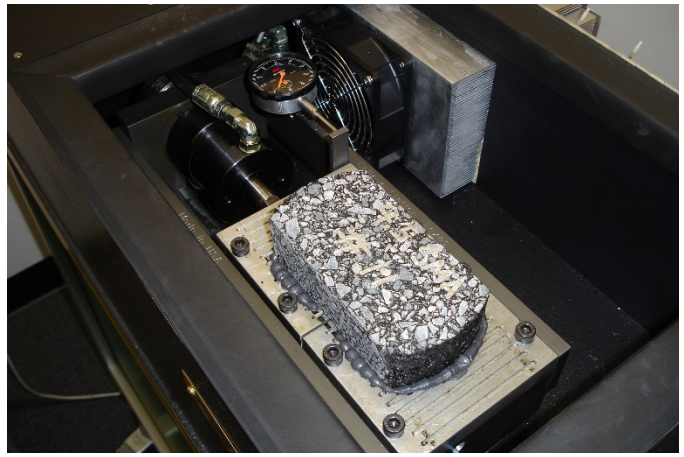


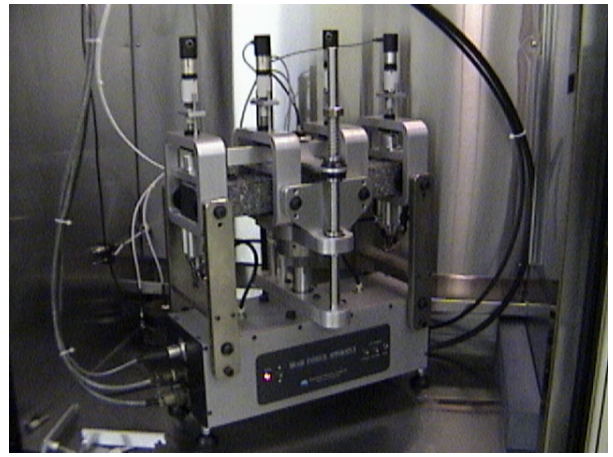
Task 1 – Recycled Asphalt Shingles

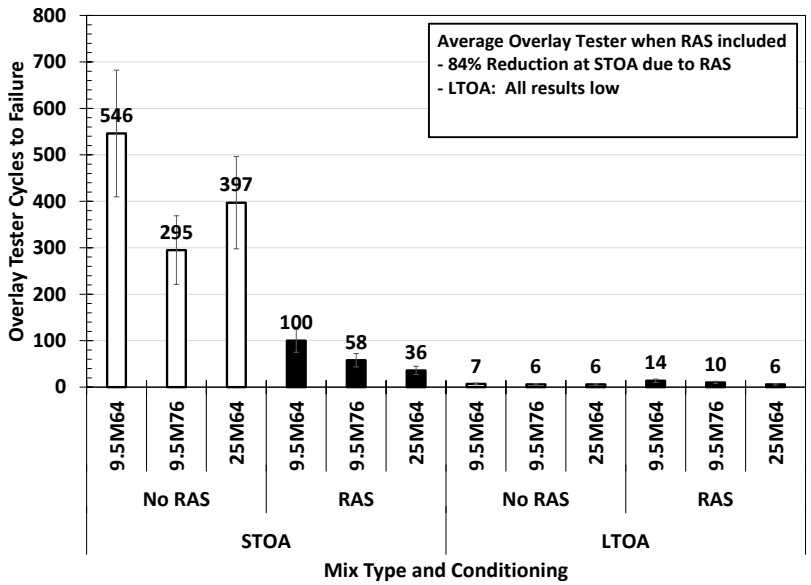
- Asphalt shingles have 10 to 20% asphalt liquid by total weight
  - Modified different and stiffer than conventional asphalt
    - Post Consumer vs Post Manufacturer
  - Little to no guidance on how to responsible use in new asphalt materials
- Evaluated proposed AASHTO PP78 on developing RAS mixtures
  - *Standard Practice for Design Considerations When Using Reclaimed Asphalt Shingles (RAS) in Asphalt Mixtures*

Task 1 – Recycled Asphalt Shingles

- AASHTO PP78 criteria may need to be further defined
  - Post manufactured RAS
    - Improved rutting by 25%
    - Reduced fatigue cracking resistance by 65%
- Overall, material greatly stiffens asphalt and reduces durability
- May need to also utilize
  - Softer binder (PG58-28)
  - Rejuvenators/WMA

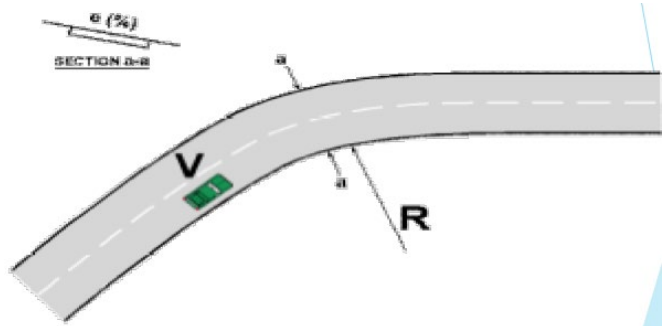






Task 1 – High Friction Surface Treatment

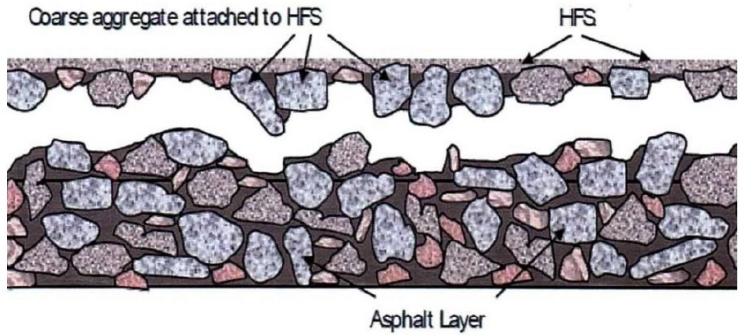
- High Friction Surface Treatment (HFST) is an initiative by FHWA to help improve driving safety
  - 5% Horizontal Curves on US Roads
  - Makes up 23% of all fatalities
  - 2016 – 336 fatalities and 517 serious injuries due to lane departures in NJ
- Calcined bauxite aggregate (high polish resistance) epoxied to pavement surface



US Customary	Metric
$R = \frac{V^2}{15\,(e+f)}$	$R = \frac{V^2}{127\,(e+f)}$
where R = Radius of circular curve (ft) V = Design speed (mph) e = Superelevation f = Side "friction" or comfort	where R = Radius of circular curve (m) V = Design speed (km/h) e = Superelevation f = Side "friction" or comfort

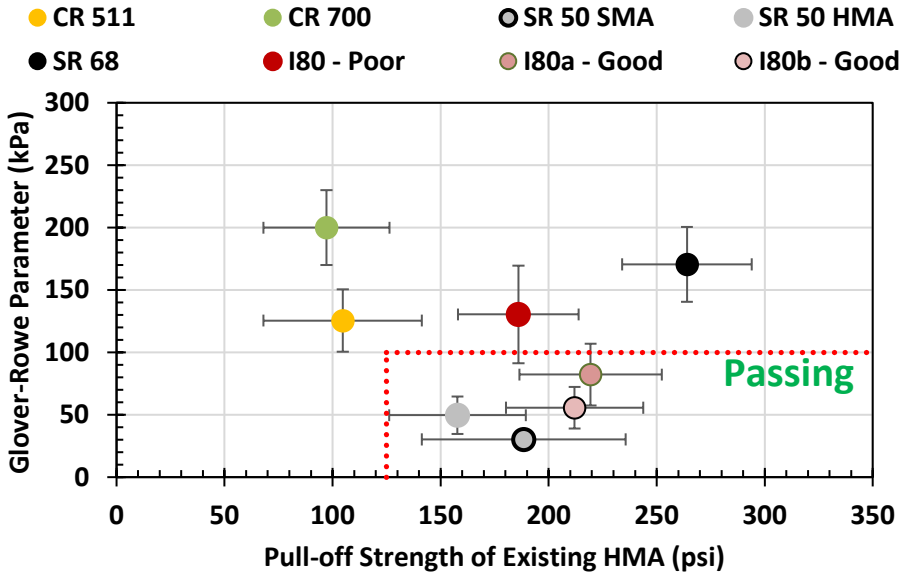
Task 1 – High Friction Surface Treatment

- General recommendation is to place on pavement in "good" condition
- Issue
  - NJ has a high occurrence of freeze-thaw cycles (large temperature swings in 24 hours)
  - Epoxy resin used has a coefficient of thermal expansion 3 to 4 times that of HMA
  - Can result in shallow delamination failures and induced edge cracking



Task 1 – High Friction Surface Treatment

- Solution
  - Developing screening method for evaluating substrate prior to application & acceptance after construction
  - Utilizing pull-off strength (ASTM C1583) and binder testing (Glover-Rowe & ΔTc) to identify aged/ravel-prone substrates
  - Improved specification for better construction practices



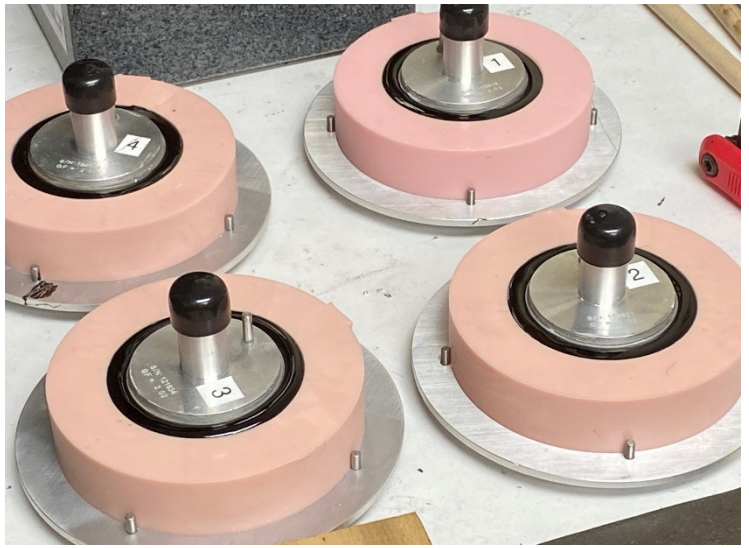
Task 1 – Innovative Materials

- Upcoming activities
  - Recycled plastic in hot mix asphalt applications
  - Use of Electric Arc Furnace (EAF) slag in hot mix asphalt applications
  - Implementation of Balanced Mixture Design (BMD) to design hot mix asphalt
  - Central Plant Cold Recycling

Examples of Activities
Task 2 – Innovative Technologies

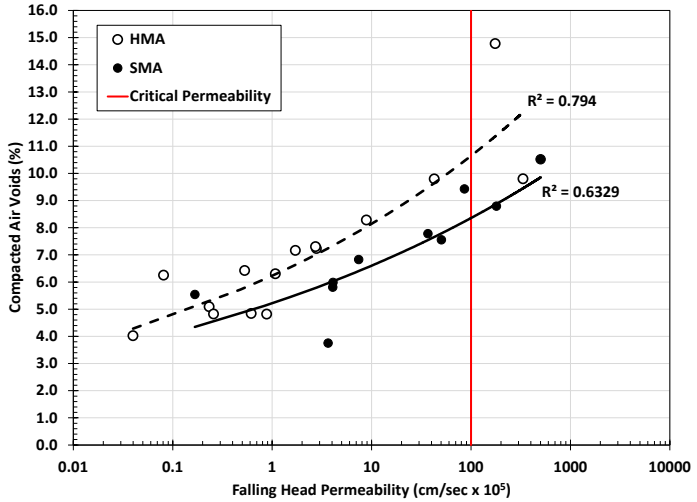
Task 2 – Innovative Technologies

- Innovative Technologies looks at new methods/ practices/equipment to improve the evaluation of construction materials, as well as improving the construction practice



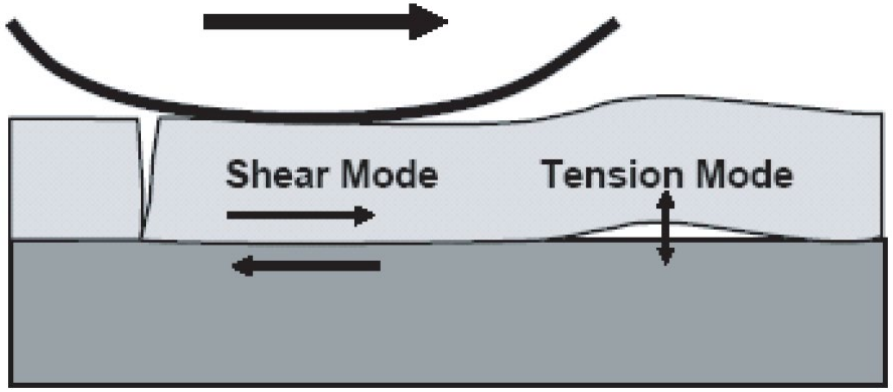
Task 2 – Longitudinal Joint Specification

- Asphalt pavements constructed transversely, leaving construction joints – called longitudinal joints
- Areas of low density that are prone to fast deterioration
- PSP focused on evaluating construction practices, developing performance based specification and evaluating new technologies to seal joint area



Task 2 – Pavement Bonding (Tack Coats & Bond Strength Test)

- Pavement construction requires construction layers in "lifts"
- Pavement design is conducted assuming layers are "fully bonded"
- Poor bonding in HMA layer is associated with;
  - Reduced fatigue life;
  - Increased rutting;
  - Slippage cracking and instability

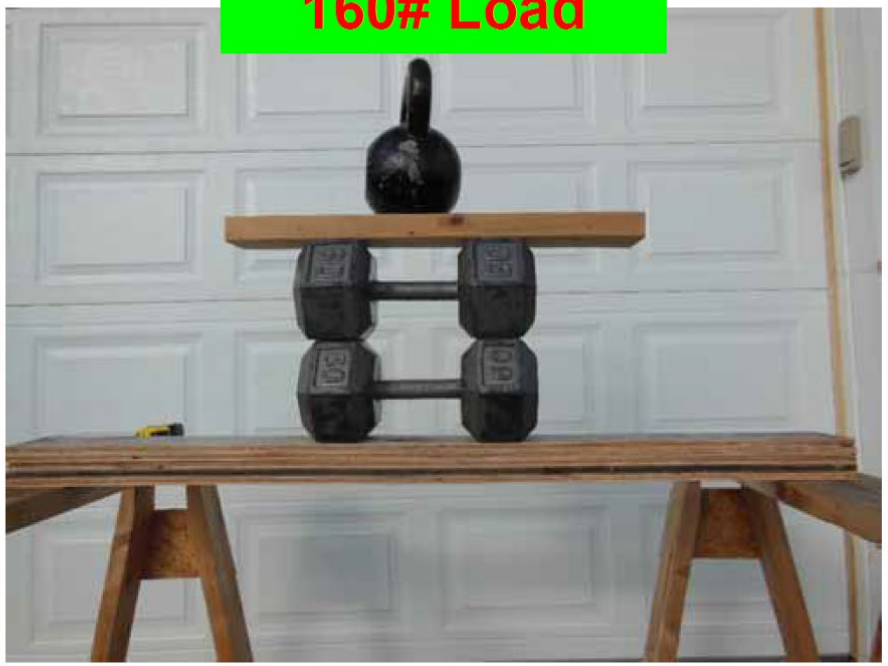


Task 2 – Pavement Bonding (Tack Coats & Bond Strength Test)

½" Deflection, 60# Load

Unbonded

¼" Deflection, **160# Load**

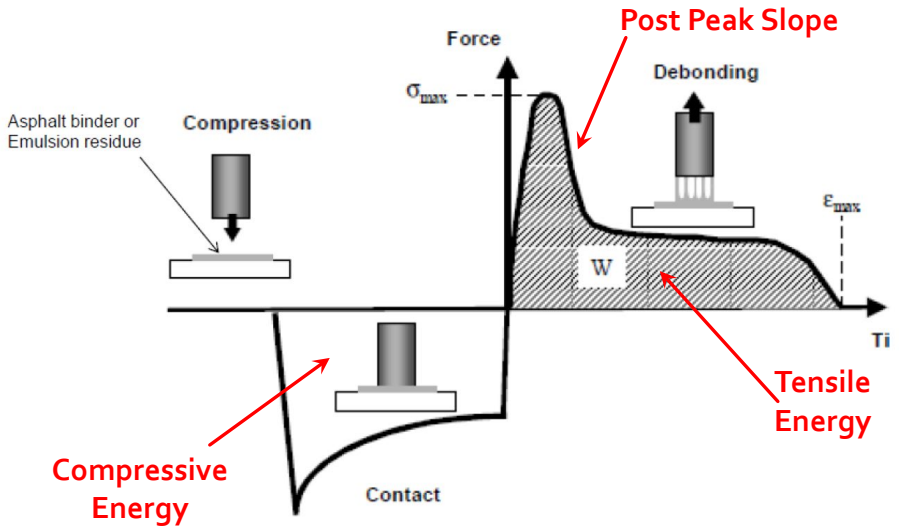


Fully Bonded

(Harder, 2018)

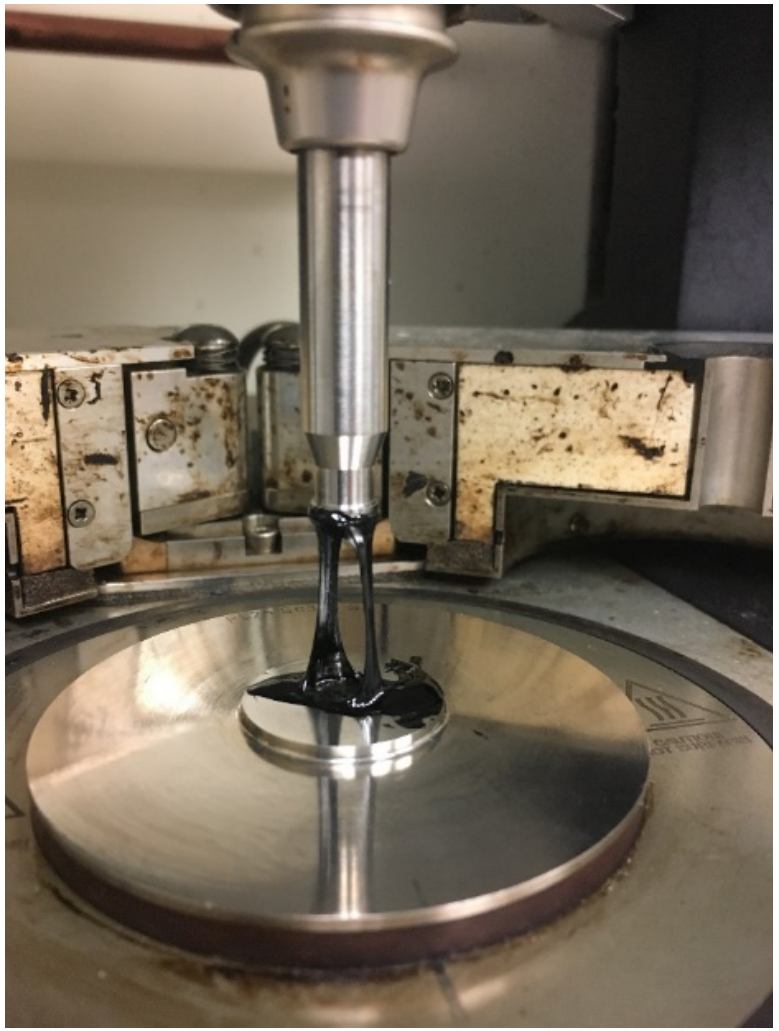
Task 2 – Pavement Bonding (Tack Coats & Bond Strength Test)

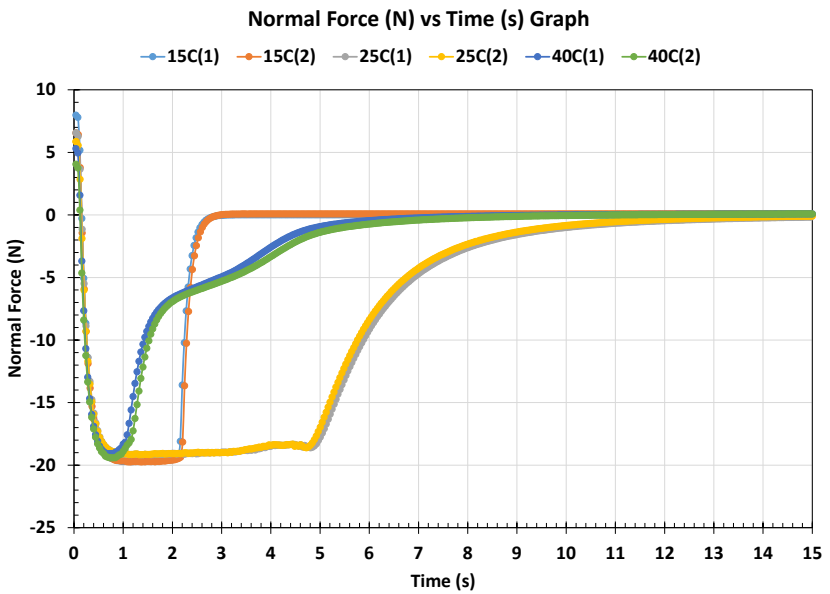
- Looking at developing a performance based specification for Tack Coats
  - Current procedures use older test methods (Penetration)
- Test methods proposed will use existing equipment but procedures based on performance mechanism (for Tack Coats = Bonding Strength)



Task 2 – Pavement Bonding (Tack Coats & Bond Strength Test)

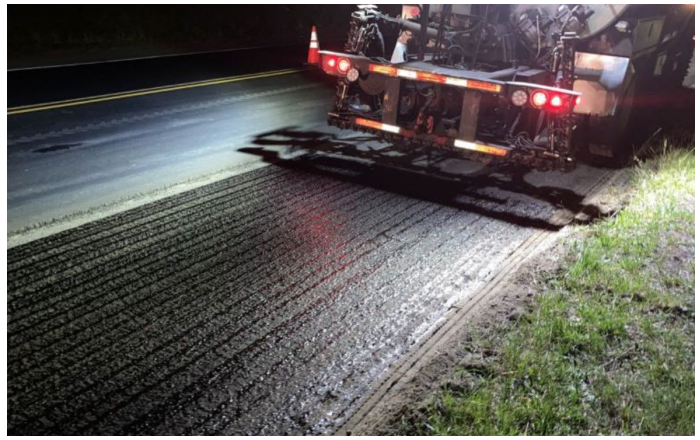
- Test method failure mechanism simulates debonding better than existing procedures
- Capable of indexing different materials
- Repeatable





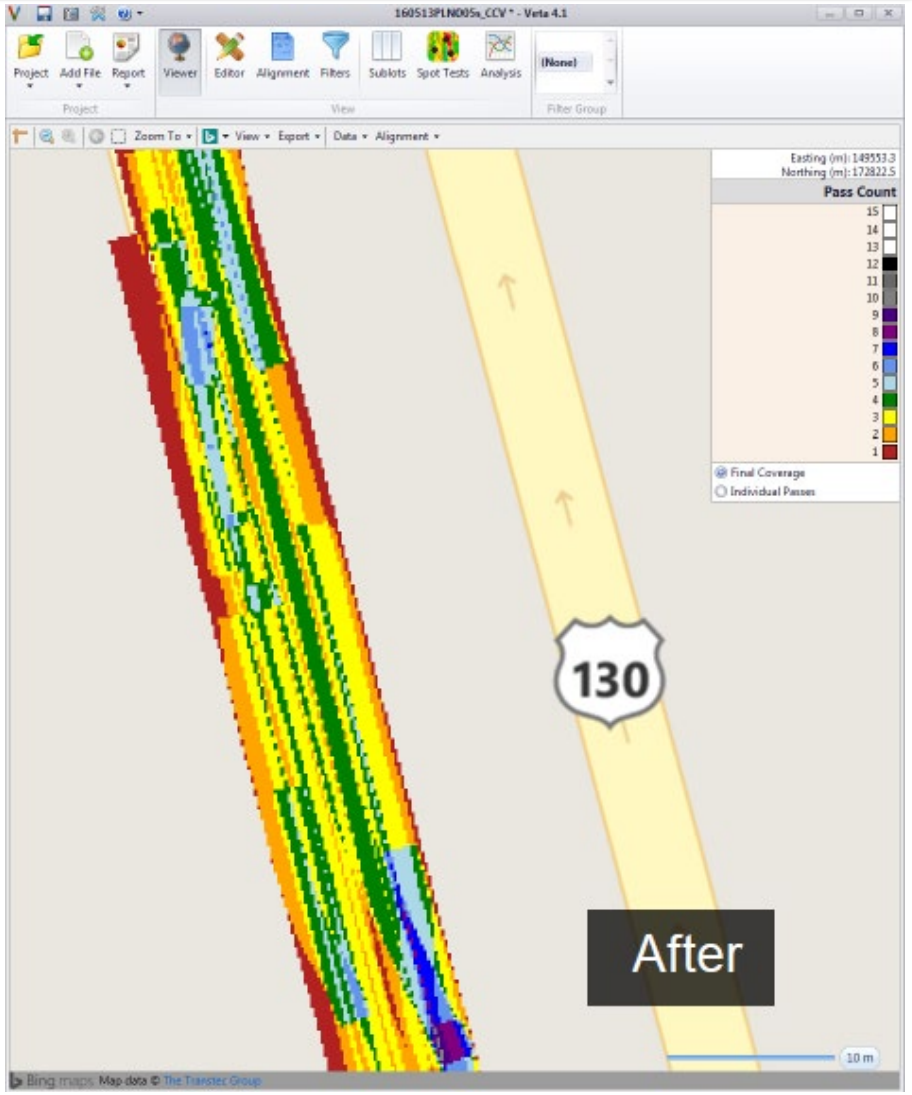
Task 2 – Performance Test for Tack Coat Materials

- Currently working on specification with pay adjustment for bond shear strength
  - Evaluating repeatability of 5 field projects; 2 different coring times after construction; 3 labs participating
- "End Result Spec" incorporates all aspects of the construction process to achieve good bonding
  - Milling, surface preparation, tack coat application

Task 2 – Intelligent Compaction

- Incorporating sensors on asphalt paving equipment to monitor process
  - Two biggest things to influence density
    - Number of roller passes
    - Temperature at time of compaction
- Pavers and rollers instrumented with GPS and infrared sensors for continuous profiles



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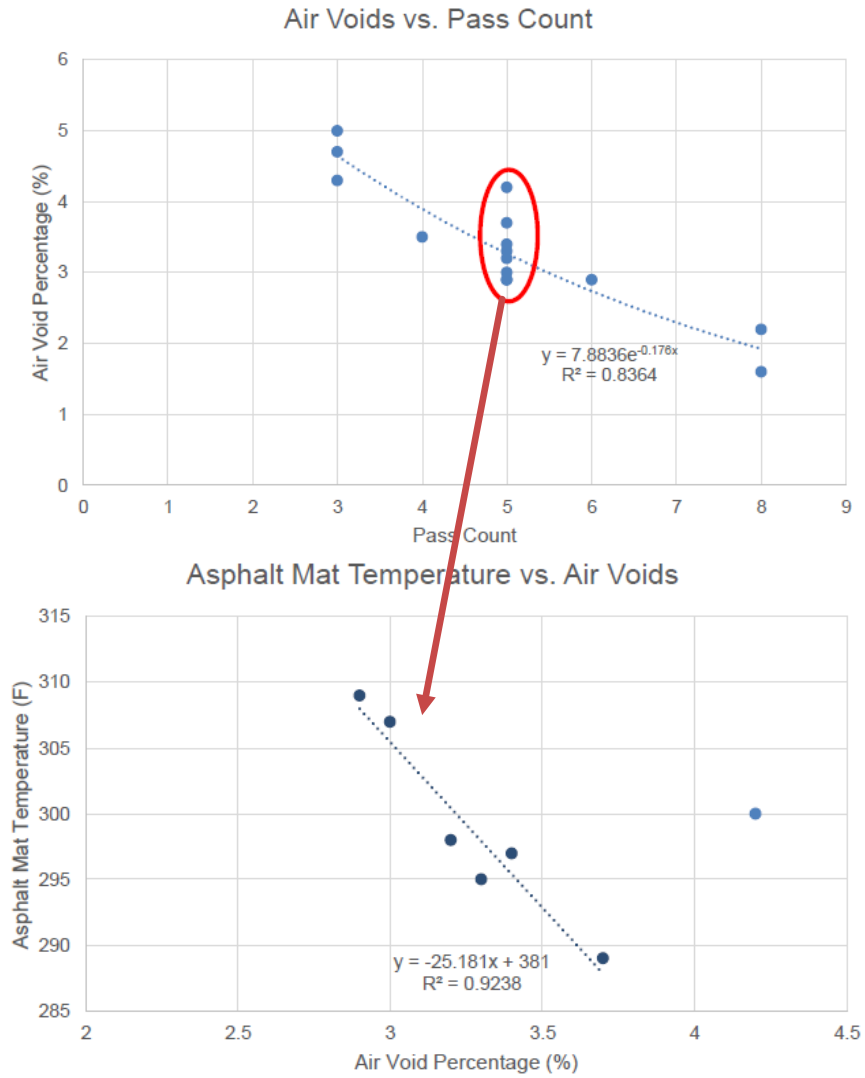
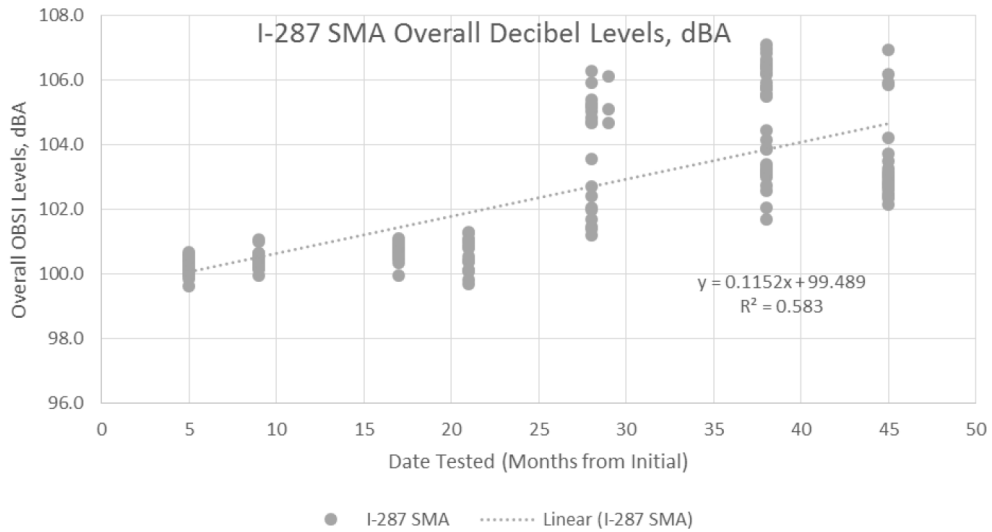


Task 2 – Noise Generating Properties of NJ Pavements

- Collecting pavement-tire generated noise properties over time for numerous surfaces and pavement applications
- Evaluating "hotspots"
- Providing recommendations for quieter pavement surface materials/applications



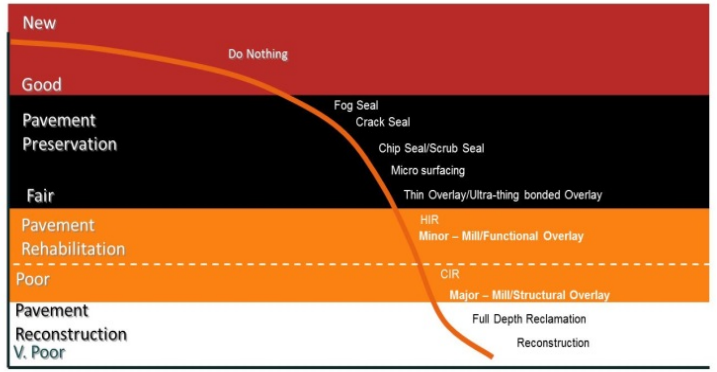
Task 2 – Innovative Technologies

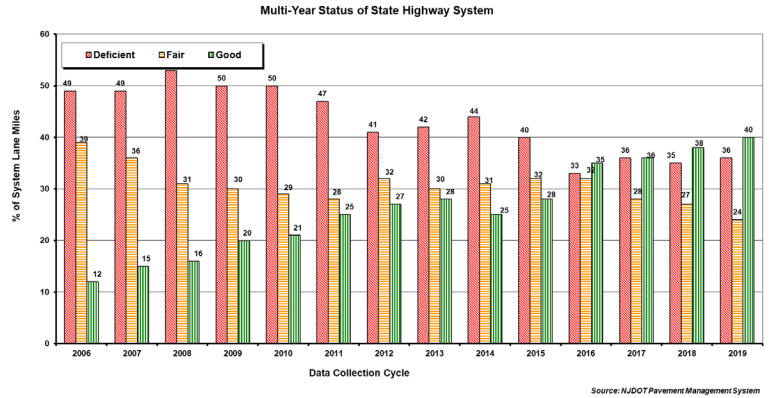
- Upcoming activities
  - Improving asphalt binder requirements and specifications
  - Implementation of performance testing during asphalt production
  - Incorporating sensors on NJDOT fleet vehicles
  - Traffic speed pavement texture measurements to predict friction/skid properties

Examples of Activities
Task 3 – Pavement Management

Task 3 – Pavement Management System Support

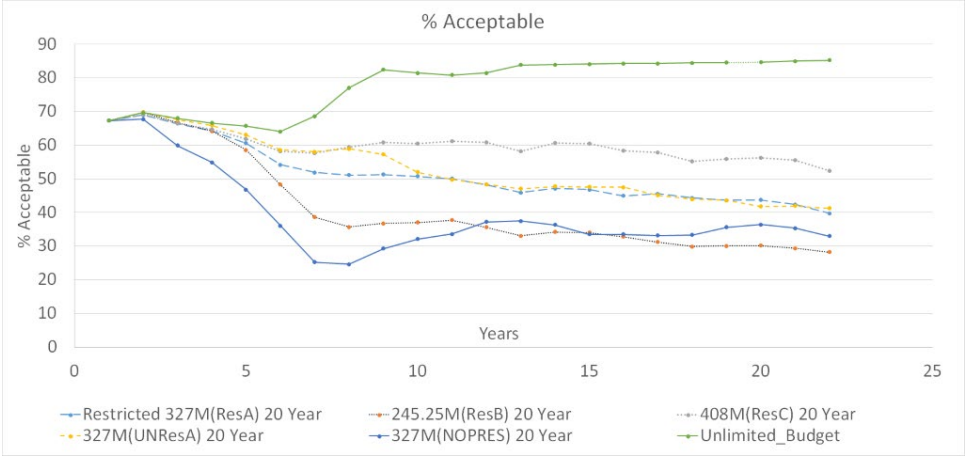
- NJDOT Pavement Management group conduct yearly pavement condition assessments to help forecast needs of pavement activities and funding allocation
- Involves collection of data, QC/QA protocols to ensure data is of quality and methods of collecting data is accurate, and analyses

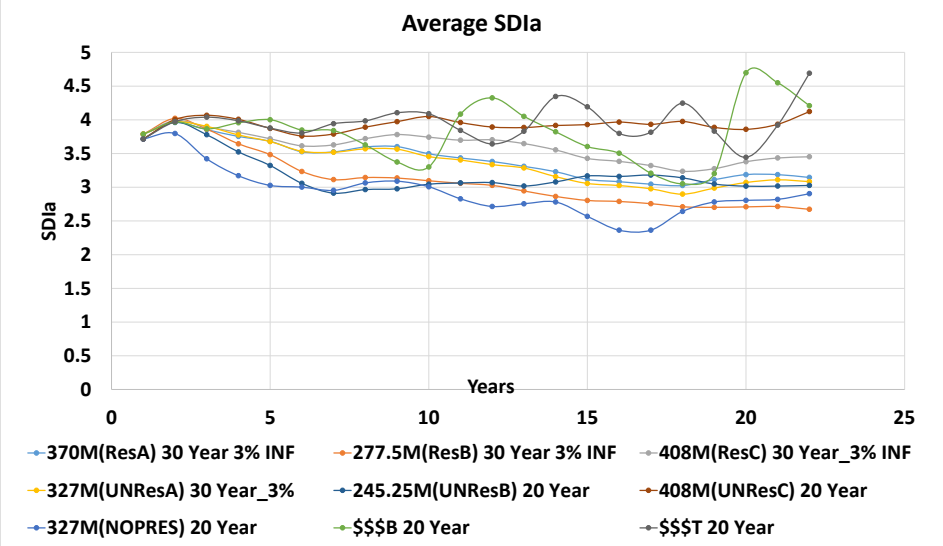




Task 3 – Condition Forecasting

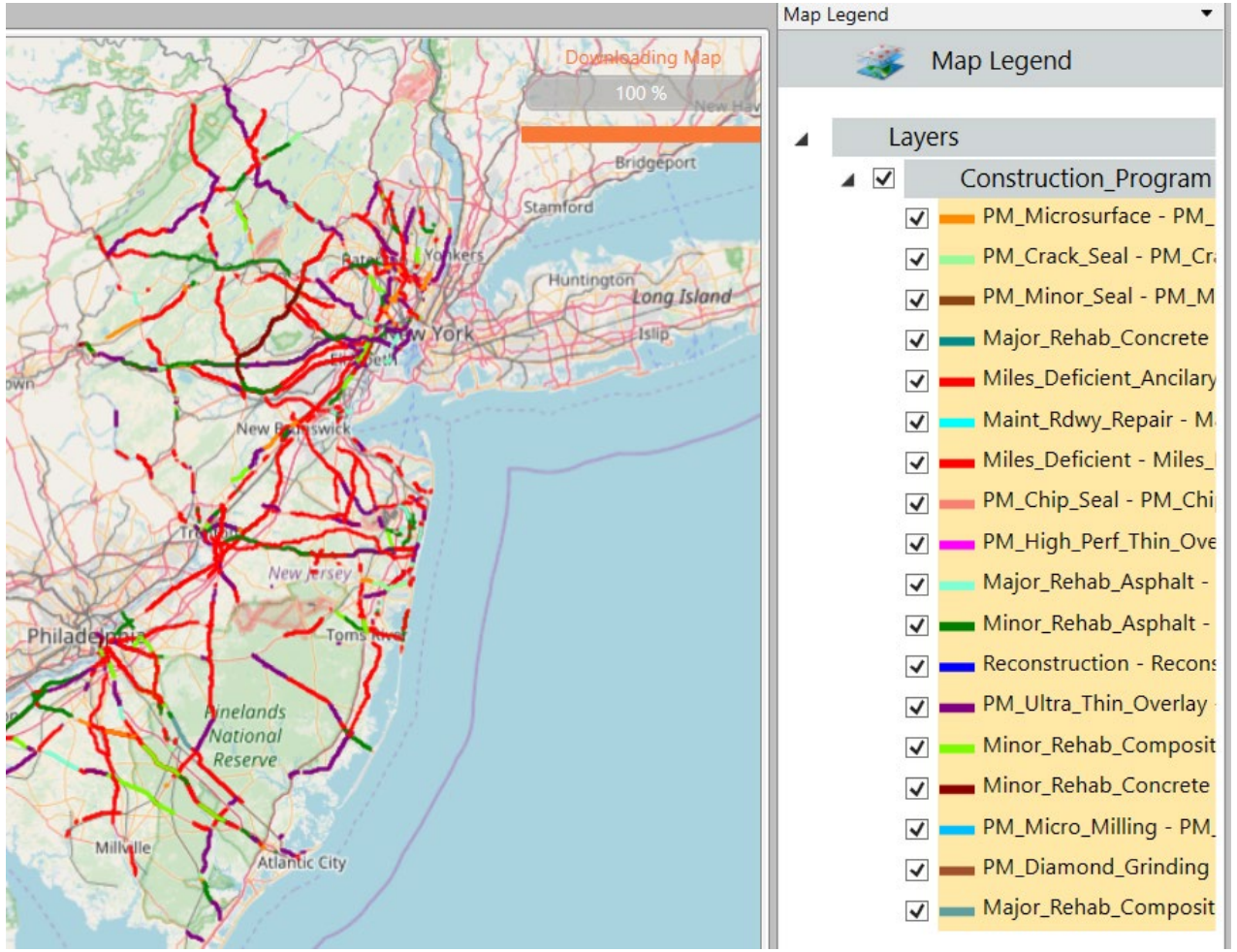
- Developing analyses to help NJDOT forecast pavement condition
  - Based of various funding scenarios
    - +/- Current; Unlimited
  - Different programming type
    - With/without preservation
  - Configured to FHWA TAMP requirements





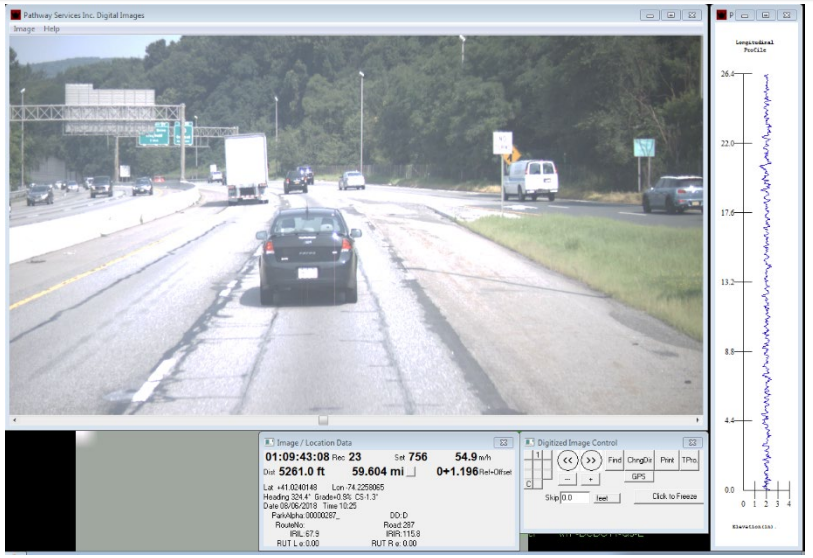
Task 3 – PMS Condition and Program Mapping

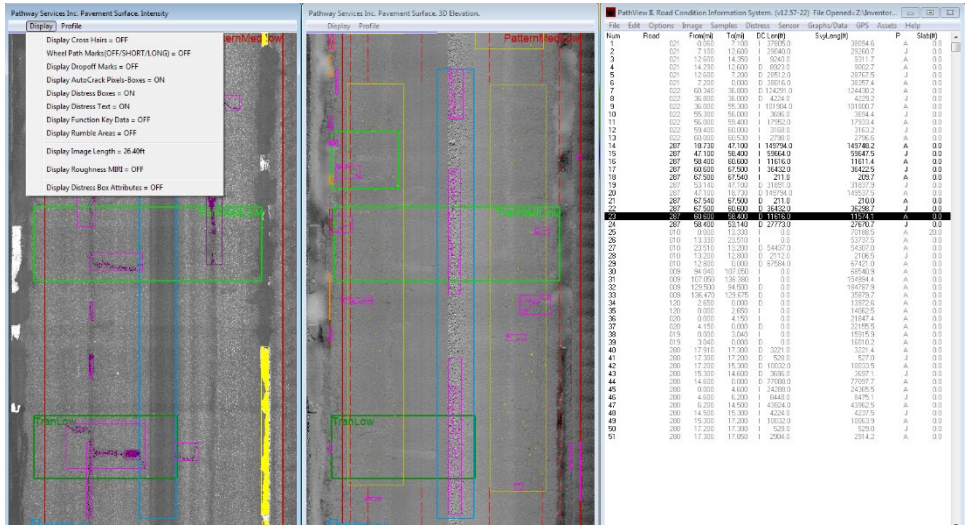
- Developing visual tools that NJDOT PMS can utilize for programming and reporting
  - Construction programming
  - Planning
  - Pavement Preservation
  - Rehab/Reconstruction



Task 3 – Migration to Automated Distress

- NJDOT previously utilized manual raters to provide condition assessment
- Since 2017, migration to automated distress
  - Updated Surface Distress Index (SDIa) for automated data collection





Task 3 – Development and Maintenance of Profiler Calibration/Verification Site

- NJDOT utilizes their equipment, and when needed, consultant equipment to provide post construction assessment of rideability (smoothness)
- 2nd generation calibration/verification site recently developed at NJ State Police, Sea Girt, NJ

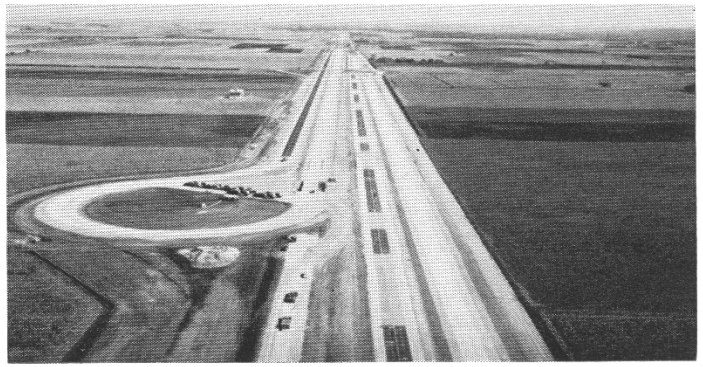
Task 3 – Pavement Management System Support

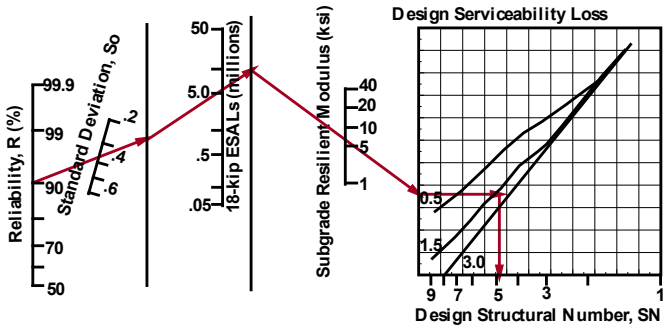
- Upcoming Activities
  - Capabilities of combining databases between Pavement Management/Design and Materials Bureau
  - Continue to enhance NJDOT equipment calibration site
  - Incorporate GIS models to assist in pavement project selection
  - Improve data reprocessing and QC/QA processes
  - Development material specific pavement performance curves to better discriminate performance and support pavement design

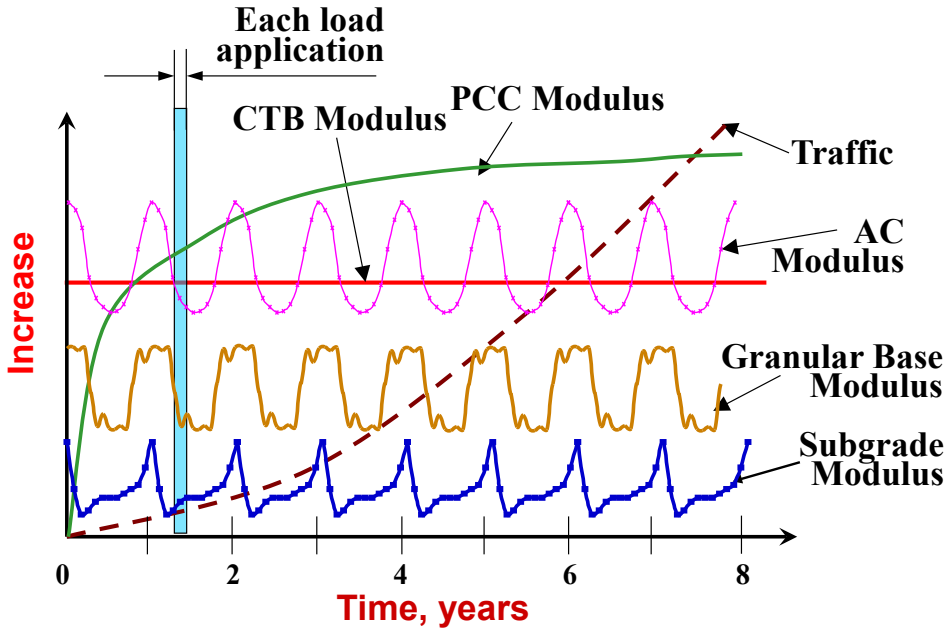
Examples of Activities
Task 4 – Pavement Design

Task 4 – Pavement Design

- Up until recently, pavement design was conducted based on the nomographs and statistics from the 1960's AASHO road test
- Computer speed/technology and better understanding of material characterization allows for more accurate pavement design and evaluation methods

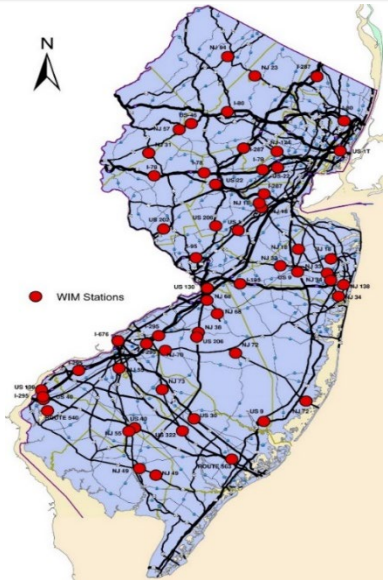


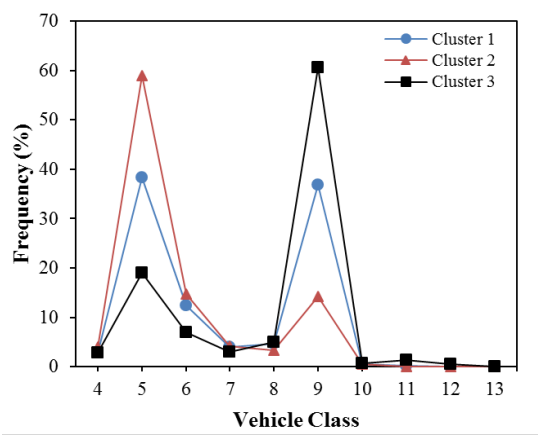


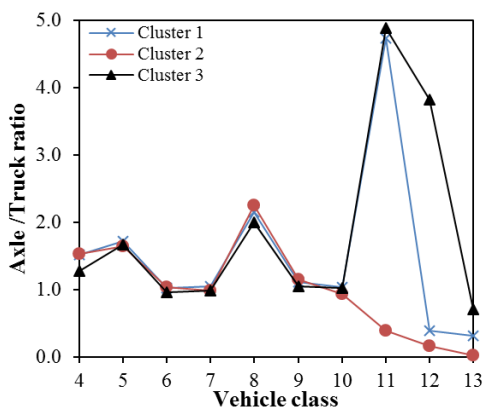


Task 4 – Traffic Families (Clustering)

- Input for site specific traffic for PAVEMENT-ME is cumbersome and time consuming
  - Pavement distress sensitivity?
- Developed "families" of traffic loading conditions for easier inputting
  - Not sacrificing accuracy!
  - Based on NJDOT WIM sites
  - Generated HTML files NJDOT can use to directly upload traffic family data into PAVEMENT-ME

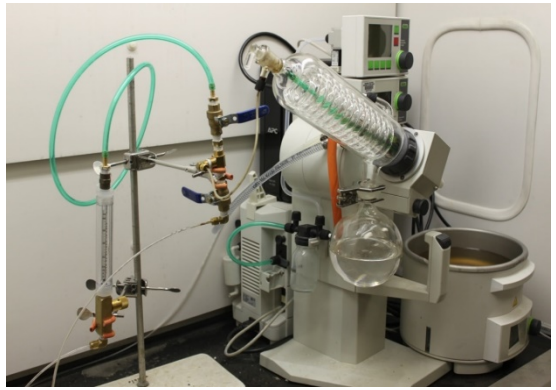






Task 4 – NJDOT Asphalt Materials Catalog

- Developed and updating HMA materials catalog for Level 1 type analysis
  - Based on plant produced HMA
    - Superpave, SMA, HPTO, BRIC
  - Aggregates and binder recovered from mixture and tested
  - Dynamic modulus and creep compliance directly measured
  - HTML files generated for direct uploading into PAVEMENT-ME



Material Information

Mix Type: 12.5M64 **NJDOT Region:** North
Producer: Stone Industries - Haledon

General Information	
Unit Weight (pcf)	154.6
Air Voids (%)	6.8
Effective Binder Content (%)	12.0
Thermal Conductivity (BTU/hr-ft-°F)	0.67
Heat Capacity (BTU/lb-°F)	0.23

Asphalt Binder

(from recovered asphalt binder - results may differ due to RAP included)

Rotational Viscosity		Dynamic Shear Rheometer (10 rad/sec)		
Temperature (F)	Rotational Viscosity (cP)	Temp (F)	Shear Modulus, G* (Pa)	Phase Angle (degrees)
230	6,100	4.4	70380210	24.3
275	1,067	21.1	10401710	38.6
329	235	37.8	1297670	49.8
348.8	148	54.44	171080	58.2

Performance Grading	Continuous	Final
High Temperature	74.4	70
Intermediate Temperature	21.9	22
Low Temperature	-23.3	-22

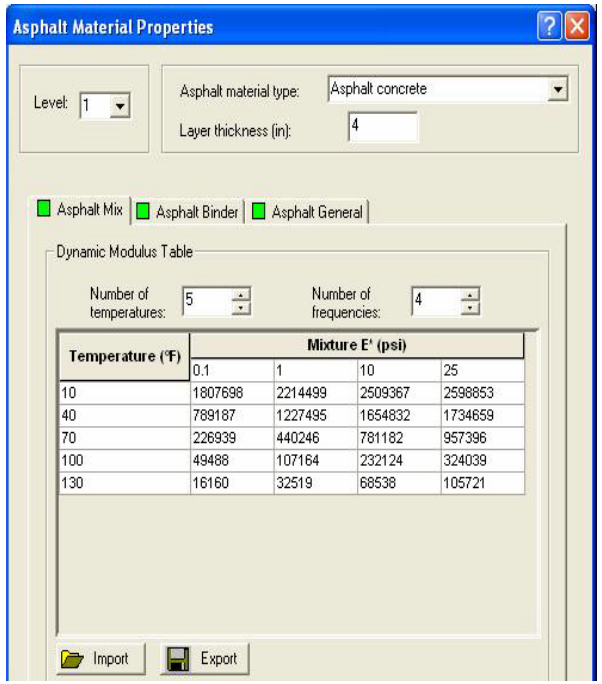
Aggregate Gradation

Gradation	Percent Passing
3/4 Inch Sieve	100
3/8 Inch Sieve	84.7
No. 4 Sieve	49.6
No. 200 Sieve	6.2

Asphalt Mixture - Dynamic Modulus

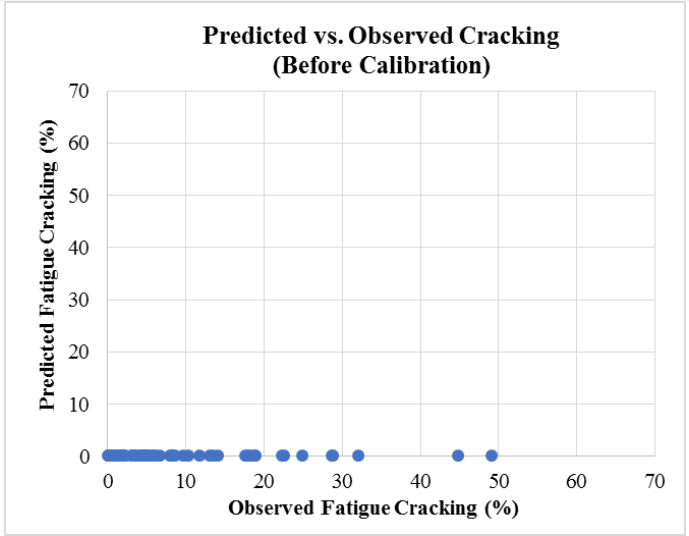
(from plant produced asphalt mixture; Reference Temperature = 70° F)

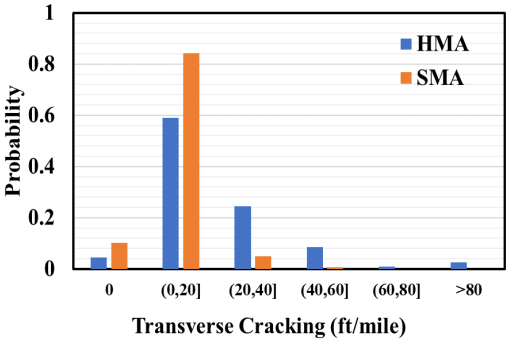
Temp (°F)	0.1 Hz	1 Hz	10 Hz	25 Hz
14	1,477,917	1,933,784	2,308,101	2,430,295
40	1,068,424	1,552,840	1,998,408	2,152,965
70	238,631	514,146	923,608	1,111,310
100	42,838	116,186	284,641	388,938
130	10,807	28,394	78,023	115,278

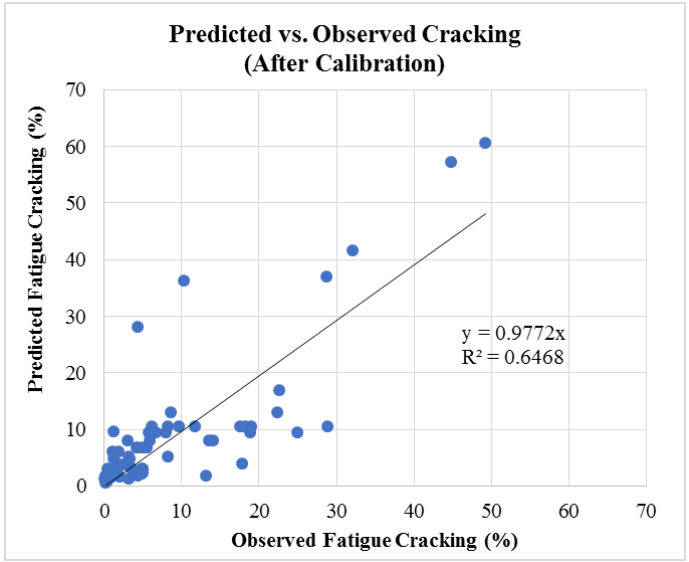


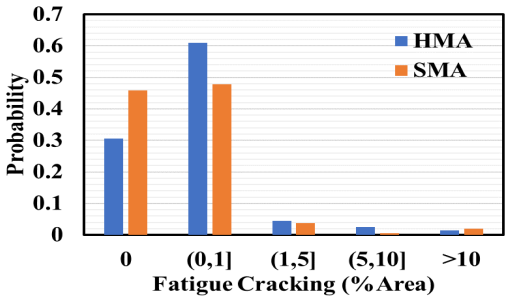
Task 4 – PAVEMENT-ME Models Calibration

- Model calibration being conducted using two large sets of data to observe differences between Level 1 and Level 3 inputs
  - NJ LTPP (Level 3)
  - NJDOT Automated Distress (Level 1)
  - Material specific calibrations to separate out asphalt mixture type
- Model calibration also being conducted with Traffic Families (shown earlier)









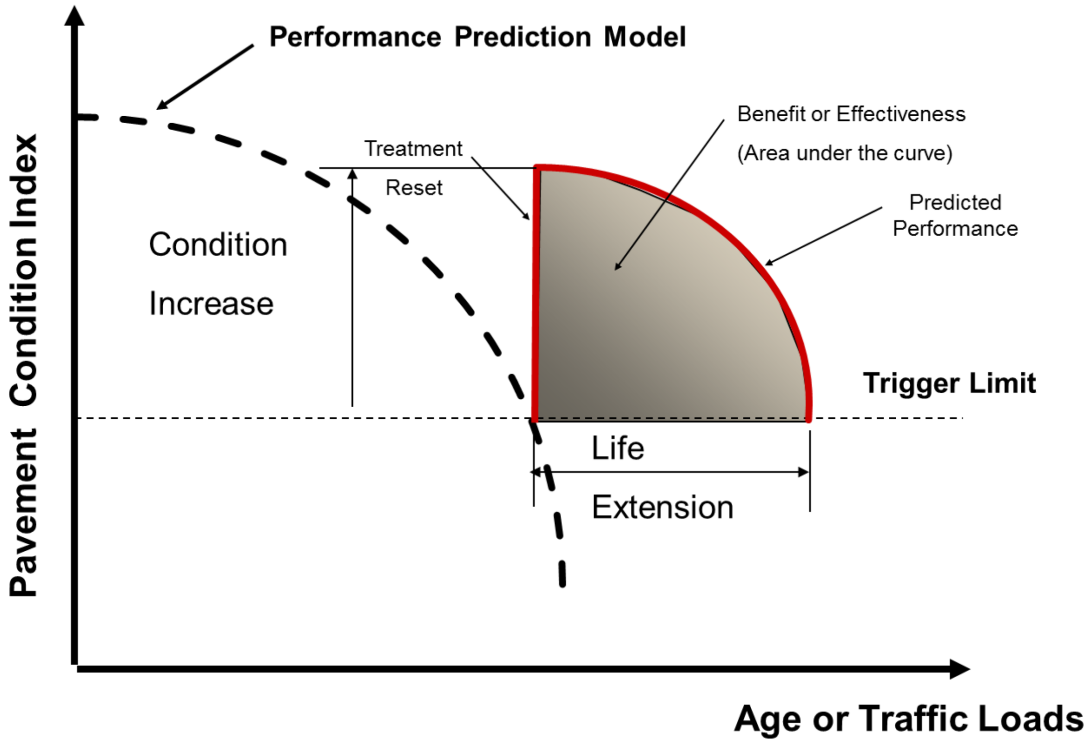
Task 4 – Pavement Design

- Upcoming activities
  - Inclusion of specialty mixture model calibration (HPTO, etc.)
  - Improve Rehabilitation design methods using measured material properties from field cores
  - Calibrating New PAVEMENT-ME Reflective Cracking Model for composite pavements

Examples of Activities
Task 5 – Lifecycle Cost and Cost Benefit Analyses

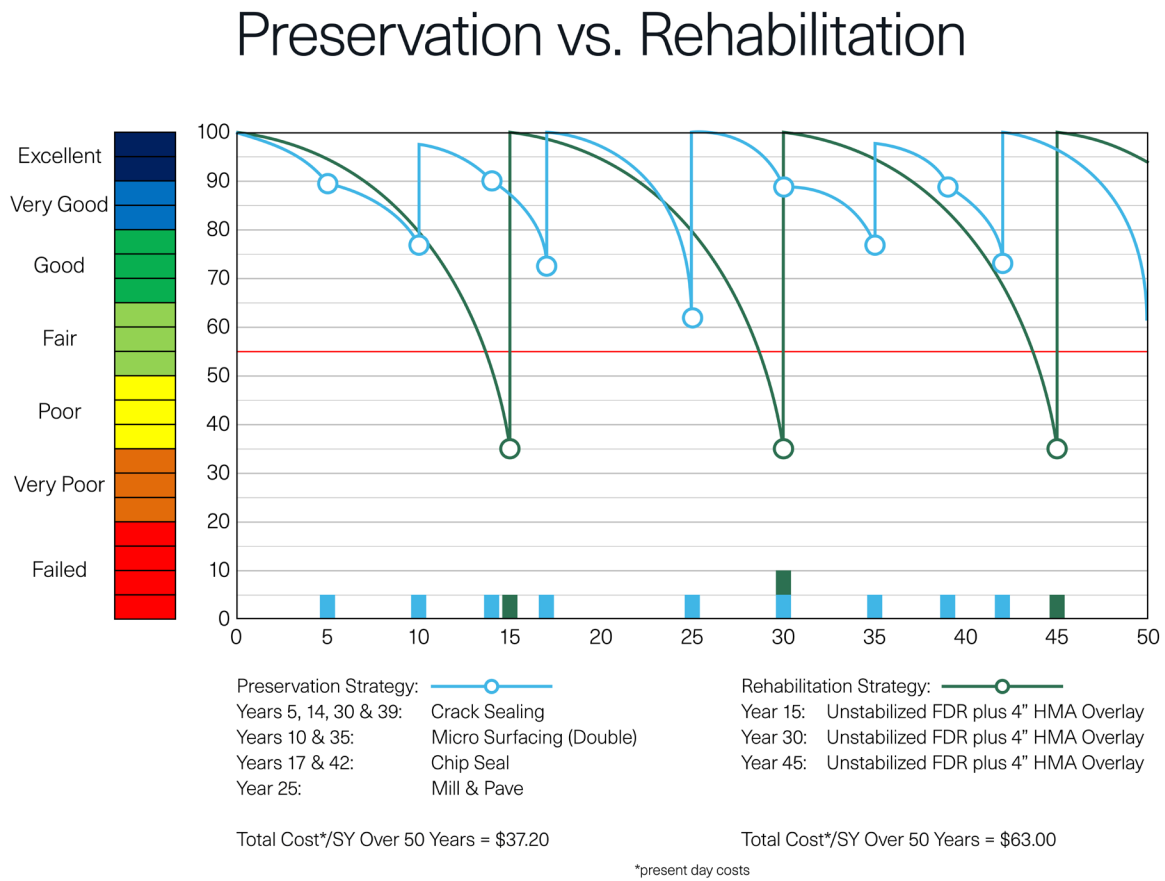
Task 5 – Life Cycle Cost and Cost Benefit

- NJDOT looking to ensure that the investment in materials for construction is "cost effective"
- Combining PMS data with cost estimates provides information able to capture this
- Often questions from industry as to why certain materials/product being used/selected



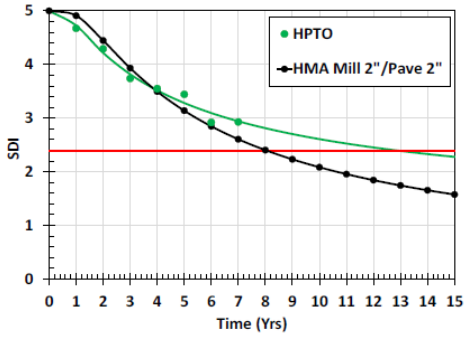
Task 5 – Life Cycle and Cost Benefits

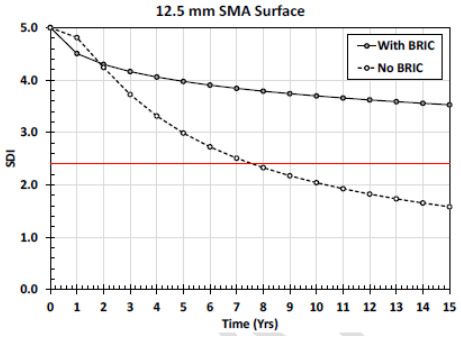
- Cost Benefit Analysis of Pavement Preservation Treatments
  - Evaluated existing NJDOT methods
  - Determined average "life" extension and associated material & construction costs
  - Provide recommendations on most cost effective and what percent of paving budget should be used to help improve the NJDOT network

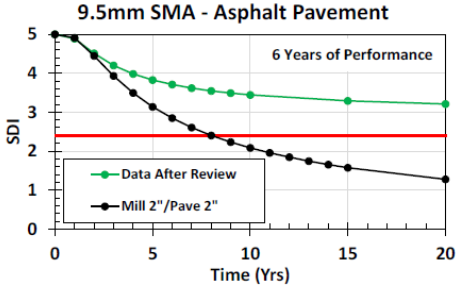


Task 5 – Life Cycle and Cost Benefits

- Developed Cost Benefit Ratio using PMS Surface Distress Index (SDI) and Construction Costs for NJDOT Specialty Mixes
  - Analysis indicates that even though some asphalt mixtures (SMA & HPTO) more expensive per ton than conventional HMA, Benefit to Cost Ratio better than HMA





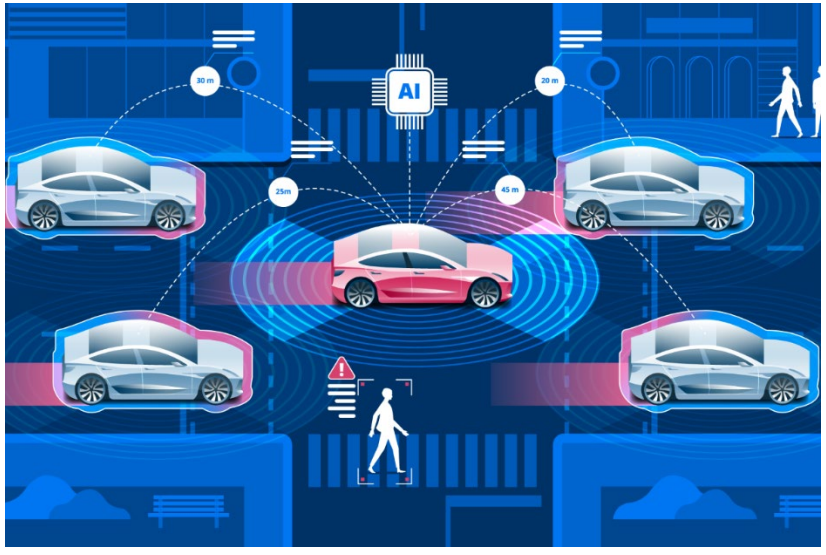


Mix Type	Compared to:	Performance Life Ratio	Cost Ratio (per Lane Mile)	Benefit/Cost Ratio (Performance Ratio/Cost Ratio)
HPTO	1.5" HMA	1.63	1.11	1.47
	2" HMA	1.63	0.83	1.96
12.5mm SMA Over HMA	2" HMA	1.88	1.84	1.02
12.5mm SMA Over PCC	2" HMA	2.67	1.84	1.45
12.5mm SMA + BRIC	3" HMA	5.00	1.75	2.85
12.5mm SMA + 12.5M64	4" HMA	2.67	1.42	1.88

Examples of Activities
Task 6 – Pavement Policy

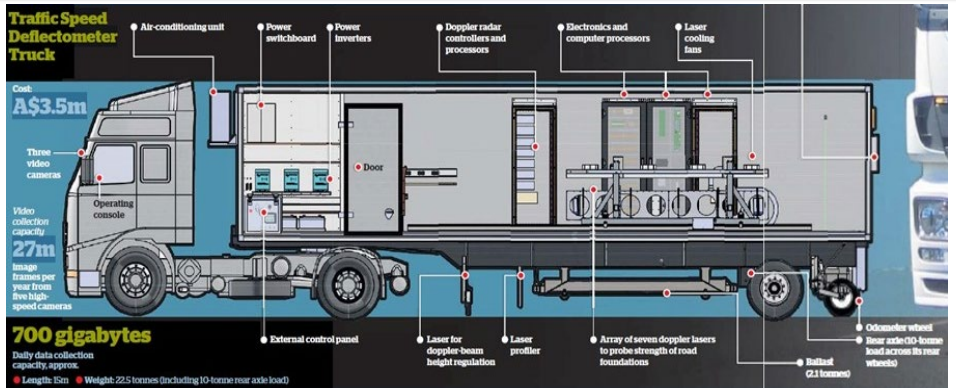
Task 6 – Pavement Policy

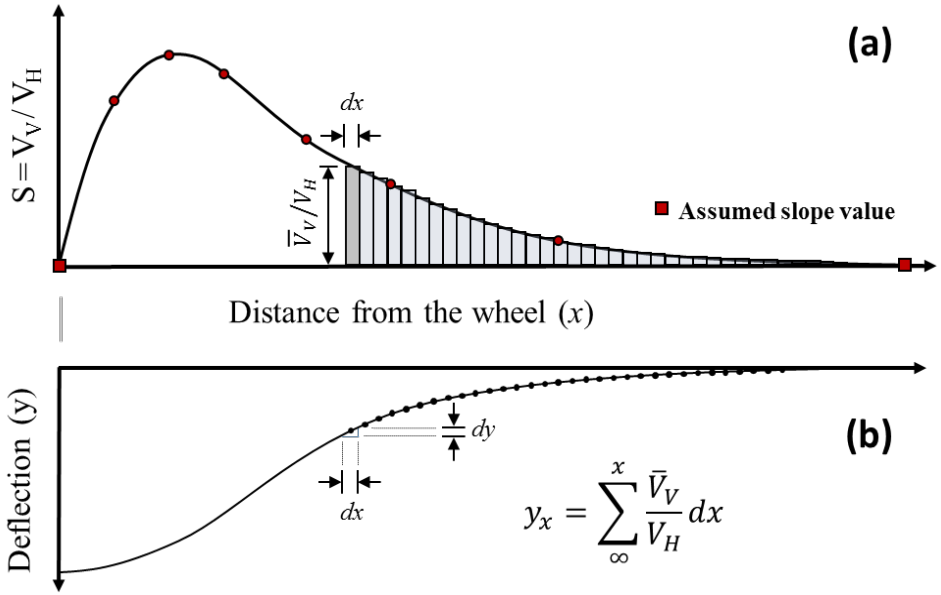
- Task 6 encompasses researching areas that would generally influence the current "pavement policy" practices of the Pavement Management & Design group
  - Pavement performance data collection practices
  - Supports the activities conducted in Task 3 – PMS
    - "White Paper" type of analyses



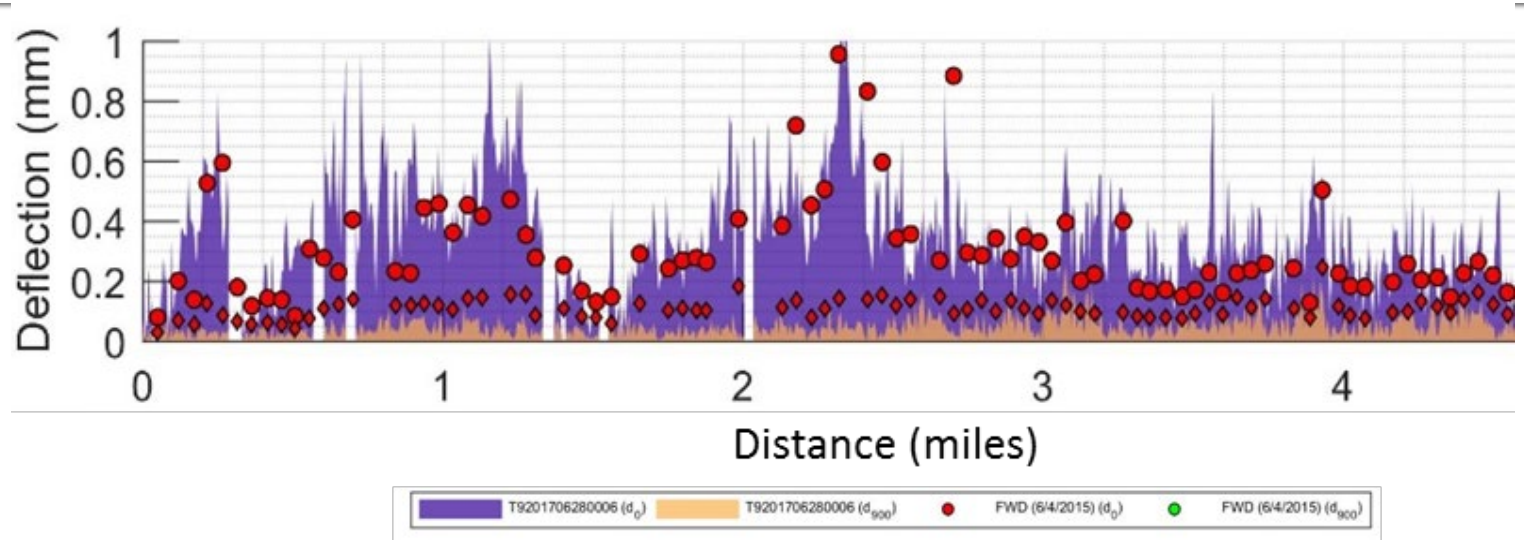
Task 6 – Traffic Speed Deflectometer

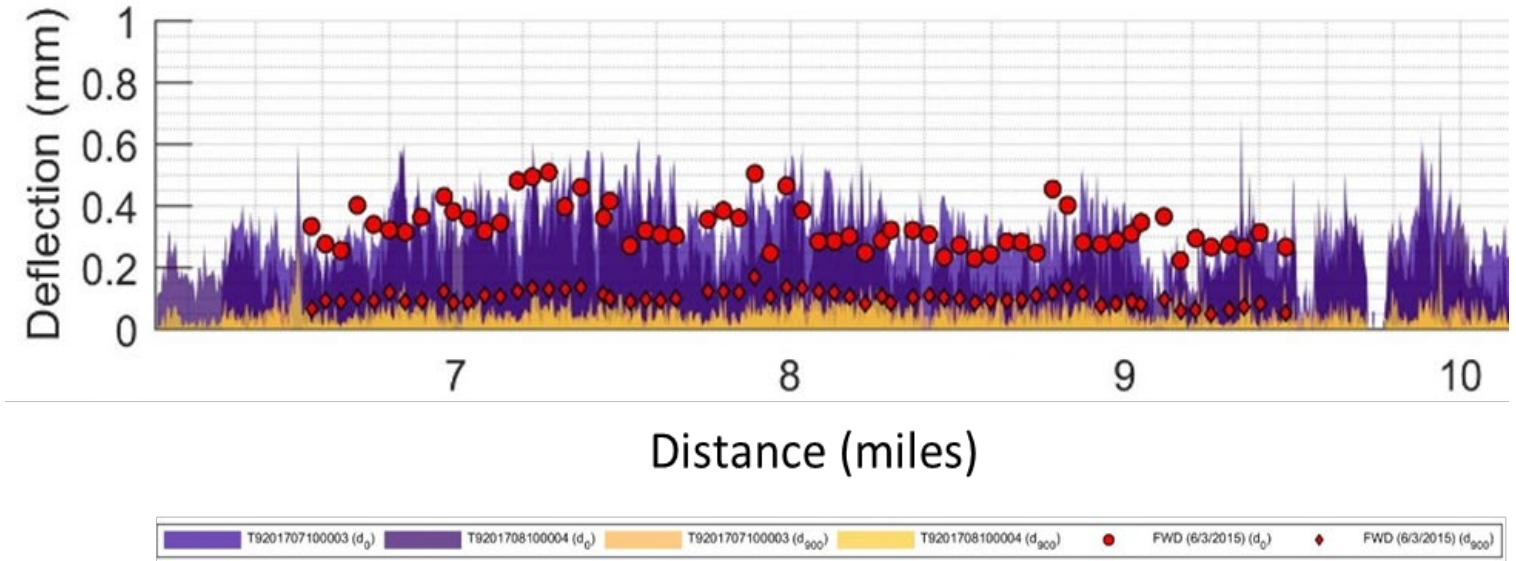
- Utilizing full scale truck loading to measure velocity of deflecting road surface
  - Integration of deflection velocity slope vs wheel offset provides deflection basin (similar to FWD)
- NJDOT evaluating if this measurement can provide guidance for network level decision making;
  - Pavement Preservation or Minor Rehab or Major Rehab



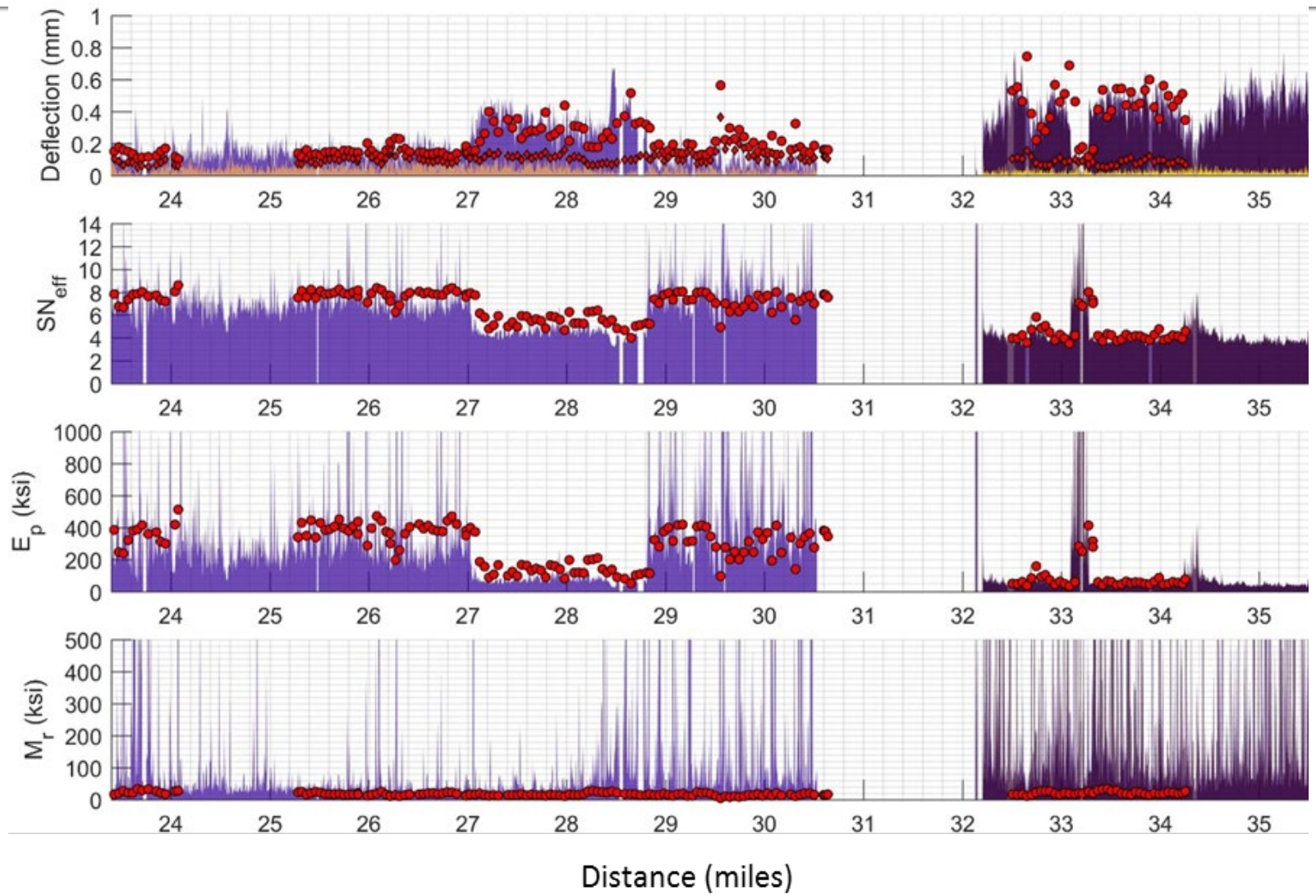


Task 6 – Traffic Speed Deflectometer

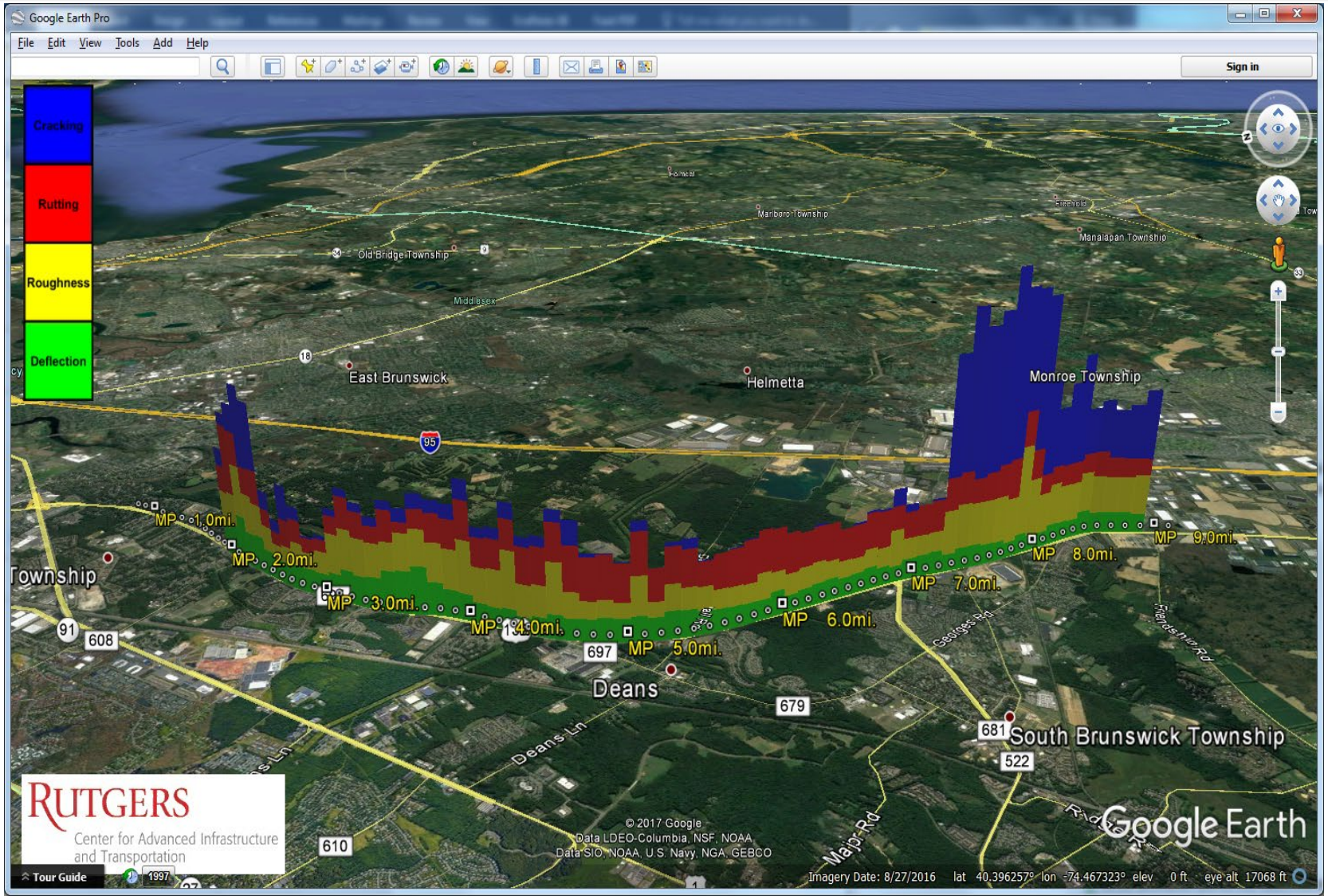




Task 6 – Traffic Speed Deflectometer

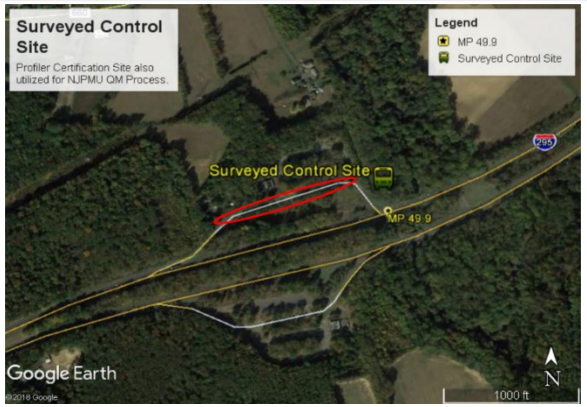


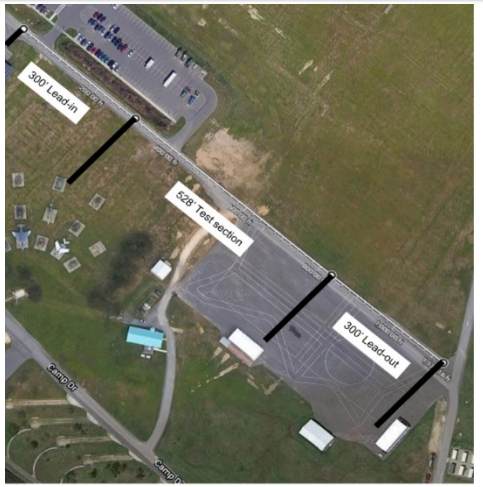
Task 6 – Traffic Speed Deflectometer

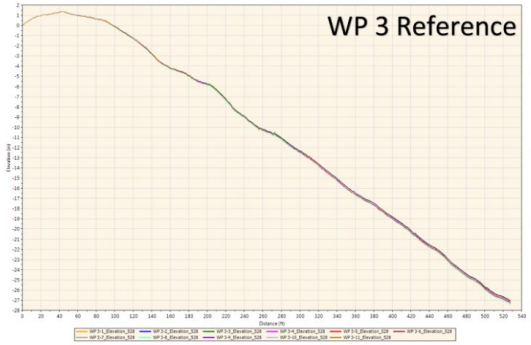


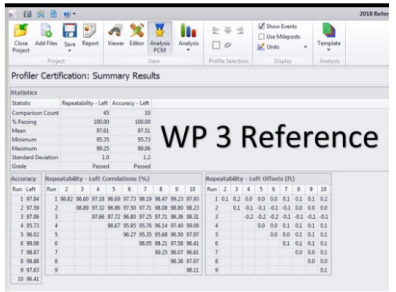
Task 6 – NJDOT Profiler Certification

- Established and maintain the NJDOT Profiler Certification site
  - Decommissioned weigh station area on I295 & NJ State Police in Sea Girt, NJ
  - Conduct longitudinal reference profiles with SurPRO Walking Profiler
  - Used for NJDOT Region Walking Profilers and NJDOT High Speed Profiler









File	IRI (in/mi)
WP 3-1	94.50082
WP 3-2	96.2994
WP 3-3	96.26919
WP 3-4	93.45005
WP 3-5	93.42684
WP 3-6	93.56133
WP 3-7	94.73637
WP 3-8	92.9762
WP 3-9	96.21339
WP 3-10	94.68621
WP 3-11	95.24393

Task 6 – Pavement Policy

- Upcoming activities
  - Impact of autonomous vehicles on pavement performance and design
  - Longitudinal Tining/Grinding Practices for Friction Increase in Horizontal Curves
  - Evaluating the Implementation of Warranties for NJDOT Asphalt Pavement Construction
  - State of practice of using NJDOT Vehicle Fleet to Aid in Pavement Monitoring

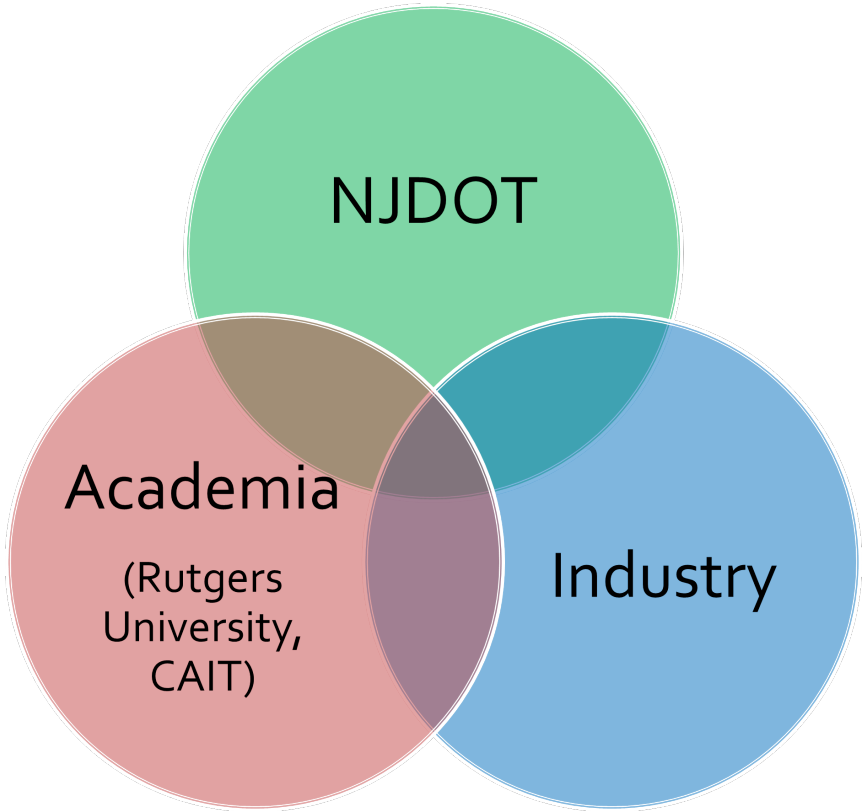
Examples of Activities
Task 7 – Training Activities

Task 7 – NJDOT Training Activities

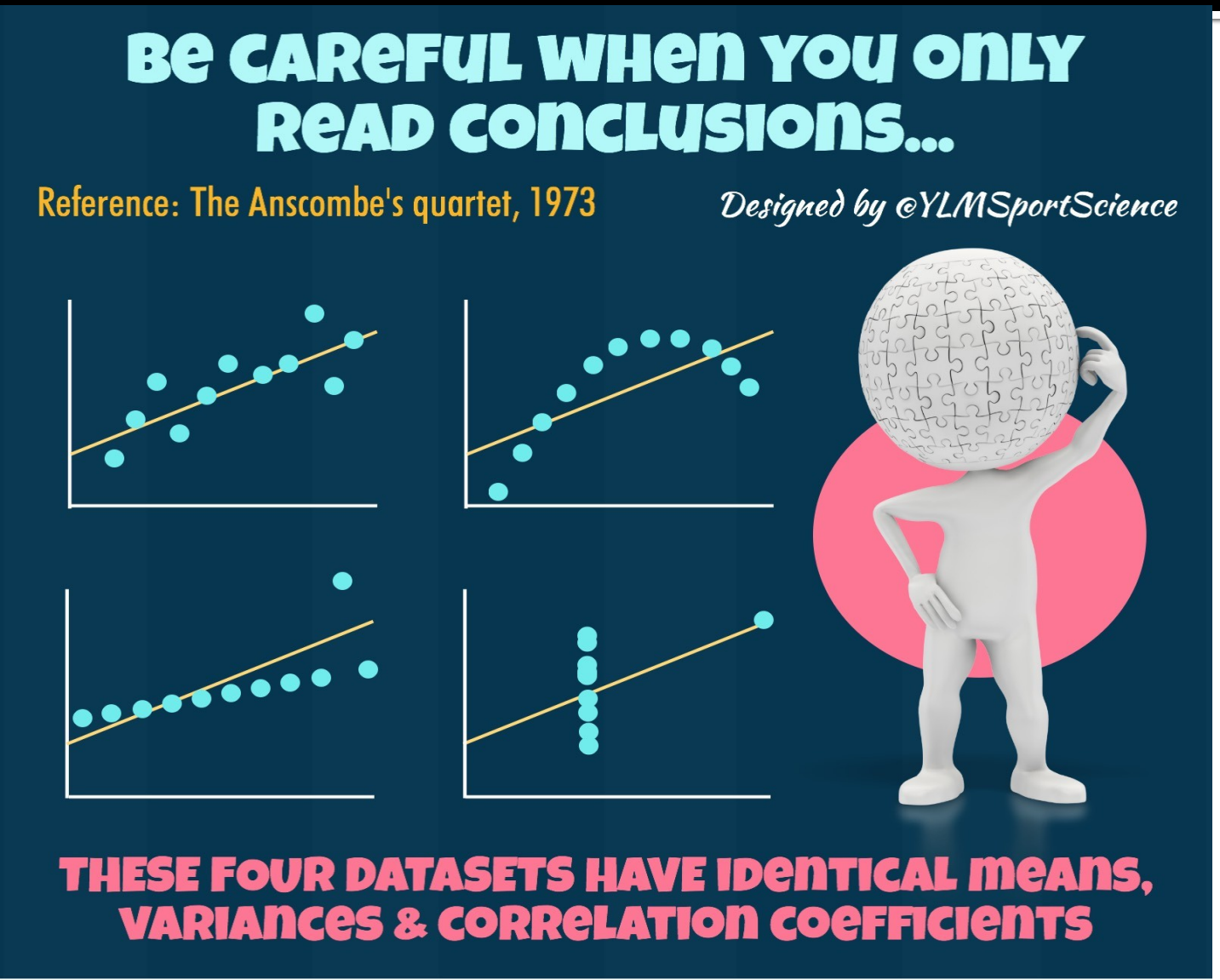
- A wide variety of training and technical presentations are conducted yearly for the NJDOT
  - Asphalt Materials and Construction – New Technologies
  - PAVEMENT-ME Use and Guidance
  - PMS Software Use and Guidance
  - SurPRO Walking Profiler Training
  - Development and Use of NJDOT's Performance Related Specifications
  - NJDOT High Speed Profiler Use and Guidance
  - NJDOT Pavement History Software Use and Guidance

Summary

- The NJDOT Pavement Support Program (PSP) is an initiative to support the immediate needs of the Pavement & Drainage Management and Technology Unit, as well as the Materials Bureau
- Emphasis on activities that can move to directly to <u>implementation</u>
  - Specifications; Procedural and Guidance Documents/Manuals; Training Activities/Programs



Thank you for your time!
Questions?



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