June 19 - 20, 2025
Hollywood, FL

TRANSPORTATION SYMPOSIUM

Evolution of Pavement Technology: Balancing Performance, Safety, and Longevity

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Presentation Objectives

- FDOT Usage of Open-Graded Friction Courses (OGFC)
  - Benefits and Challenges
  - Future of OGFC
- Performance Evaluation of Open-Graded Friction Courses
  - Replace visual surveys with automated 3D imaging
  - Digitize OGFC raveling detection
  - Leverage AI for OGFC analysis
  - Propose a cost-saving resurfacing strategy using new technology

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FDOT Usage of Open-Graded Friction Courses

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Open-Graded Friction Courses (OGFC)

- Special type of asphalt surface mixture
  - Designed to be permeable
- Composed primarily of coarse aggregate
  - Only a small portion of fine aggregate, creating a pavement with a relatively large percentage of air voids.
- Typically placed on high-speed multi-lane roadways to minimize the risk of hydroplaning and minimize splash and spray
- In Florida, OGFC is referred to as FC-5

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Dense-Graded Pavement Surface

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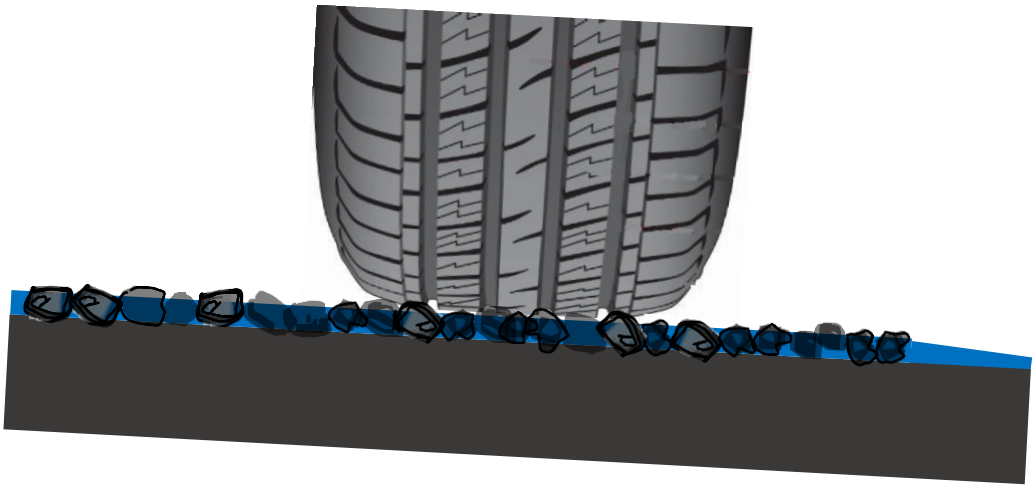
Open-Graded Pavement Surface



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OGFC in Florida (FC-5)

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Dense-Graded Friction Course

FC-12.5 Microtexture

Open-Graded Friction Course

FC-5 Macrotexture

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FDOT Usage of OGFC

- Policy
  - OGFC used on high-speed Arterials, Interstate, and Turnpike. Multilane roadways 55 mph or greater
  - 48% of FDOT's roadways are OGFC (~22,000 lane miles)
- Why Florida uses it:
  - Safety; Reduces Hydroplaning Potential and Splash/Spray During Rain Events
- Shorter Pavement Life
  - On average 14-year service life
  - OGFC is vulnerable to raveling

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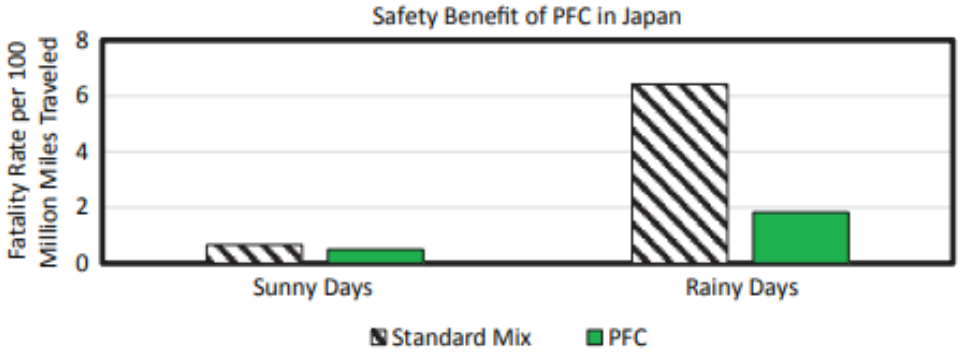
Safety

- OGFCs improve the safety of high-speed roadways



Fatality Reduction on Rainy Days (Shimero & Tanaka, 2010)

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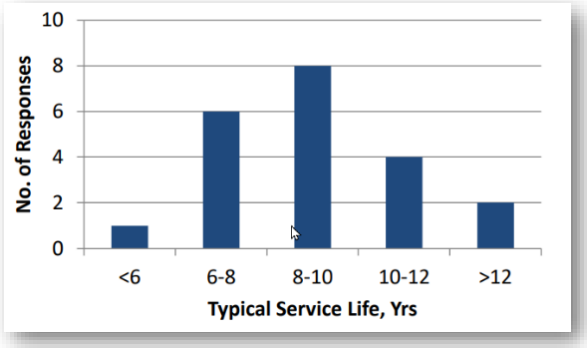
Longevity

- Open-Graded Friction Courses are safer, but their long-term performance is not as good as dense-graded friction courses
  - This is true in Florida and in other states
- In Florida, its 12-14 years vs. 17 years for dense-graded mixes.

Typical Service Life of State DOT OGFC Mixtures



NCAT Report 16-04 Phase V (2012-2014) NCAT Test Track Findings

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The Balancing Act with OGFCs

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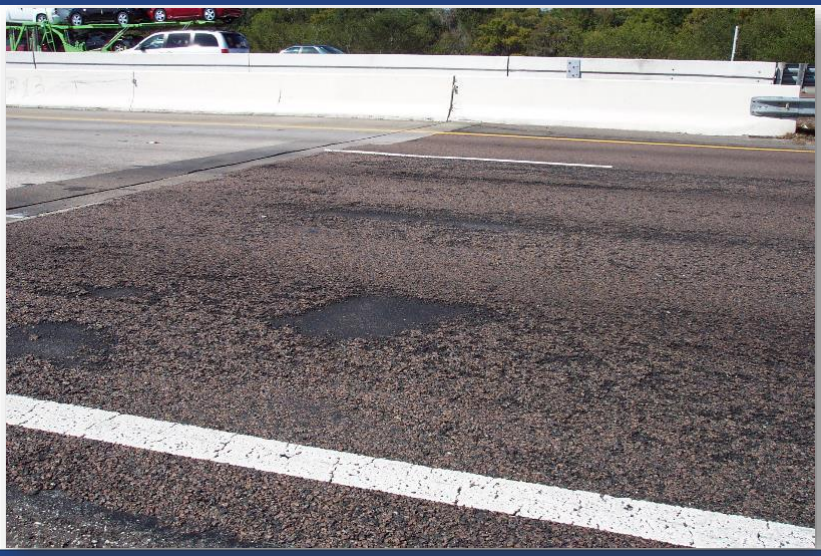
Raveling FC-5



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So how can we improve the longevity of FC-5 without compromising safety?

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FC-7

- FC-7 is a new OGFC with a smaller aggregate size (9.5 mm)
- Research shows FC-7 has better durability than FC-5
- Usage: Multi-lane Arterials with design speed 55 mph or greater
- To-date it has been placed on:
  - US-19 Levy County (2010) – Quiet Pavement Study
  - US-301 Clay County (2024) – Asphalt Test Road
  - US-1 Monroe County (2025)

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FC-5 vs. FC-7

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Summary of NCAT OGFC Research

Factor	Durability	Permeability	Drainability	Cracking Res.	Rutting Res.	Friction	Macrotexture
FC-5	O	O	O	O	O	O	O
HP	++	O	O	++	O	O	O
9.5 mm OGFC	+	O	O	O	O	O	O
AFC	++	-	-	+	+	+	-
SMA	++	--	--	+	++	+	--

Notes: 'O' = no change; '+' positive effect; '-' negative effect

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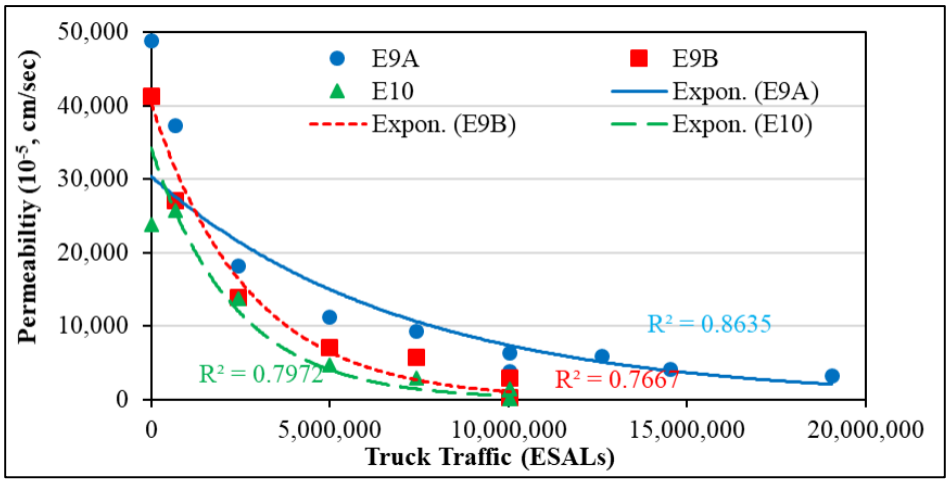
Typical Loss of Permeability



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FC-7 Adoption

- Flexible Pavement Design Manual changes currently being reviewed
- Construction Specification (Section 337) currently out for Industry Review
  - Will become effective July 2026 Letting

Summary

- FC-7 is a new alternative to FC-5.
- It is recommended for use on Arterial roadways.
- FC-5 mixtures continue to be used on Limited Access facilities.
- Construction specifications for FC-7 are similar to those for FC-5.
- Material costs for FC-7 are estimated to be approximately $2–$3 per ton higher than FC-5.

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Early Detection of Raveling Conditions with 3D Imaging System and Future Open Grade Only Resurfacing Program

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Presentation Objectives

- Highlight goals:
  - Replace visual surveys with automated 3D imaging
  - Digitize OGFC raveling detection
  - Leverage AI for Open Grade Friction Course (OGFC) analysis
  - Propose a cost-saving resurfacing strategy using new technology

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Assessment of Raveling

- Balance
  - Safety, Performance, & Longevity
- Raveling:
  - Primarily in OGFC
  - Monitor loss of aggregate
  - Determine decay rate of aggregate loss
  - Identify hazards
    - ✓ Can cause windshield damage from loose aggregates

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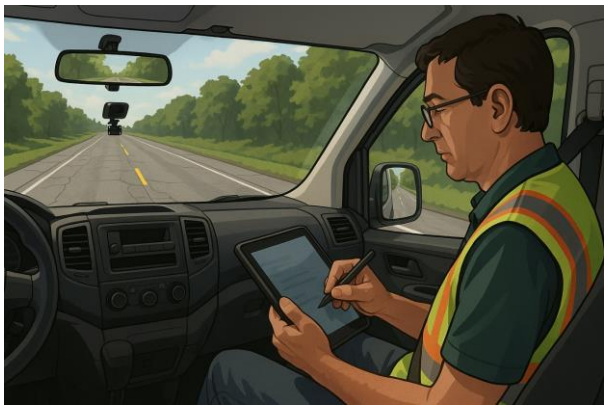
Old Method: Raveling Limitations of Visual Surveys

- Subjective distress ratings
- Slower Process (frequency/cost/time)
- Safety and labor constraints (MOT)
- Poor resolution of data (Chunk Data)
- Lack of data verification (images)



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Business Need: Automating Pavement Surveys for Raveling

- Objective surveys and data driven decisions
- Digitize Pavement Surveys
- Tools - Allows for early resurfacing (raveling) intervention/project selection
- Pavement lifecycle (provides cheaper resurfacing cost options)
- Early detection would provide maintenance strategies options and resurfacing solutions which are timely and cost effective

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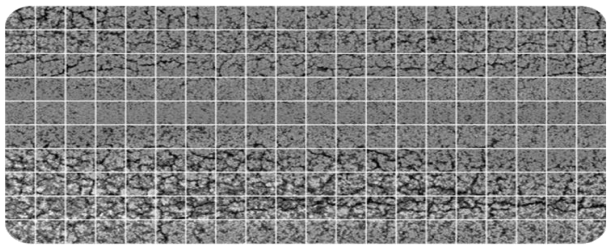
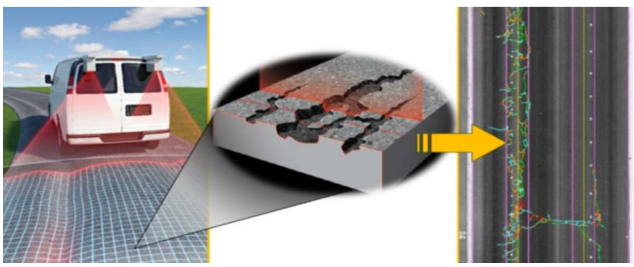
Solution: Introducing the New 3D Automated Distress Measurement System





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3D Automation Distress Measurement System

- 3D laser-based collection for cracking, raveling, rutting, & faulting
- Pavement Smoothness
- Cross-slope & grade
- Forward/Downward imaging (20 ft)
- GPS (sub-meter accuracy)

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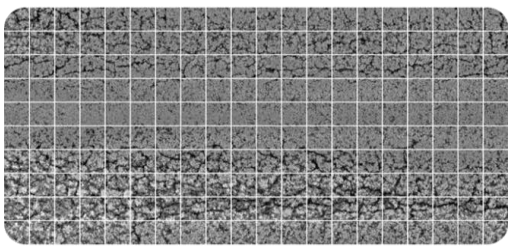
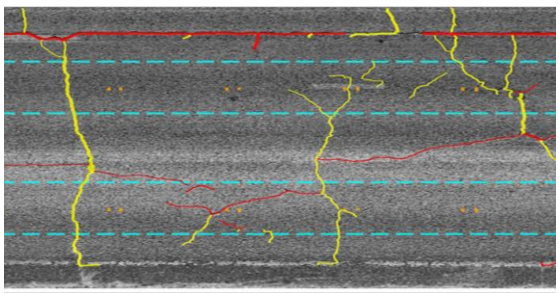
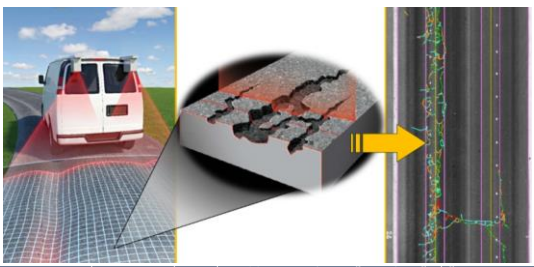
Digitize Pavement Data to Information

- **Leveraging Computing and Analytics Tools**
  - High-resolution 3D digital data, automate data analysis, reduce field verifications, and increase data accuracy.







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Automated Pavement Condition Survey Program

- Collect 100% Annual Survey
  - Measuring Crack, Rut, Ride and Raveling
  - Forward Imaging
  - 25,000 lane miles tested per Year
- Department has five 3D systems
  - 4 Production Systems
  - 1 QC System
- Implemented full automated reporting in 2024

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How is Artificial Intelligence used to Detect Raveling?

- Role of AI in Pavement Analysis
  - Pattern recognition with Machine Learning
  - Feature extraction from 3D images
  - Continuous learning model

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Machine Learning Development for Raveling Detection

- FDOT Research Project
- Building AI model (Machine Learning)
  - Utilized 3,000+ downward images (ground truth) from FDOT network
  - Convert each 3D image into a raveling category:
    - ✓ None, Low, Medium, and Severe
- Accuracy – 84% Confidence

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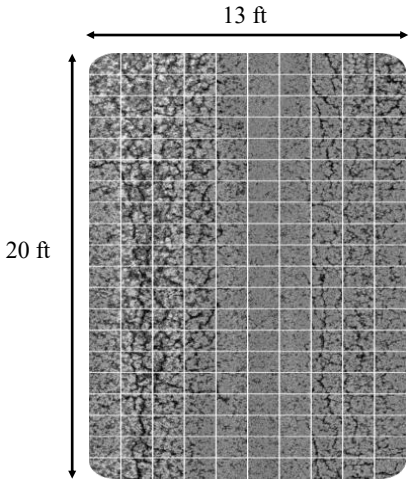
3D Image Processing (Raveling Detection Reporting)

- Using laser-based technology, pixel values are identified and cataloged
- High resolution Image (~1.5M pixels)
- Approximately 200 tiles
- Random Forest Raveling model combined with statistical information from the pixel values in each tile are used as the input for the category (none, low, medium, severe)



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Implementation of Categories on a Statewide Level for Raveling (2.3 Million Images for OGFC)

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Raveling Tools for Project Selection

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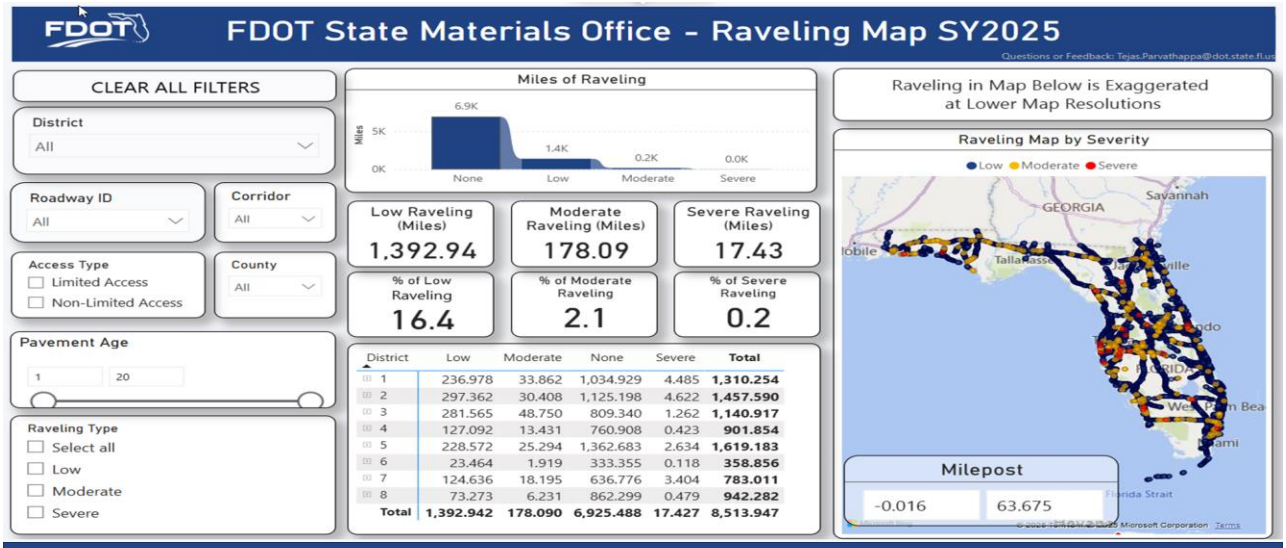
Statewide Raveling Map (All Raveling)



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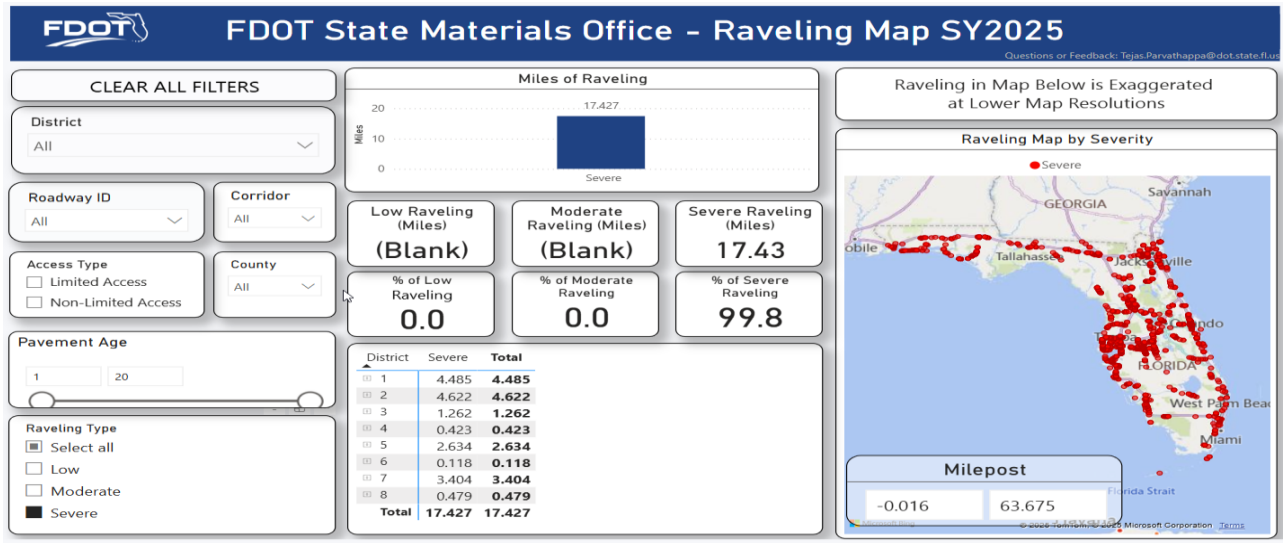
Statewide Raveling Map (Severe Raveling)



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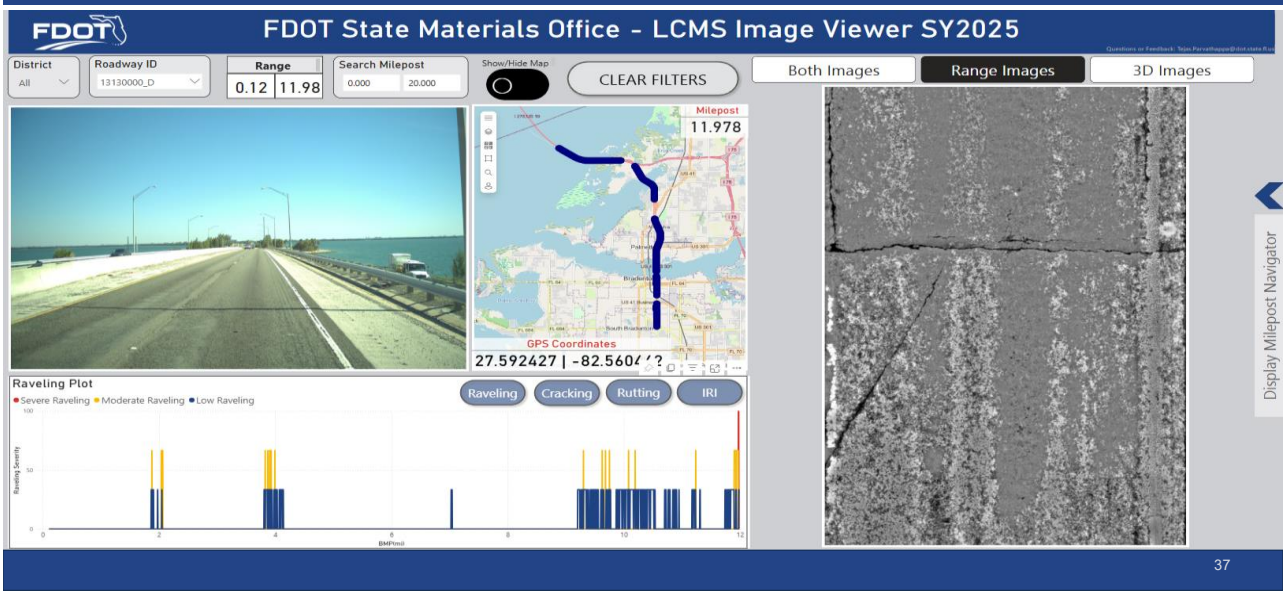
Raveling Segmentation



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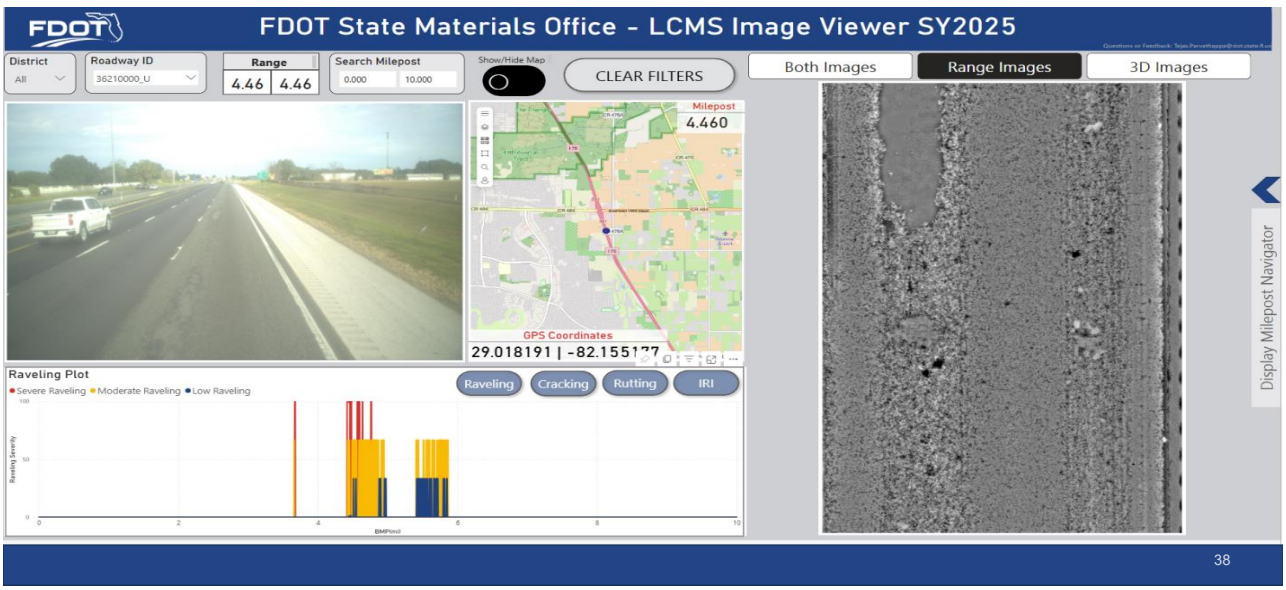
Raveling Segmentation



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Resurface Efficiency Goal: Using Technology for Data Driven OGFC Only Policy

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Open Grade Friction Course Only Policy

- The 2025 Resurfacing Program modernizes FDOT's approach with adding AI, OGFC-only resurfacing, and digital rating tools
- Statutory goals, cost efficiency, and predictive planning form the foundation for the program
- The program remains in a refinement phase—calibration and validation are ongoing
- Support and collaboration are key to building a smarter, resilient resurfacing system

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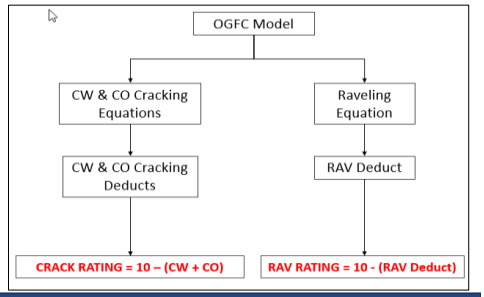
PCS Raveling Rating – 4th Dimension

- **Today – Identify Distress**
  - Rating of three Characteristics: Crack, Rut, and Ride
  - Ravel is embedded in crack rating
- **Tomorrow – Identify Distress**
  - Standalone ravel metric for a "3+1" dimension system

Crack
Rut
Ride
Ravel



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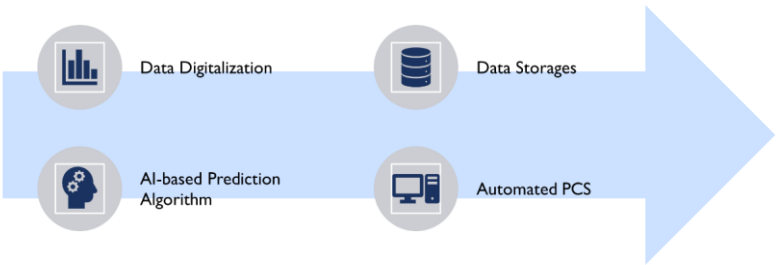
Evolution of Building an OGFC Only Program

Before 2025
- **No OGFC Only Resurfacing Program**
- Develop Raveling Model with Automated Data Equipment

2025-2027
- **Implement Raveling Detection**
- Cure Severe Raveling Area Concerns, Isolated Spots
- 528'-1/4 Mile Minimum Segment Length

2028 and Beyond
- Develop OGFC Friction Course Only Project Level Process
- Counts as Resurfacing Lane Miles
- Cost Saving Resurfacing Initiative



OGFC Only Resurfacing

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OGFC Only - A Targeted and Agile Program

Future: Project Response with Strategic Impact

- Surface-Level Opportunity:
  - Only friction course layer replaced (mill and fill 1”)
  - Structural layer must be in good condition
- Smarter Project Selection
  - AI + 3D Imaging: Machine learning pinpoints surface-only raveling.
  - Focus: Filters out structural issues—targets only what needs OGFC treatments.
  - Efficient Segments: Uses flowcharts and segmentation logic to define smart, workable sections.
- Delivery Flexibility: Construction, Maintenance, or Asset Management

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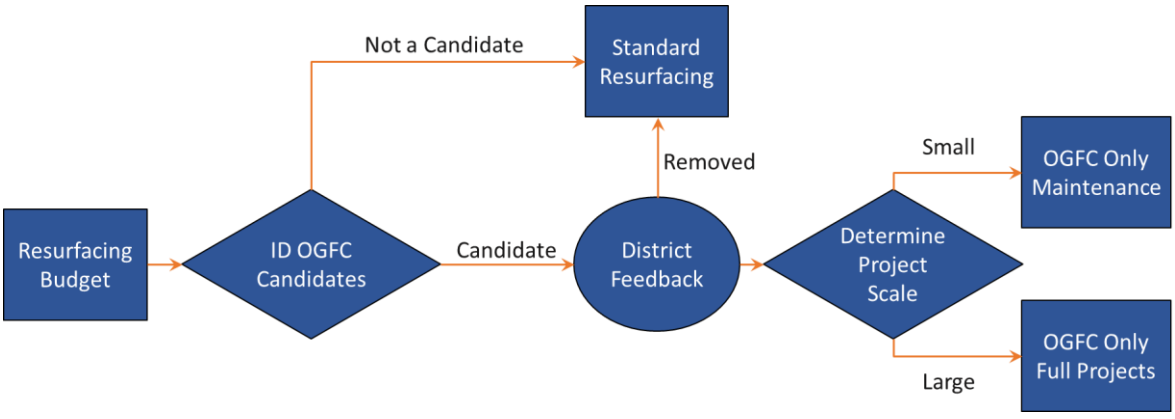
OGFC Only - Mainstream into Resurfacing

- **FY28**: Transition from reactive, emergency repairs (band-aid) to planned and full-size resurfacing projects; district collaboration
- **Credited**: OGFC Only projects will count for LM targets



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Proposed OGFC Only Resurfacing (Core)

- Project Level
- Full Lane Width
- Full Project Length
- All Lanes
- Cost Effective
- Minimum Plans
- Acceptance
- Warranty
- Smoothness

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Proposed OGFC Only Resurfacing (Option)

- Projects with minimum or discrete structural issues
- OGFC only but allows isolated deeper milling repairs for these areas

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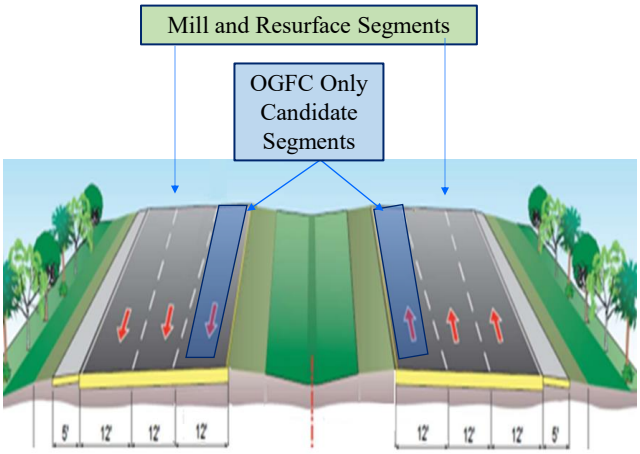
Proposed OGFC Only Resurfacing (Hybrid Option)

- Conventional resurfacing projects. Add OGFC only to projects where it makes sense
- Example:
  - Based on 3D Imaging
  - Inside lanes of a six-lane interstate resurfacing project.
  - Outer lanes will be standard mill and resurface



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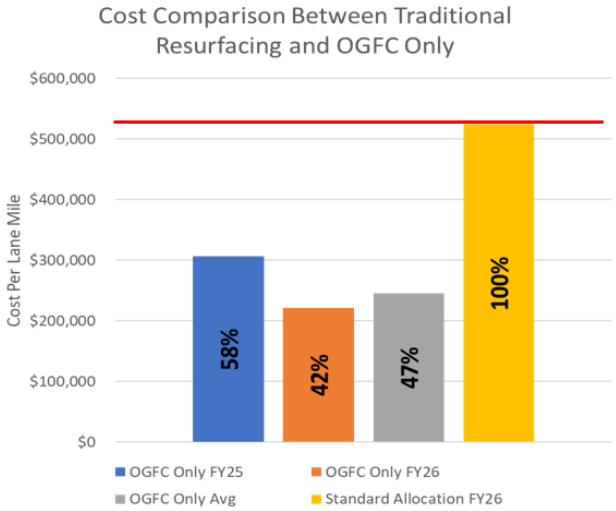
Cost Savings In OGFC Only Resurfacing

- FY 25-26 Cost Estimate
  - Isolated/Discrete raveling projects
  - 53% Reduction in paving costs/mile
- FY 27
  - Pending programming projects
- FY 28
  - Anticipate longer full project level
  - Anticipate further reduction in paving costs/mile



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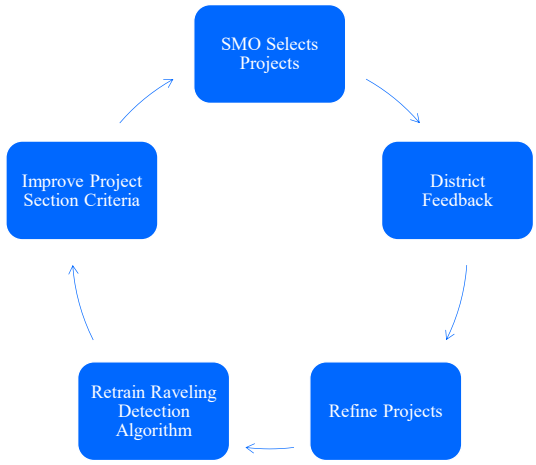
Continuous Improvement

- All aspects of the OGFC Only program will be continuously revised and improved based on feedback:
  - Leverage District relationships and coordination
  - Retrain the Machine Learning model for detecting raveling
  - Revise the project selection flowchart to better identify projects



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Questions?

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Contact Us

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