

Improve Road Safety with Wet Reflective Pavement Markings

Michael Allen 3M Senior Government Transportation Safety Specialist

Transportation Safety Division

3M Traffic Safety Specialist, ATSSA NE Chapter Steering Board Member and Immediate Past President

Mike has been with the 3M Company for 15 years, currently covering NH, MA and ME. Mike is an active advocate for transportation safety participating in several New England DOT Strategic Highway Safety Plans as well as Immediate Past President for the Northeast Chapter of ATSSA (American Traffic Safety Services Association). Mike is the ATSSA New England Chapter Technical Chair for Pavement Markings and has instructed many FHWA Retro-reflectivity, Science of Retro and Pavement Marking workshops for Transportation Agencies and Local LTAP Training Centers.

Mike has a Bachelor of Science degree in Marketing from the University of Connecticut and a Web Certification from Merrimack College. Mike is an avid traveler and currently resides in Atkinson, NH with his wife Shannon and three sons Jude, Levi and Caleb where he coaches soccer and also enjoys hiking and traversing the NH White Mountains and Tallest Peaks in New England.



3M Technology improves the visibility of roadway infrastructure



Signing

Pavement Markings

Temporary Traffic Control



A History of Roadway Safety



Safety is only the beginning.

At the core of 3M[™] Connected Roads is our mission to bring everyone home safely.

Families and commuters.

Pedestrians and road workers.

We're pursuing a future of zero deaths on the road. But there are a variety of other advantages to building simple, redundant infrastructure to support the vehicles of tomorrow.

1. Center for Transportation Research, The University of Texas at Austin. http://library.ctr.utexas.edu/ctr-publications/0-6847-1.pdf.



By 2023, 71% of all new cars will have LDW

Existing challenges with LDW/LKA* inhibits the full safety potential of lane assist systems

Automotive ADAS Applications and Associated Sensors



ADAS Sensors by Application	Camera	Infrared	Lidar Laser	Radar	Ultrasonic	GPS	V2V
Side Mirror Replacement	х	0					
Rear Mirror Replacement	х	0					
Blind Spot Information	х		0	х	х		0
Night Vision	0	х					
Driver Monitoring	0	х					
Park Assist	Х		0	0	х	0	0
Autonomous Park Assist	х		0	0	х	0	0
Surround-View Systems	Х	0			Х		
Lane Departure Warning	х	0	0			0	0
Automatic High Beam	Х	0				0	0
Traffic Sign Recognition	Х	0				Х	0
Forward Collision Warning	Х	0	Х	х	х	Х	0
Adaptive Cruise Control	х	0	х	х	0	х	0
Automated Driving / Autopilot	Х	0	х	х	x	х	0
x = currently used in production vehicles o = future or potential use							

New Car Penetration Forecast of ADAS Features



North America, Europe, Japan

LDW: Lane Departure Warning LKA: Lane Keep Assist

Source: ADAS Production Forecast Database, March 2018, IHS Markit © 3M All Rights Reserved. 3M Confidential.



What do you mean, "existing challenges"?

Wide variety of surfaces and conditions that effect contrast and visibility

Humans can often interpret what's real- can machines?



Pavement markings must be visible both day and night





Driving at night in the rain is a big problem

ln 2017, 6,952 people died in crashes on U.S. roads when it was raining¹.

55% (or 3,811) of those deaths occurred at night or in low light conditions¹.



Only 25% of travel occurs at night².



Why Wet Reflective Pavement Markings Matter

What do drivers see?



Daytime Dry

Night-time Dry

Night-time Rainy



What happens when pavement markings disappear?





Research links wet reflective markings to helping reduce crashes Safety Evaluation of Wet Reflective Pavement Markings: FHWA-HRT-15-083







Reduction in Run-off-road crashes on multi-lane roads

Reduction in crashes with injury on multi-lane roads Reduction in crashes with injury on freeways

Key Findings:

- For MN, NC and WI combined, the results of the study indicated that wet retroreflective Pavement markings reduced the number of total crashes, injury-crashes, run-off-road crashes, wet-road Crashes, nighttime crashes and nighttime wet-road crashes. The reduction of injury crashes was statistically Significant (95% confidence level).

- After analyzing the data, the researchers determined that the benefit to cost ratio for multi-lane Roads is 5.44 and the benefit to cost ratio for freeways is 1.45





Research links wet reflective markings to helping reduce crashes

Safety Effects of Wet-Weather Pavement Markings: TRB 19-04199



Reduction in Wet – Night Crashes



Reduction in Wet – Night Fatalities





Not all pavement marking optics are created equal



Optics in the pavement markings return light back toward its source.

When light travels from air into water, the direction changes. This change is called refraction.



1.5 refractive index glass beads are commonly used for dry conditions, but fail in wet/rainy conditions



Dry 1.5 Refraction Index



Wet 1.5 Refraction Index



1.9 refractive index beads are more efficient and increase light return in dry conditions, but still fail in wet/rainy conditions



Dry 1.9 Refraction Index



Wet 1.9 Refraction Index



For beads, only 2.4 optics provide useful light return in nighttime rainy conditions



Dry 2.4 Refraction Index



Wet 2.4 Refraction Index



For all weather performance you want both 1.9 and 2.4 refractive index optics.



Dry 1.5 Refraction Index



Dry 1.9 Refraction Index



Dry 2.4 Refraction Index



Wet 1.5 Refraction Index



Wet 1.9 Refraction Index



Wet 2.4 Refraction Index

© 3M All Rights Reserved.



What to consider when building a wet reflective specification

Visibility of lane markings – What the research says

- In general, improving the visibility of lane markings for humans makes them more visible to machine vision systems
 - Minimally need presence of marking on the road consistency of implementation is helpful
 - Lane markings often include optical elements intended to provide visibility at night
 - Contrast markings help visibility on light colored pavement
 - Lane marking dimensions and performance are not uniform
- Automated vehicles rely on the sharp contrast between the luminance of the pavement marking and the luminance of its immediate background to detect the pavement marking¹.
- Poor pavement markings, adverse weather conditions and glare interfere with continuous automated vehicle operation and require special consideration

• Consistent dimensions and geometries are helpful and appropriate metrics ensure markings are effective

1 - A review of recent advances in lane detection and departure warning system. Narote, Sandipann P, et al. s.l. : Elsevier, January 2018, Pattern Recognition, Vol. 73, pp. 216-234.



Select the Right Test Method for Wet Retroreflectivity ASTM Wet Continuous vs. Wet Recovery – during rainfall and after rainfall

Wet-Continuous ASTM E2832-12

- Condition of continuous wetting
- Simulates wet reflectivity of marking <u>during rainfall</u>
- 5-10 mins to complete

Wet Recovery ASTM E2177-19

- Condition of standard wetness
- Simulates wet reflectivity of marking after it's stopped raining
- 3-5 mins to complete



Wet-Continuous ASTM E2832-12 Wet-Recovery ASTM E2177-19



Forthcoming Human Factors Research from TTI & MnDOT

Final report expected to be published this month

Background: Currently no minimum wet visibility retroreflectivity standards

Project: Determine driver needs, recommended wet continuous retroreflectivity values

How it will be used: Justify state-wide standards for wet reflective pavement markings

DEPARTMENT OF TRANSPORTATION



Wet Reflective Pavement Markings from 3M All weather solutions for many applications



3M[™] Connected Roads All Weather Elements 3M[™] Stamark[™] High Performance Tape Series 380AW 3M[™] Stamark[™] Wet Reflective Removable Tape Series 380AW



Key Takeaways

To learn more visit: www.3M.com/wetreflective

- Rain and light conditions are aggravating factors in crash risk
- At night, during rainy conditions, non-wet reflective markings can't be seen
- Recent research links wet reflective pavement markings to helping reduce crashes

- Not all pavement marking optics have the same performance capabilities
- 2.4 refractive index optics provide optimal light return during rainy conditions at night
- Wet continuous test method is preferred
- Forthcoming human factors research from TTI/MnDOT to set visibility standards

3M Transportation Safety Mission

WE HELP BRING FAMILIES HOME SAFELY.

Questions?

Thank you!

Wet reflective pavement markings help bring families home safely

A data driven safety case for wet reflective pavement markings



Rain and light conditions are over aggravating factors in crash risk

- 6952 fatalities on US roads during rain event¹
- 25% of road travel occurring at night²
- 55% of fatalities during rain occurred at night¹

Wet Reflective Markings Matter



At night, during rainy conditions, non-wet reflective markings disappear

- Reduced driver visibility³
- Less effective CAV guidance systems⁴
- Increased crash risk⁵

Proven Safety Countermeasure



Recent research links wet reflective markings to helping reduce crashes

- FHWA*: 46% reduction run off road crashes⁶
- FHWA*: 40% reduction crashes with injuries⁶
- TTI: 49% reduction wet night fatalities⁷

*On multi-lane roads



Sources: USDOT Federal Highway Administration, European Road Federation, Transportation Research Record, Accident Analysis And Prevention, Texas Transportation Institute 32