VDOT
Virginia Department of Transportation

Virginia Asphalt Conference & Expo - December 5-6, 2018
Innovation: Driving The Future

http://www.virginiadot.org/programs/connected_and_automated_vehicles.asp

NATIONAL PERSPECTIVES ON PAVEMENT MARKINGS

Human Drivers and Automated Driving Systems Levels 1 - 3

Harry A. Campbell, PE, PTOE, VDOT Traffic Control Devices Engineering Manager And
Task Force Chair, NCUTCD Markings Technical Committee's Review of the FHWA Automated Driving Systems RFI Responses

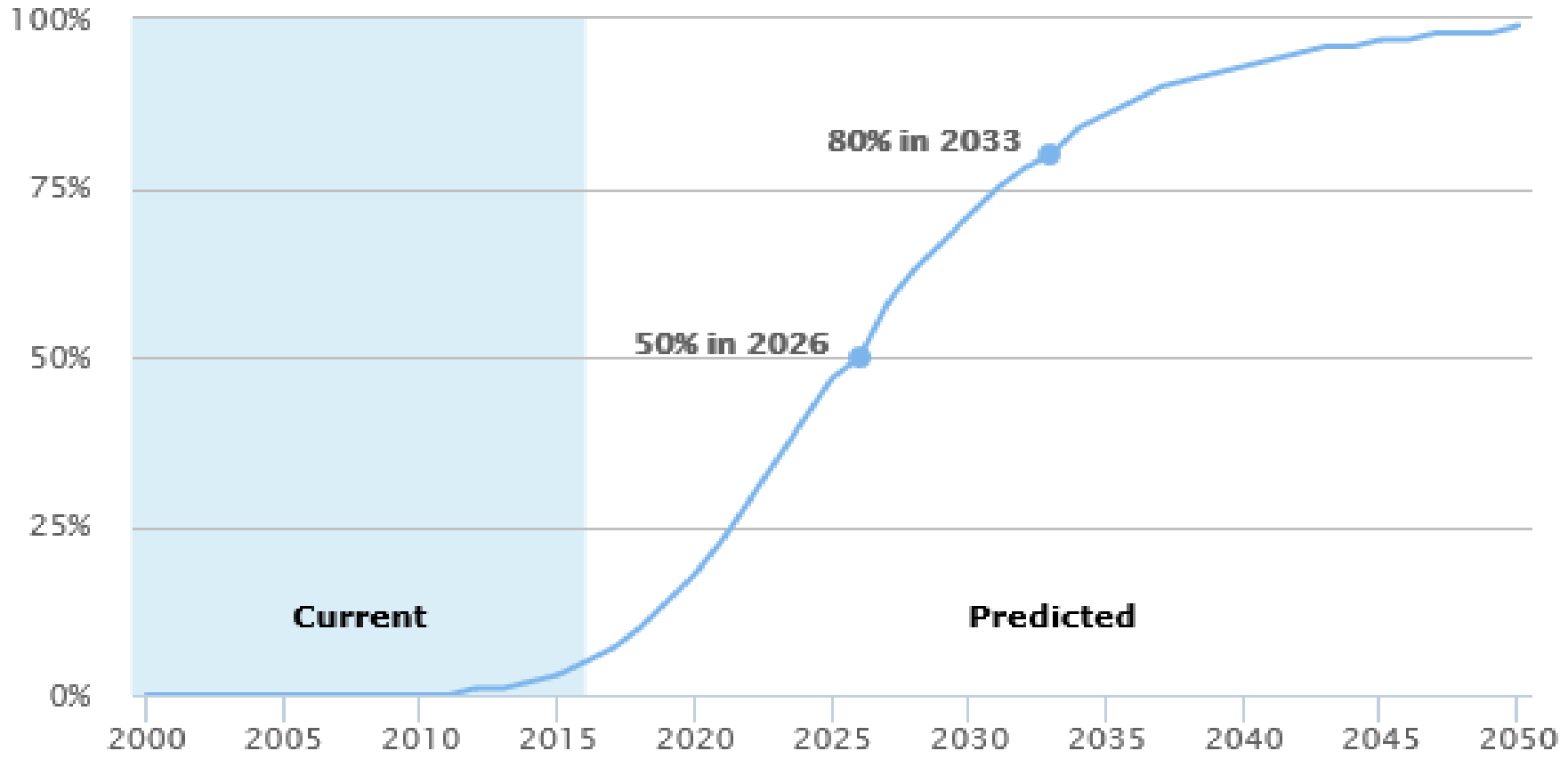
December 6, 2018

Human Driver – Pavement Marking Safety Improvements

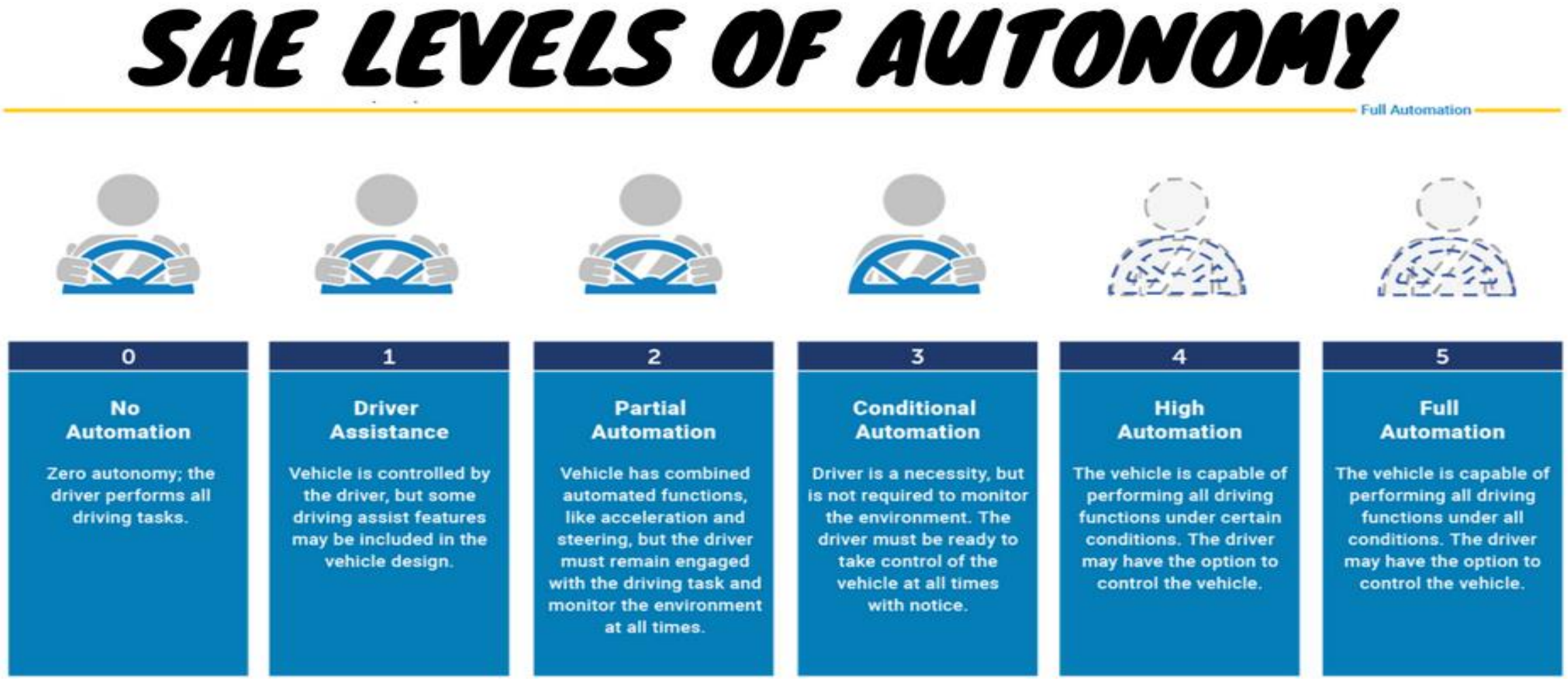
- Wider Lane and Edge Lines,
- Retrorefectivity Improvement (175 mcd desirable)
- Increase Skip Line & Decrease Gap (15’-25’ or 20’–20’),
- Raised Reflective Markers supplementing lane lines,
- Contrast Markings on concrete pavements
- Center and Edge Line Rumble Strips (not always feasible)
- Intersection Marking, proper placement symbols & messages
- Consistency and Uniformity in Markings (harmonization)
- Maintain Pavement Markings

Numbers of Vehicles with Automation Will Increase One Prediction Example Is

Automatic Breaking Systems Prediction of Market Penetration



Society of Automotive Engineers (SAE) Levels 0 to 5



Sensor Systems In Vehicles Today:

- The primary vehicle automation sensor technology that reads pavement markings is a forward looking passive camera.
- Driver assist features such as lane departure warning and lane keep assist are available when the camera technology can detect the edge lines, lane lines, and center lines.
- Automated driving technology that allows hands-off driving also relies on the detection of these same markings.
- In areas with inadequate markings, automated vehicle functions become unreliable or are disabled.
- Criteria needed to increase the detection rates of passive camera technology.

Important Objectives:

- **Focus on what human drivers need that also helps Automated Driving Systems (ADS) – Machine Vision,**
- **Increase the detection rates of passive camera technology, and therefore increase the benefits of these automated driving functions (The potential will exist to reduce roadway departure crashes by an estimated 50 percent),**
- **The criteria presented today does not conflict with the current MUTCD or other National policies.**
- **The criteria is intended to enhance the performance of automated driving technologies, and in many cases they also provide benefit for human drivers.**

Road Markings - Immediate ADS Needs (current research):

- Focus on Roadways with posted or 85th percentile speeds equal to or above 40 mph (presumed to be the most benefited),
- Edge lines, lane lines, and center lines *should* have a width of 6-inches,
- Broken lane lines *should* be 15-feet with a 25-feet gap, or dimensions in a similar ratio,
- Dotted lane line extensions *should* be used along exit ramps on limited access highways and have a width of 6-inches,
- Gore markings, and other wider-than-normal markings, *should* have a width of 10-inches, Gore areas *should* include a chevron style pavement marking pattern,
- Edge lines, lane lines, & center lines *should* be maintained to a retroreflectivity level of 35 mcd (dry) – Recent Research: Cameras Need Wet Retroreflectivity,
- Phase-out ceramic buttons (Bott's Dots) as a substitute for road markings.

Road Markings - ADS Optional Criteria (current research):

- **Focused on Roadways with posted or 85th percentile speeds equal to or above 40 mph (presumed to be the most benefited),**
- **Edge lines, lane lines, and center lines on light colored pavements *may* include parallel contrast striping (1-inch minimum width) along both sides of the markings,**
- **Edge lines, lane lines, and center lines *may* be maintained to a retroreflectivity level of 70 mcd (dry) and 20 mcd (wet).**

Note: FHWA is developing minimum retroreflectivity levels for human drivers that will replace the criterion when FHWA finalizes.

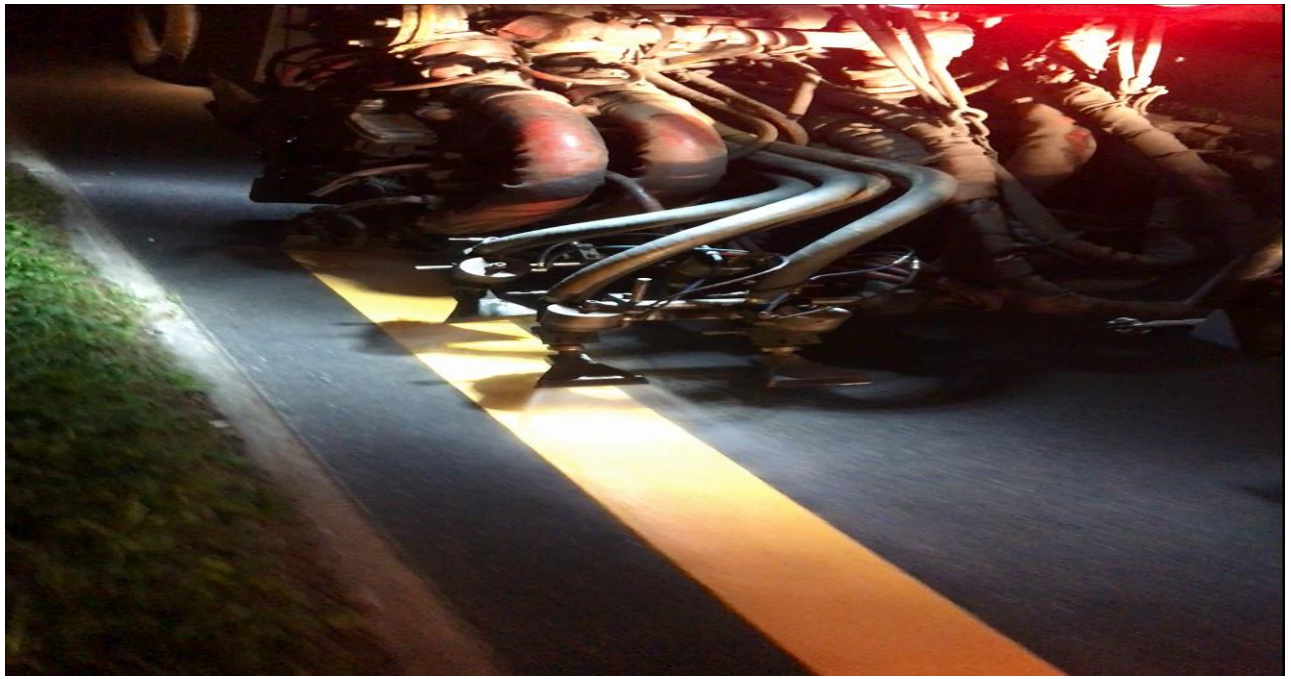
Road Markings - ADS Criteria To Be Considered & Uncertainty That Exists:

- Focused on Roadways with posted or 85th percentile speeds equal to or above 40 mph are presumed to be the most benefited,
- Edge lines, lane lines, and center lines could be maintained to a retroreflectivity level of 150 mcd (dry) and 35 mcd (wet),
- Edge lines, lane lines, and center lines used on light colored pavements could include parallel contrast striping (2-inch minimum width) along both sides of the markings.

- Uncertainty in infrastructure investment and allocation of limited resources is a key concern for state and local agencies,
- As the infrastructure requirements and timing of ADS technology remain unclear, state and local DOTs are not currently in a position to significantly invest in infrastructure improvements for automation.

Lane Departure crashes produce at least a quarter of the nation's vehicle crash deaths each year:

- **A combination of advanced driver lane keeping assist systems with consistently applied and well-maintained edge and centerline pavement markings offers a viable and achievable solution for safer two-lane rural roads.**



A Recent Comment to FHWA:

"maximize on what can be done to use readily available technologies to reduce crashes and crash severity NOW for both human drivers and Advance Driver Assist Systems (ADAS – SAE levels 1 thru 3) with an eye on what works or will need to be done to help provide redundancy for fully automated vehicle"

Seth Chalmers PE – Pima County Department of Transportation, October 24, 2018

FHWA National Dialogue:
https://ops.fhwa.dot.gov/automationdialogue/index.htm

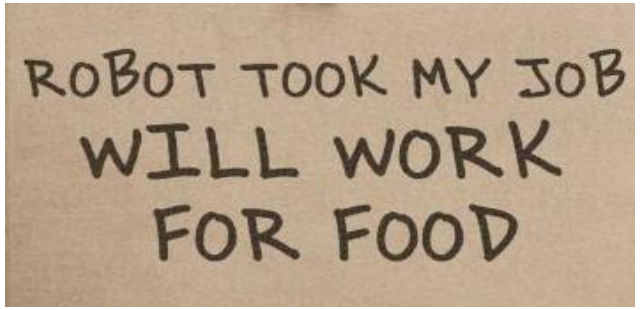
Pavement Marking Policy and Practices and Automated Driving Systems Are Going To Evolve – Predictions Are:

- By 2030, up to 70 percent of new vehicles sold could have self-driving features and SAE Level 4 fully-autonomous vehicles could even be widely available before that.
- Based on current rate of new vehicles sold and the older vehicle turn-over rate, it may not be until 2050 or later before the US vehicle fleet becomes saturated with vehicles equipped with self-driving features.
- Nationally, the question is what can Highway Agencies do to prepare for this innovation—to help accelerate the benefits while not sacrificing the needs of human drivers in the mixed vehicle fleet era?

“Failure To Plan Is Planning To Fail”

“Insanity can be defined as continuing to do the same thing over and over again expecting different results”

References Includes: Harper, C. D., Hendrickson, C. T., Samaras, C. Cost and benefit estimates of partially-automated vehicle collision avoidance technologies. Accident Analysis & Prevention, 95, 104–115. 2016



If you would like more information, email me at:

Harry.Campbell@VDOT.Virginia.gov

THANKS TO: The National Committee on Uniform Traffic Control Devices’ (NCUTCD) Markings Technical Committee (MTC) and the Members of the Task Force.

SPECIAL THANKS TO: Paul Carlson, PhD, Road Infrastructure, INC, NCUTCD MTC and Robert Dingess, Mercer Strategic, NCUTCD MTC and ATSSA MTC