

Infrastructure for Assisted and Automated Vehicles

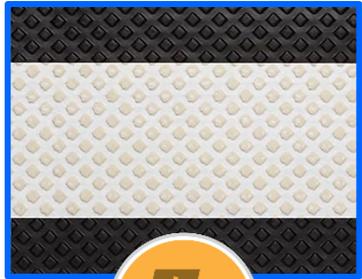
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Global Government Affairs
3M™ Connected Roads

January 9, 2019

3M's Long History of Innovation in Road Safety

For 80 years, 3M working to improve safety and mobility



Pavement Markings



Traffic Signs & Services



Temporary Traffic Control



Vehicle Registration



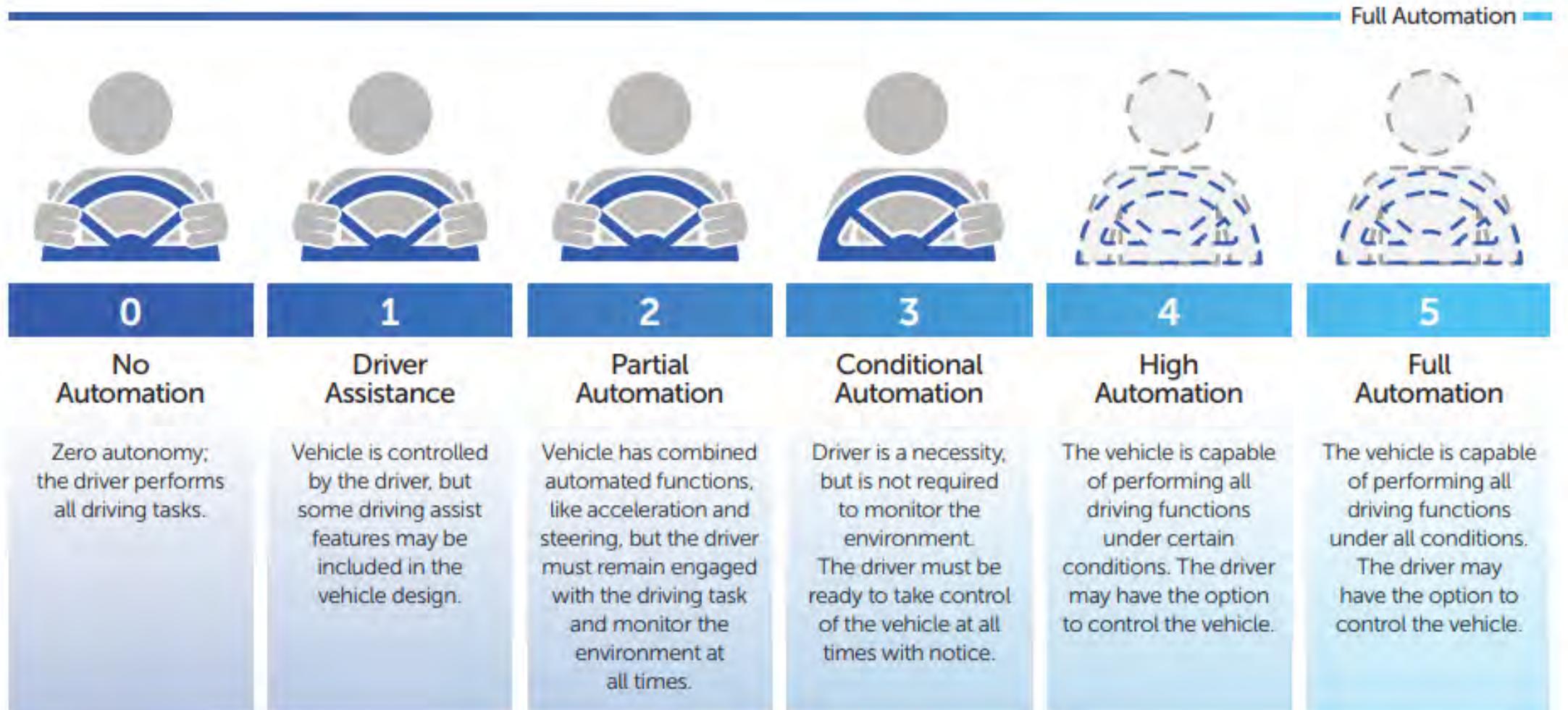
Vehicle Markings (Conspicuity)

Roadway Applications

Vehicle Applications

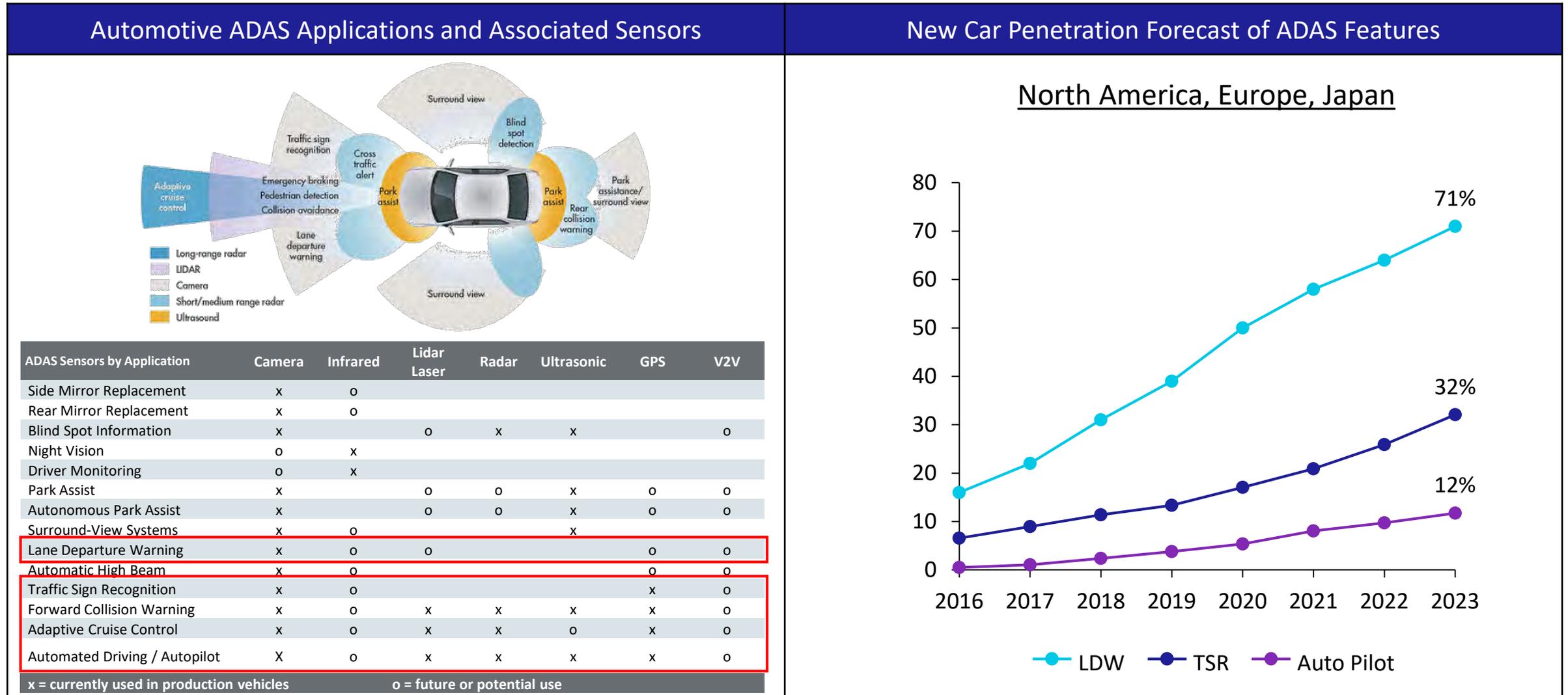
SAE J3016 Levels of Automation

Society of Automotive Engineers (SAE) levels have become industry consensus



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

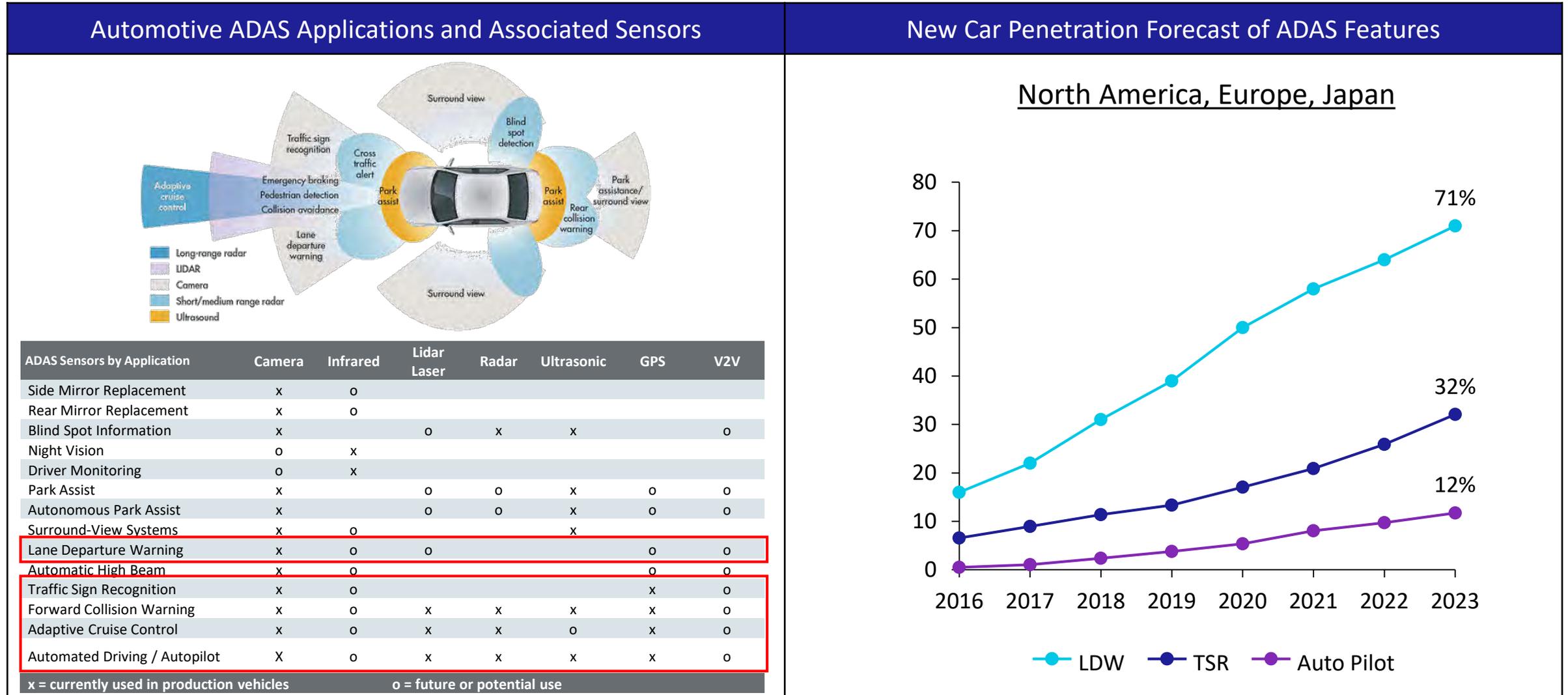
Existing challenges with LDW/LKA* inhibits the full safety potential of lane assist systems



Source: ADAS Production Forecast Database, March 2018, IHS Markit

By 2023, 32% of all new cars in key regions will have TSR

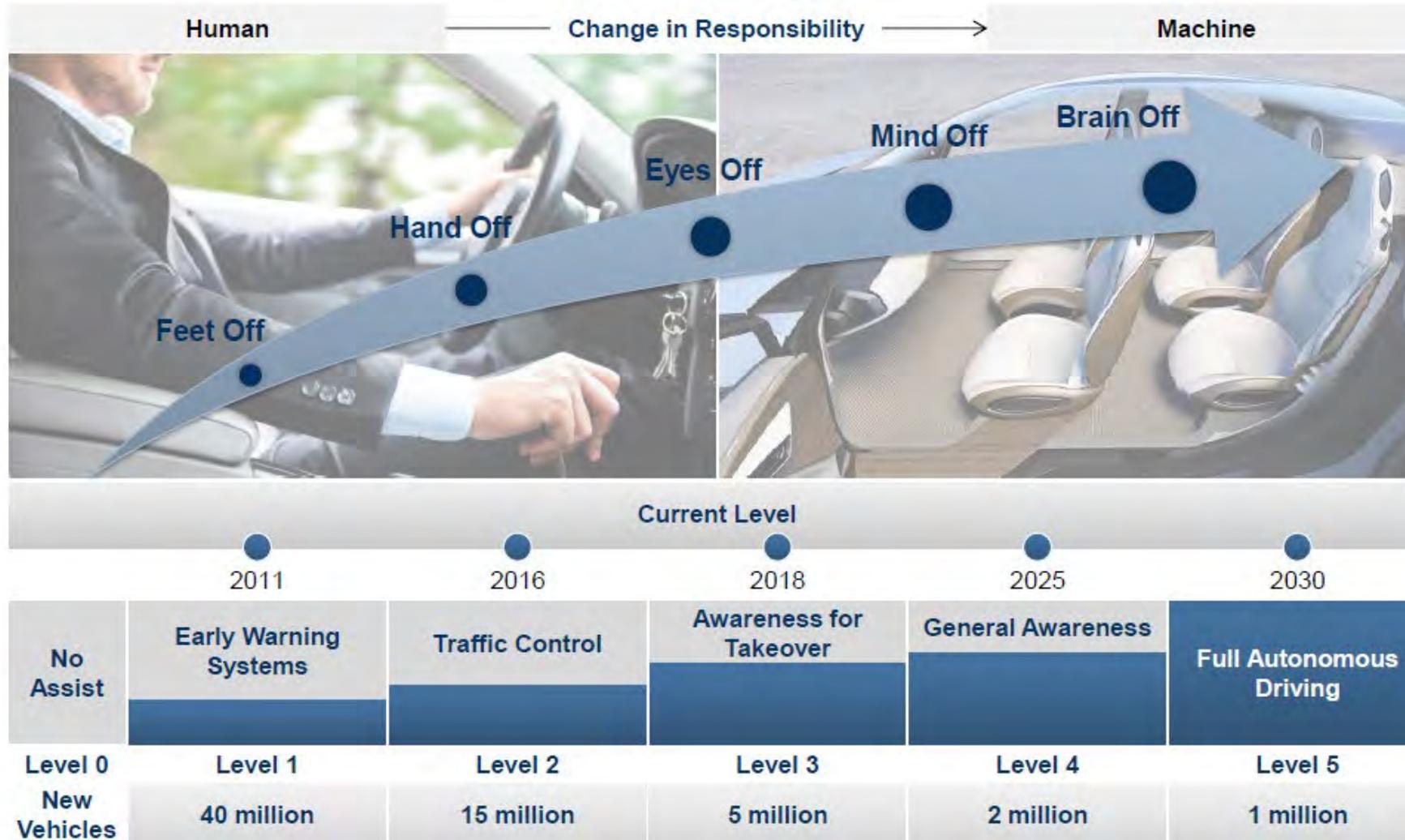
TSR still has challenges in detecting and recognizing the signs correctly



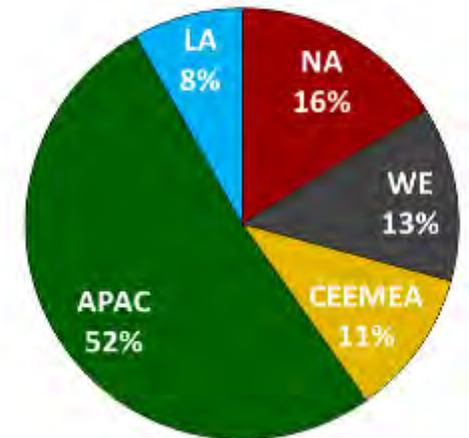
Source: ADAS Production Forecast Database, March 2018, IHS Markit

Evolution to Autonomous Vehicles

Driving estimated to be fully autonomous by 2030



... by Region in 2035



Levels 2-5 vehicles growing >25% CAGR globally

3M™ Connected Roads

Delivering solutions for safe human and intelligent machine navigation of infrastructure

Delivering Unique 3M technology



All Weather & Smart Lane Markings



Machine Readable Signs

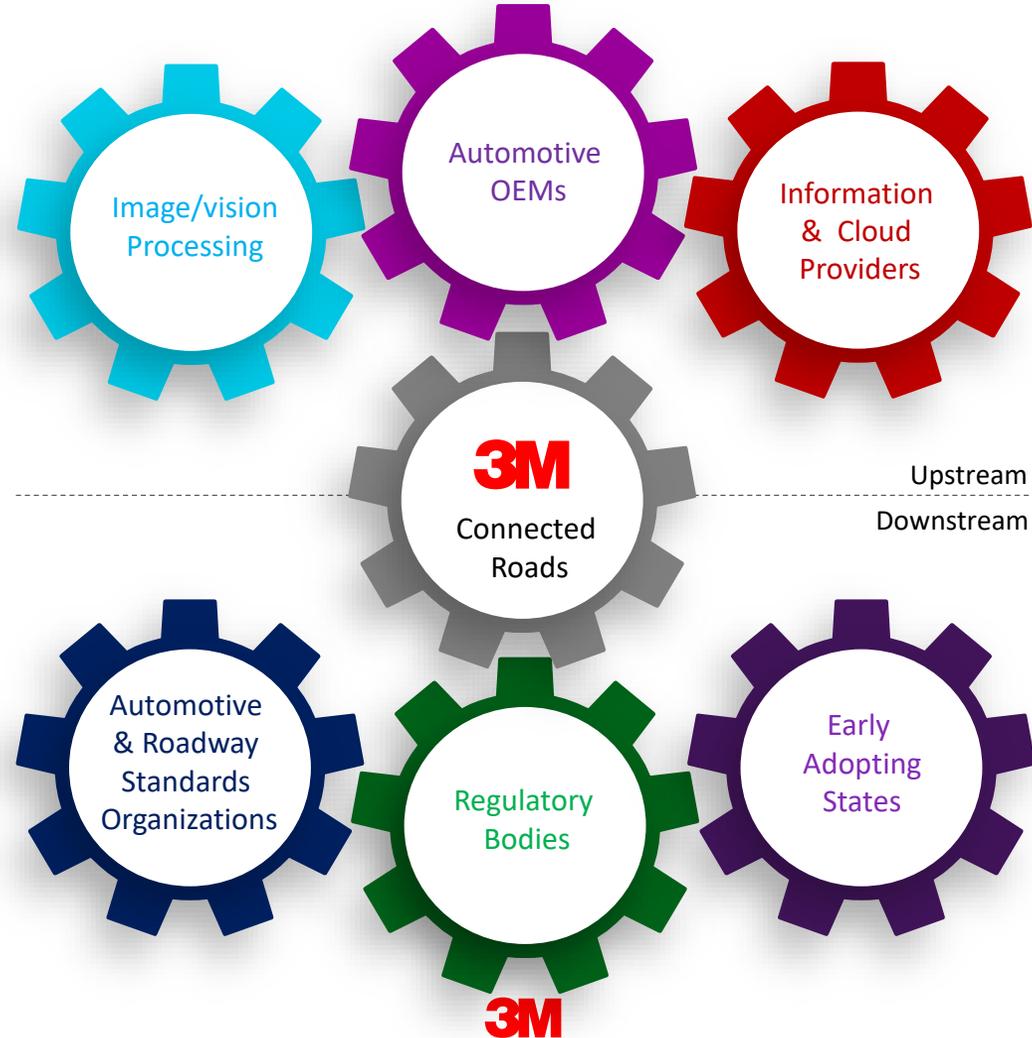


Machine Readable Traffic Control Devices

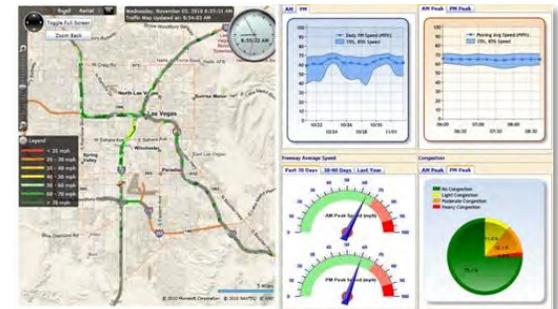


Work Zone & Road Information System

Engaging strategic, selective early adopters & ecosystem

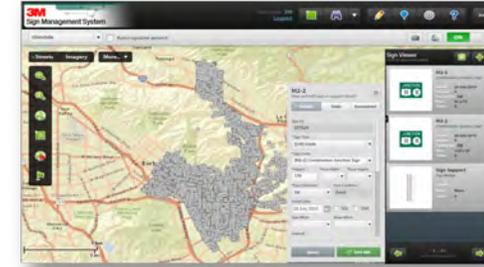
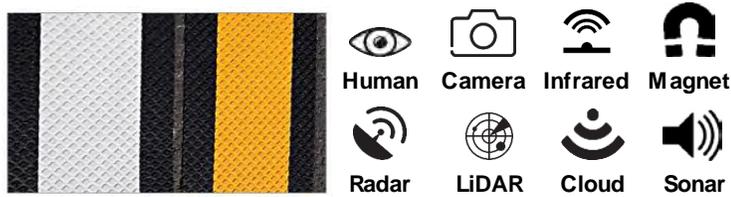


Helping build Connected Roads



Solutions that will serve a spectrum of vehicles

Human and CAVs will coexist on roadways for many years



Pavement Markings

- Goal: Read by all sensor modalities in poor weather
- Helping to enable:
 - safe human & vehicle navigation
 - cyber-physical security

Smart Code

- Goal: Clear, standardized navigational markers
- Providing:
 - Safety systems with multiple layers of info
 - cyber-physical security

Information Systems

- Goal: Aid in roadway and work zone safety and in the assessment of infrastructure* quality
- Helping to enable safe and secure navigation by humans and CAVs

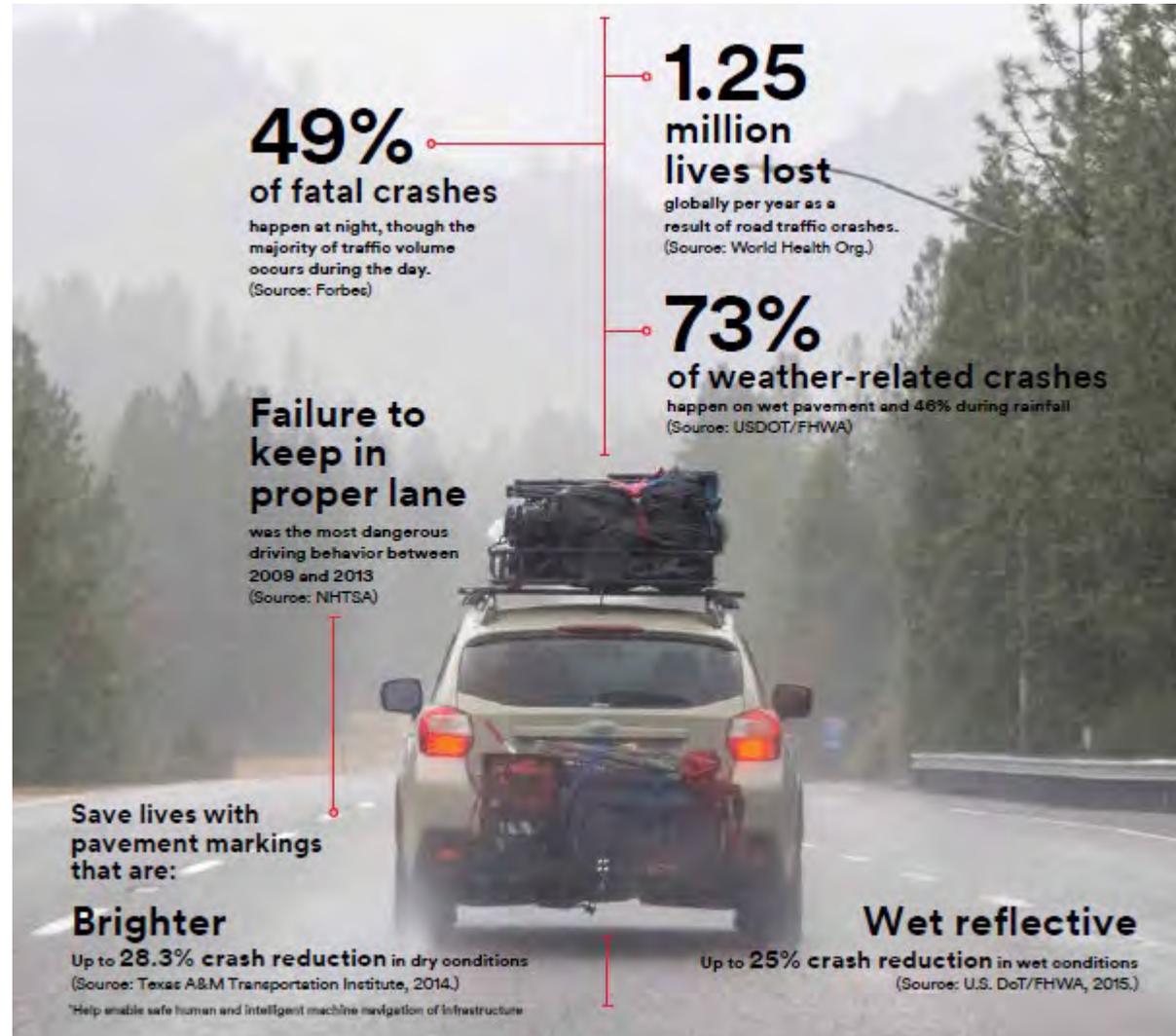
Engineered context for simplified decision making

Localization Boundaries Uniqueness
Classification Guidance

Data exchange to improve safety

There's a lot riding on the line

Pavement markings optimized for human and machine vision help enable safer navigation



Better quality road markings can further improve Lane Departure Warning systems.

An optimally working LDW system can:

Prevent 7,500 fatal crashes annually*

Reduce injuries by 8.9% per annum in EU*

Provide a socio-economic benefit-cost ratio of greater than 1:20*

- Crash Avoidance Potential of Four Passenger Vehicle Technologies, Jermakian, 2011, Accident Analysis & Prevention
- Effects of Lane Departure Warning on Police-Reported Crash Rates, Cicchino, 2018, Journal of Safety Research
- Economics of Lane-Departure prevention technologies: benefits resulting from reduced traffic-accident losses*, Miyoshi, 2017, ITEC

Key Characteristics of Pavement Markings

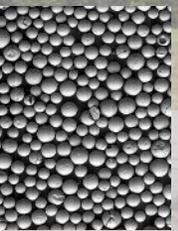
Likely to Improve Detection by Machine Vision Cameras

High Luminance*

Increases light return available to each pixel at all lighting conditions

Wet Retroreflective Optics*

Increase light return in nighttime and low-light wet conditions

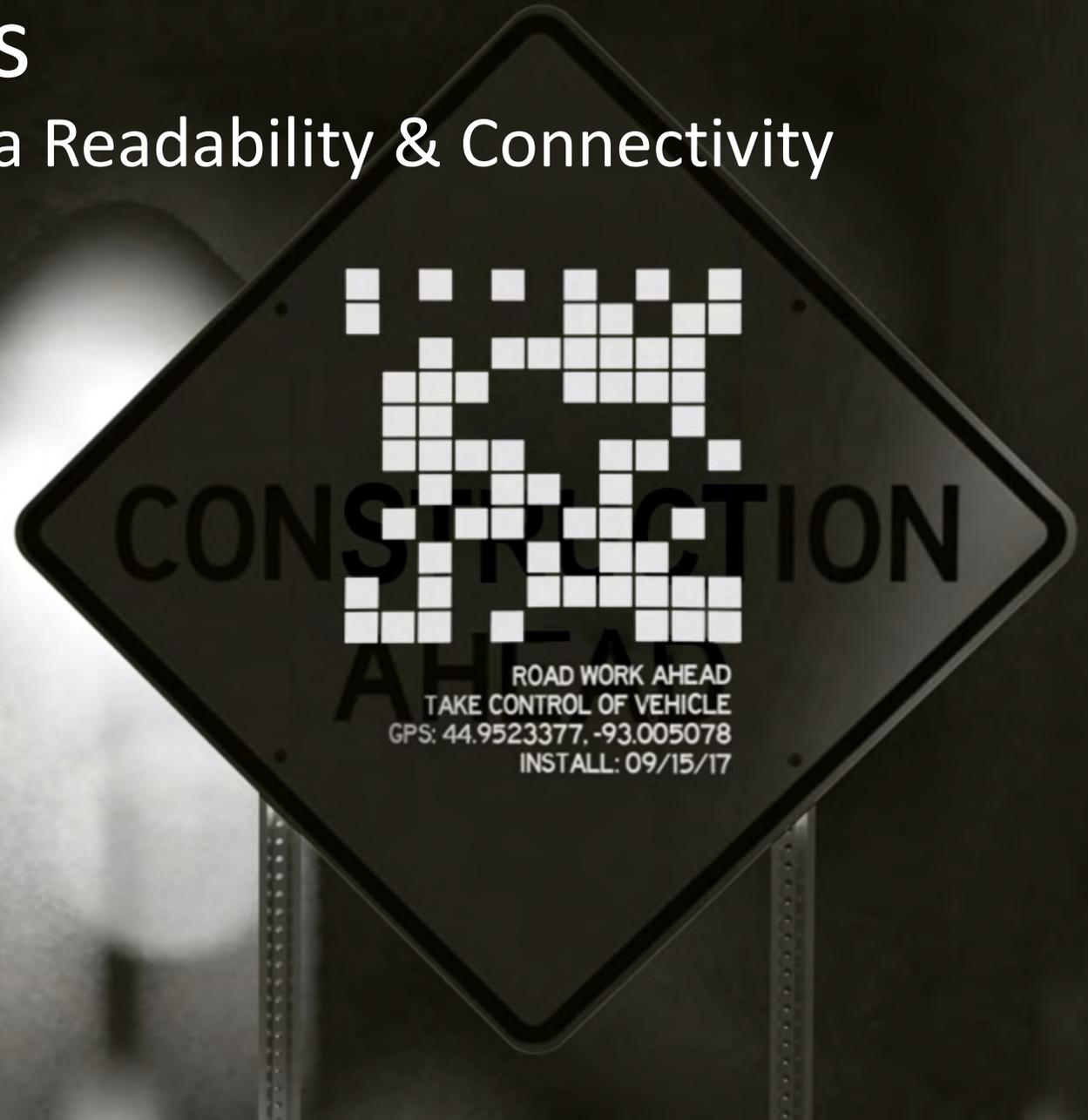


High Contrast*

Improves differentiation between marking and pavement substrate at all lighting conditions

3M™ Connected Roads

Traffic Signs Optimized for Camera Readability & Connectivity

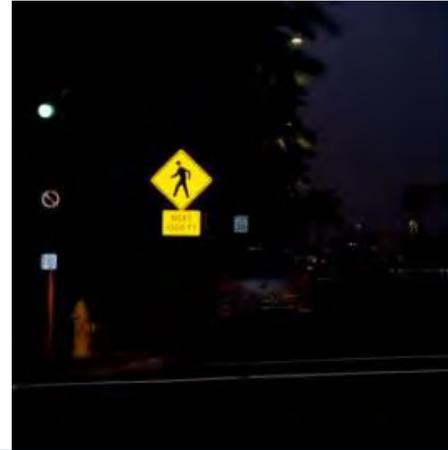


Optimized Messaging: Machine Readable Signs

Solutions to enable more accurate sign detection and classification



Human Optimized Diamond Grade™ (DG³)



DG³ Fluorescent



Machine Vision Optimized with Decoded Metadata



Current 3M Signs

- Up to 58% light return to *all* drivers
- Superior (human) legibility

Future 3M Signs

- Secure localization
- Reliability - Sign class redundant
- Embedded digital information and metadata
- Dynamically changeable
- Digital certainty

3M™ Smart Code Potential Benefits

Solutions to enable more accurate sign detection and classification

- Readable and optimized for both human and for machine vision systems.
- Each sign has a unique ID.
- Static and dynamic metadata (cached or requested).
 - GPS – high quality fiducial to support localization.
 - Local/variable conditions & rules.
 - Maintenance info, install date.
 - Unambiguous interpretation.
- Trustable system for metadata & verification.
- Passive, no power needed on the roadside.



Visible Appearance

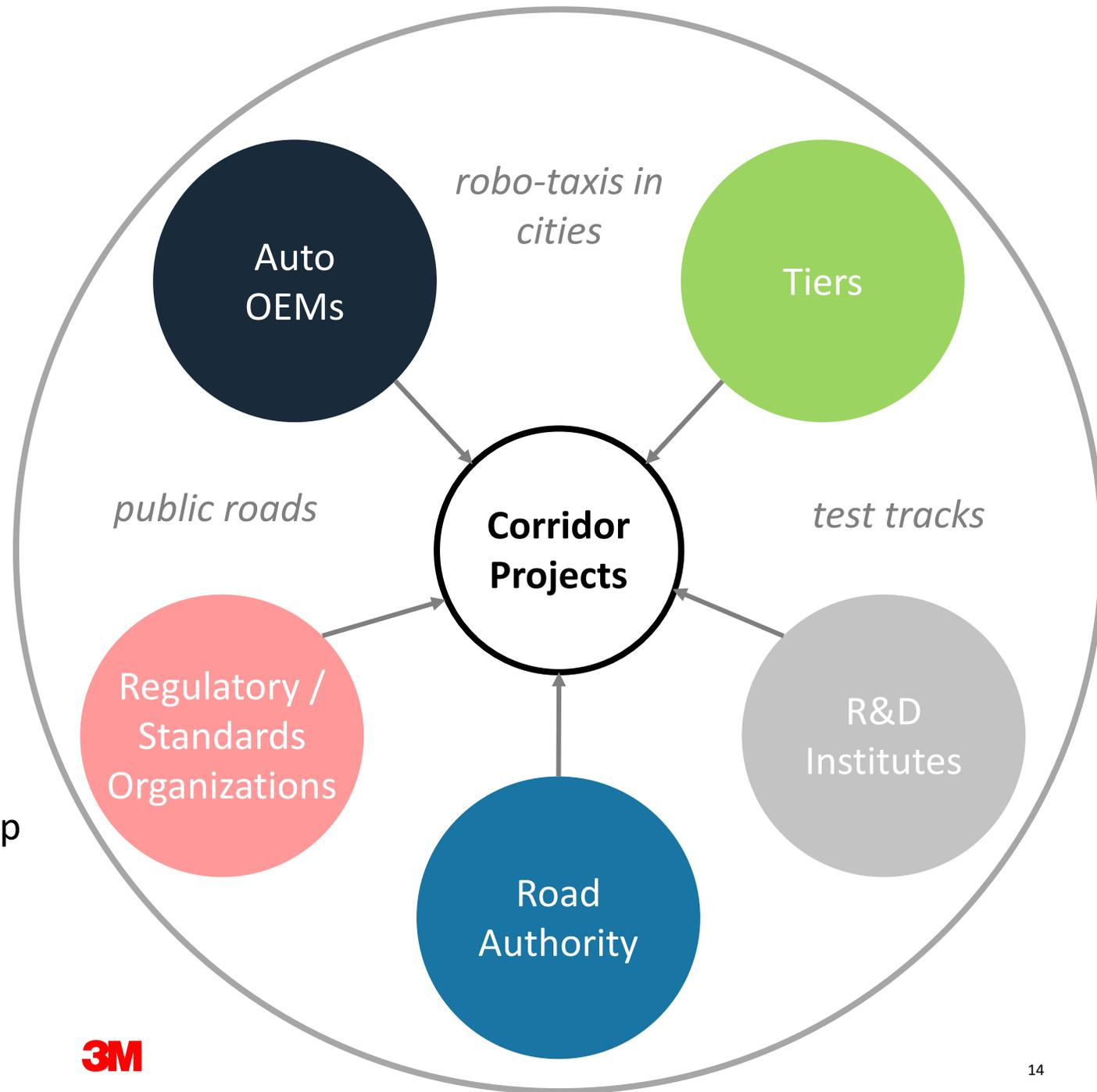


Near-IR Appearance

New Technology Deployments

Evaluate and validate infrastructure technologies optimized for CAVs

- **Accelerate robo-taxi deployments** via authenticated navigation fiducials
- Cooperate to help develop self-driving capability that is **safer than current capabilities**
- Resilient connectivity and data exchange between vehicles and infrastructure; **improve functional safety**
- Infrastructure optimized for ADAS/AV help **reduce processing power** in vehicles



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