

How Can You Drive an Evolution?

We can't truly know what the future holds, but we can put our best effort and biggest creative ideas into preparing ourselves for the journey.

At 3M, we're working to ensure this journey is as swift—and safe—as it can possibly be.

This seismic shift in mobility will depend on partnerships, collaborations, and tireless examination of safety standards and the ever-changing realities of the roadways.

As global leaders in roadway safety innovation, we are excited to partner with you to power a transportation revolution—and bring more people home safely, every day.

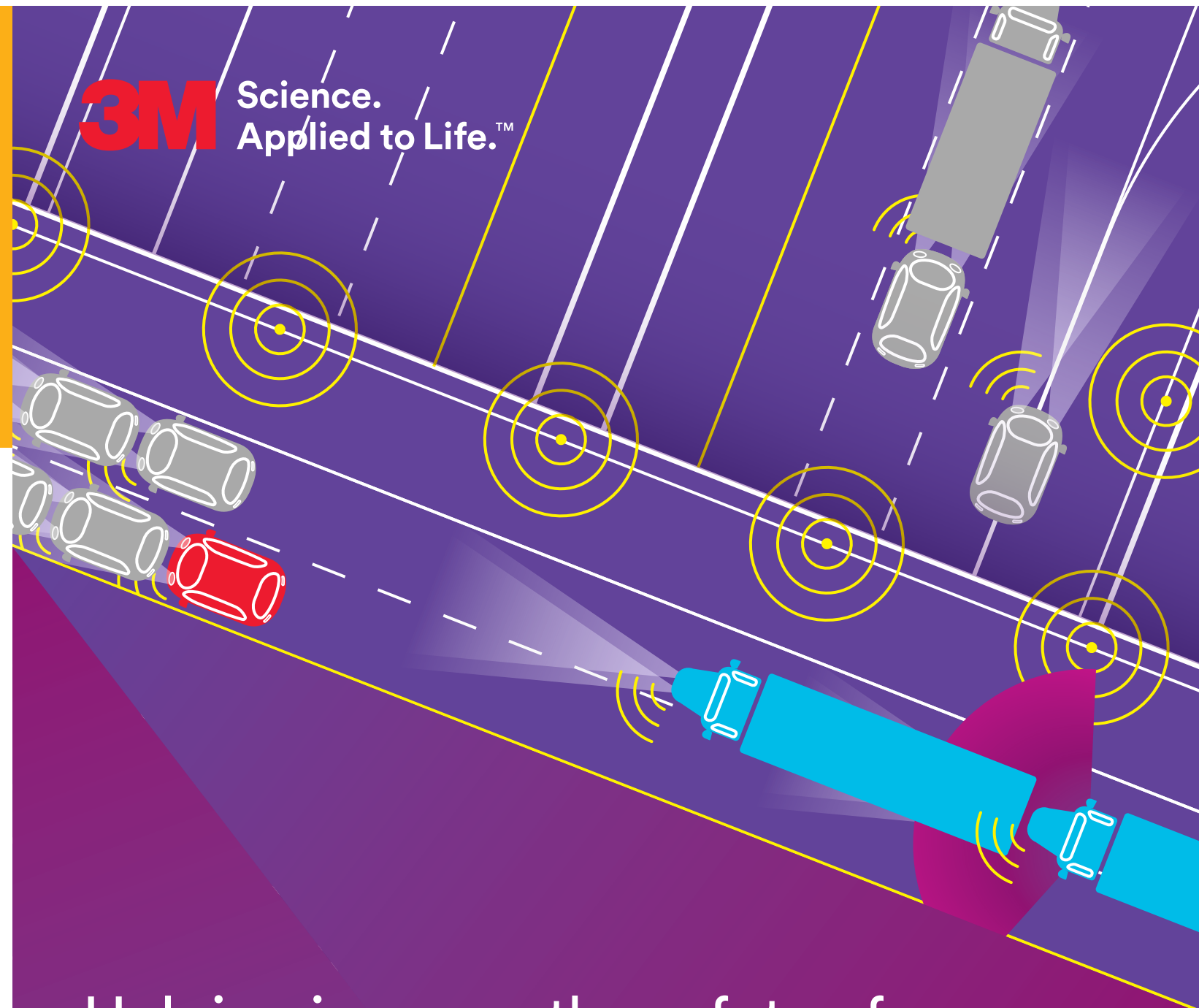


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3M Science.
Applied to Life.™



Helping improve the safety of your
road systems today and in the future

3M™ Connected Roads

3M Transportation Safety Division

Driving a Transportation Evolution

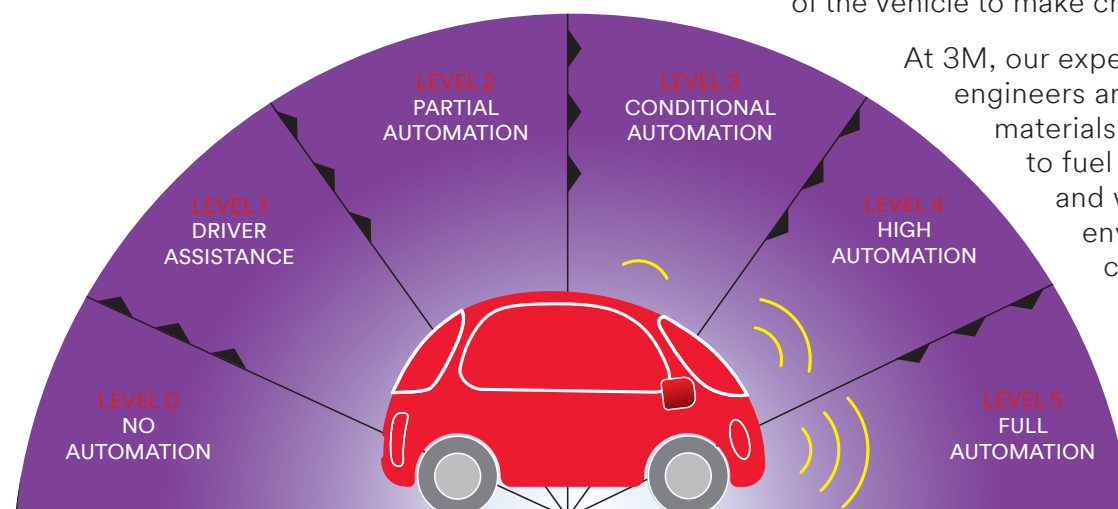
More than 64 million kilometers of roadway cover the globe, connecting us and allowing us to trade goods and services. The lane markings, highway signs, and traffic lights that help us navigate our roads are such a familiar sight that we almost take their presence for granted. But without them, we'd be lost.

These roadways are soon to be the stage for a revolution. Self-driving vehicles, long dreamed of, are becoming a reality. The race to make a successful and safe autonomous car is on, with everyone from young tech companies to traditional auto manufacturers entering the competition.

Change is just around the corner. And it's going to bring huge benefits, including a possible end to nearly 90 per cent of traffic fatalities, a public health triumph that could mean almost 30,000 lives saved a year in America alone, plus \$190 billion dollars in health care costs saved.¹

In order for this evolution to take place, the environment surrounding our vehicles must move from analog messages designed for human eyes to digital messages designed so the cameras, radar, and lasers of automated cars can interpret the surrounding environment and quickly respond, creating redundancy which increases the confidence of the vehicle to make critical driving decisions.

At 3M, our expert scientists and engineers are developing new materials and systems that will help to fuel mobility, improve safety, and work with the data-driven environment of tomorrow's cars and roadways.



◀ SAE J3016 Levels of Automation

¹. <http://www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world>

Why 3M?

For more than 75 years, 3M has provided leading roadway safety solutions that have drastically changed the way people move, connect, and operate.

We're a global science company that never stops inventing. We know that real innovation happens when science is applied to life. That's why 3M is more than just a leading global company.

We are a hub for collaborations that can help change the world.

Some of the innovative ways 3M has improved infrastructure and safety:



Pavement Markings

3M innovations include durable Stamark™ tapes and microcrystalline beads have helped improve visibility and durability for more than seven decades.

In the 1990s, 3M researchers designed a new durable high refractive index bead that anticipates the light-bending quality of water to create reflective pavement markings provide superior retroreflectivity in both dry and wet conditions.

Retroreflective Sign Materials

3M Full Cube technology features nearly 100% efficient optical elements.

When this technology is incorporated into 3M™ Diamond Grade™ DG3 Reflective sheeting, it nearly doubles the average brightness of road signs using truncated cube technology.

Fluorescent Technology

In the 1990s, 3M introduced florescence technology that would improve sign visibility during dawn and dusk.

Combining fluorescent colors with Diamond Grade™ Reflective sheeting ensures maximum visibility for traffic signs in all weather conditions, day or night.

Improving Safety—Together

As vehicles become increasingly automated and connected, we have an opportunity to help make our roads even safer.

Our unique ability to collaborate—and to innovate—bodes well for an industry that will require an ecosystem to work together.

At 3M, we are driven to think about what's next. That's why we're collaborating with thought leaders like the Center for Automotive Research, the University of Michigan Mobility and Transformation Center (MCity), Texas Transportation Institute (TTI), Stanford Center for Automotive Research (CAR), CLEPA European Association of Automotive Suppliers, and ERTICO ITS Europe to pave the way for the roadways of the future and develop solutions to questions like:

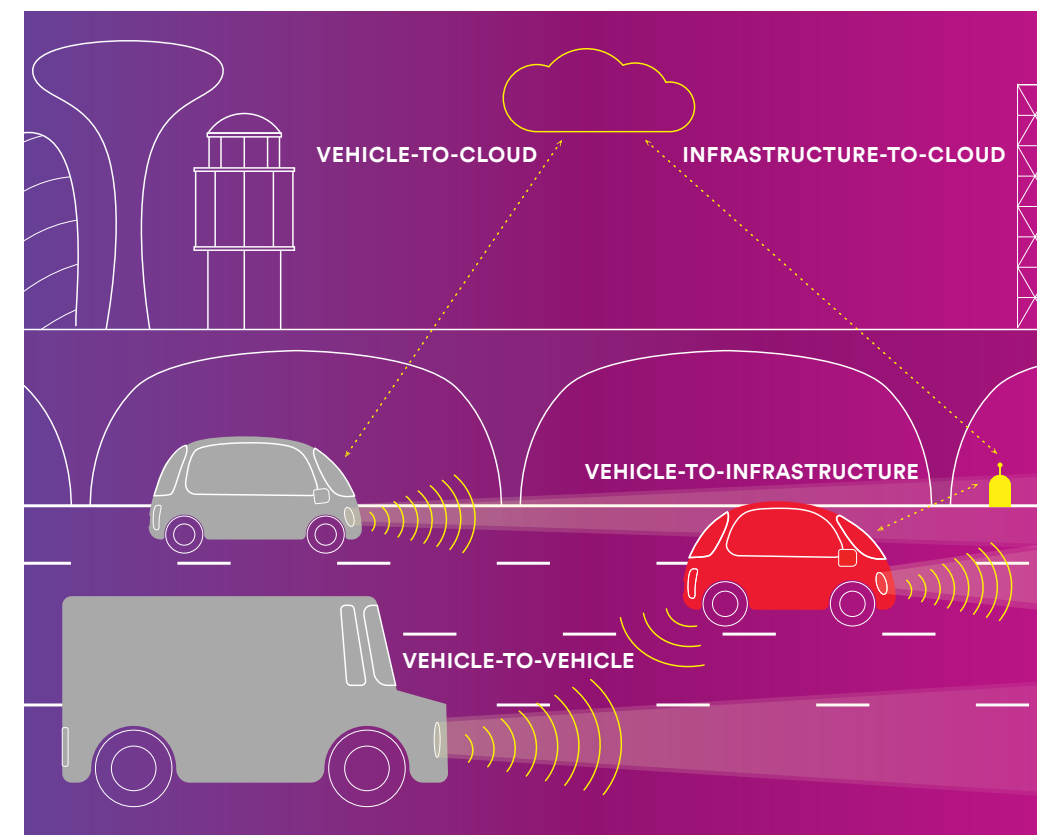
- What infrastructure and connectivity requirements are necessary to advance connected and automated vehicles?
- How can 3M inspire innovation and provide solutions that can drive the future of transportation?



“Everybody has some level of interest in the future of autonomous vehicles—insurance, OEMS, electronics, data, cell phone, infrastructure components, state and federal government — there aren't too many people who won't have their life impacted in some way, shape or form.

Everyone will be impacted—it's just a question of how. It's not going to happen in isolation. Change will come from everywhere, simultaneously.”

— James Sayer,
University of Michigan
Transportation Research Institute



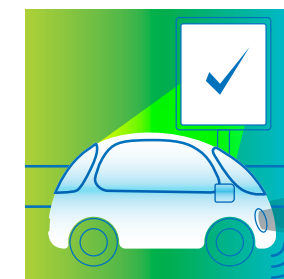
Ecosystem Simplified ▲

Driving Innovation

We can drive innovation and improve safety through smarter infrastructure.

We can drive innovation and improve safety through smarter infrastructure.

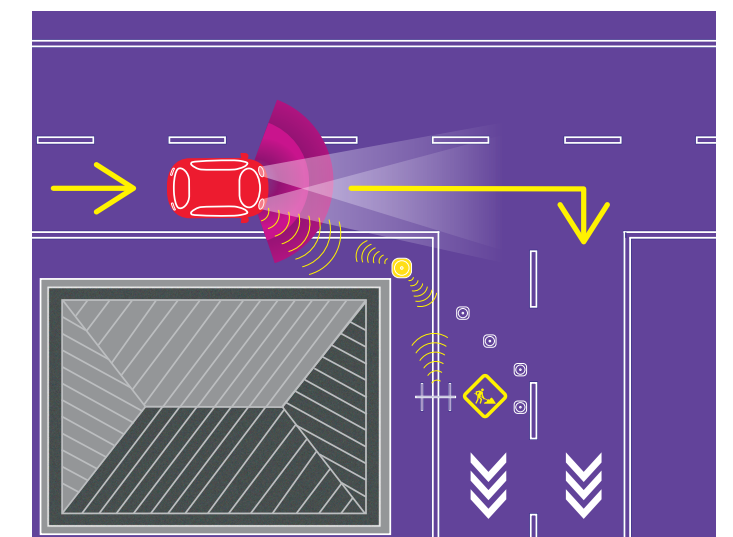
Machine-vision is here. Vehicles are already using automation to warn drivers of hazards and lane departures. Fully connected vehicles, ones that communicate directly with infrastructure, are only a few years away and infrastructure and driver systems will have to operate together.



▲ Smart Signs

But infrastructure will still need to support both human and machine vision. Roads need pavement markings and directional signage that are visible to humans and machines in any road condition.

There is also a need for wireless communications that connect directly to vehicles, quickly helping identify construction zones and potential safety hazards so vehicle mobility and traffic flow can improve. It means sensors like LiDAR and cameras working together can improve readability, helping drivers make decisions faster, and improve roadway safety for everyone.



▲ LiDAR Sensors

“The system has to work together. If you design each part with other parts in mind, the whole ecosystem can work better together.”

— Danny Lorentz,
Lab Manager,
Advanced Technologies at 3M



Developing Solutions for the Road Ahead

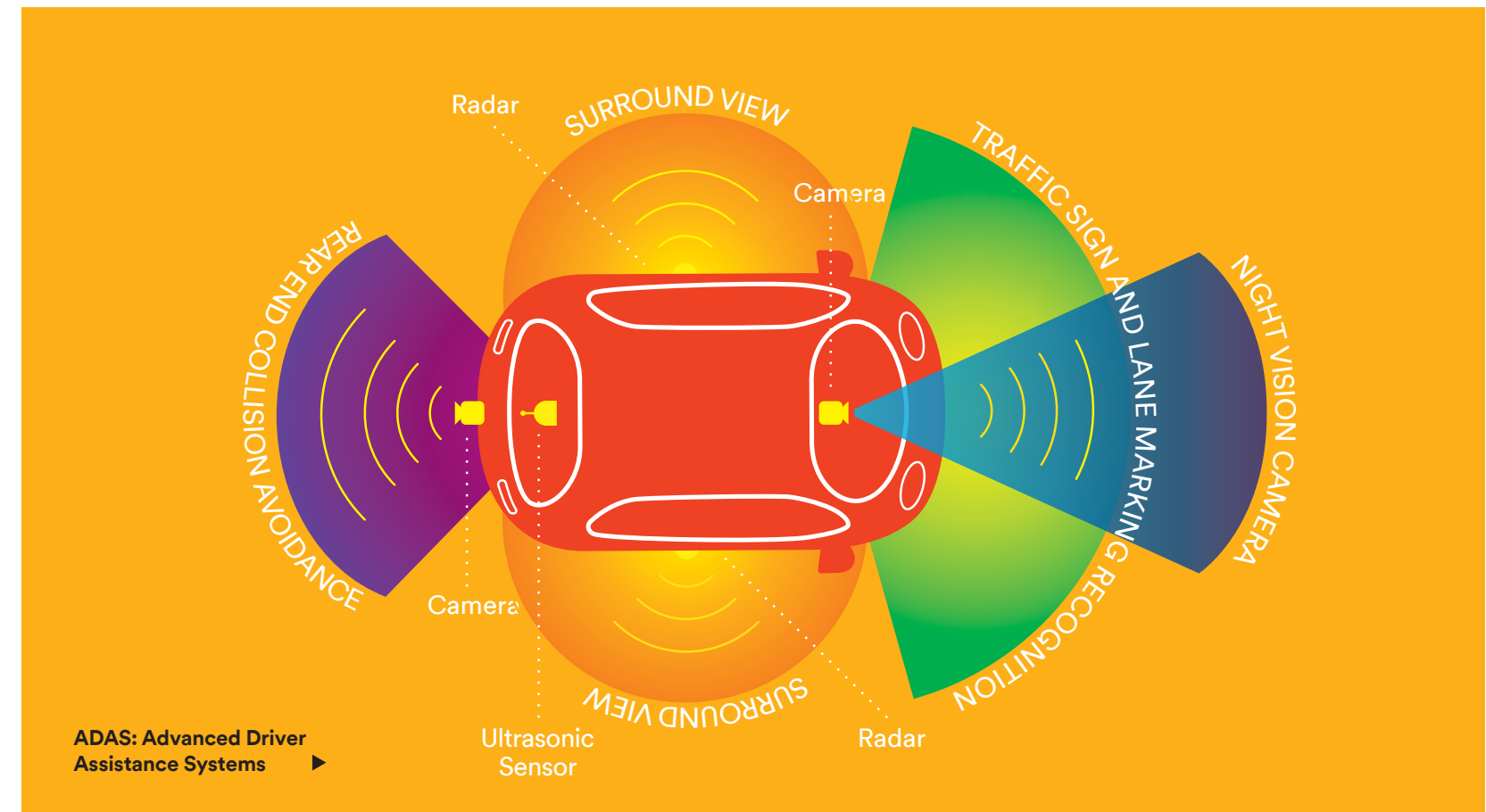
We're engineering new materials and designing systems that will fuel mobility, improve safety, and work with the data-driven environment of tomorrow's cars and roadways.

1. Building a Digital Infrastructure

As cars get smarter, infrastructure plays an important role and computerized systems bear more of the driving burden. We've already taken the lead in this area, with pavement markings and signs supporting features like driver assistance, cruise control, and auto braking. The next step is for vehicle systems to exceed the human driver's ability to recognize signs and lines accurately, reliably, and in any weather condition. That means signs, markings, and lines need to provide digital information as guaranteed back-up systems. Smart signs and pavement markings need to communicate with cars equipped with optical character recognition.

At 3M, we are developing materials and systems that support both human and machine vision, with safety as a top priority that can help drive us toward zero deaths.

"We've worked for 30 years to increase pavement marking durability, and making markings brighter for humans—it's a crucial safety factor for driving in bad weather," says Tom Headblom, 3M scientist, who has led human-factors research in retroreflective pavement markings. "Now, we need to increase the durability, weather range, time, and distance that a machine or camera could 'see' the pavement markings even further. We're always asking ourselves: How do we bridge the gap from today to what'll be needed in the future?"



2. Vehicle to Infrastructure (Vtol)

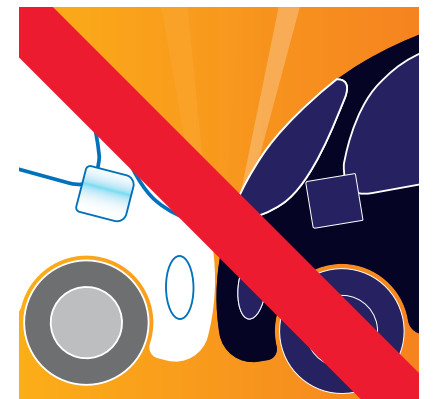
As we leave behind the days when cruise control and assisted driving were the smartest operations the car could perform, we move into new levels of automation. Vehicle systems will take on more responsibility and the role of the driver will diminish.

To accomplish this, vehicle sensors will receive information from the ever-changing road environment. Humans will still play a strong role as we evolve to fully automated vehicles. In order to empower this vehicle evolution, infrastructure needs to be in place to allow vehicle sensors and wireless communication to continue advancing automation technology.

- **Advanced Road Markings:** Durable, removable, magnetic pavement lane markings work with automated vehicle sensors to detect lines outside of human vision, improving lane detection and traffic safety in even the most extreme weather conditions.
- **Smart Signs:** Retroreflective signs provide better readability, which results in more accurate navigation and faster decision-making for both drivers and automated vehicle systems.
- **Wireless Communication:** 3M™ DSRC Multi-Channel Test Tool is an independent multi-channel listening device that provides vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. The test tool is an unbiased 3rd party resource, used to decode standards and connected vehicle requirements; SAE J2735, IEEE 802.11p and IEEE1609.

3. Redundant Systems for Safety

No single system will guarantee safety. Safety will only increase if all vehicle systems are working together to improve the readability of pavement markings, traffic signs, temporary traffic control and help drivers navigate safely. Redundant systems take over when GPS isn't able to work, such as in a tunnel, or when pavement markings aren't visible to the camera because of the sun's glare. Systems working together improve mobility and safety for everyone.



▲ A single system will not guarantee safety

At 3M, we know state-of-the-art vehicles require state-of-the-art infrastructure. Improving infrastructure through redundancies is how we drive innovation, increase safety, enhance mobility, and create roadways of the future.