

**A GUIDE TO LINE MARKING AND  
THE USE OF TECHNOLOGY TO  
DELIVER A SAFE, EFFICIENT AND  
FUTUREPROOF INFRASTRUCTURE**



Preparing the way for autonomous vehicles

# ABSTRACT:

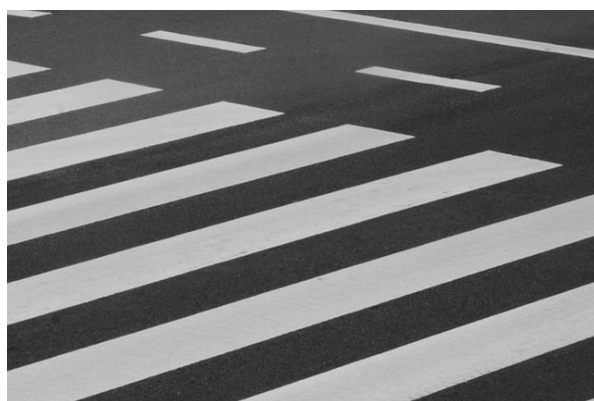
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## PREPARING THE WAY FOR AUTONOMOUS VEHICLES:

Autonomous or 'self-driving' vehicles have been designed and tested and will soon be on our country's roads. Making sure line markings on public roads are properly maintained is more important than ever. The vehicles of tomorrow rely on a complex system of optical sensors being able to 'see' the road around them. They 'read' surface markings and require visibly distinct line markings in daytime and night in order to drive safely. In fact, autonomous vehicles rely on road markings even more than humans do.

Even today, there are automated smart features in new cars that rely on sensors and assist drivers to stay in their lane. These cars take their cue from line markings. Highways England is working hard to improve our network, with the introduction of smart motorways and an investment strategy to support the government vision of having fully self-driving cars on UK roads by 2021. But one of the greatest challenges is the country's underinvested local authority-maintained roads, which have become blighted with worn-out line markings and potholes.

There is no longer one solution that fits all line marking requirements, and with rising costs and public expectation, it is now more critical than before to get it right. This white paper examines the current state of play and what can be easily implemented to greatly improve our networks and aid the advances of autonomous vehicles.



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**1918**

First white road markings on UK roads

**1930s**

Stop lines at junctions and cats eyes.

**1950**

Yellow lines were introduced to UK roads

1

2

3

4

5

6

**1926**

White markings were made official by the UK government

**1944**

White lines were used to establish the side of the road

**1960s**

Yellow box junctions.

# LINE MARKING TODAY:

## A BRIEF HISTORY TO PRESENT DAY:

According to traffic signs and meanings, the first line markings date back to 1918 in the UK, but they were not recognised as road safety protocol until 1926.



**1972**

1000 miles of motorways were built in the UK

**1986**

M25 was completed

**2000s**

First MMA cold plastic paints were used on UK roads

7

8

9

10

11

12

**1984**

'The 1984 act'  
Road traffic regulations

**1991**

Red lines are introduced in London to help with traffic flow.

**2018**

Highways England introduce transforming road markings programme

## INDUSTRY CHALLENGES:

There has, and continues to be, relentless effort to improve road marking systems. Technological breakthroughs over the years include the advent of retro-reflectivity and thermoplastic markings.

Here are the top seven challenges facing the line marking industry:

Longevity & performance	Extreme weather conditions – rain, heat and frost – cause lines to fade and wear. Short lifecycles mean constant re-marking and maintenance.
Traffic management & downtime	There is immense pressure to avoid road closures and congestion. The time it takes to complete line painting and maintenance needs to be kept to a minimum. Longer lasting lines mean that lines need to be refreshed less.
Whole-life costs	The industry and local authority asset owners are rightly looking for long-lasting line markings that maintain their vital characteristics and produce efficiency savings.
Environmental issues	Impact of micro-pollutants from marking paints entering the waterways. Pressure to reduce carbon footprint and increase sustainable work practices.
Health & safety	Working on the roads is increasingly hazardous, coupled with the operation of heavy equipment, hot works and pollutants. The safety of the general public and other road users is another significant consideration.
Skills shortage	The industry faces a declining number of skilled workers with an urgent need to do more to attract qualified professionals and graduates.
The force of change	There is a fear of change and reluctance to evolve basic principles, leaving the road infrastructure playing catch up to the faster technological advancement of the motor industry.



#### **SPECIALIST LINE MARKING:**

It is important to source a company experienced in the road marking industry. They need a reputation for product innovation and delivering high quality results within tight deadlines, whilst offering great customer service and professionalism.

You should look for suppliers affiliated with health and safety associations and organisations such as the RSMA (Road Safety Markings Association). The products supplied should be BSI certified. The BSI evaluates materials used in road marking applications on highways administered by Highways England and local authorities against stringent performance criteria which meets European standards.

In the UK, it is preferential for road marking systems to have a test certificate to EN 1824; this can be secured under any UKAS or EA accredited certification body. The certification requires a road trial. In the absence of an official road trial site in the UK, (at the time of writing this document) overseas sites e.g. Belgium have been approved as suitable. Only tapes require a CE certificate (to EN 1790).



## HIGH PERFORMANCE SURFACE MARKINGS:

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The development of a large variety of products and application equipment for high performance surface markings has led to the availability of choice. We no longer need to adopt a 'one product fits all' approach.

### THERMOPLASTIC (HOT MELT):

Thermoplastic paint is a solid powder, which is heated to 150-200°C and then sprayed or extruded onto the surface. The coating then cools rapidly to form the line marking. It is a thick coating, wear-resisting, fast-drying strong adhesive, that is bright and reflective. Extra additives can be added to retain colour over time, help prevent skidding, and improve its reflective capabilities. Because of this, thermoplastic markings are perfect for touching up previous road markings which may have faded or need added reflective properties.

In the UK, thermoplastic road marking materials are commonly used on main roads and motorways. It has become a popular system because of its durability in certain applications and relatively low initial installation costs. The only real drawback is that thermoplastic road marking does require specialist hot-works equipment and experienced technicians for its application and can have a short life cycle in high wear areas.





#### **PREFORMED THERMOPLASTIC (BURN-ON):**

Preformed thermoplastic is an easily laid, durable line marking tape. It meets highway standards and is an economical way of re-installing short runs. Specialist boilers or complicated equipment are not required for the application of preformed thermoplastic. Due to quick cooling properties of thermoplastic, it can be trafficked very quickly to minimise road closure. Many of the formulations available have been specially developed to ensure the product retains flexibility in cooler conditions when road surfaces are more prone to cracking.

This system can also be used to create durable informative markings on the road surface, communicating upcoming hazards and detail such as speed limits, cycle lanes and disabled parking.





## **METHYL METHACRYLATE (MMA) COLD PLASTIC SYSTEMS:**

This is a 2 or 3 component material that offers improved characteristics without the use of heat in the application process. It is highly adhesive and ideal for high traffic areas, such as busy local roads, junctions and mini roundabouts. MMA is fast-curing and extremely durable, so that if it's applied correctly, it could last up to 10 years. This is more than 3 times longer than hot thermoplastic, subject to favourable application including substrate, preparation and weather conditions.

Another advantage of cold plastic road marking is their contribution towards reducing environmentally damaging emissions. A single, thin layer is usually sufficient to achieve a high-performance marking, and by using cold plastics they have a drastically lower VOC (Volatile Organic Compound) content than solvent-based paints, coupled with low energy requirements in the application process.

## **PERCEIVED DRAWBACKS FOR USING SYSTEMS OTHER THAN THERMOPLASTICS ARE AS FOLLOWS:**

- The initial application is more expensive.
- Inability to be used in high humidity weather conditions, consequently, some would argue reduces versatility.
- Thermoplastic can be trafficked within minutes of being applied, whereas most other road marking systems must be protected from traffic until they are dry, which can be as much as 1 hour.
- When applied to newly laid asphalt, the road surface must be either 4-6 weeks old and slightly worn, or a primer is required in the form of an acrylic base line or clear tack coat. The priming is required to enhance adhesion and reduce bitumen bleed.

**PAINT:**

In addition to the options above, there are other paint options for line markings. These include:

Solvent-based Epoxy	Solvent-based Acrylic	Water-based Acrylic
Excellent adhesion on hard surfaces, such as asphalt and concrete	High wear options available with P5 rating.	Solvent free for full environmental credibility.
Hardwearing and well-proven in demanding locations.	Toluene free solvent for improved VOC ratings.	High compatibility with asphalts and concretes.
Fast drying, trafficable in 30 minutes.	Excellent adhesion on hard surfaces, such as asphalt and concrete.	Excellent colour retention and UV exposure stability.
Can be manufactured to multiple colours, with short lead times.	Fast drying, trafficable in 30 minutes.	Minimised bleeding when applied to new bitumen and asphalt surfaces.
Resilient to fuel and chemical exposure.	High solids content gives excellent opacity and colour retention.	Premium bead retention properties.

**TAPE:**

Factory produced tape systems are widely used as primary markings in countries across Europe and the Americas. The benefits of using tapes include:

- Controlled factory production guarantees retro reflectivity performance
- Consistent anti-skid properties
- Long term retro reflectivity through specialist bead technologies
- Tape systems are best suited for longitudinal lines on strategic network applications

In addition to high performance markings, tape systems are also very effective for temporary markings and blacking out existing lines without the need for removal.

# ENVIRONMENTAL CONSIDERATIONS:



We all have a duty to protect the environment and take our share in accepting responsibility to minimise our impact on it. There is increasing pressure on local authorities and contractors alike to adopt more environmentally sustainable practices when choosing a line marking system, comprising both of product and application methods. Here are some factors to consider when completing.

## ELECTRIC MACHINES VERSUS THERMOPLASTIC TRUCKS:

There is an environmental shift away from fossil fuel power to other sources of power such as electricity. The line marking industry as a whole relies heavily on oil-based fuel power but with is in mind change is coming. For example, smaller electric powered line marking equipment is becoming more common in built-up residential areas and low emission zones. Also, hybrid engine powered thermoplastic trucks for highway line marking are now available and becoming popular in certain regions.

“The UK Government has national and international commitments to reduce greenhouse gas emissions including a stretching commitment to be carbon net zero by 2050. The infrastructure sector has a key role to play in this.”

HIGHWAYS ENGLAND: Carbon Tool Guidance - June 2019

## POLLUTANTS FROM PAINT AND VEHICLES:

Low emission zones are becoming more common and this poses a threat for fuel-powered thermoplastic trucks and pre-heating equipment. Potential solutions for these zones are the use of electric powered machines and equipment, hybrid engines (see above) and also paint systems instead of thermoplastic where appropriate.

Over a period of about 2-5 years, thermoplastic starts degrading and breaking down. The erosion of the thermoplastic creates micro particle waste which is subsequently washed into drains and waterways, increasing the level of pollution in the water. Similarly, glass beads used for reflectivity can become dislodged and washed away, further impacting the environment. Reducing the film thickness or applying more durable materials favourably reduces micro particle pollution.

# SAFETY CONSIDERATIONS:

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Safety is a primary consideration when selecting choice of system. The line marking industry has made significant advances in safety, in line with the construction industry, and there are now many health and safety guidelines in place to protect operatives. Further thought should be given to other road users both during application and in their ongoing use of the highway network. Line marking exists to help prevent road traffic deaths and serious injuries from happening.

## SAFETY OF THE OPERATIVE:

Contractors regularly work close to high speed traffic and with heavy machinery and other tools that have potential to cause injury or death. These risks can be mitigated with effective traffic control and efficient line marking systems that minimise application times.

Highways England are currently trialling self-driving dump trucks for road construction. It believes there is plenty of potential for autonomous machines on road building projects to improve efficiency. It's been said, that unlike human drivers, autonomous trucks can work non-stop around the clock. It hopes to have self-driving dump trucks in full service by 2022.

There also needs to be consideration of the type of materials being used by contractors. For example, dozens of operatives are injured every year while applying hot thermoplastic. These burns can be seriously damaging and, in some cases, life threatening.

## SAFETY OF ROAD USERS:

The visibility of line markings is vitally important; they convey the rules of the roads and alert drivers about hazards to help make driving safer. The lack of informative markings, reflective studs, signage and failed road markings are often the cause of mistakes leading to road traffic accidents that can cause death or serious injury. Increasingly, advanced vehicle technology is included in cars. This eases the burden of safety by assisting people to drive correctly, reducing the potential for human error that can cause accidents. Furthermore, the safety of road users is critical during application to avoid harm or injury. A wet night's visibility is the litmus test for a good linemarking system.

# ADVANCED VEHICLE TECHNOLOGIES:

Cars in the showroom today go much further in protecting life than vehicles a decade ago. They can warn, guide and brake by reading road markings and signs without human intervention.

Advanced Driver Assistance Systems (ADAS):	Now common in many vehicles, it includes SatNav, traffic information, Adaptive Cruise Control, Collision Avoidance, Intelligent Speed Adaptation and Night Vision.
Lane Keeping Assistance (LKA) and Lane Departure Warning (LDW):	These systems read the road markings and give a visual, acoustic or tactile warning if the vehicle crosses the lane markings without signalling.
Traffic Sign Recognition (TSR):	In-car systems that read and interpret a range of traffic signs, including speed limits.

The basic principles of effective road markings and traffic signs have not changed:

- Road markings must be clearly visible so the driver can respond quickly to their message
- What they convey, be it guidance on keeping in lane or what the driver must do or not do, must be clear, concise and unambiguous
- They must be standardised and consistent along the route
- They must be checked regularly, be cleaned and replaced when worn out

Until recently, it has been the drivers' eyes alone that have absorbed the information given by markings and signs to be able to read the road. The maintenance, consistency and uniformity of road markings are even more vital for safety and navigation now that cars need to be able to instantly detect markings as well as their drivers. This technology is set to go a huge step forward with the evolution of autonomous vehicles.

Vehicle technologies currently mostly use optical systems. While night-time retro reflectivity is important, the systems have more issues with poor contrast in daylight and wear than humans, making the use of 150mm lane lines over 50 mph advisable as

is using interventions levels from TD26/17 (CS126). By the time we get to SAE level 4 (autonomous some of the time) there will likely be solid state Lidar or equivalent fitted. This may possibly need higher index beads in the marking material for wet night visibility. Since solid state Lidar is still not a mainstream product, unresolved issues such as wavelengths means future design parameters for marking materials may need tweaking.

## GHOST MARKINGS:

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The process of traffic management and road layout changes inevitably leave evidence of original lines, however faint, known as ghost markings. This has the potential to confuse drivers, especially in bright sunlight, and can cause an accident. It could also affect autonomous vehicles, which need clear and obvious road markings to operate safely. In a project called Transforming Roadmarkings.

Line markings need to be removed without damaging the surface, leaving a finish that is inconspicuous. To prevent this in future, Highways England is investing £685,000 designed to address the problem of 'ghost markings'. This has included testing 36 different products from around the world at a testing centre in Madrid. The aim is to find the most durable and effective road markings that minimise damage to the surface when the lines are removed.

The best products have been identified and are now being tested in all weather conditions. This is over a 12 month period on section of the M5 motorway in the south west of the UK.

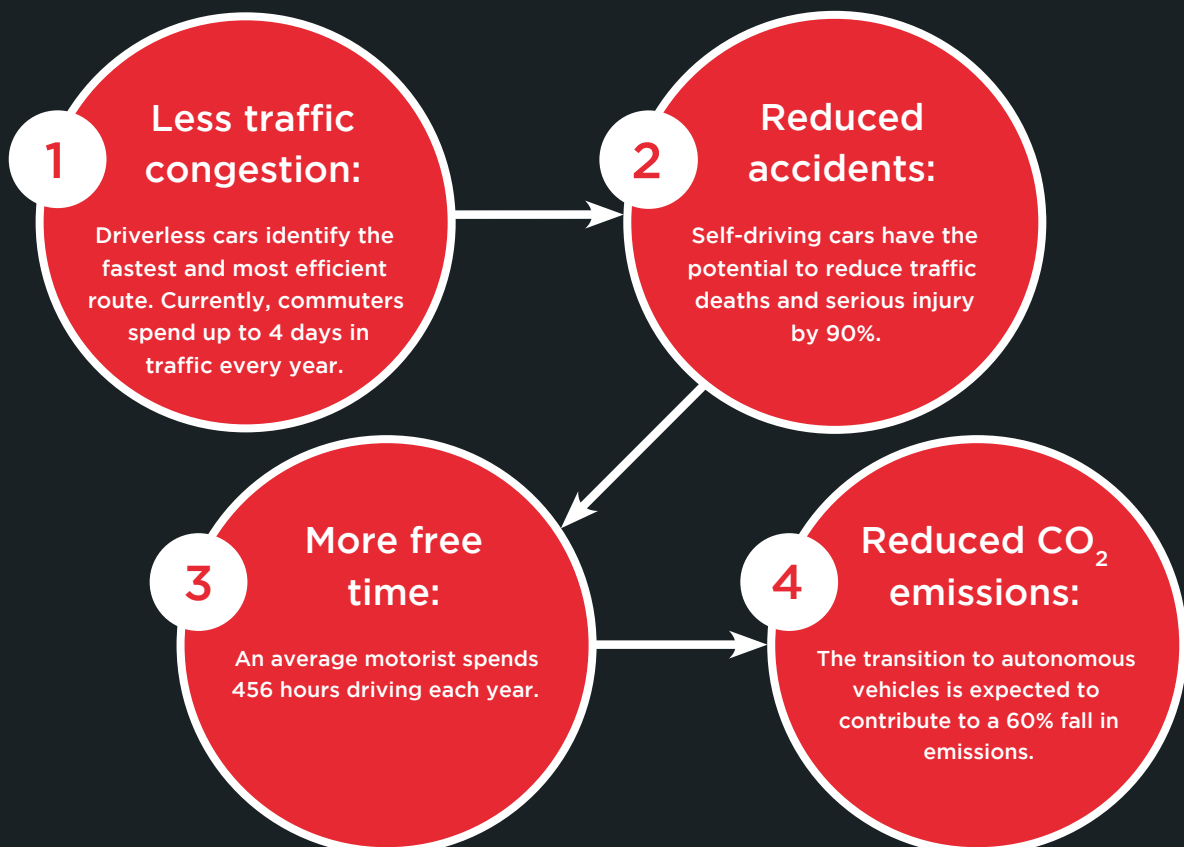


# PREPARING THE WAY FOR AUTONOMOUS VEHICLES:

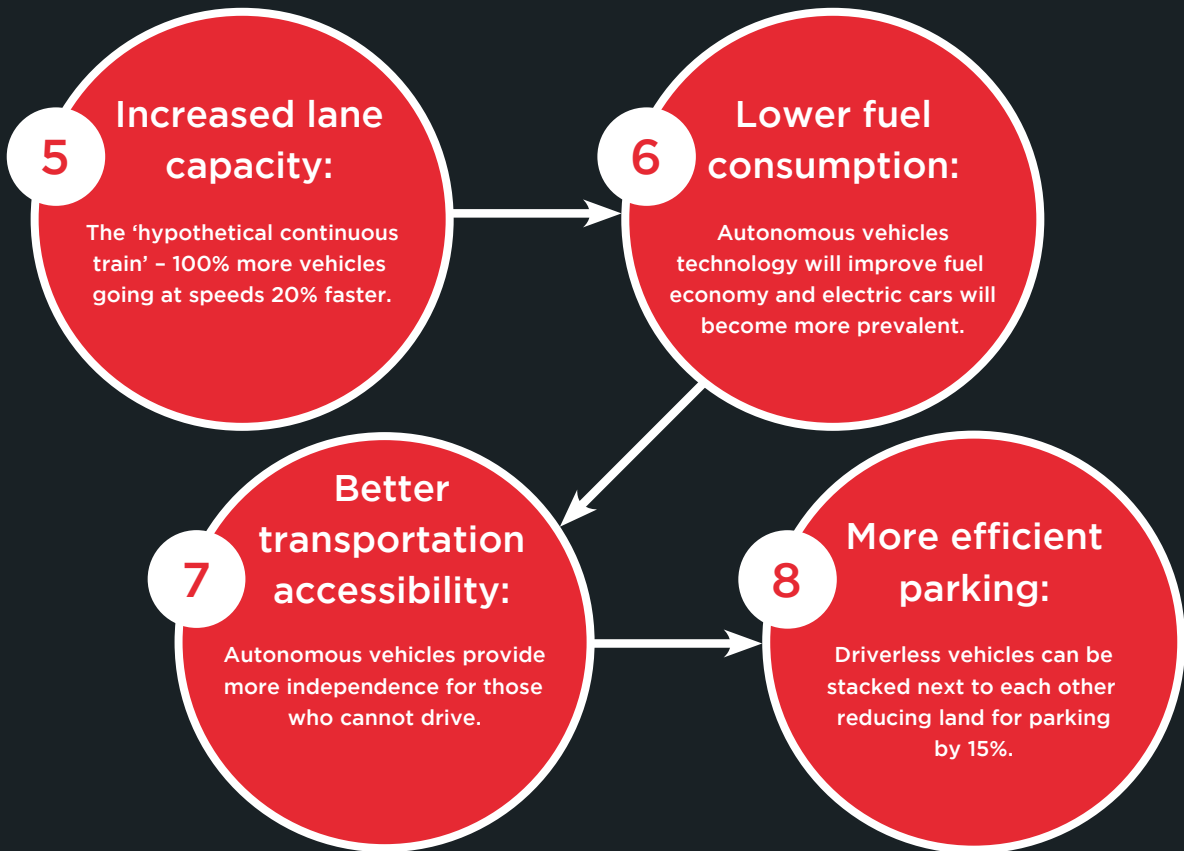
It is estimated that by 2025 at least 50% of the vehicles on European roads will have some ability to 'read' the road ahead. These vehicles will not work if road markings are not maintained to a high standard. This is placing pressure on governments and road safety authorities around the world to ensure that the roads they are responsible for are fit for purpose. While there is likely to be SAE level 4 cars in the near future, a level 5 vehicle (fully autonomous) that can be used outside a limited bubble of time is quite some time in the future.

Highways England is delivering a record £15 billion of government investment designed to give people safe, efficient and reliable journeys, and provide businesses with the links they need to prosper and grow.

## BENEFITS OF DRIVERLESS CARS:







Automated vehicles cannot function reliably if basic road markings are non-existent, non-compliant, worn-out, obscured, inconsistent or confusing. Our roads must become ones that driverless cars can 'read' before we can reach a high level of vehicle autonomy. Alongside the challenge of road markings not being clear enough, there is another line issue that needs to be addressed.



# STRATEGY FOR THE FUTURE:

There is no one solution that fits all and any approach should consider a range of factors for performance and maintenance. Looking for alternative systems and suppliers will facilitate efficient and effective line marking solutions.

## SAFE

Pragmatic and achievable solutions that eliminate the number of road users and contractors of KSI (killed or seriously injured)

## INNOVATIVE

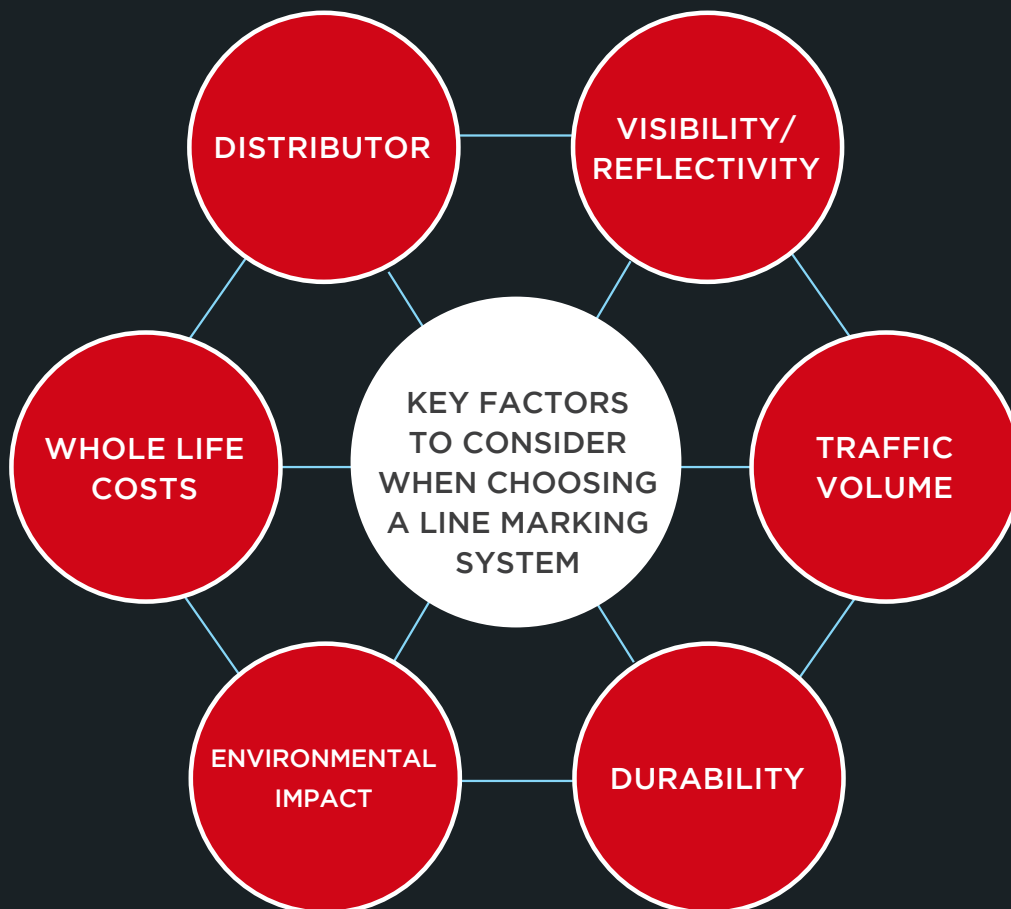
A new approach that delivers demonstrable benefits to a network fit for the 21st Century.

## SUSTAINABLE

Meeting environmental and social needs by listening, predicting and responding to the customer.

## EFFICIENT

A solution that can be delivered against the background of challenging human and financial resources.



Traffic is often the biggest factor when planning a line marking project; it affects line performance, the kind of materials needed, and the level of disruption caused.

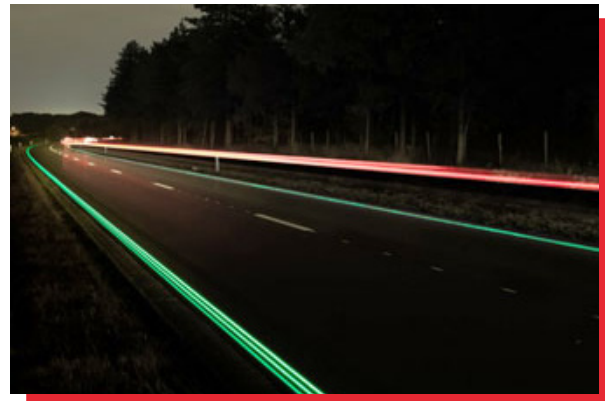
# FURTHER INNOVATION & TECHNOLOGY

The surfacing industry has seen more innovations than ever in recent years. Solutions are being created and designed that have a significant impact on our commute. Here are some of the road innovations that are expected to arrive in the near future.

## Reactive line markings:

A 500m stretch of road in the Netherlands has removed its streetlights and painted the line markings with specially formulated glow-in-the-dark paint. The idea is that the paint would 'charge' during daylight hours, then glow for up to 8 hours straight in the darkness. This innovation makes a very positive impact on the environment and reduces electricity costs. There are also plans for a paint that reacts to changes in outdoor conditions to warn of weather

conditions, such as snowflake-like patterns becoming visible only when it reaches 5°C or below.



## Remote monitoring:

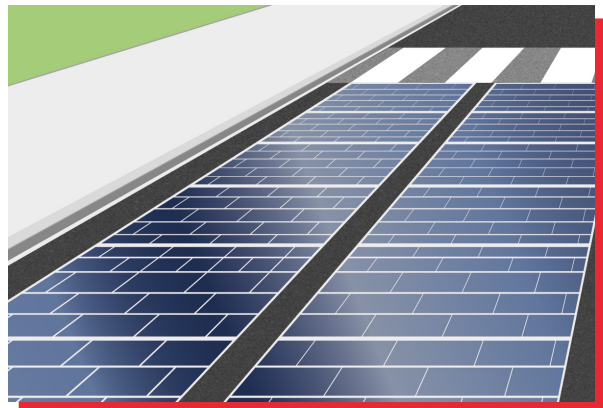
Highways England is trialling the deployment of drones to help identify faded line markings, surface cracks and potholes that require maintenance. Manual visual inspection is time-consuming, costly and dangerous for the professionals undertaking the work. Furthermore, detection results are subjective because decisions are entirely based on the experience of the personnel. Automated detection via unmanned aerial vehicles (UAVs) equipped with digital cameras provide a uniform and more efficient way to

survey the state of our roads. Further investment is being made into data collection equipment with a programme for specialist monitoring vehicles to be deployed across the network over the next 2-5 years.



## Solar roads:

A town in Normandy, France, claims to have the world's first solar-panel road. They are currently testing to see if it will generate enough energy to power streetlights. If so, this innovation would represent significant savings and be a huge step to improving our environment. The solar panels have been coated in a resin containing fine sheets of silicone, making them durable enough to withstand all means of traffic, including HGVs.



## Plastic roads:

A road in Cumbria has been re-surfaced using an innovative new asphalt mix that contains recycled plastic pellets known as MR6. The material is believed to last much longer than the average road reducing lifelong costs and carbon emissions.



## TV-P-E-D methodology

### Traffic Volume Performance Environment Disruption

- What **traffic volumes** does this project receive?
- What level of **performance** is required?
- What **environmental** impact needs to be considered?
- What level of **disruption** is likely?
- What is the whole life **cost** effectiveness?



# CONCLUSION AND NEXT STEPS:

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There are many factors that need consideration before the UK and other countries reach a high level of automation. It seems unlikely that this will be achieved by 2021, which is the date that the British government has suggested.

What we do know is that autonomy will require enhanced standards of road maintenance to ensure that the driverless vehicles are able to 'read' the road environment accurately. Their optical sensors will need to clearly see line markings, delineation of the carriageway, traffic signs and signals.

Much needs to be done before our road network reaches an acceptable level; it is thought that the maintenance backlog is running into many billions. This is an ongoing concern, but it now has the added pressure of preparing the roads for autonomous vehicles.

Using performance assured line marking systems installed by qualified and trained contractors minimises risk and ensures a consistent and sustainable quality for the longer term. It also reduces costs and improves the public's perception of our roads and the asset owners that are responsible for their maintenance.



# APPENDIX – CASE STUDIES

## **N40 KINSALE ROUNDABOUT:**

A highly trafficked busy interchange junction at the N40 Cork Ring Road, joining the N27 Kinsale Road, was showing signs of premature wear to the thermoplastic road markings. With daily traffic counts in excess of 85,000 (AADT), a harder wearing alternative road marking material was required in order to reduce traffic disruption and ongoing maintenance costs of regularly refreshing the existing thermoplastic markings. Due to its hard-wearing characteristics and long-lasting track record, methyl-methacrylate (MMA) cold plastic road marking material was specified by Atkins Global on behalf of the client. Transport Infrastructure Ireland (TII). All directional markings, symbols, arrows, pedestrian crossings, stop lines and lane lines were refreshed by Highway Markings Ltd in October 2017, using Meon's UltraLine MMA, which was applied over the existing worn thermoplastic markings after surface preparation & cleaning had been carried out. The application of UltraLine MMA has resulted in longer lasting road markings at this heavily trafficked junction, meaning reduced maintenance, traffic disruption and associated costs. Life expectancy of MMA markings is predicted to be at least 3 times the life of thermoplastic markings at the same location.

## **TARLETON BRIDGE:**

A heavily trafficked bridge in Lancashire had seen a rise in accidents, which was attributed to poor quality markings on both the road and the bridge. As the bridge is situated on one of the main through roads in the area, the challenge was to improve visibility of markings whilst keeping any road closures to an absolute minimum. The proposed solution was to re-mark all the road markings, re-apply the chevron stripes to the bridge parapet and replace the road stud inserts. Meon products, such as; Spectrum UltraLine for the road marking's which helped provide maximum durability even under high traffic volumes; Spectrum ViaLine, to provide bright, sharp contrasting chevrons on the parapets; glass beads, in both Spectrum products to provide retro-reflectivity and new depressible stud inserts, further improving night-time safety. The whole install was expertly carried out to a very high standard. Deployment of class-leading equipment such as the LineLazer 130HS airless spray machine facilitated a rapid and effective install, and the use of advanced materials from the Spectrum range assured a long service life. The finished result is crisp vibrant markings, which have been well-proven to improve road safety and reduce the incidence of accidents.

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### MEON UK

Meon offer a wide range of high-quality lining and marking materials, including line repair, suitable for both indoor and outdoor applications. Our products include paints, taping, stencils, sprays and additives, which are suitable for many industries and complex problems requiring specific solutions. It also offers professional quality line marking and removal machines for purchase and hire.

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