

**3M** Science.  
Applied to Life.™

# Transportation Safety Division

Bringing families home safely

Vusumuzi Tshabangu  
Technical Manager



# Traffic Safety Division: Portfolio

## Roadway Applications



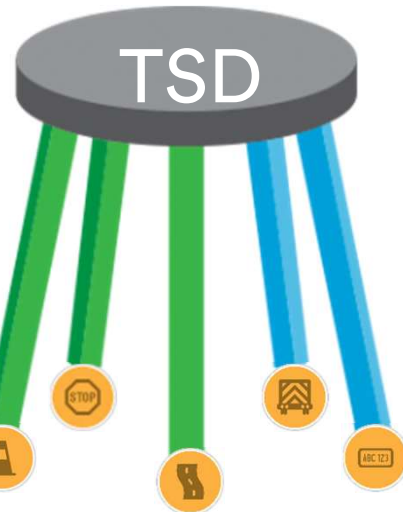
Traffic Signs



Temporary Traffic



Pavement Markings



## Vehicle Applications



Conspicuity



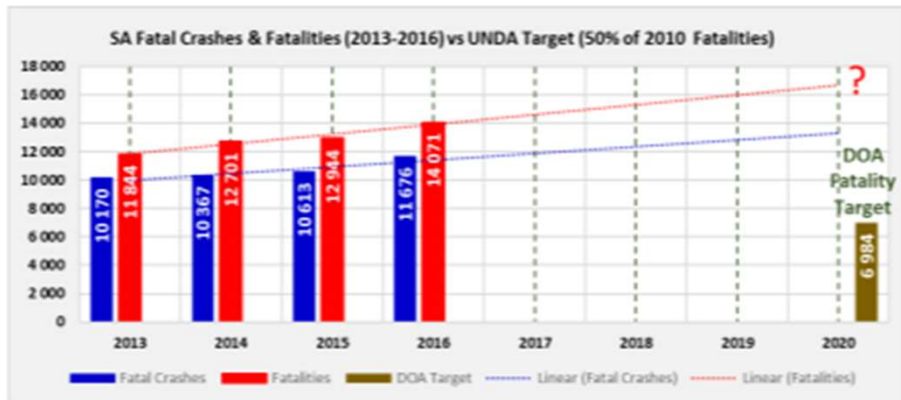
Vehicle Registration



# Pain point: Road fatalities

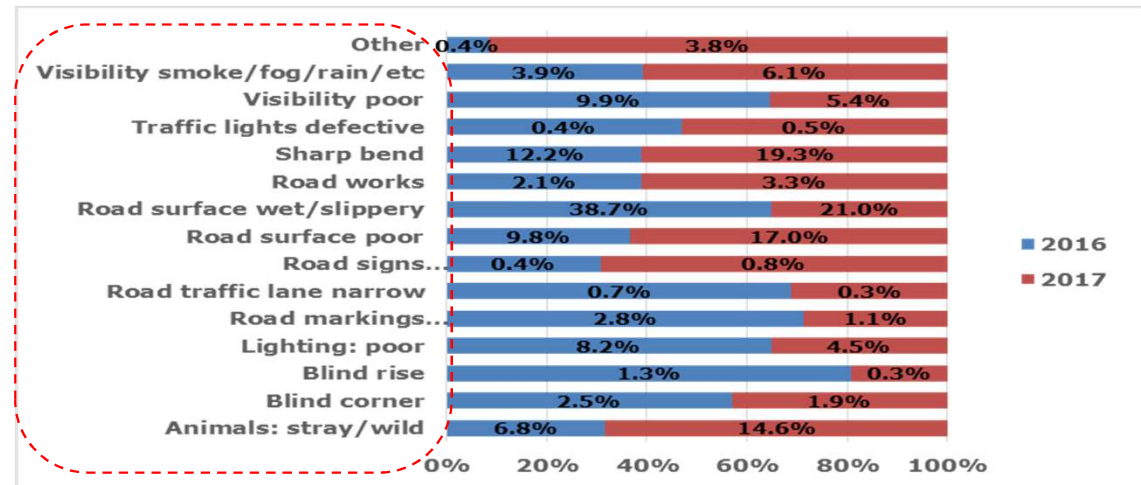


Figure 1: SA Fatal Crashes & Fatalities (2013-2016) vs UNDA Target



SA-RAP REPORT South African Road Assessment Programme Report '26.5 km of the N14 - Road P158/1' (N1/N14 to Kgosi Mampuru Correctional Service) Gauteng Province

## Environmental factors contribution to road fatalities



RTMC, Three(3) years annual overview of state of road safety statistics 2018

- **703** individuals perish as a result of environmental factors in South Africa in 2017
- **75% and 60%** of the environmental factors are linked to visibility in 2016 and 2017 respectively
- Accidents are prone to occur between 17:00 pm – 21:00 pm in the evening and with the spike on weekends

# Reflective Solutions to Enhance Road Safety

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# Why do we require road sign or safety device

## WHY Road Signs

- Fulfill a need
- Command attention
- Convey a clear, simple message
- Command the respect of road users
- Allow adequate time for the correct response from road users



## Signing Considerations & Trends

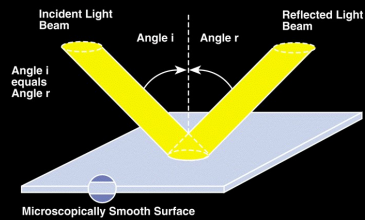
- Older drivers
- Larger vehicles
- Changing headlamp pattern
- Increasing urbanization

## Benefits of higher luminance

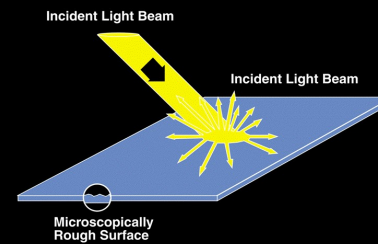
- Increased conspicuity
- Increased legibility
- Improved information acquisition time
- Increase in safety

# Basics on Retroreflective

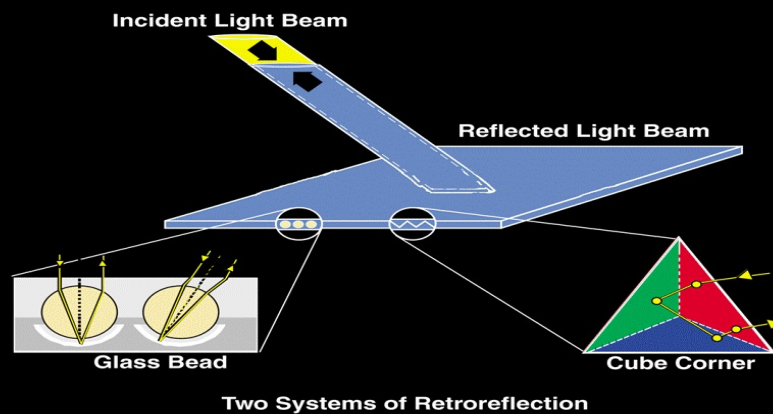
## Mirror Reflection



## Diffuse Reflection

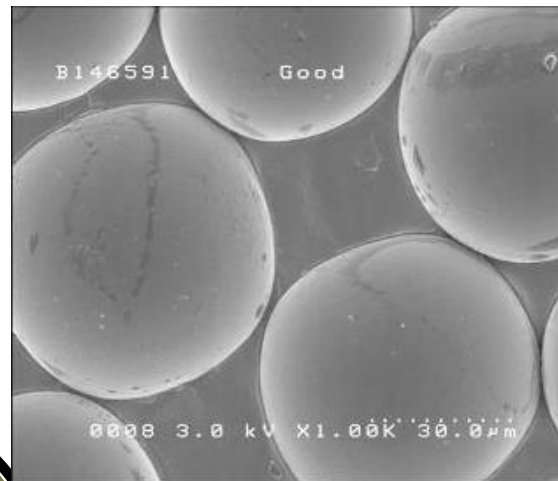
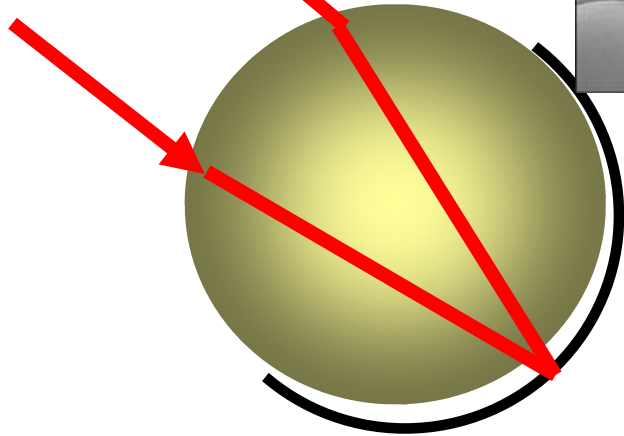
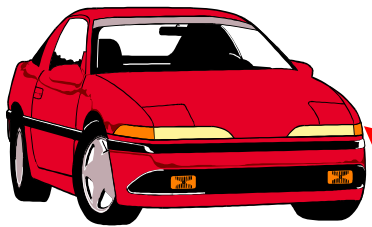


## Retroreflection

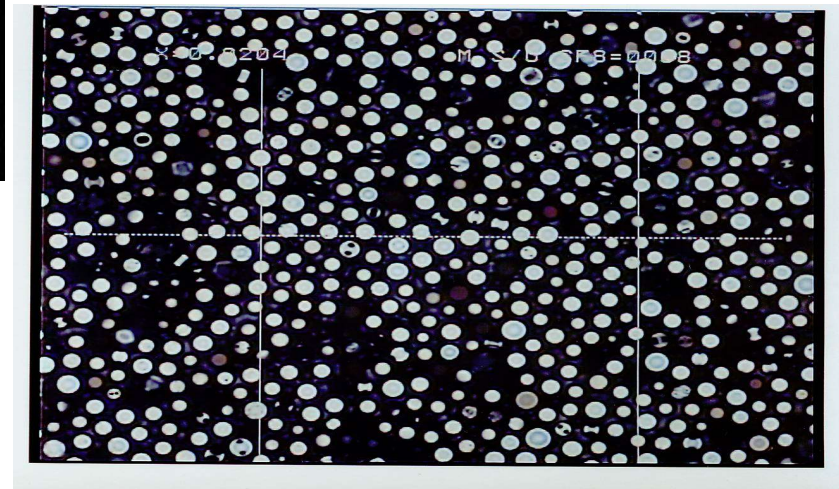


# How the Technology Works

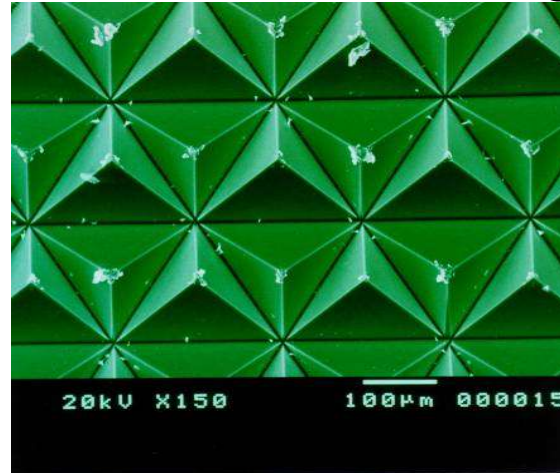
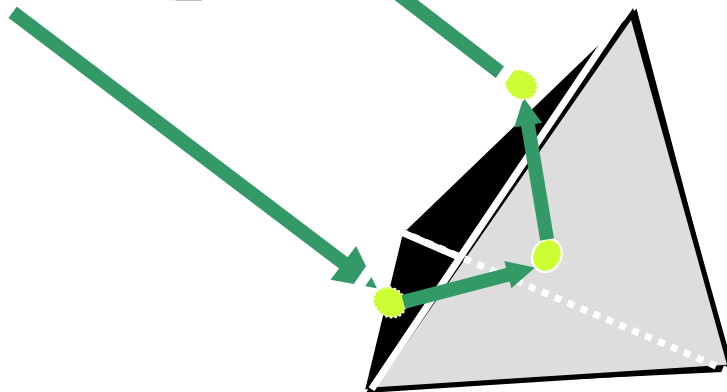
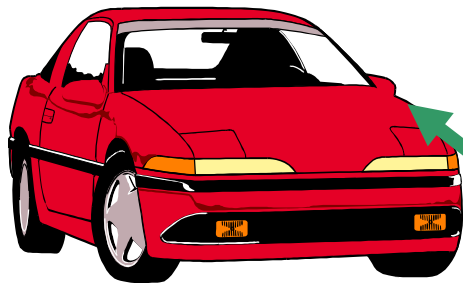
## Glass Bead Technology



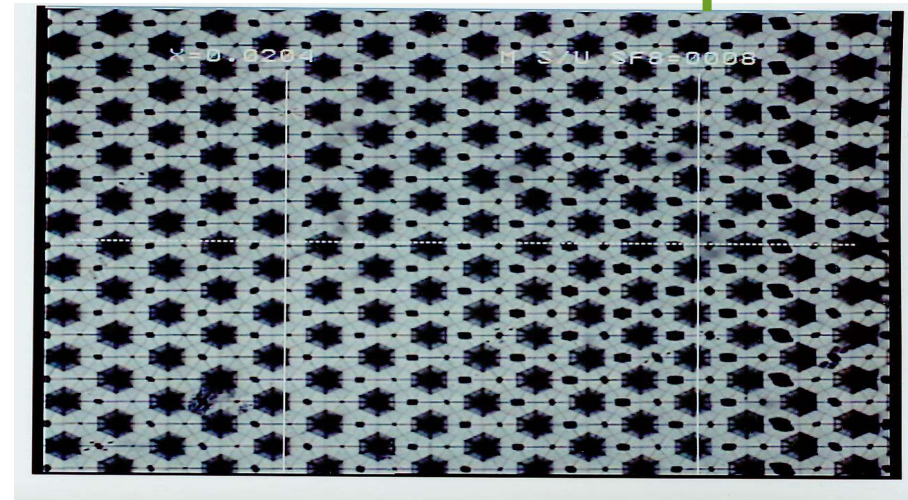
## Engineer Grade



# How Prismatic Technology Works

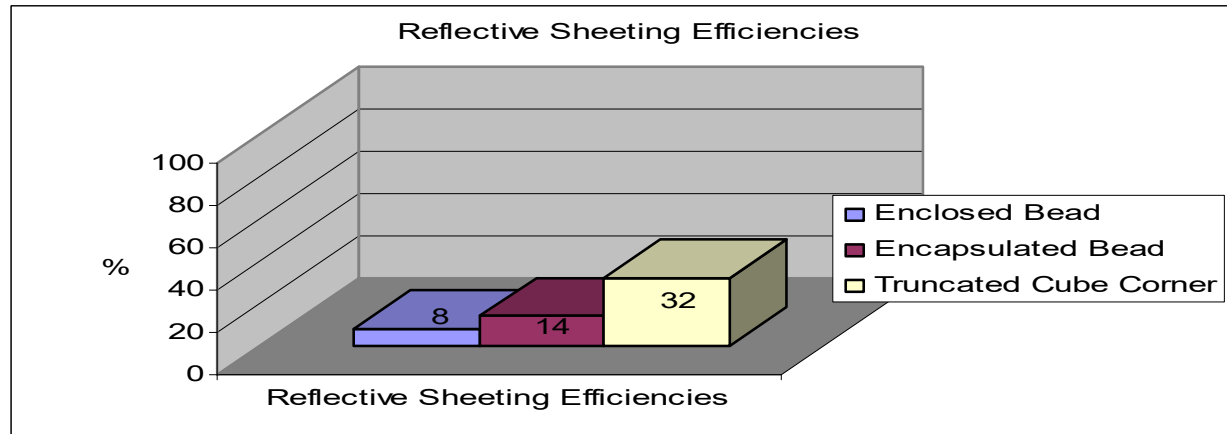


Truncated Cube Optics

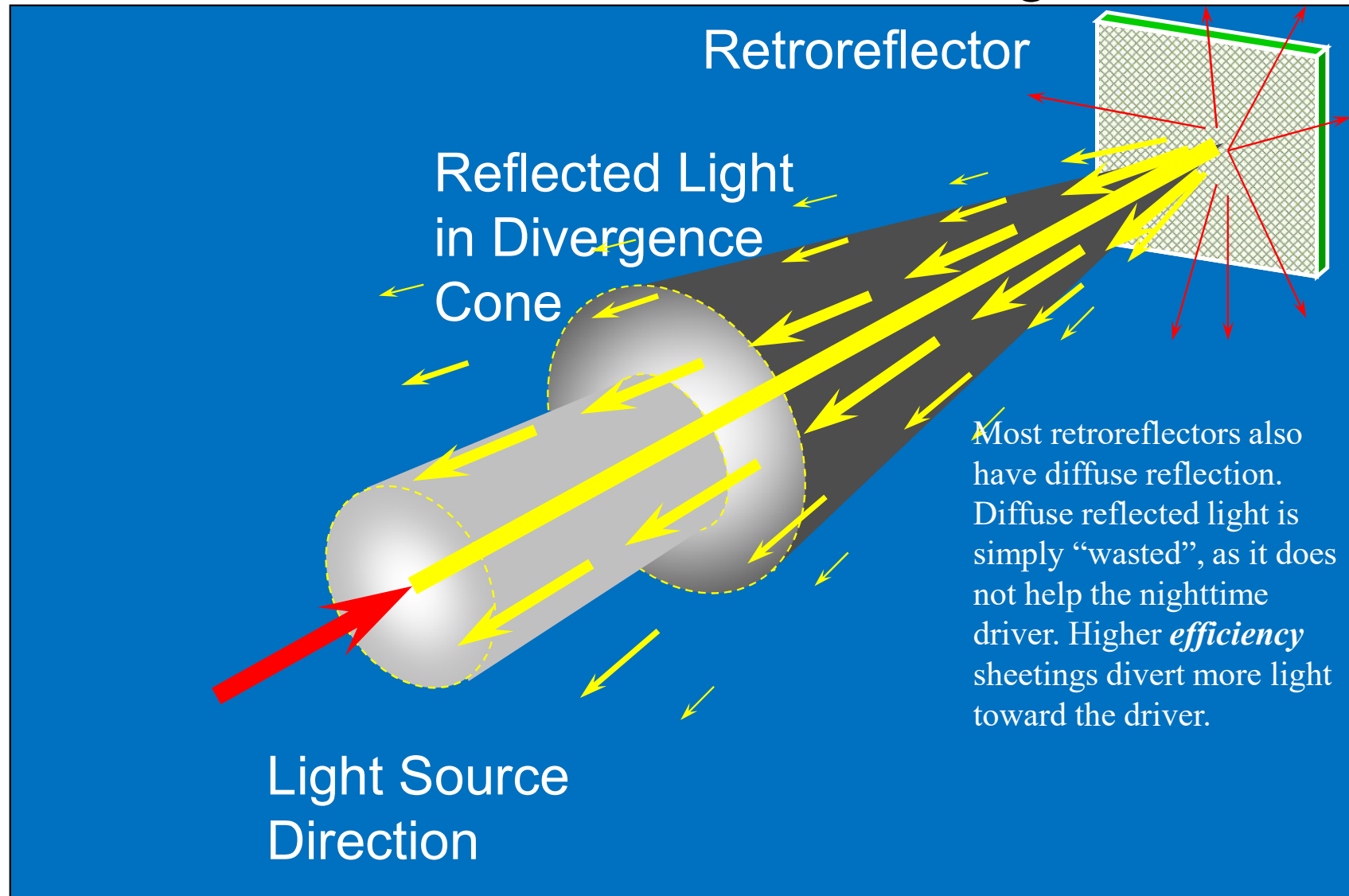




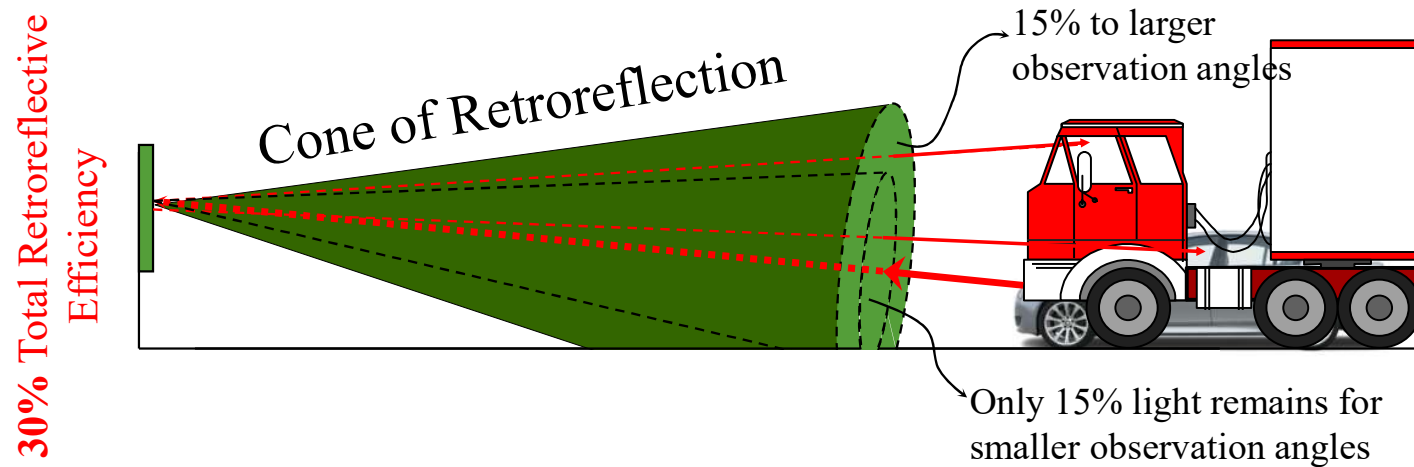
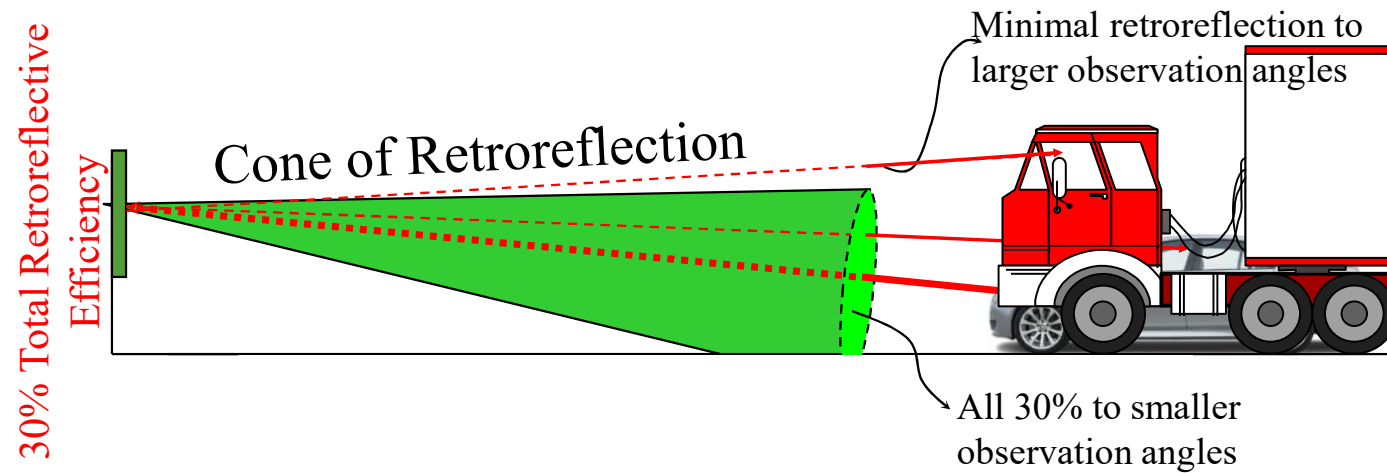
# Reflective Sheeting Efficiency



# Cone of Returned Light



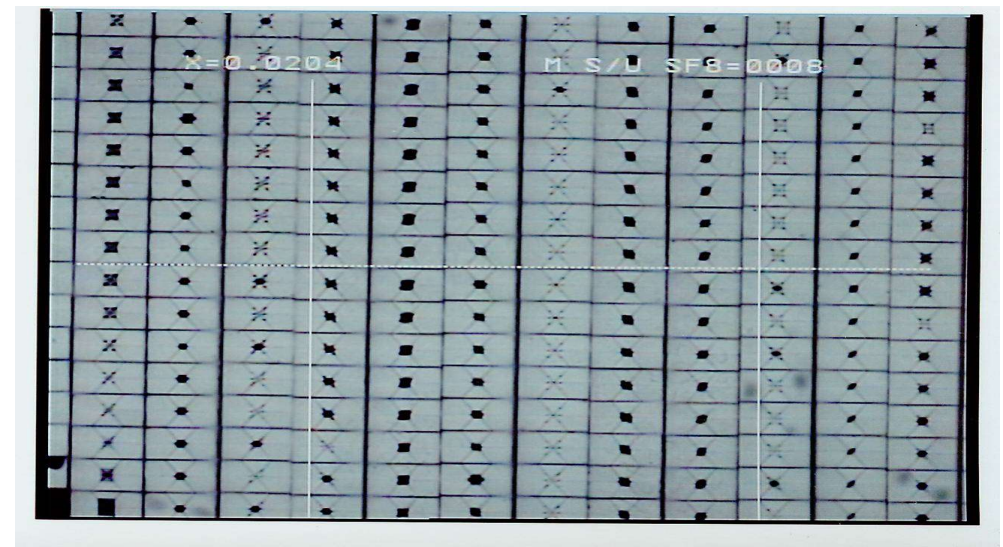
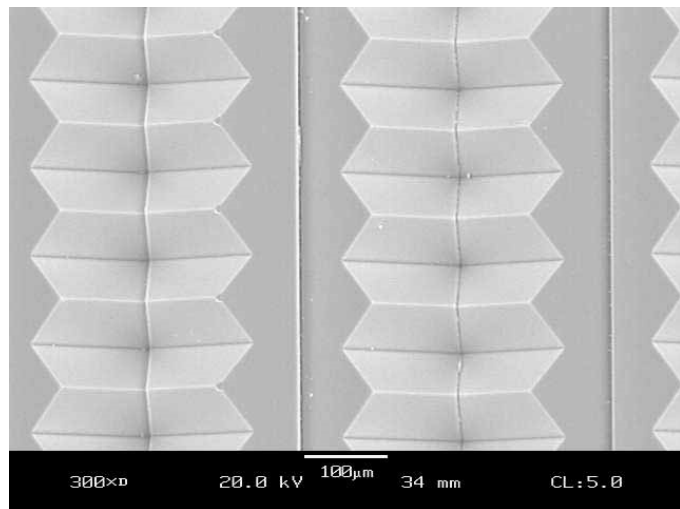
# Retroreflective Efficiency



All truncated cube corner sheetings have nearly 30% retroreflective efficiency.

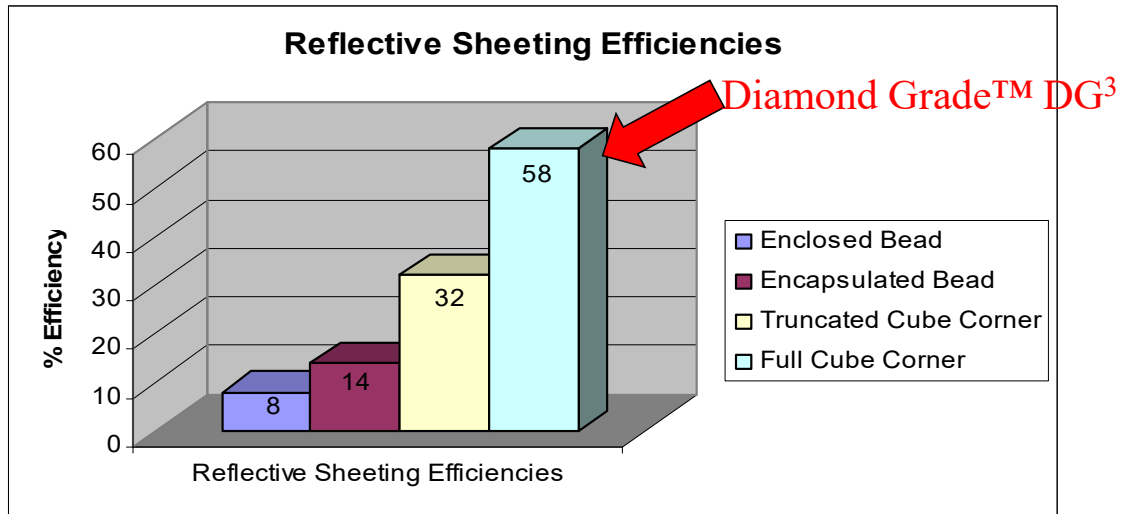
# Full- Cube Optics DG3

DG<sup>3</sup>





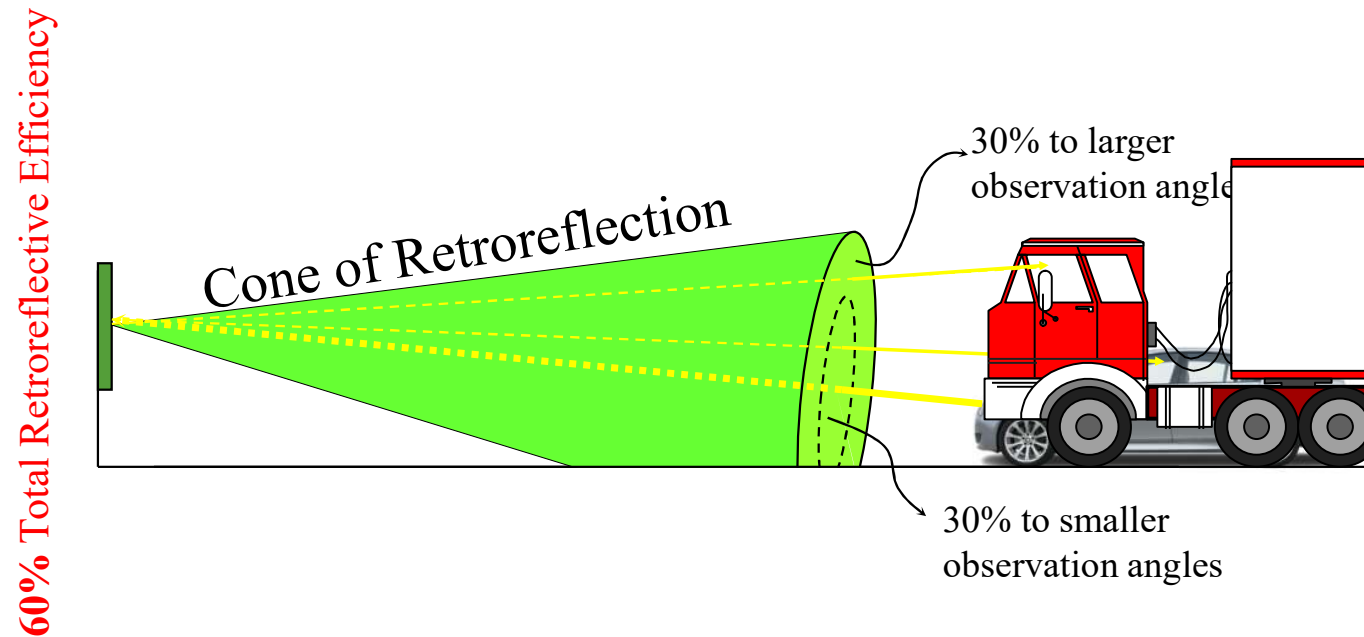
# Full-Cube Reflective Sheeting Efficiency



**Total Efficiency  
(RT)  
Warranty (Yrs)**

DG3	High Intensity Prismatic	High Intensity Glass Bead	Engineer Grade Beaded
			
58%	30%	14%	8%
12	10	7	7

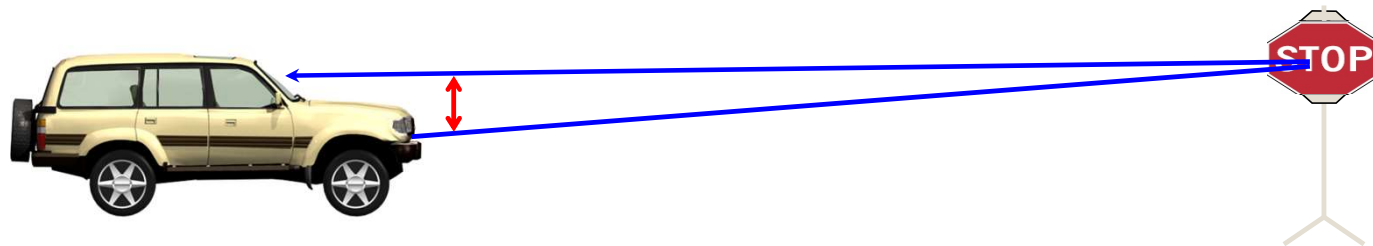
# Retroreflective Efficiency



Increasing the overall total retroreflective efficiency ensures serving the greatest segment of nighttime vehicle and driver population.

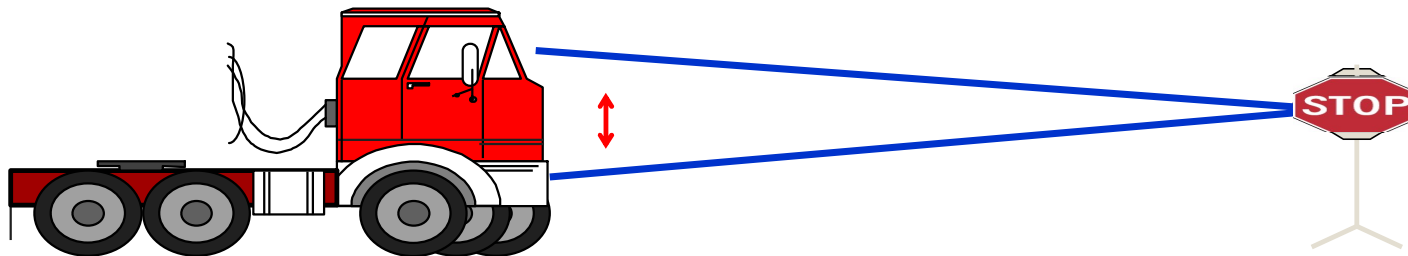
# Observation Angle

- The angle between the line formed by a headlight beam striking a sign surface and the line formed by the retro-reflected light beam at the driver's eye
- This angle is usually a very small figure (e.g. 0,2 / 0,33 degrees)



# Observation Angle

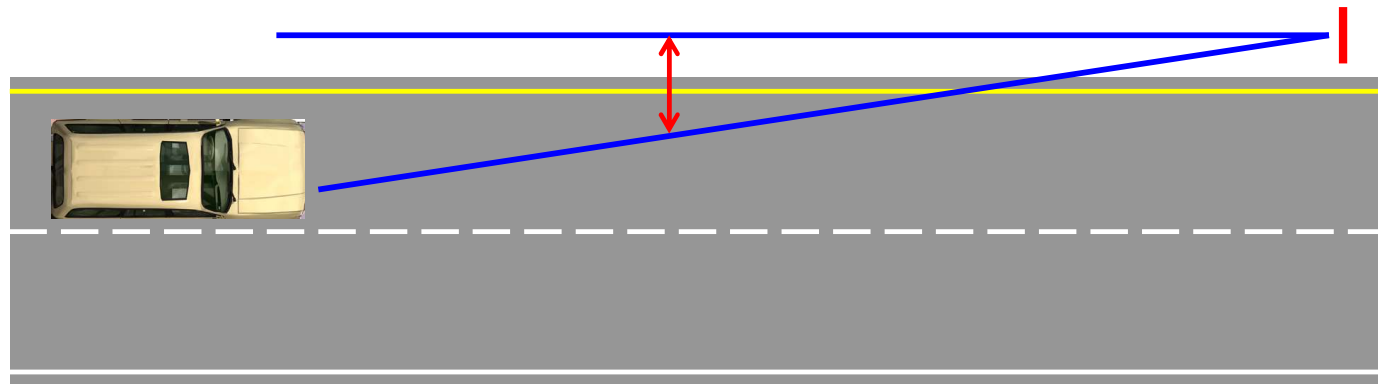
- Observation angle is a critical factor when determining how bright a sign appears
- As the observation angle increases the sign will appear less bright





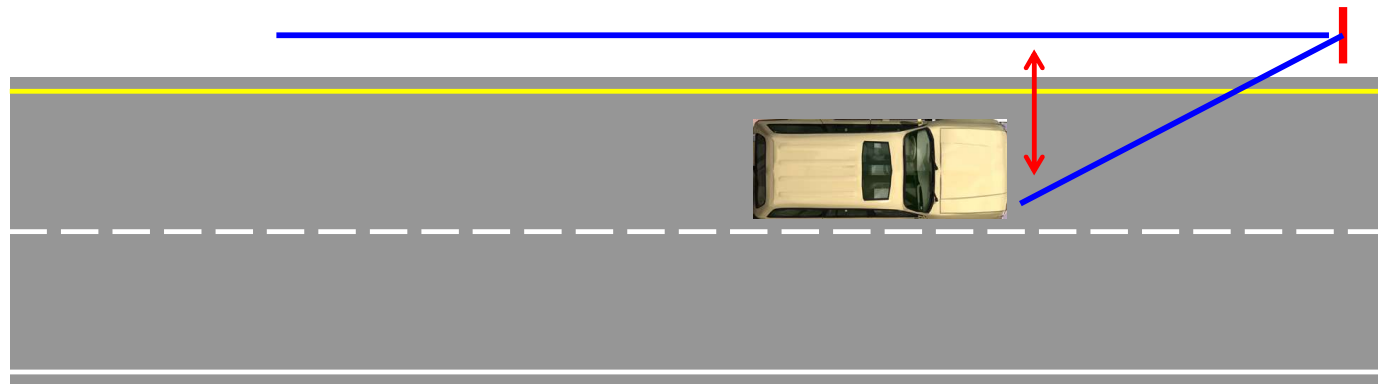
# Entrance Angle

- The angle between the line formed by a light beam striking the sign surface at some point and a line perpendicular to the sign surface at that same point.



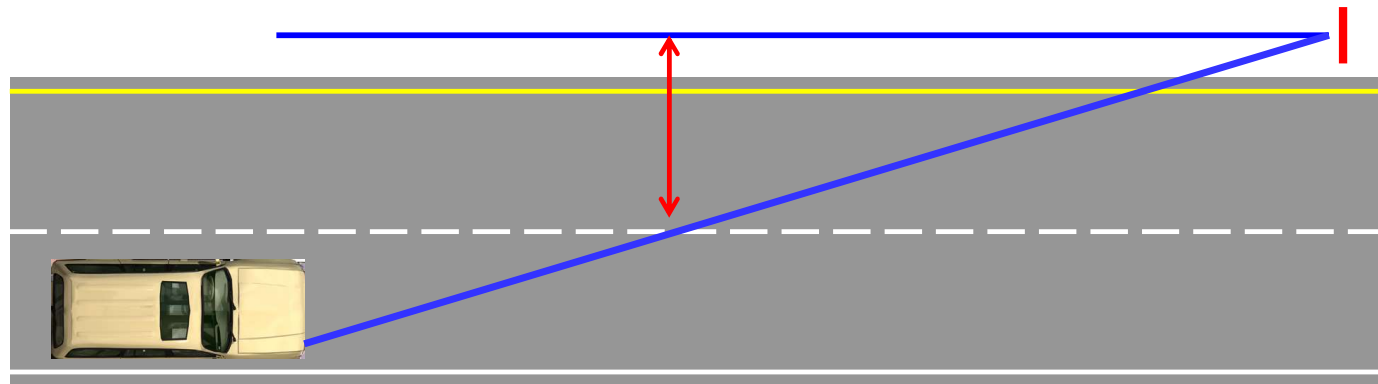
# Entrance Angle

- The position of the vehicle in relation to the sign will determine the Entrance Angle
- Larger angle (eg 5deg/30deg/60deg etc)



# Entrance Angle

- The wider the Entrance Angle becomes will reduce the reflective performance (brightness) of the sign



# General Policy and Sign Design Principles are contained in the “Southern African Development Community (SADC) Road Traffic Signs Manual

- SANS 1519-1:2006 Road signs Part 1: Retro reflective sheeting material
  - *Class I / Class III / Class IVa & IVb*
  - *Marking requirement*
- SANS 1519-2:2004 Road signs Part 2: Performance requirements for road signs
  - *Coatings on finished sign (printing/vinyl/ECOF etc.)*
- SANS 1555:2011 Roadworks delineators
  - *SANS 1519-1 Reference*
  - *Class III minimum*
- COTO: Standard Specifications for Road and Bridge Works for State Road Authorities
  - *Chapter 11*



# SABS

South African Bureau of Standards



Standard Specifications for Road  
and Bridge Works for South  
African Road Authorities

Draft Standard (DS)  
CHAPTER 11: ANCILLARY ROAD  
WORKS  
October 2020

Permission is granted to freely copy, print and distribute  
this Draft Standard document for industry use.



VT1

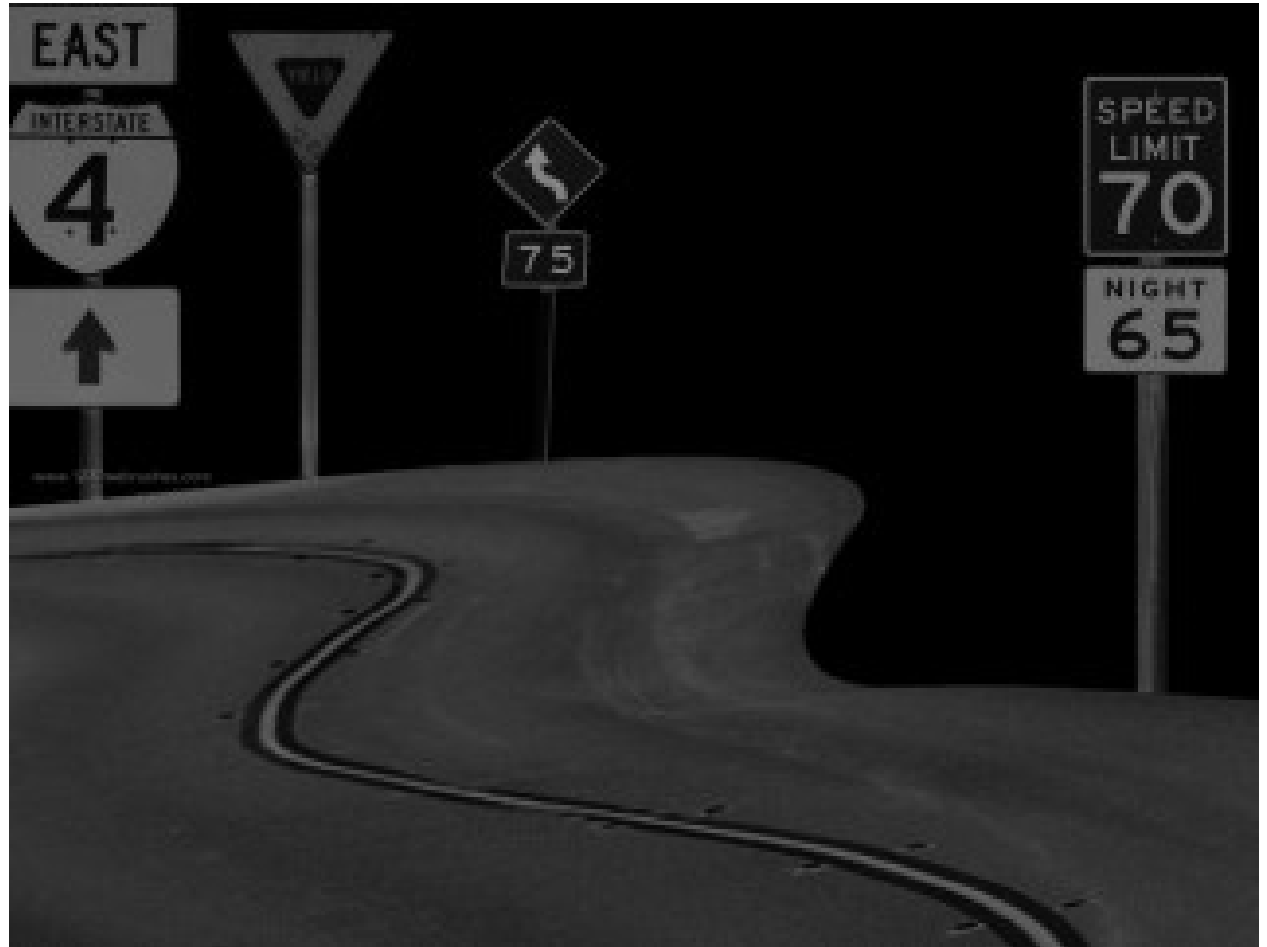
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Vusi Tshabangu, 2021/08/26

# Summary –3M Reflective Sheeting

Attributes	3M Engineer Grade	3M Engineer Grade Prismatic	3M High Intensity Prismatic	3M DG3
Technology	1940 Glass Bead	2009 Truncated Prismatic	2004 Truncated Prismatic	2005 Full Cube Prismatic
SABS Class	I	I	III	IV a & IV b
Optical Efficiency	8%	10%	32%	58%
Warranty	7yrs	7yrs	10yrs	12yrs 10yrs
Typical Brightness 106mtr distance for sedan	60 cd/lux/m2	110cd/lux/m2	400cd/lux/m2	600cd/lux/m2

Why do we  
need  
Brighter  
Signs?



# Signing Considerations & Trends

- Aging Population
- *Growing Truck Fleet*
- *VOA Headlamps*



# Older Drivers Need:

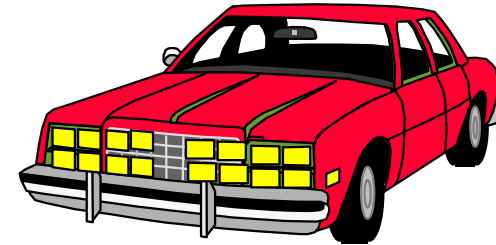
- More light to see and read a sign
- Light need doubles every 13 years.
- Longer reaction time

Perceived Brightness often Correlates with Age

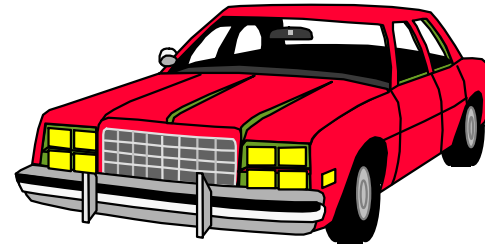




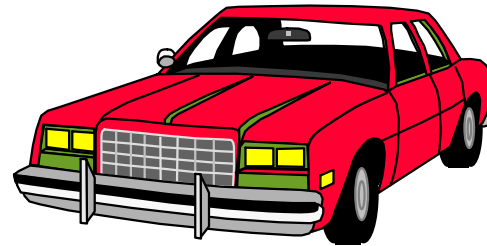
Older Drivers need more than  
what cars can offer



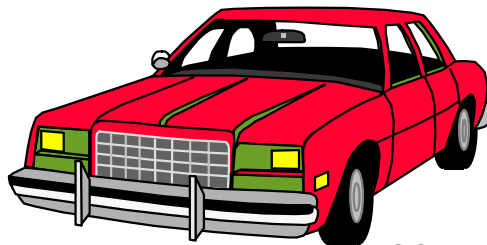
59



46



33



20

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# Larger Vehicles

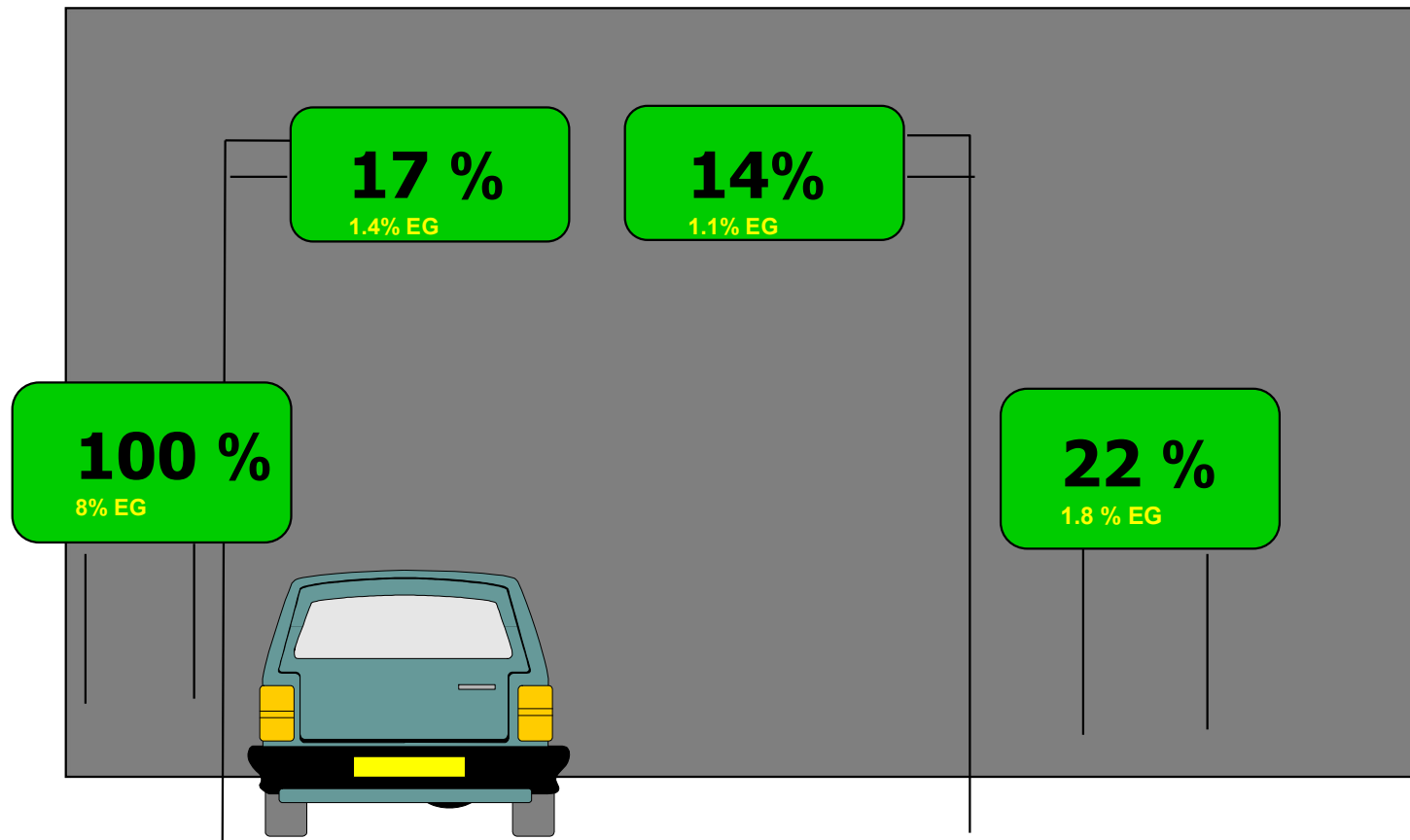
- The number of large trucks on the road have **increased** while the number of passenger cars have remained reasonably unchanged.



- Drivers of larger vehicles are disadvantaged due to the **increased observation angles to view the signs**. Lower grade sign sheeting does not meet the needs of these higher observation angles.

# Sign Design Principles

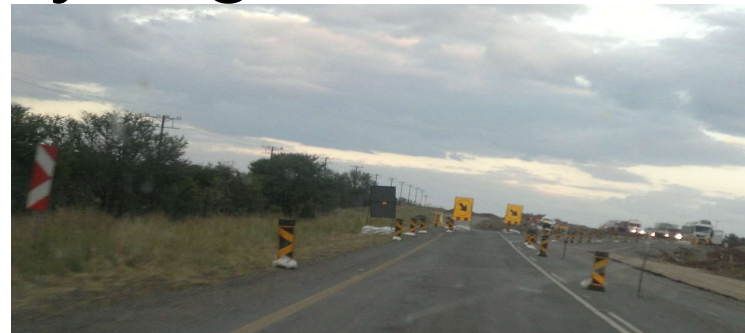
The amount of light available to the traffic sign varies depending on the position of the sign and the vehicle.



# Permanent Signing



# Temporary Signs

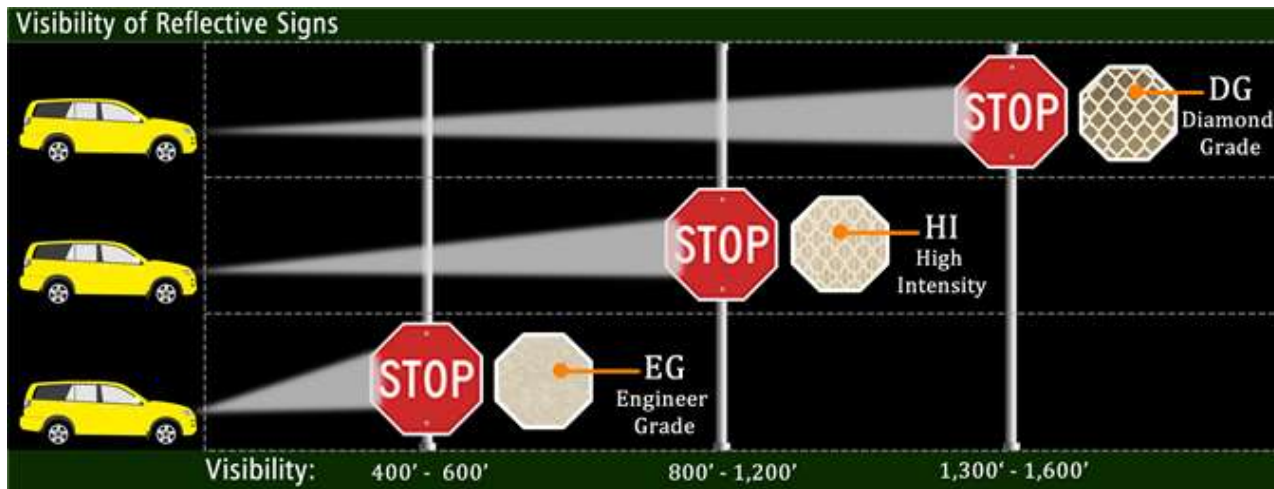




# Non-Compliant / Ineffective Signs





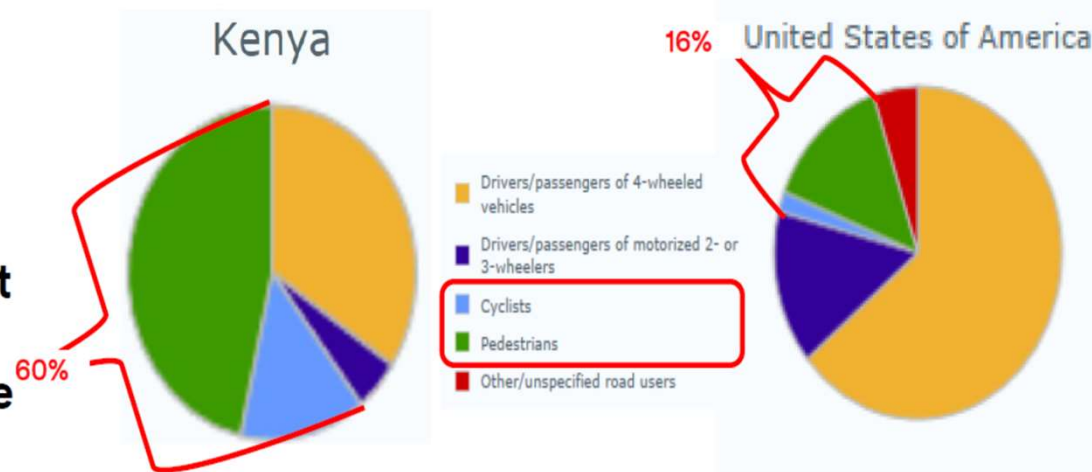


- Road sign should be designed
  - With the **Road User** in mind
  - To mitigate the risk present
- Brighter Signs
  - Allows more reaction time
  - Improve visibility

# Sign visibility

## Vulnerable Road Users:

**Pedestrians & cyclists represent a significant percentage of the road traffic deaths**

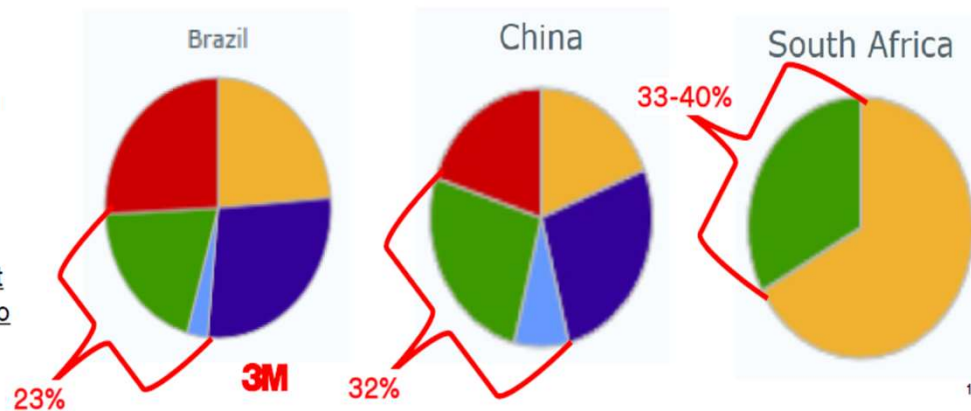


Distribution of road traffic deaths by type of road user, 2013

Source: "World Health Organization (2015). Road traffic Deaths Data by country. Global Health Observatory data"

[http://www.who.int/gho/road\\_safety/mortality/traffic\\_deaths\\_distribution/en/](http://www.who.int/gho/road_safety/mortality/traffic_deaths_distribution/en/)

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# USA and Europe

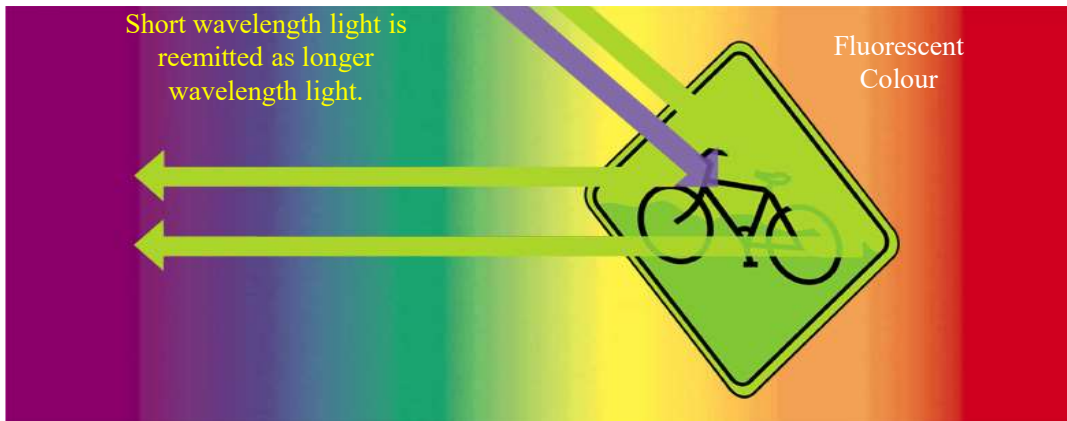
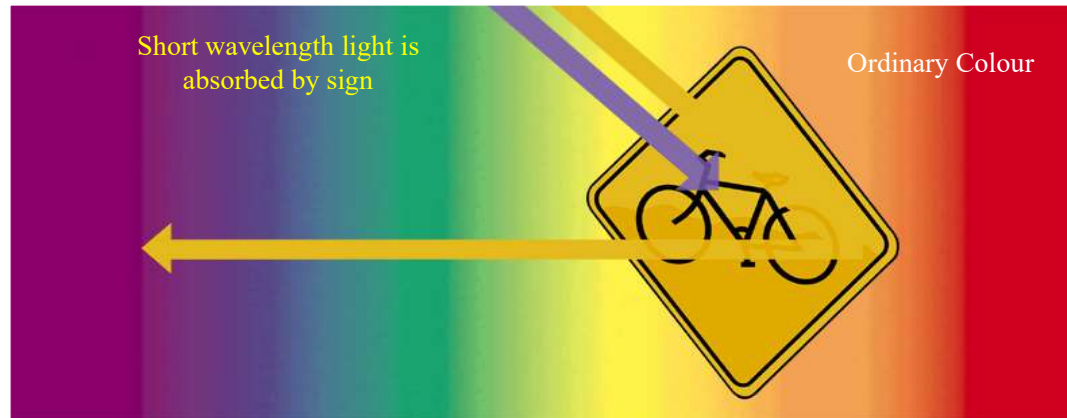




# School Zone in South Africa



# How Fluorescence Works



Fl.  
Yellow  
Green



Std  
Yellow







Fl.  
Yellow



Std  
Yellow

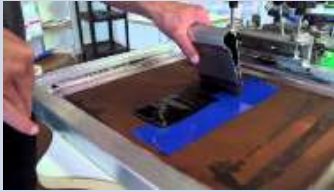


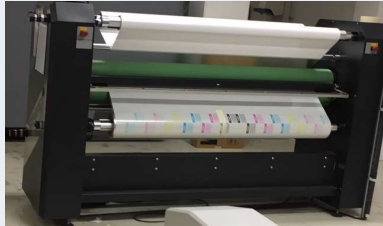
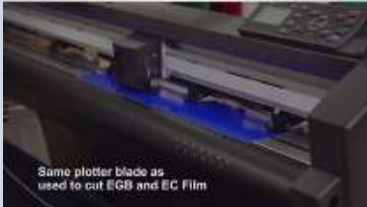



# Driver Behaviour Studies in relation to reflective material

<b><i>New York DOT Special Report 121 : FYG vs Yellow for Pedestrian/School/Bicycle Crossings</i></b>					
<b>Before &amp; After Study of Driver Behaviour at Crossings with Pedestrians present (Dhar &amp; Woodin 95)</b>					
 		<b>Site 1</b>		<b>Site 2</b>	
		<b>Yellow</b>	<b>FYG</b>	<b>Yellow</b>	<b>FYG</b>
<b>% Slowing</b>		<b>17.2*</b>	<b>32.5*</b>	<b>24.3</b>	<b>38.2*</b>
<b>% Stopping</b>		<b>13.0</b>	<b>20.2</b>	<b>14.4</b>	<b>24.3</b>
<b>% Conflicts</b>		<b>4.1</b>	<b>2.6</b>	<b>30.9</b>	<b>4.4*</b>
<b>% Conflicts = Swerving, suddenly breaking</b>				 	
<b>* Statistically significant change (<math>p &lt; 0.02</math>)</b>					



# Sign Imaging Methods

Imaging Method	Digital Printing
 <u>Screen Printing</u>	
 <u>Cut Out Copy Imaging</u>	
 <u>Colored Film Imaging</u>	

Prismatic sheeting is compatible with conventional traffic sign imaging methods.

# 1 Programs

3M Traffic Safety and Security Division

## Outsmart the Dark With 3M™ Diamond Grade™ DG<sup>3</sup> Reflective Sheeting

### Using science to turn black spots into bright spots.

Black spots are places where the number of crashes is higher than average. Often the reason for black spots is the physical configuration of the road or intersection, such as:

- Sharp corners in a straight road, concealing oncoming traffic
- Hills or winding roads that limit visibility ahead
- Hidden junctions and intersections
- Poor or concealed warning signs



3M™ Diamond Grade™ DG<sup>3</sup> Reflective Sheeting has twice the brightness of our lower-grade sheeting. Brighter sheeting is more visible to drivers and has been shown to increase safety by cutting nighttime crashes by 25 to 46 percent.

### Section 1 – Manufacture and Supply – Traffic Signs

#### 1.0 SPECIFICATIONS for Reflective sheeting

- 1.1 All road signs manufactured shall comply with the ROAD TRAFFIC ACT, 1989, its Regulations and the latest editions of the SOUTH AFRICAN ROAD TRAFFIC SIGNS MANUAL and SANS 1519-1. By submitting a tender, the Contractor acknowledges acquaintance with the relevant aspects contained in the above-mentioned Act, Regulation, Manual and Standards
- 1.2 The Department shall only accept tenders from manufacturers who will supply signs:  
Manufactured from SABS approved reflective sheeting suppliers
- 1.3 No overlaying of Retro-Reflective sheeting from different manufacturers shall be allowed.
- 1.4 *The use of screen printed signs will not be permitted.*
- 1.5 **Advanced Engineering Grade Prismatic or equivalent, non-metalized reflective sheeting** that employ the Micro Seal™ technology, with the uniform appearance, shall be used in the manufacture of the signs and shall carry clearly visible Water-mark, with

Reflective sheeting manufacture's name  
Class  
7 year

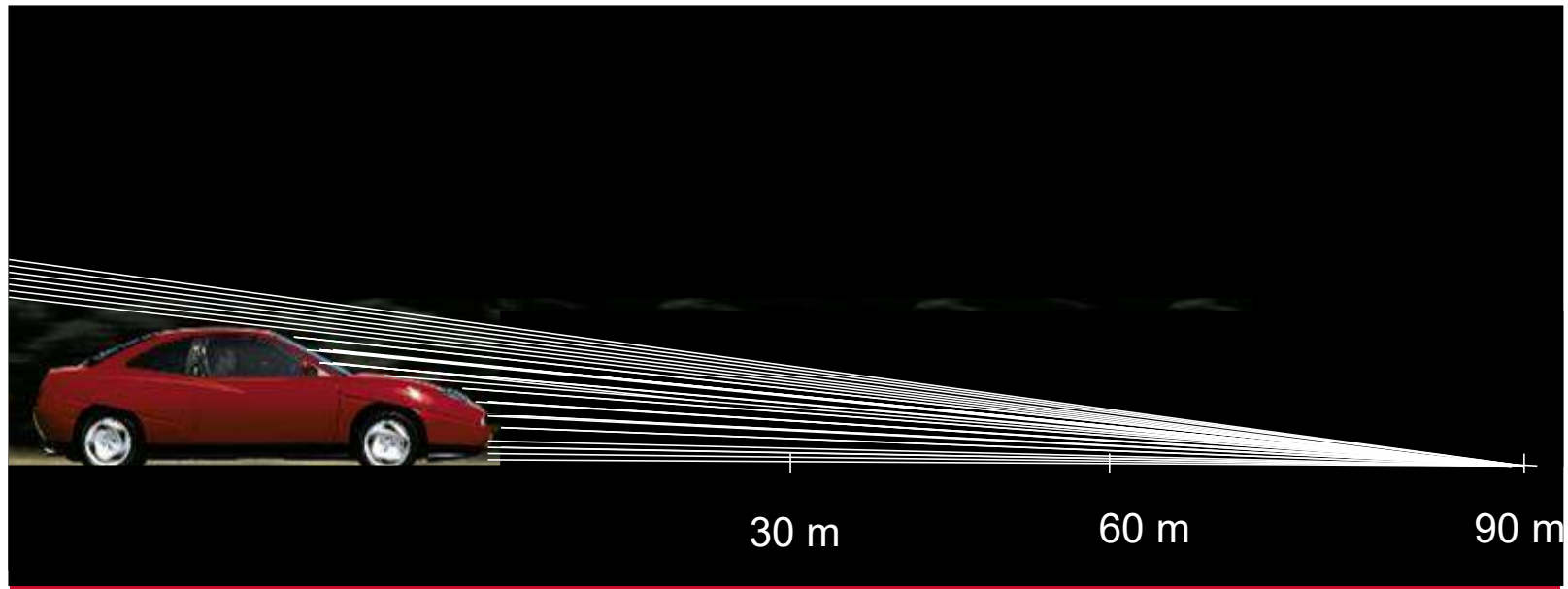
**High Intensity Prismatic or equivalent, non-metalized reflective sheeting**, shall be used in the manufacture of the signs and shall carry clearly visible Water-mark, with  
Reflective sheeting manufacture's name  
Class  
10 year

The material shall comply with the minimum SANS1519-1 standards for Class (iii) sheeting.

**Diamond Grade Full cubed (DG<sup>3</sup>) or equivalent, full cube technology, non-metalized reflective material**, designed to have the highest retroreflective characteristics at medium and short road distances as determined by the RA values at 0.5° and 1.0° observation angles also sharp curves and danger plates, it shall comply with minimum standards for both Class IV (a&b) sheeting and shall carry the clearly visible watermark with

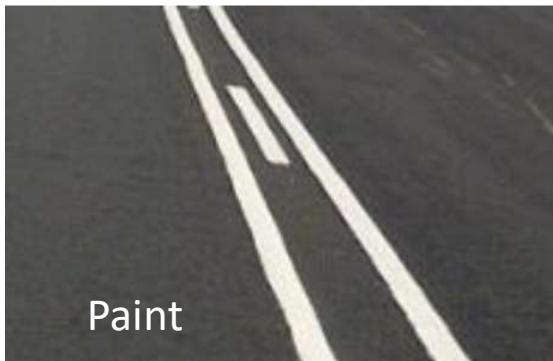
Reflective sheeting manufacture's name  
Class  
10 + year

# The Principle of Retroreflection



# Pavement Marking

- Government agencies have **unmet** pavement marking needs and are seeking more durable, higher performance solutions at an affordable total cost of ownership
  - Many liquid pavement markings are not durable enough on high-traffic roadways
  - Less durable pavement markings must be re-stripped frequently
  - Thermoplastic has poor adherence on concrete surfaces
  - Standard glass beads used in conventional paint, epoxy, and thermoplastic can lose their retroreflectivity quickly, unable to provide adequate nighttime visibility



# Pavement Markings



Visual Guidance



Warning



Daytime Visibility



Lane Delineation



Pedestrian Safety



Nighttime Visibility

Help Make Our Roadways Safer



# What's said about Pavement Markings

## Roadmarking Lottery

- ▣ Tendering for Road marking Contracts are highly competitive – lowest price rules
- ▣ Very little testing of these road markings takes place hence the standard of the finished road marking is not what it should be.

Standard of road marking varies depending on the Road Authority, the Engineer and the Contractor.



## Why worry about Performance?

Traditional specification:  
the more lines that are applied, with the recipe product, in a minimum time, more money will be earned → EASY MONEY, NO INCENTIVE

Durability is not a priority

Road authority carries the risk

Low-performance markings - Safety suffers



# *The Solution: Stamark™ 380 Tape*

**Implementation of 3M™ Stamark™ High Performance Series 380IES Tape on your Highway/ Streets will provide unique advantages and benefits to the government agency and motorist.**

Such as:

- Improved visibility and more reaction time for drivers
- Superior initial / retained retroreflectivity
- Durability (road presence) 6 – 8 years
- Product Warranty
- Reduced frequency of restriping
- Improved worker and motorist safety

## Applications

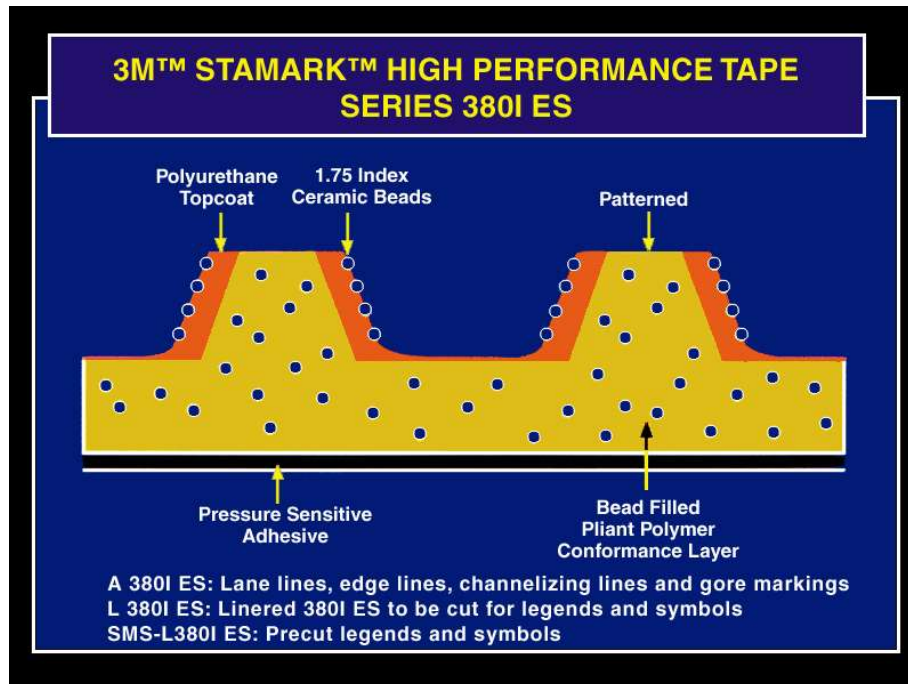
- Skips, edgelines, gore markings
- Contrast markings
- Symbols & Legends
- Crosswalks





# Stamark™ High Performance Tape

## 380 Features & Benefits



- 3M Microcrystalline Ceramic Beads
  - *More durable than glass beads*
- Raised Pattern
  - *High initial and retained retroreflectivity*
- Pressure Sensitive Adhesive
  - *Reliable adhesion to asphalt and concrete surfaces*
  - Reinforced Netting for durability
- Warranted Performance for retained retroreflectivity and road presence



# Stamark™ 380 Tape Performance

## Minimum Initial Retroreflectivity Performance

	<b>380IES White</b>	<b>381IES Yellow</b>
Entrance Angle	88.76°	88.76°
Observation Angle	1.05°	1.05°
Retroreflected Luminance	500	300

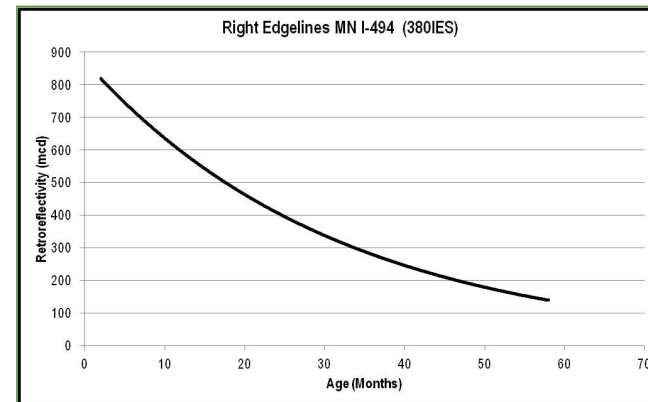
$R_L [(mcd \cdot ft^{-2}) \cdot fc^{-1}]$

## Standard Warranty Offering

<b>Application</b>	<b>Warranty Period</b>	<b>Min. Retained Retrorefle ctivity</b>
Longitudinal Markings	4 years min.	100 mcd
Symbols and Legends	2 years min.	100 mcd

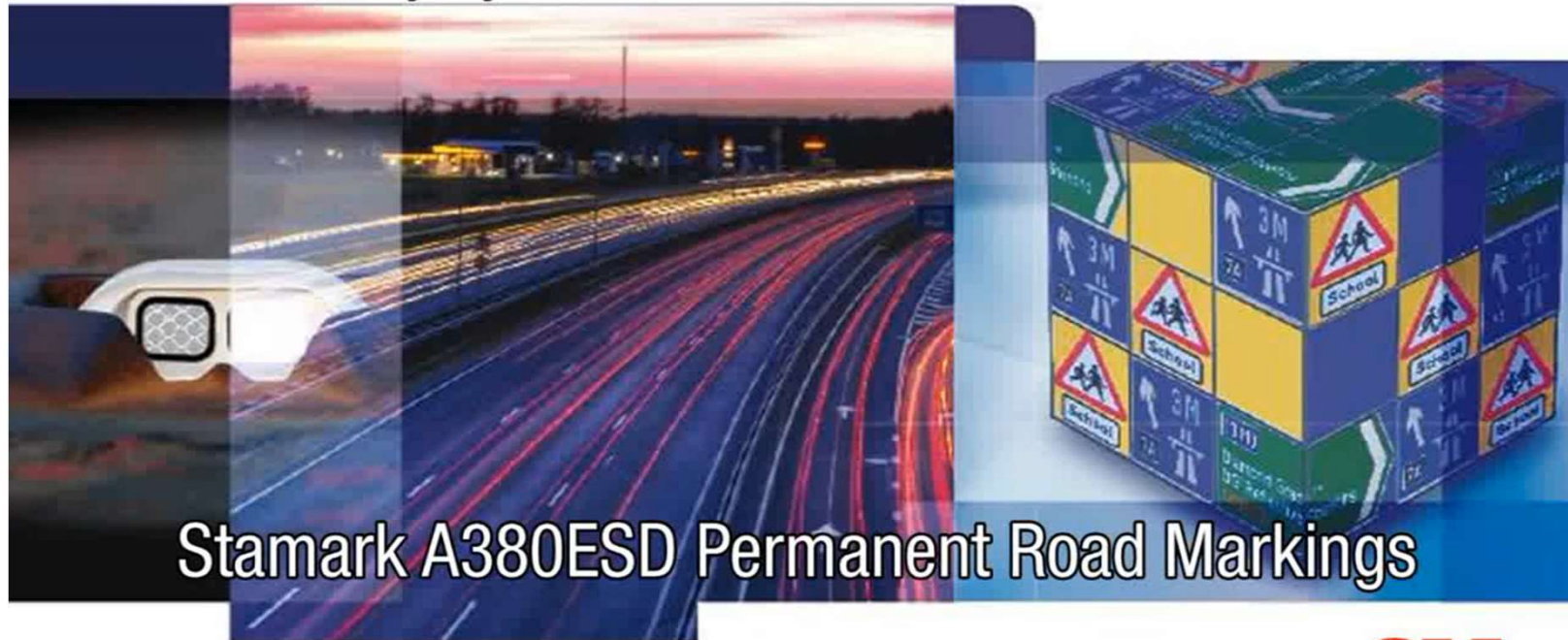


*Minnesota DOT 380IES Tape Data:  
I-494 Project (2005-2010)*



**Warranted, Proven Performance**

## Traffic Safety Systems



Stamark A380ESD Permanent Road Markings

**3M**

# Raised Pavement Marker Basics

RPMs are used to supplement traditional pavement markings at night and in rainy conditions

## Benefits of Raised Pavement Markers

- Improves roadway visibility during all weather conditions
- Decreases in nighttime crashes
- Decreases in day and nighttime wet weather crashes
- Decreases in guidance related crashes (e.g.) sideswipes

## Typical Placement Locations of RPMs

*Longitudinal Lane Markings*



*Other Markings*



## Road visibility before/after 3M™ RPM 290s are installed



Source: *Safety Evaluation of Permanent Raised Markers*, NCHRP Report 518, Transportation Research Board, 2004 | Video 3M™ RPM 290 Installed in Israel, 2017

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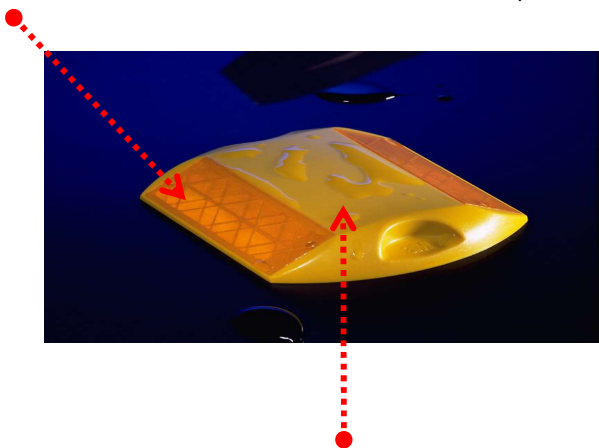


# Unique Advantage: Highly Reflective

- 3M Diamond Grade™ microprismatic optics delivers on brightness performance

## RPM 290 Reflective Features

Highly reflective 3M™ Diamond Grade™ microprismatic optics



Polycarbonate lens with protective hardcoat protects against abrasion or scratches to keep the lens clearer

## Driver Retroreflection Performance

3M™ 290 Lens Minimum and Typical Retroreflectivity: (mcd/lux)\*

Simulated Distance		White		Yellow		Red		Blue	
Feet	Meters	Min.	Typical	Min.	Typical	Min.	Typical	Min.	Typical
100	30	40	80	24	48	10	20	4	8
300	91	350	500	210	300	88	125	35	50
500	152	600	1000	360	600	150	250	60	100

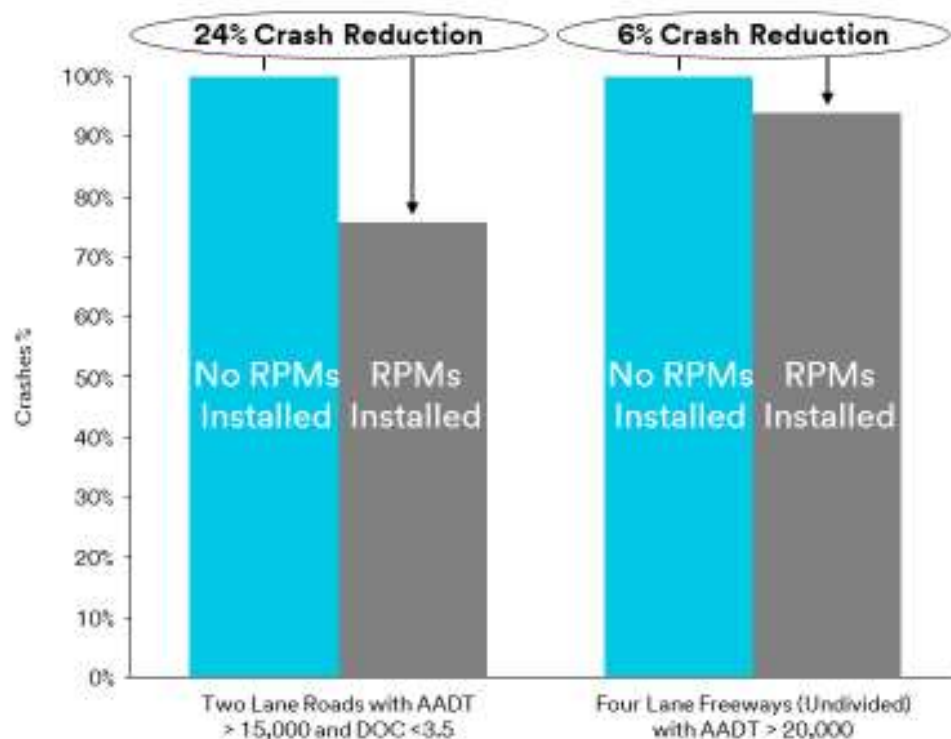
Bottom Line: Raised Pavement Markers are highly visible at night and in rainy conditions

# RPMs Help Bring Families Home Safely

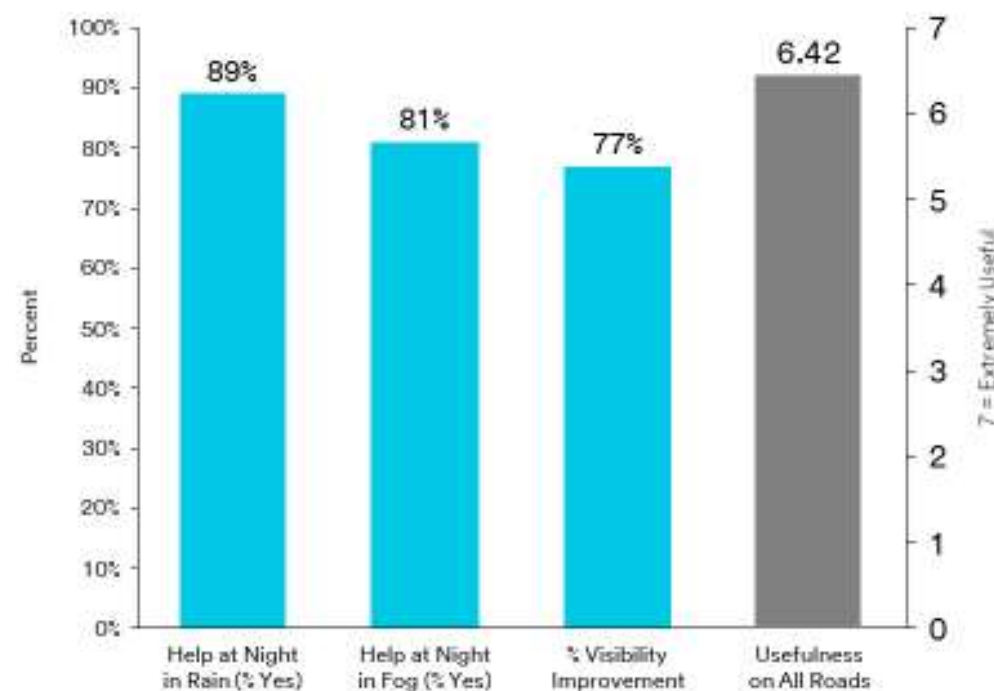
RPMs reduce crashes, help save lives and drivers find them useful



Road Safety Improvement: With and Without RPMs<sup>1</sup>



Driver Perceptions of RPMs<sup>2</sup>



Source: <sup>1</sup>Safety Evaluation of Permanent Raised Markers, NCHRP Report 518, Transportation Research Board, 2004

<sup>2</sup>St. Louis Inlaid Pavement Marker Survey, MoDOT #TR201611, Applied Research Associates, 2017

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## Increased Traffic Safety Risks in Rainy Conditions

*“...drivers are three times as likely to be involved in an accident during rainy or wet pavement conditions...”*

Source: *Development of Human Factors Guidelines*

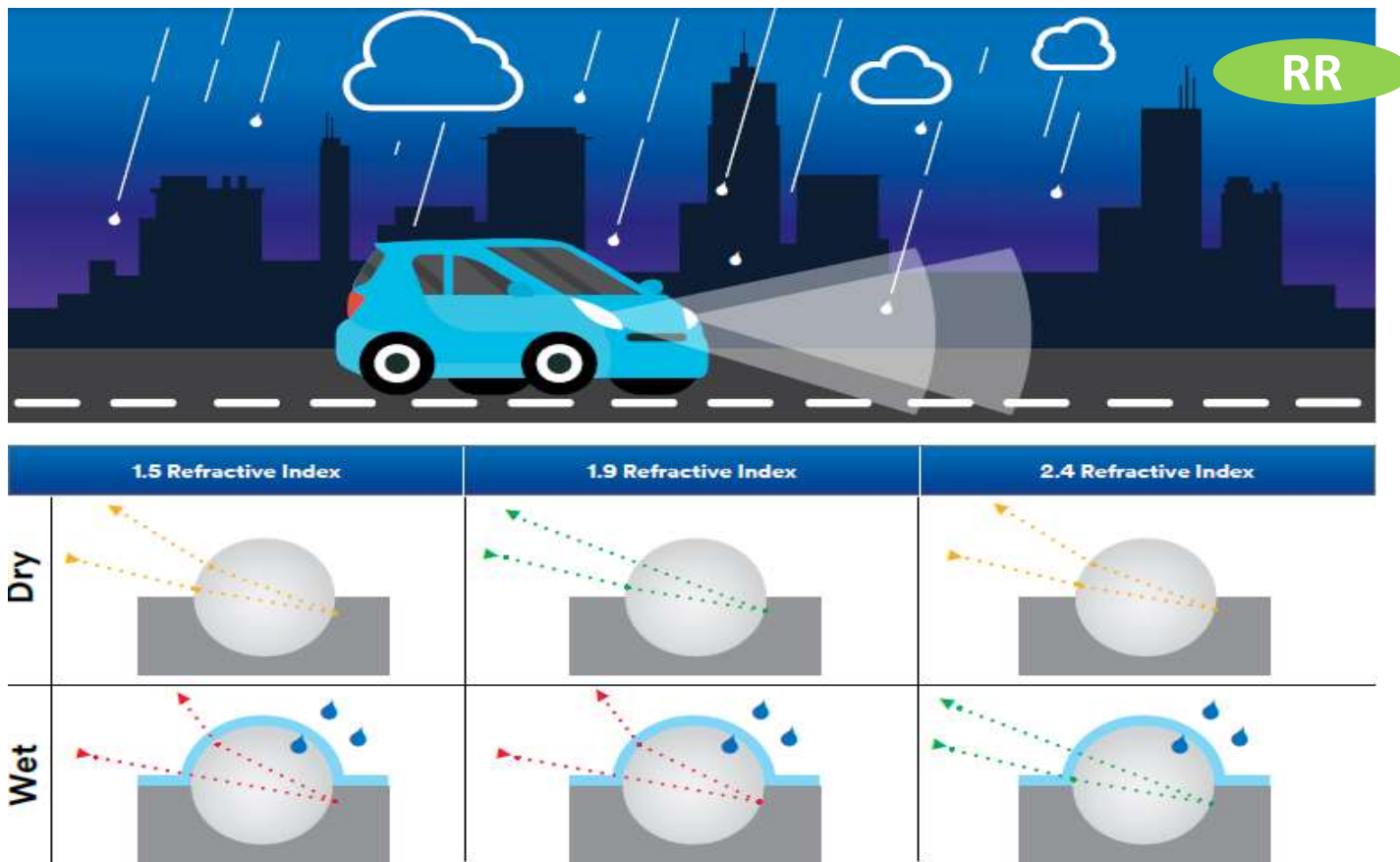
FHWA-RD-99-130 December, 1999, Page 6

Brodsky & Hakkert (1988) *Accident Analysis and Prevention*, 20(3) 161-176

8/31/01



# Rain Reflectivity



# Next Generation of Pavement Markings

The next generation of performance for liquid pavement markings

Enhanced durability\*

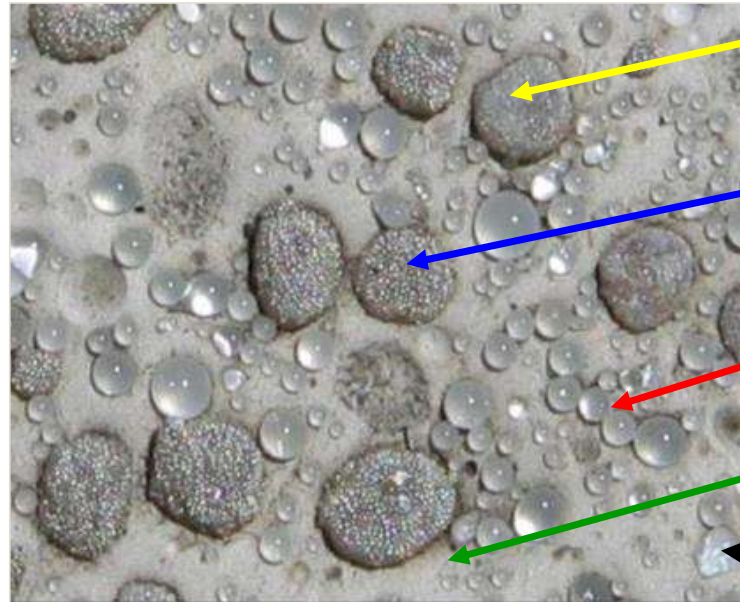
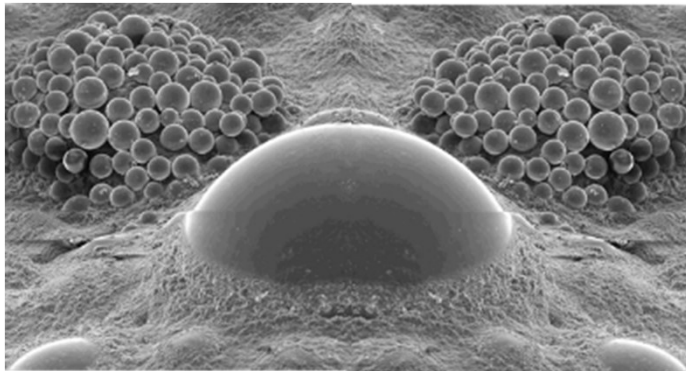
Increased brightness\*

Wet and dry reflectivity



# All Weather Elements

RR



3M Optical elements  
for dry reflection (Typ I)

3M Optical elements  
for wet reflection

Beads

Binder

Skid particels

# Connected Roads All Weather Elements Basics

When used with compatible binders, CR AWE form markings that are highly visible in many conditions

## Benefits of Connected Roads All Weather Elements

- Improves roadway visibility during all weather conditions
- Decreases in nighttime crashes
- Decreases in day and nighttime wet weather crashes
- Superior durability compared to our legacy All Weather Elements

## Typical Placement Locations of Elements

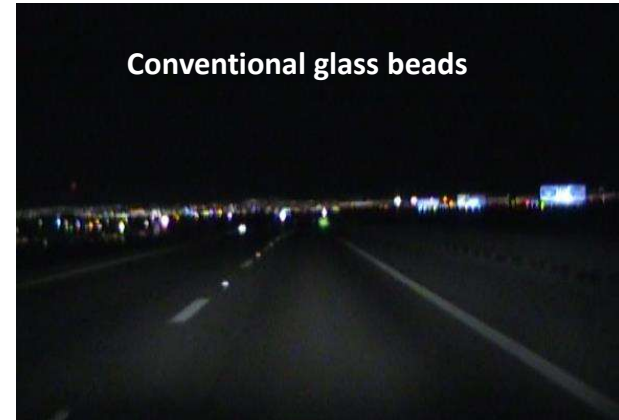
*Longitudinal Lane Markings*

*Maintenance Markings*



## Road visibility before/after 3M™ Elements are installed

Conventional glass beads



3M Elements; double drop system

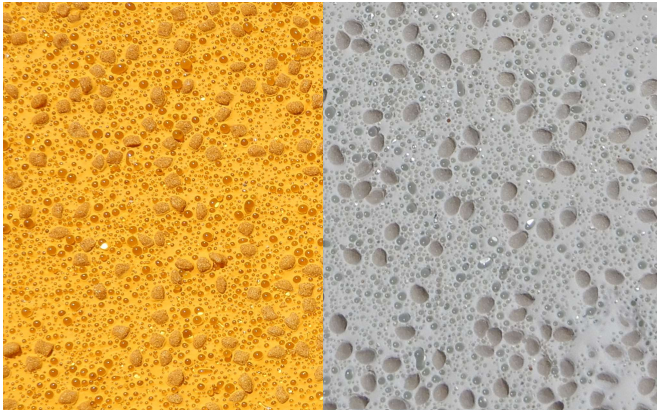




# Distinctive Advantage: Brightness

The toughest beads stay bright for a longer a longer period of time\*; day and night, rain or shine

True reflected white and **yellow** color from colored beads, pigment and core



- 3M's microcrystalline ceramic beads feature 3M's high efficiency pigments to deliver great reflectivity
- Our true **yellow** beads reflect yellow back to the driver

\*compared to standard glass beads.

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Avg. Initial Coefficient of Retroreflected Luminance\*  
[mcd/m<sup>2</sup>/lx]

Property / Test Method	Series 50, 50E, 50M	Series 70E, 70M, 90
Retroreflectivity, Dry Avg. ASTM E1710	White 700 Yellow: 525	White: 500 Yellow: 375
Retroreflectivity, Wet Recovery Avg. ASTM E2177	White: 275 Yellow: 225	White: 375 Yellow: 300
Retroreflectivity, Wet Continuous Avg. ASTM E2832	White: 200 Yellow: 150	White: 275 Yellow: 225

\* Typical initial retroreflectivity which is the average of values over many applications.



# Distinctive Advantage: Binder compatibility & use

- 3M™ CR AWE are effective as a new marking or maintenance marking

Applied with a Double Drop System; compatible with most liquid pavement marking binders



Glass Beads

3M™ CR AWE

Liquid binder


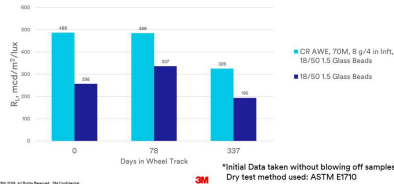
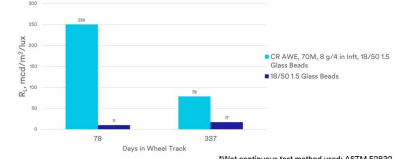
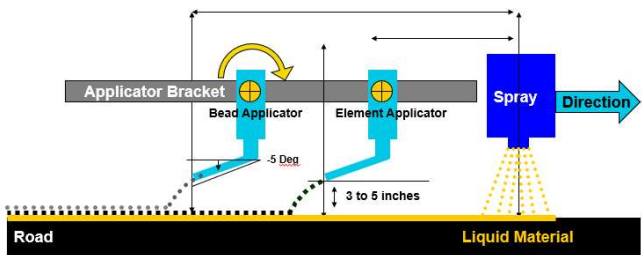
We have a CR AWE solution for both 3M & Non-3M Binders

Liquid Pavement Marking Binder	3M™ CR AWE Series
3M All Weather Paint	50, 51, 90, 91
3M Liquid Pavement Marking (3M LPM5000)	50, 51, 90, 91
High-Build Waterborne Paint	50, 51, 90, 91
Thermoplastic	50, 51, 90, 91
Epoxy	50E, 51E, 70E, 71E
Polyurea (excluding 3M LPM5000)	50E, 51E, 70E, 71E
MMA	50M, 51M, 70M, 71M



# Top Municipalities/DOT Customer Needs

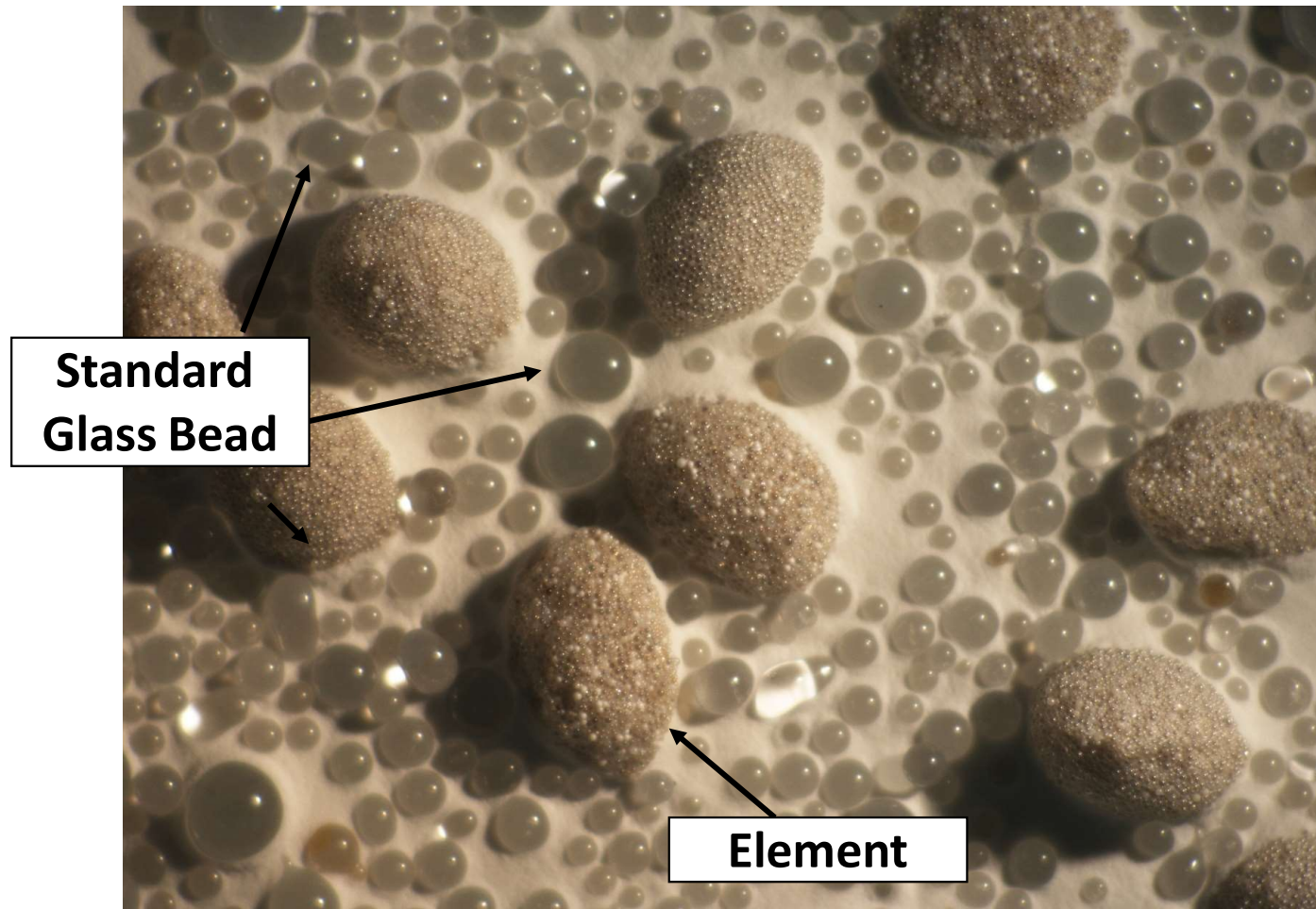
- Value proposition of 3M™ Connected Roads All Weather Elements align to customer needs

Visibility	Durability*	Application (Ease & Safety)
 <p>Daytime, nighttime, <b>wet and dry conditions</b>, retained over life of elements</p>	<p><b>CR AWE 70M and 1.5 Glass – Dry Performance</b> New Orleans Deck, Installed March '17 in LPM: 0, 78, &amp; 337 Days in Wheel Track</p>  <p><b>CR AWE 70M and 1.5 Glass – Wet Continuous Performance</b> New Orleans Deck, Installed March '17 in LPM: 78 &amp; 337 Days in Wheel Track</p>  <p>Overtime, CR AWE outperform glass beads in both wet and dry conditions</p>	 <p>Double drop system for elements and glass beads; large trucks and handcarts</p>
<ul style="list-style-type: none"> <li>Cost/Price: Contractors are most concerned with price: in competitive markets, margins are thin and will go with lowest priced specified product</li> <li>Model specification: In some markets, customers are asking for performance enhance solution</li> <li>Other Localized Customer Needs: Understanding which binders as well as how to use the proper equipment is essential for successful element project.</li> </ul>		

\*Data shown here can also be found in the [appendix](#)  
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# 3M™ Connected Roads All Weather Elements



# Non-Wet Reflective vs Wet Reflective Optics

Comparison Video: Eastbound is non-reflective and Westbound is reflective



# Pavement marking reflectivity has impact on safety



Research links dry and wet reflective markings to helping reduce crashes

## 46%

Accidents due to lane departure on multi-lane roads were reduced by wet-visible lane markings<sup>1</sup>



## 27%

19% of accidents occur at night, but with 27% of fatalities<sup>2</sup>



## 11-24%

Fewer accidents when night reflection is increased by 200-300mcd<sup>3</sup>



1) <https://www.fhwa.dot.gov/publications/research/safety/15083/index.cfm>

2) [https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/Publikationen/Downloads-Verkehrsunfaelle/verkehrsunfaelle-jahr-2080700197004.pdf?\\_\\_blob=publicationFile](https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Verkehrsunfaelle/Publikationen/Downloads-Verkehrsunfaelle/verkehrsunfaelle-jahr-2080700197004.pdf?__blob=publicationFile)

3) <https://trid.trb.org/view/1339399>



# 3M Pavement Marking Portfolio



380ESD



RPMs



All weather  
elements



Application  
equipment



380 IES



380 AW



Speed reducers

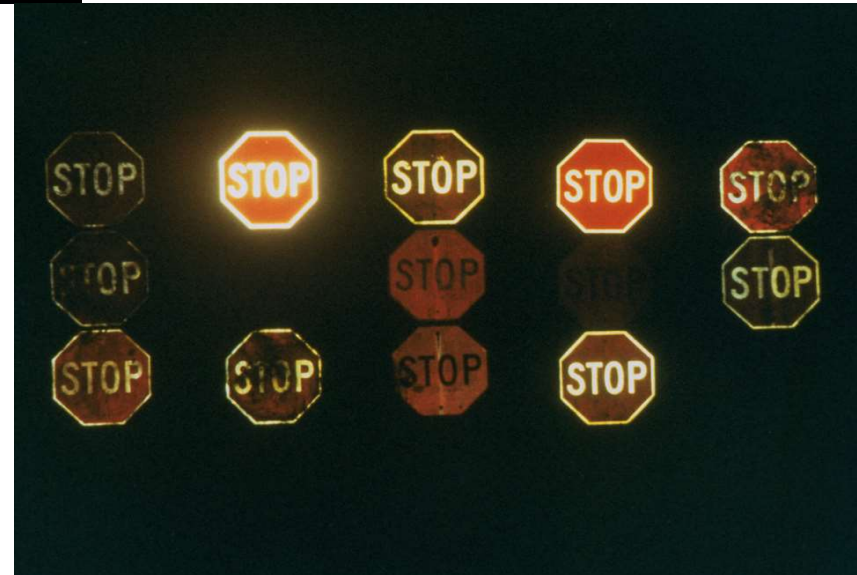


P50 primer



**What is seen during  
the day...**

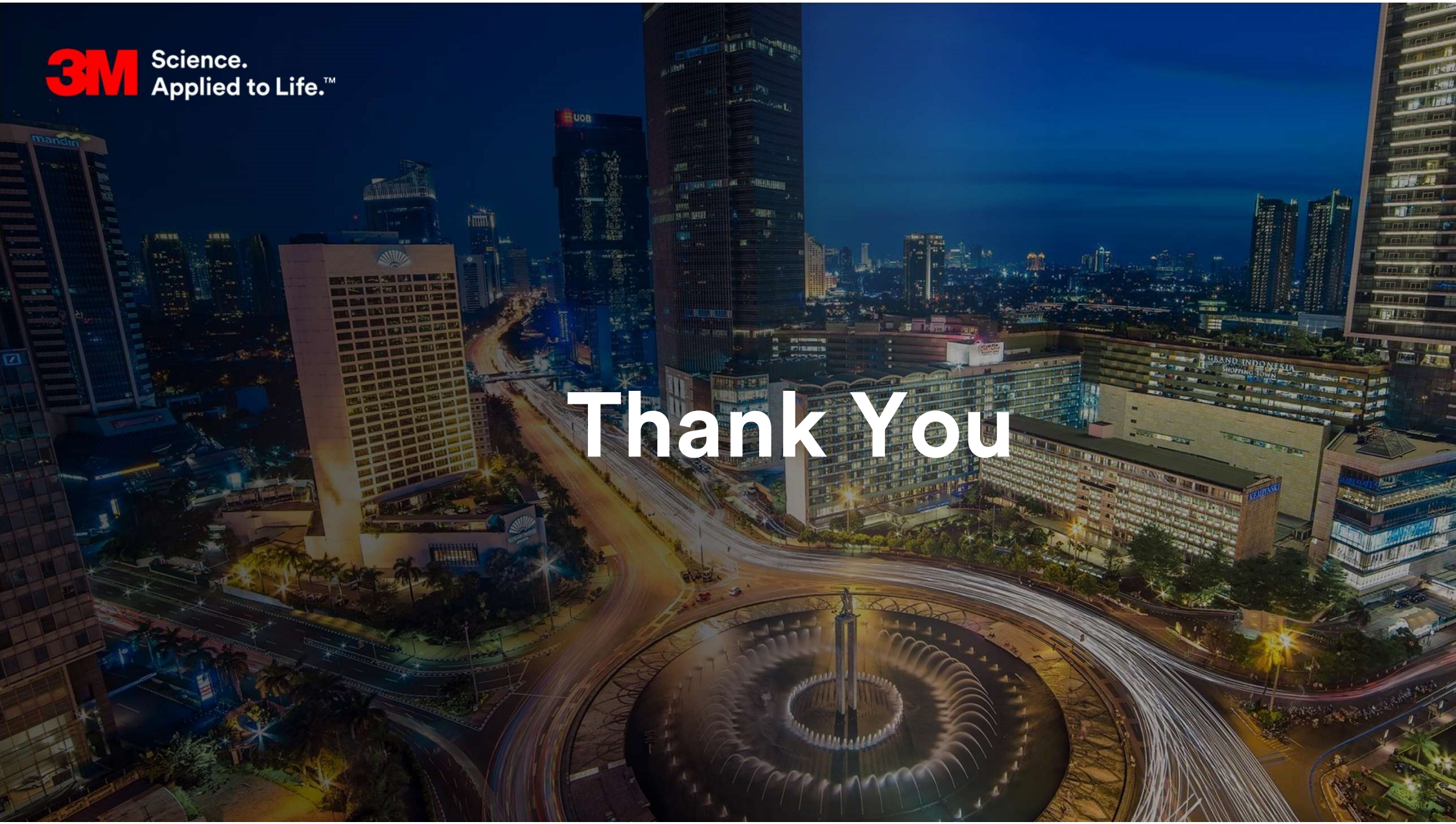
**Is not necessarily what  
you see at night**





**3M** Science.  
Applied to Life.™

Thank You





**Vusi Tshabangu** | Application Engineer

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