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5th International Conference

Safety through Retro-reflectivity

Presented by

Urban Camenzind

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What is on the road network

Do we know?

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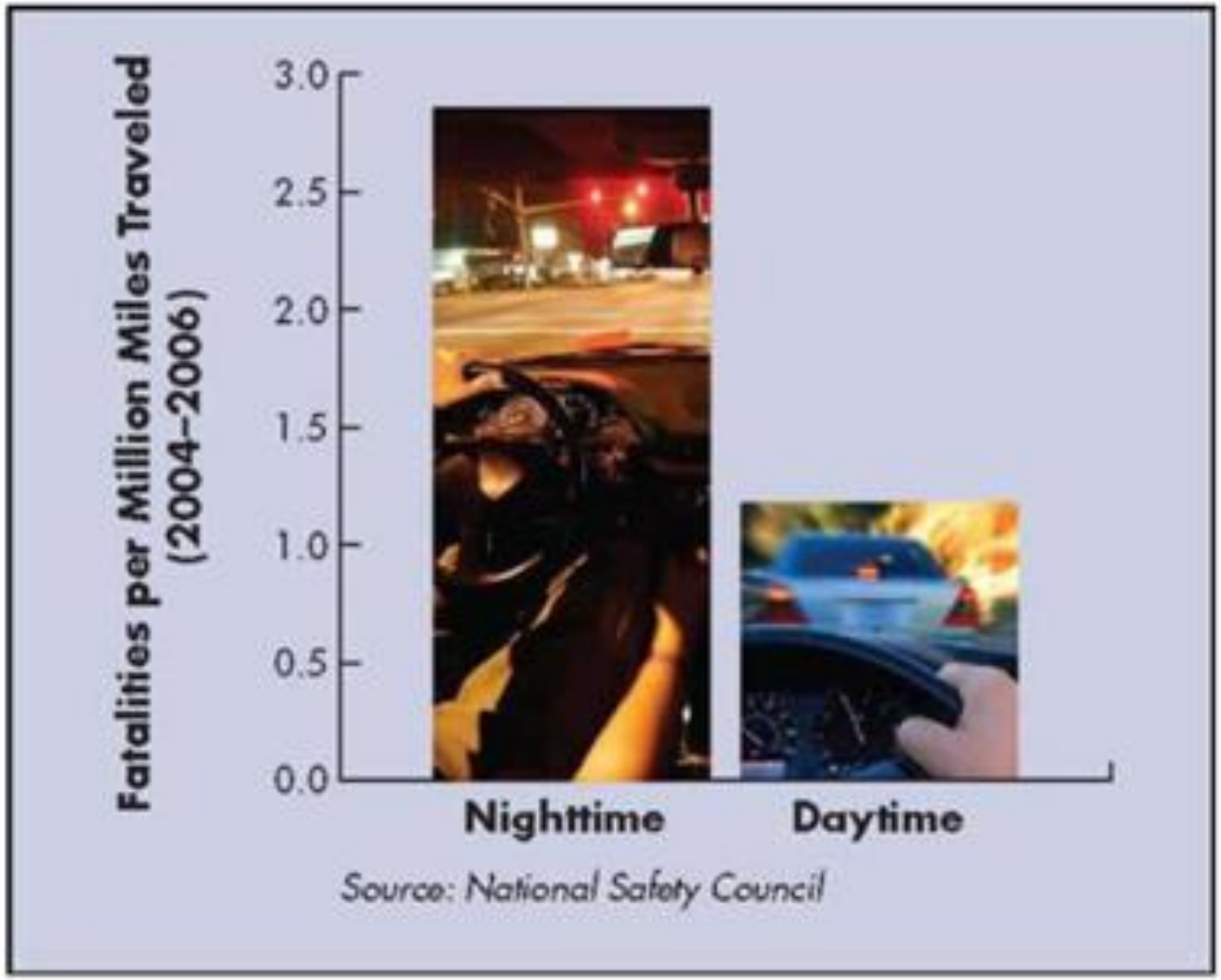
Why worry about assets and condition of retro-reflectivity?

FHWA Statistic
Federal Highway Administration



Risk of a fatal accident, more than doubles at night.

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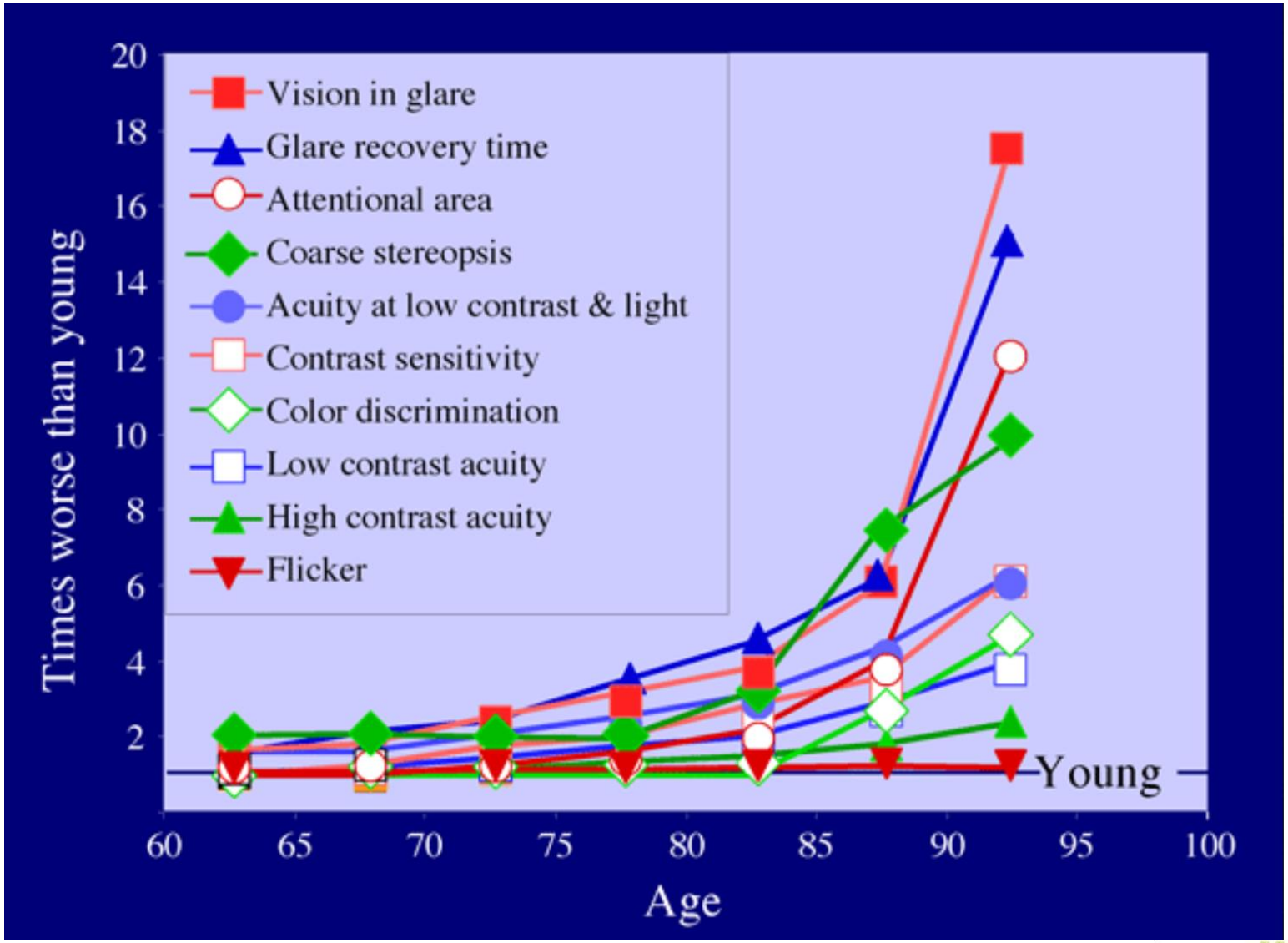
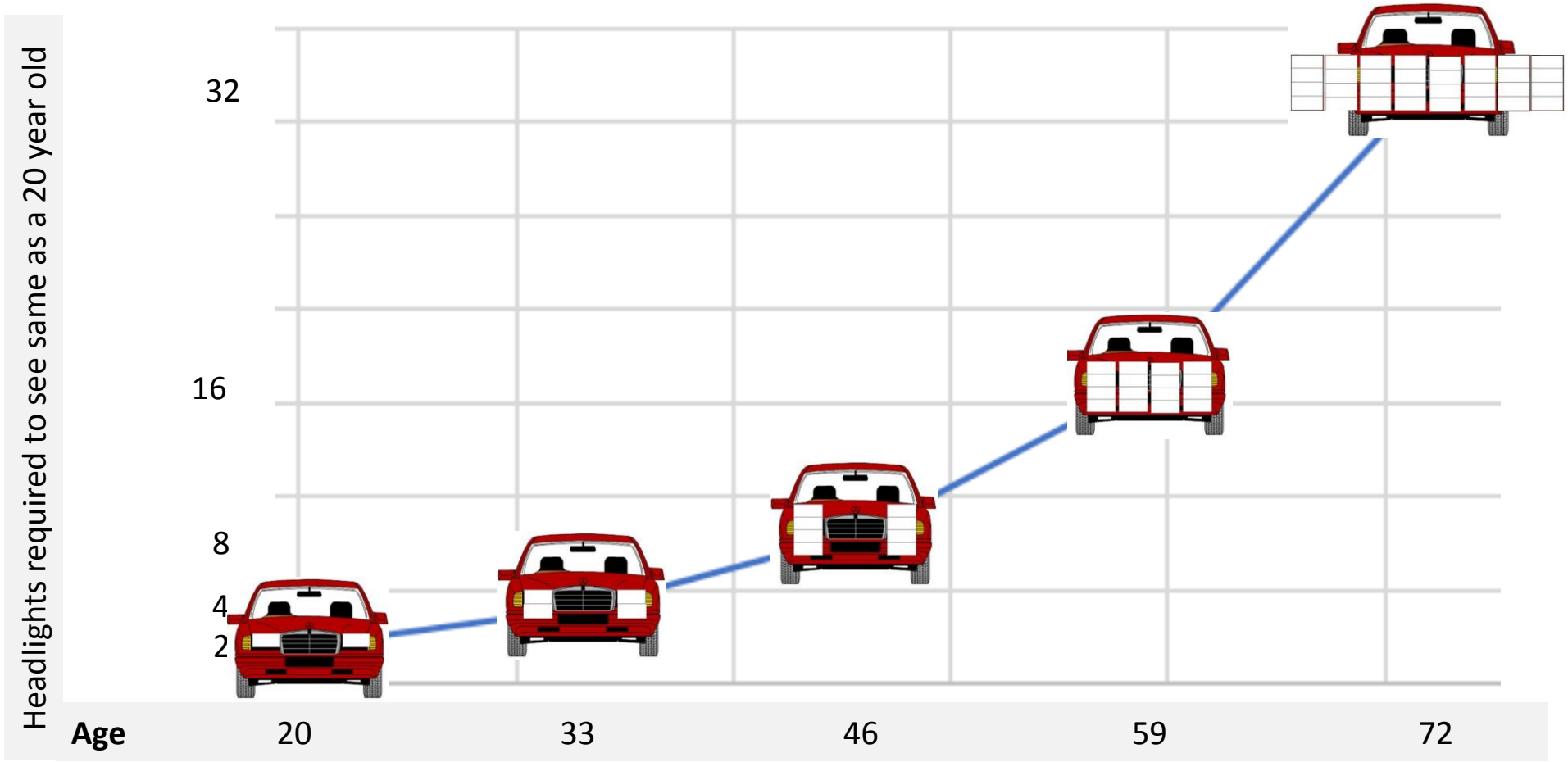
Human eye-sight degenerates with age



Night time visibility degradation by age



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Night time visibility degradation by age

NZTA Older Drivers statistic

2007	152,801 drivers age 70+
2012	301,474 drivers age 70+

2007	4.9% of drivers were 70+
2012	9.2% of drivers were 70+

97% increase in 5 years

Older driver population continuous to grow as baby-boomers age.

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Why worry about retro-reflectivity?

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90% of information is processed visually

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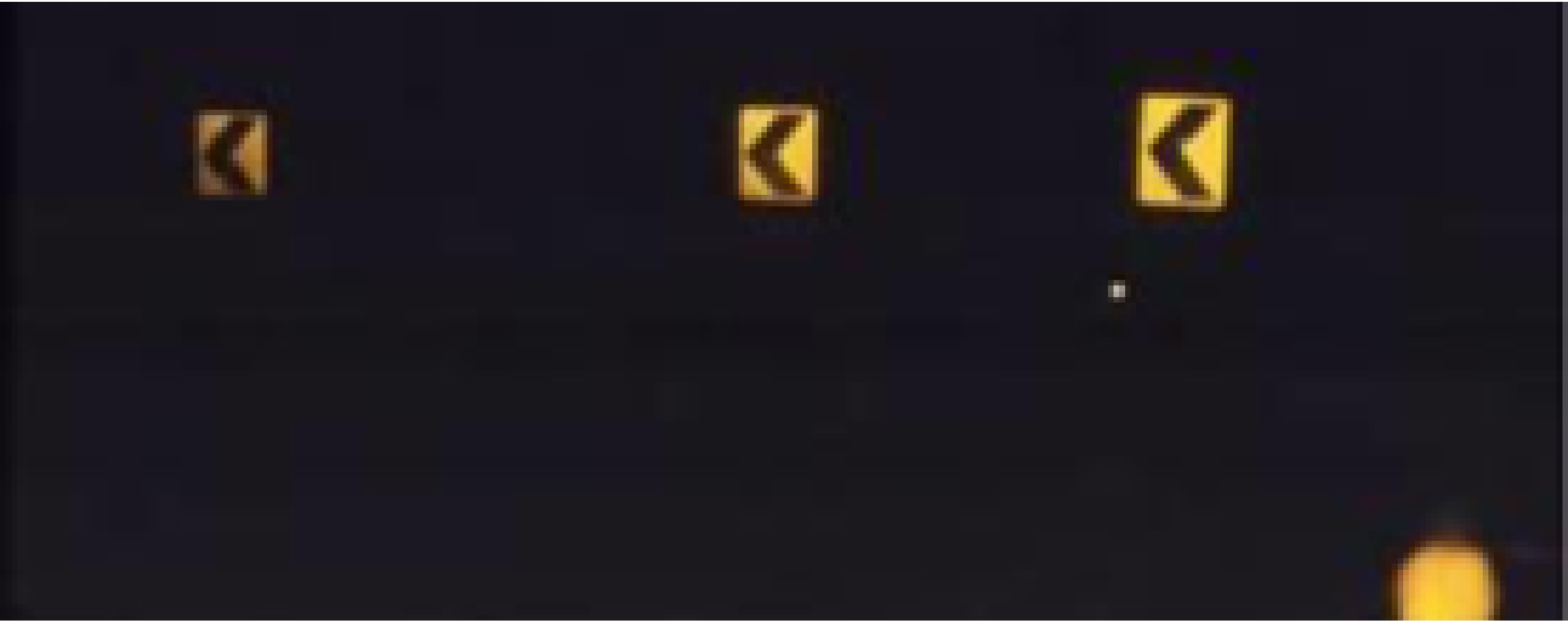
Why worry about retro-reflectivity?



Visual performance in darkness drops to **5%**

Why worry about retro-reflectivity?

Daylight

Why worry about retro-reflectivity?

At night we depend on retro-reflectivity for information.

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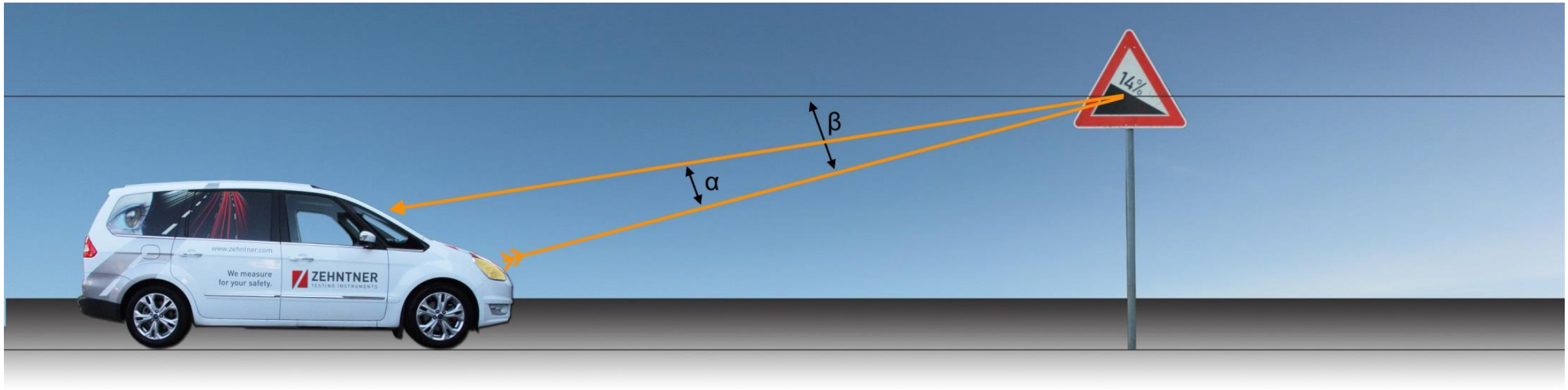
Why worry about retro-reflectivity?

Contrast of new marking, merging with old marking
Yellow road marking less retroreflective than white
Yellow road marking has low contrast

Retro-reflectivity and how do we measure it

Signs



		ASTM E1709
Illumination angle β		-4°
Observation angle α		0.2°, 0.5°, 1°

R_L = mcd/m²/lux

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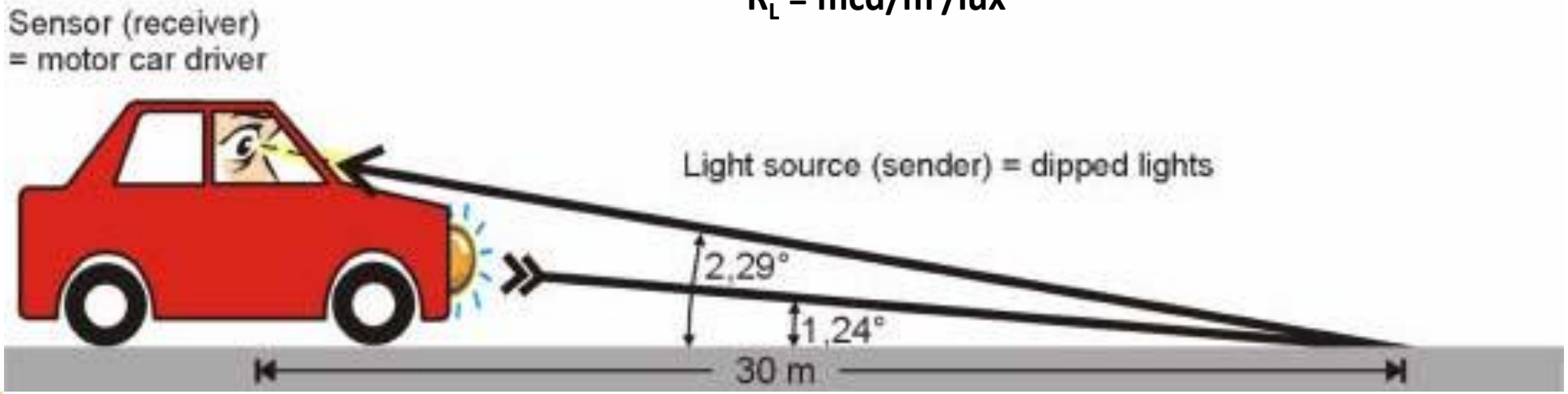
Retro-reflectivity and how do we measure it
Marking

R_L
Measures, true to scale, the retroreflection (night visibility) of a road marking.
The observation angle of 2,29° corresponds to the viewing distance of a motor car driver of 30 m under normal conditions. The illumination angle is 1,24°.

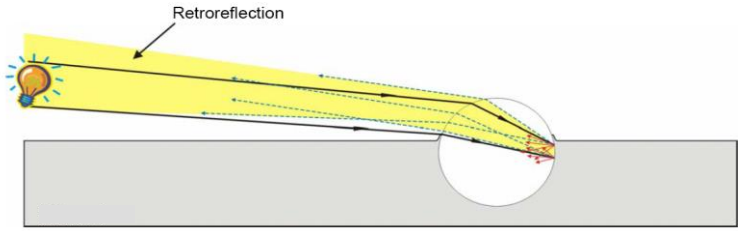
R_L = mcd/m²/lux



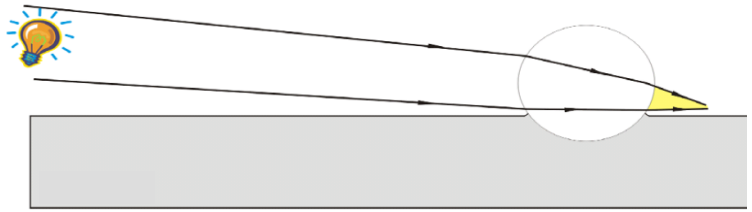
EN 1436 Standard R_L

How does retro-reflectivity work on line marking?

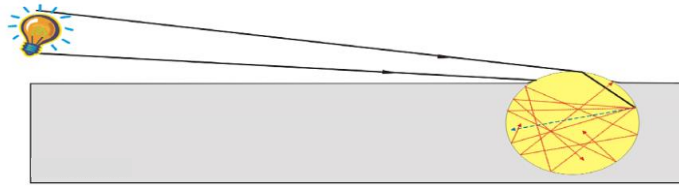
For flat Lines Approximately 50-60% embedded into material for best retro



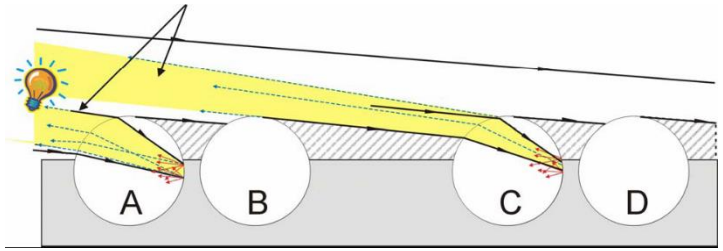
Not deep enough
→ no retro reflection



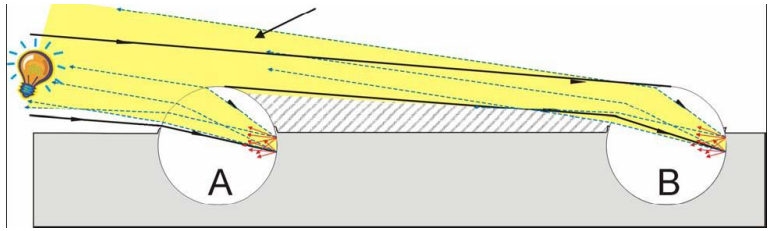
To deep → retro reflection gets lost inside of the glass bead

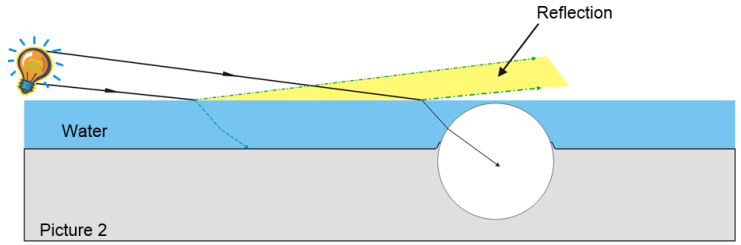


Excess of glass beads
A and C retro reflects the light best
B and D are in the shadow of glass bead A and C no light will reach them → no retro reflection



… the right amount of glass beads





Distance A to B 6mm for 300 micron beads
Distance A to B 21mm for 1200 micron beads

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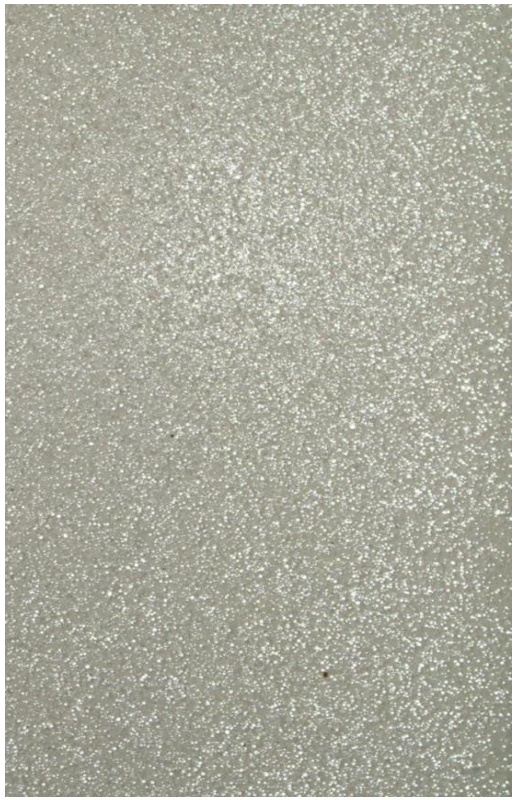
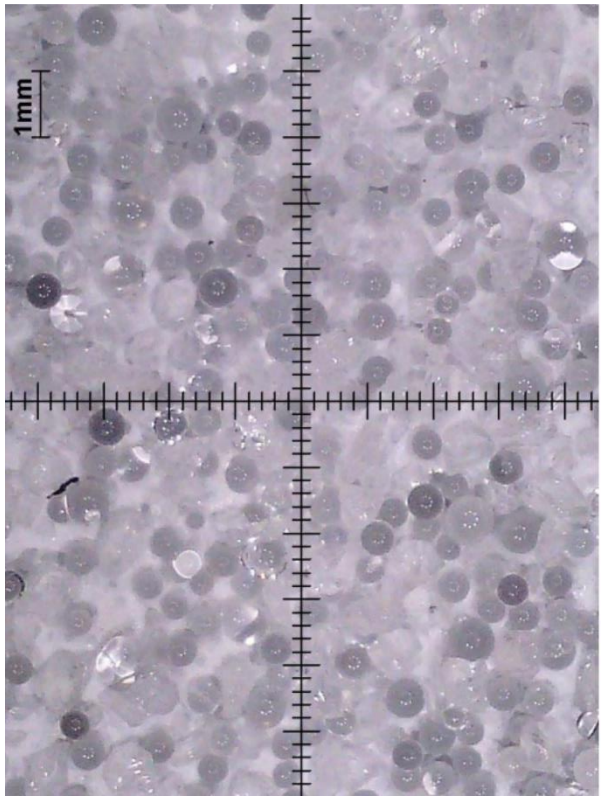
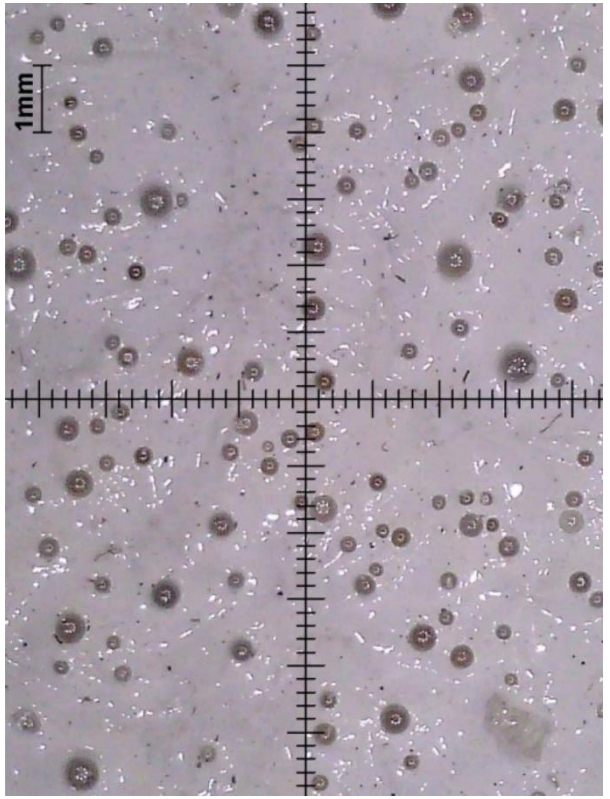
High bead-application rate





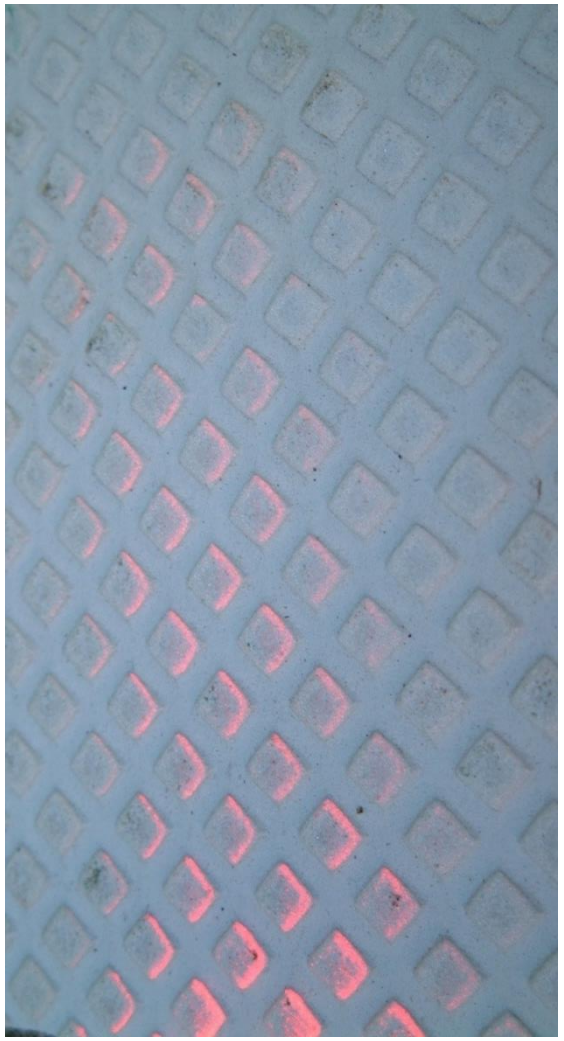
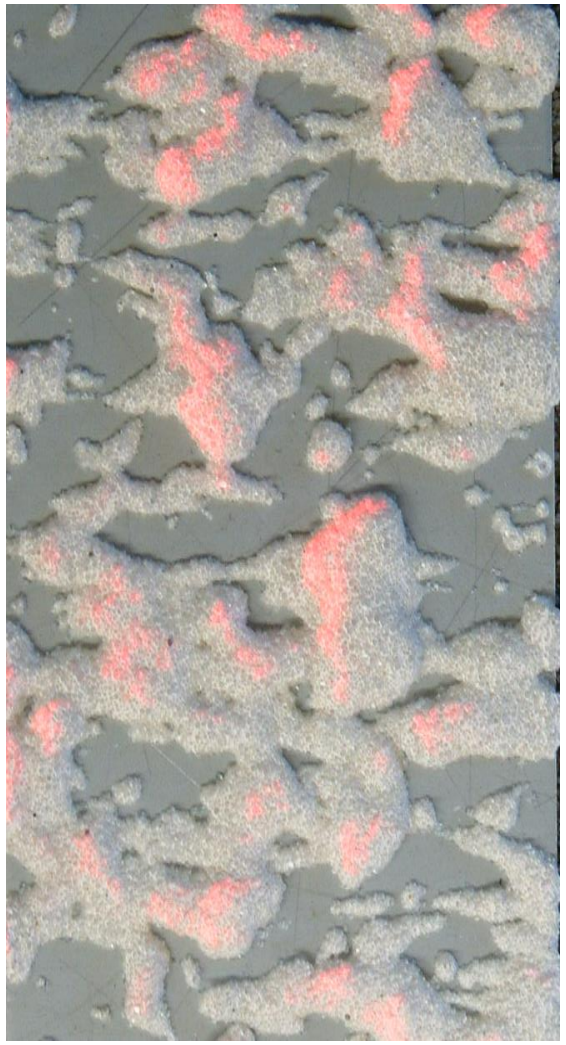
R_L 63

Correct bead-application rate



R_L 1295

30 meter geometry road-markings Illumination samples?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Only illuminated areas can produce retro-reflectivity

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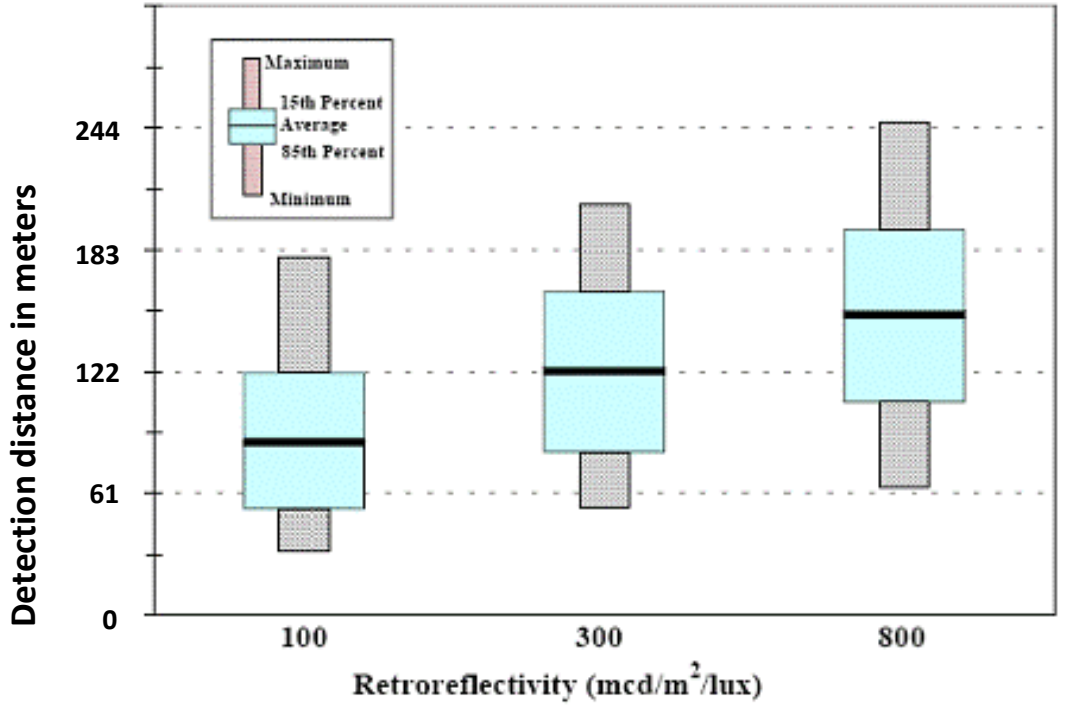
Line Marking Retroreflectivity

Research has shown that increasing the retroreflectivity of a pavement marking will increase the detection distance—the distance at which a driver will initially see an approaching pavement marking (or its end). The Texas Transportation Institute (TTI) conducted a study evaluating the visibility of markings from the perspective of commercial vehicle drivers.

Three different markings were tested, representing low, medium, and high retroreflectivity coefficients. Pavement marking detection distance data were collected in a 1998 Chevrolet Lumina and a 1986 Freightliner traveling at 48.3 km/h. Participants were following a solid white right edge line and asked to indicate to the researcher in the vehicle with them when they could clearly see the end of the pavement marking. The results showed that as the retroreflectivity increased from 100 to 800 mcd/m²/lux, average detection distance also increased from 86.9 m to 152.7 m



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Zwahlen's recommended minimum R_L values

Vehicle Speed [km/h m/s]		Minimum Required R_L [mcd/m²/lux]			
		Without RRPMs		With RRPMs	
		3.65 s Preview Time/ Distance		2.0 s Preview Time/ distance	
60	16.6m/s	R_L 50	60.59m	R_L 30	33.20m
90	25.0m/s	R_L 170	91.25m	R_L 35	50.00m
105	29.1m/s	R_L 340	106.21m	R_L 50	58.20m
120	33.3m/s	R_L 620	121.54m	R_L 70	66.60m

70

150

340

Zwahlen, H. T. and T. Schnell. *Pavement marking Visibility Research and Proposed Values for Minimum Required Pavement marking Retro Reflectivity.* Unpublished report, Department of Industrial and Systems Engineering, Ohio University Athens, Ohio. August, 1998

What is the real efficiency of road markings

In 2007, Road Safety Marking Association (RSMA) published the report « **White Lanes Save Lives** » which provided a cost-effectiveness Analysis of new road markings in selected counties. Eg : Cheshire Country County decided to apply a wet-night visible marking on a section of the A556 highway which had recorded 16 personal injury accidents during the last three years at an estimated cost of 1'400'000 £. (3'270'000 NZD)

Status	Total accidents	Serious accidents	Minor accidents	Wet-dark accidents
Before Implementation	**16**	**2**	**14**	**4**
After Implementation	**6**	**0**	**6**	**0**

Cost of new Road marking : £ 20 000

(48.000,- NZD)

$3'000'000.00 saving for a $50'000.00 invesment

Good value for Money

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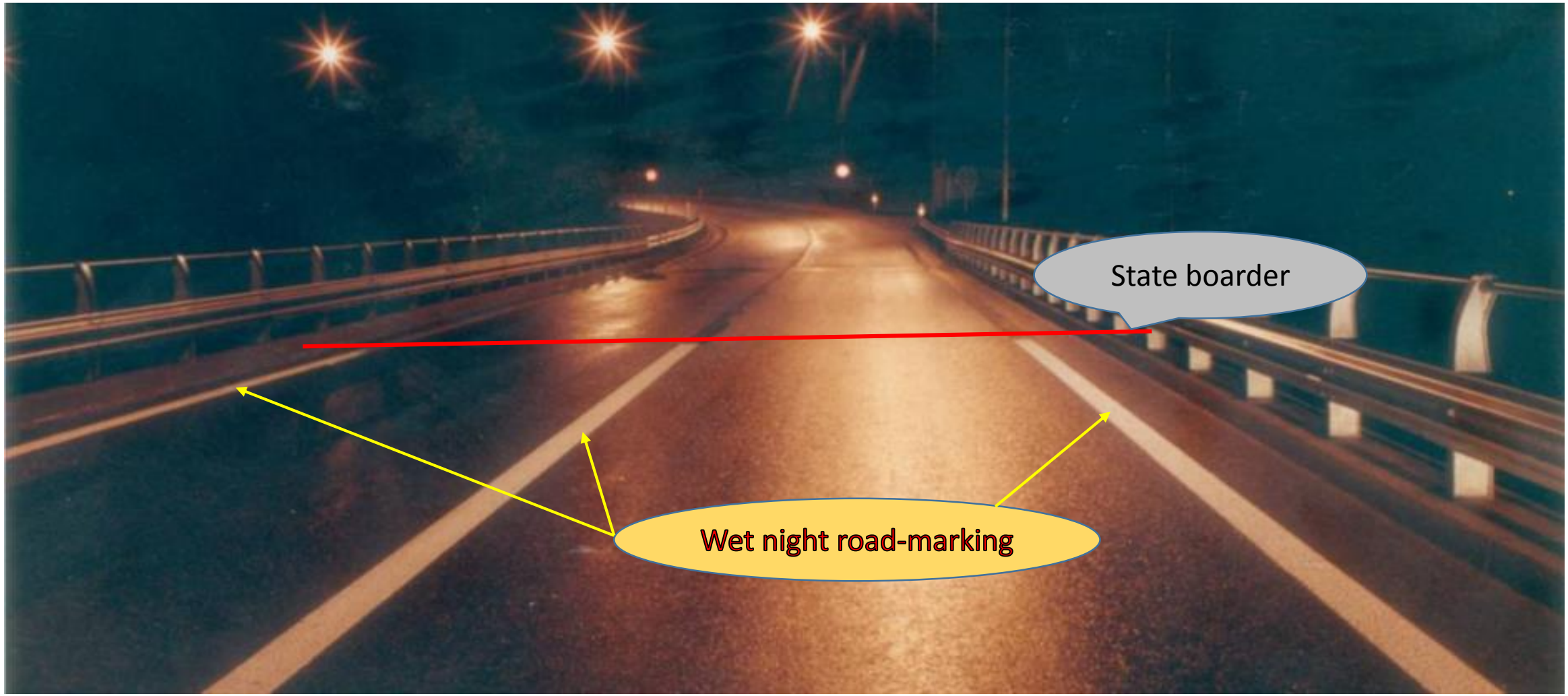
Wet night visible road marking



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Requirements of R_L in different countries.

2.4.1 Testing of Retro Reflectivity

After 1 month but before 2 months after application, the marking shall be clearly visible for a forward distance of 150m, or as far forward as possible until obstructed by the road geometry if less than 150 m, when viewed from a vehicle at night (with lights on full beam) in the absence of overhead lighting.

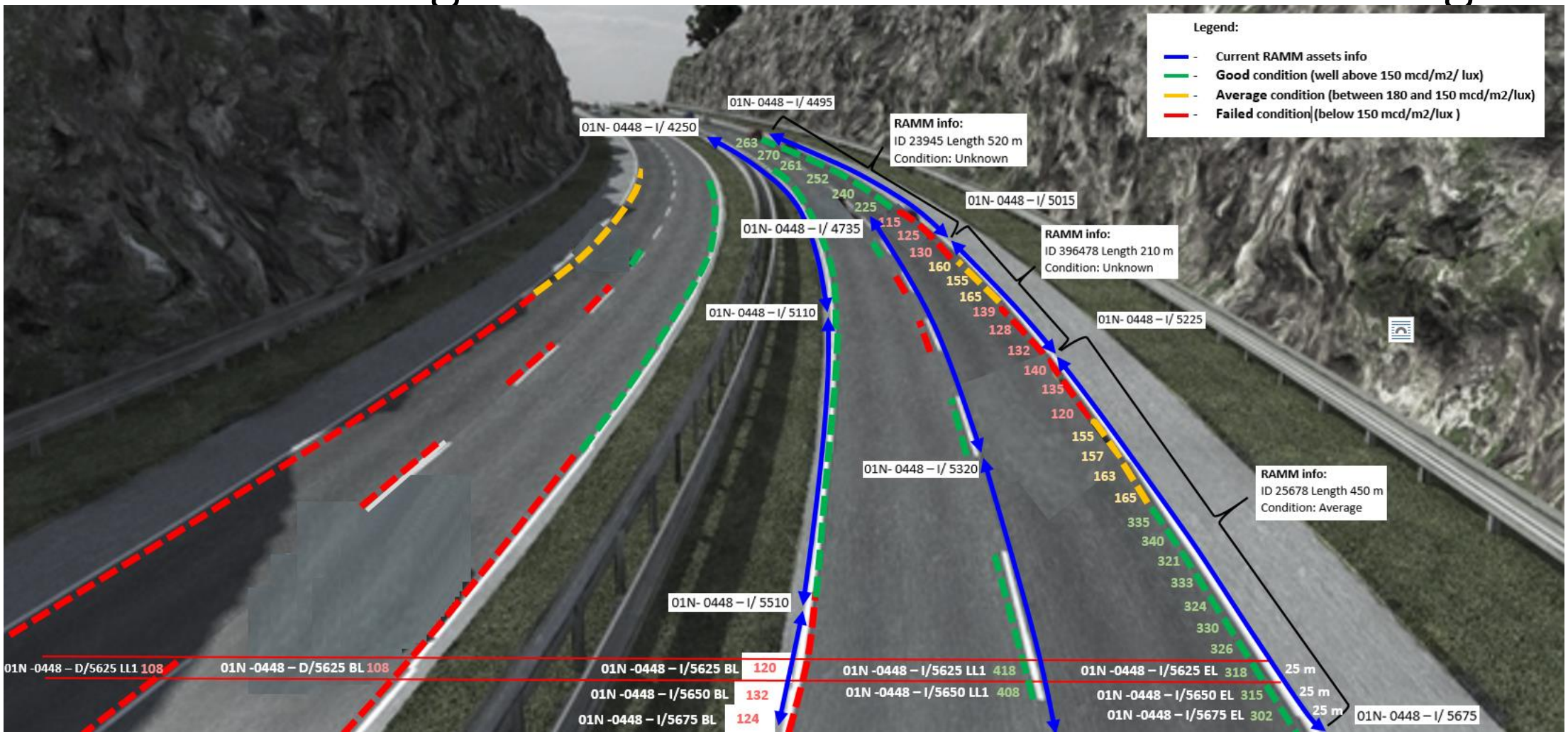
Guesstimate produces low quality outcome

Performance Criteria (per TS45 Cl 6.1.1)

a. Minimum Retroreflectivity between 10 and 20 days of wear: 350mcd/lux/m^2
b. Minimum Retroreflectivity between 360 and 380 days of wear: 300mcd/lux/m^2
c. Minimum Retroreflectivity at any time after 380 days of wear: 150mcd/lux/m^2

Actual measuring performance based outcome

Road-markings actual condition versus visual rating



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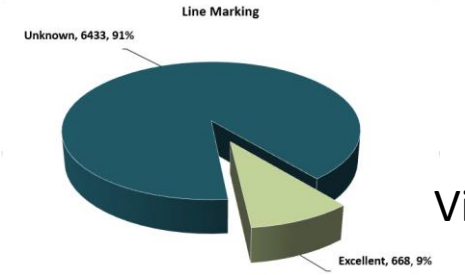

Visual Condition Rating

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RRPM's and Road-markings actual measurements

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Green Star recognized RRPM
Red Star assumed missing RRPM
Lines Indicate R_L line-marking

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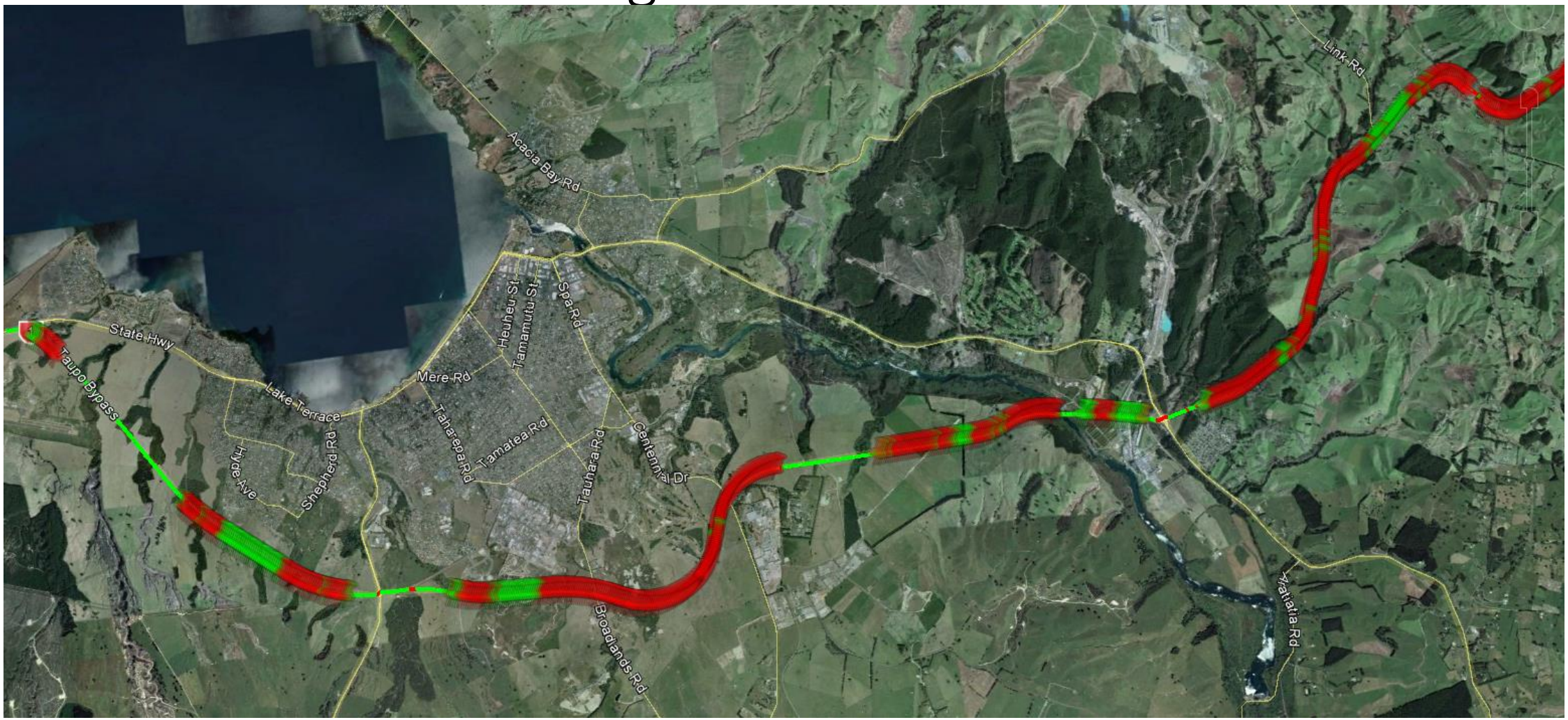
Road-markings actual measurements



Lines = White marking Pins = yellow marking

R_L below	100	red
R_L above	100	green

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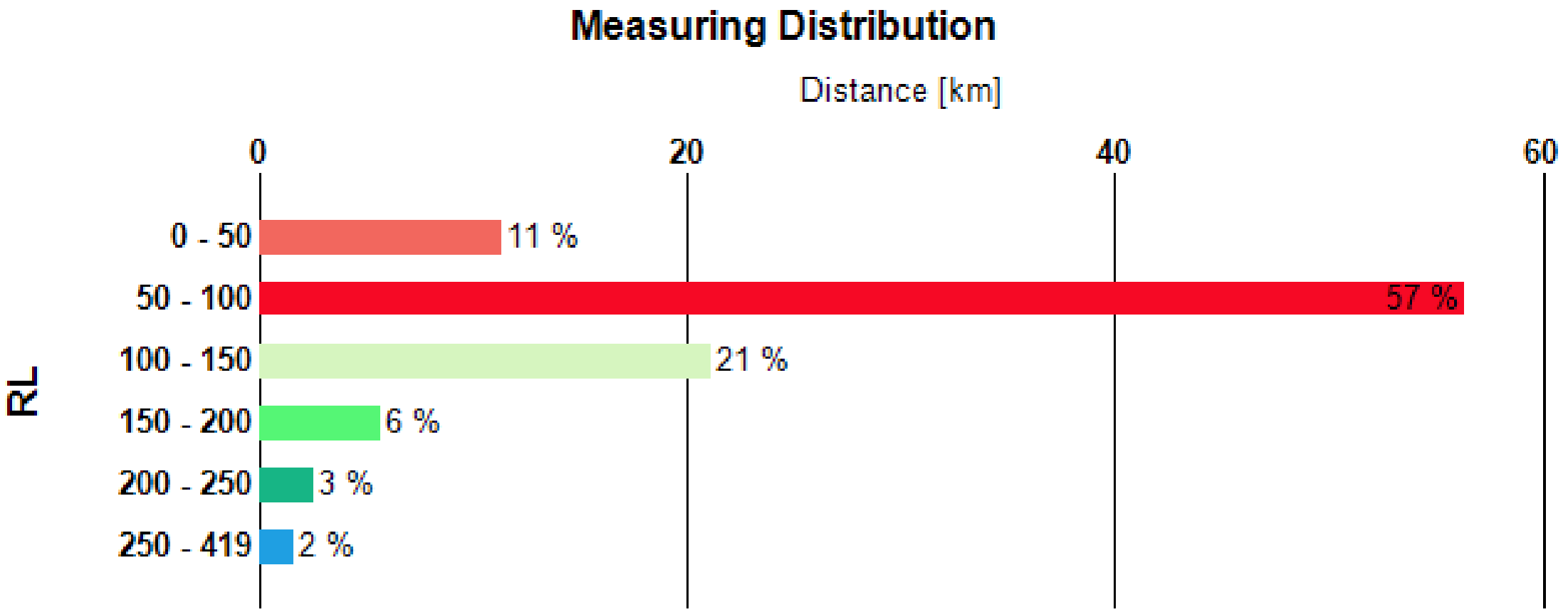
Statistical retro-reflectivity of white road-marking NZ



68% of white is below R_L 100
Total sample length 100km

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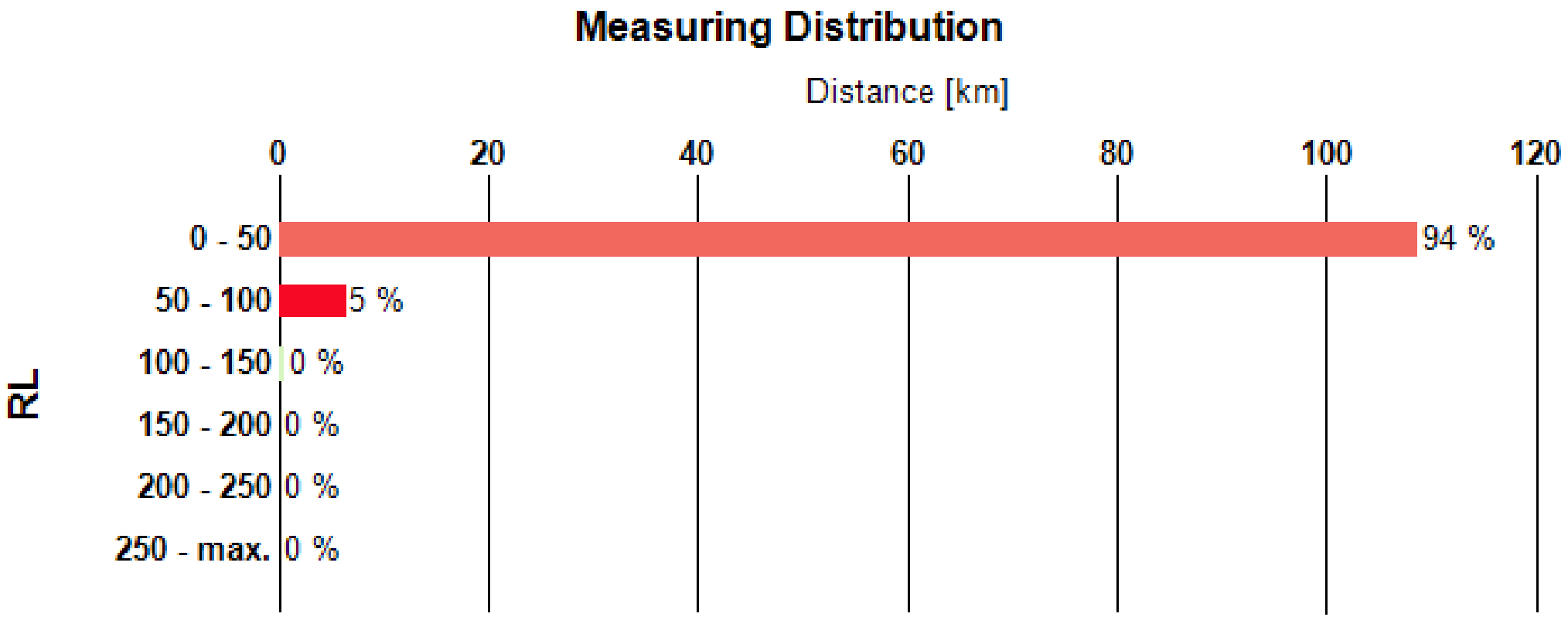
Statistical retro-reflectivity of yellow road-marking NZ



100% of yellow line marking is below R_L 100
Yellow marking is failing badly
Total sample length 100km

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Retro-reflectivity of yellow and white road-marking

Yellow R_L is ½ of white R_L

Contrast ratio of yellow is lower

As a relative new marking it would have failed a Performance based standard

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Time to eliminate Yellow road marking ?

- Yellow road marking is more expensive than white
- Yellow marking only produces half of retro-reflectivity of white (half the value for money)
- Many of Yellow road-marking appear white at night (may as well just use double white lines with yellow RRPM's)
- Yellow marking has lower contrast ratio to road surface
- White markings perform for longer time periods
- Reduced remark cycles (less roadwork less risk for road-user)
- Creates consistency of Line marking with Australia and most of Europe (safer for tourists)

High quality road-marking can reduce fatalities

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High quality road-marking without Yellow

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Achieved through high Standards and quality control

Measuring not guessing

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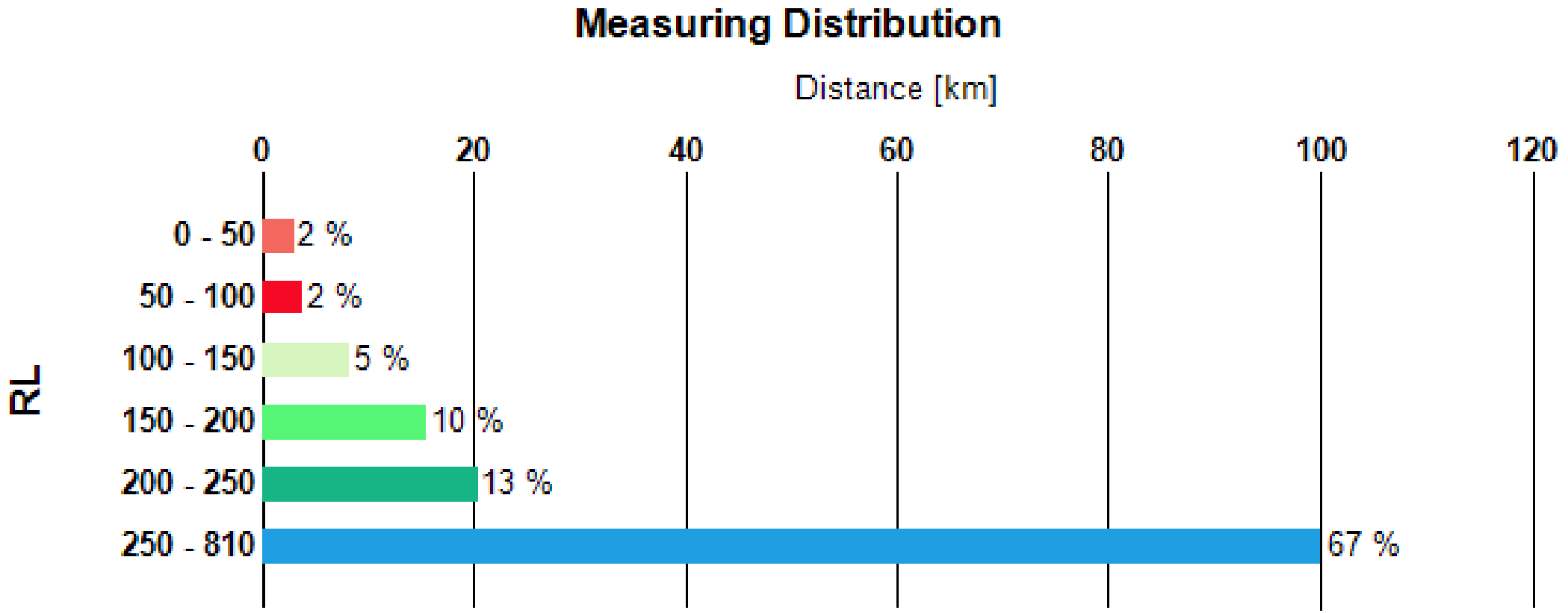
Statistical retro-reflectivity of white road-marking AU



4% of white is below R_L 100
Total length measured 150km

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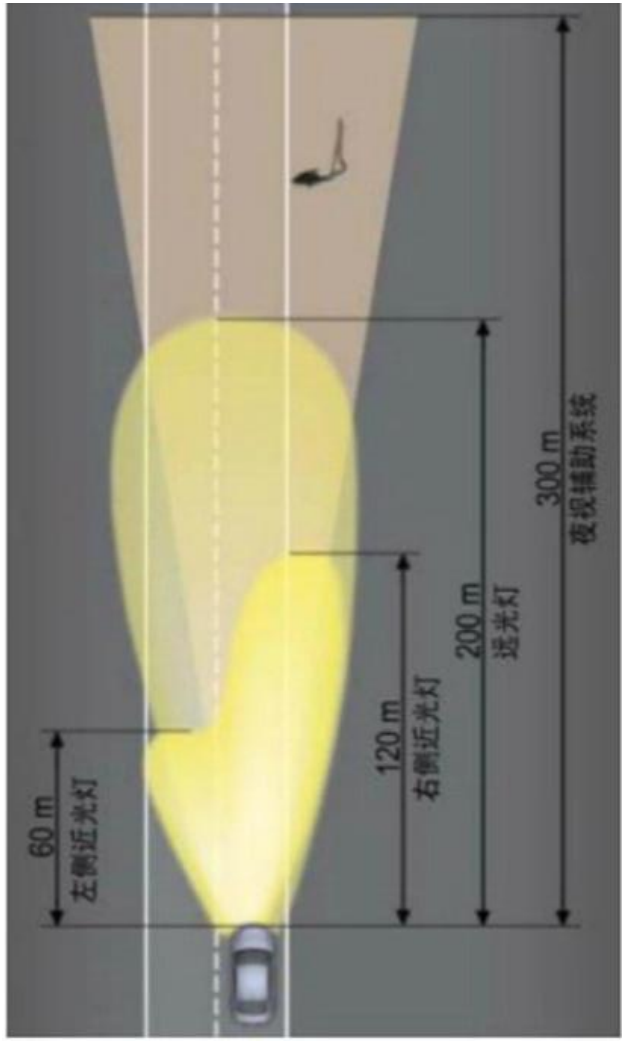
Improve road-safety at night trough technologies

- Cars with more or more power full headlights
- Adaptive headlights



- Improve retro-reflectivity of line markings
- Eliminate yellow road-marking
- Only use high quality road-signs
- Make sure that signs are mounted correctly
- Cars with infrared night time cameras

- Semi autonomous cars
- Autonomous cars (need high quality markings)

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- Euroconsult
- 3M
- Zehntner
- AMA
- NZTA
- FHWA
- Texas Transportation Institute

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