



Nordisk vägmarkeringskonferens

Köpenhamn 2018



- The Swedish market – a challenge for the industry
- Need for human driving
- Statistics
- Need for machine driving (ADAS /Autonomous driving)
- Tools like Nordic certification and GPP
- Recommendations



❖ Svenska Vägmarkeringsföreningen, SVMF, bildades 1972.

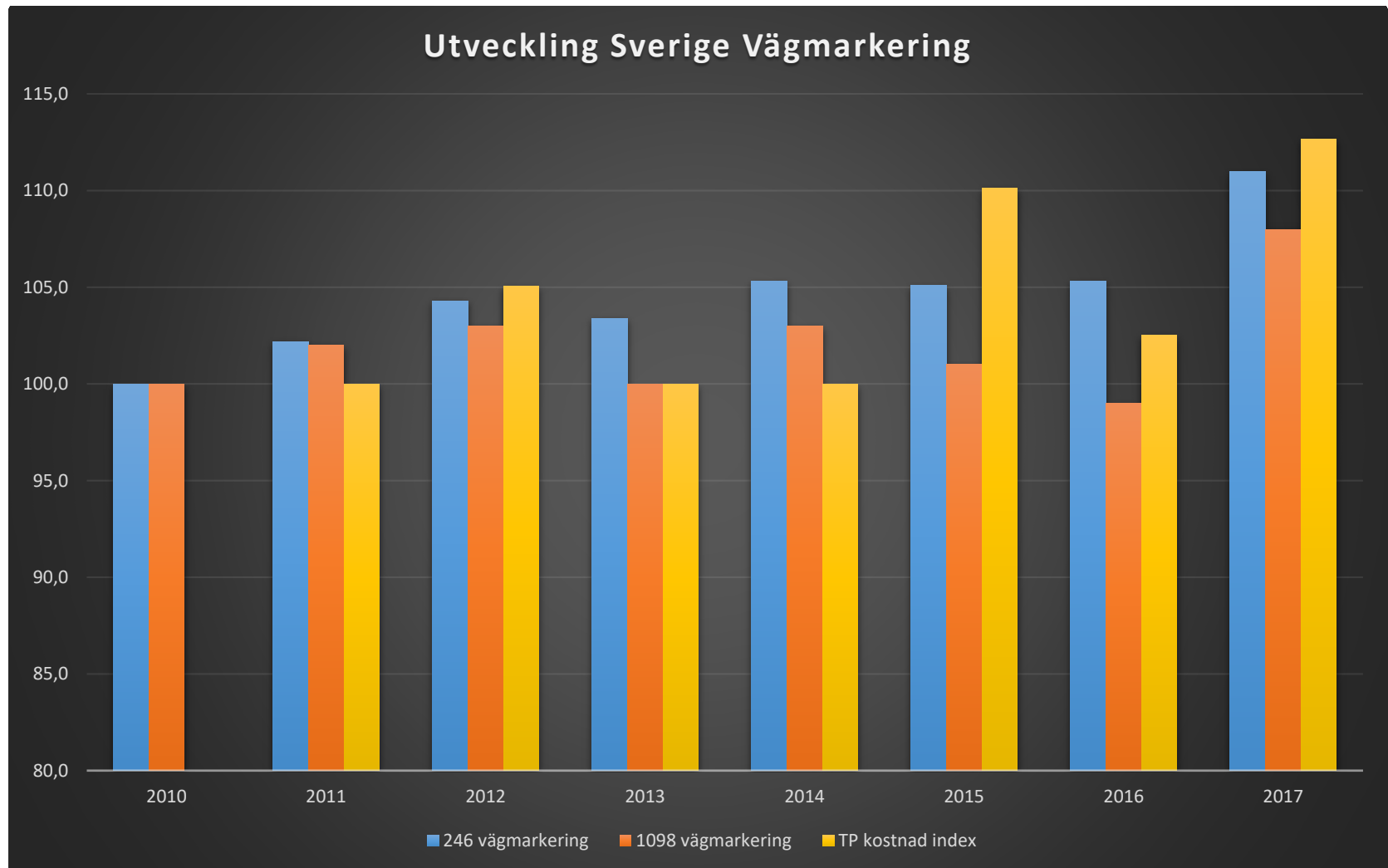
❖ Föreningen är en intresseorganisation för företag, organisationer och andra institutioner verksamma inom vägmarkeringsbranschen.

Föreningens syfte:

❖ SVMF ska verka för en utvecklingen av vägmarkeringar

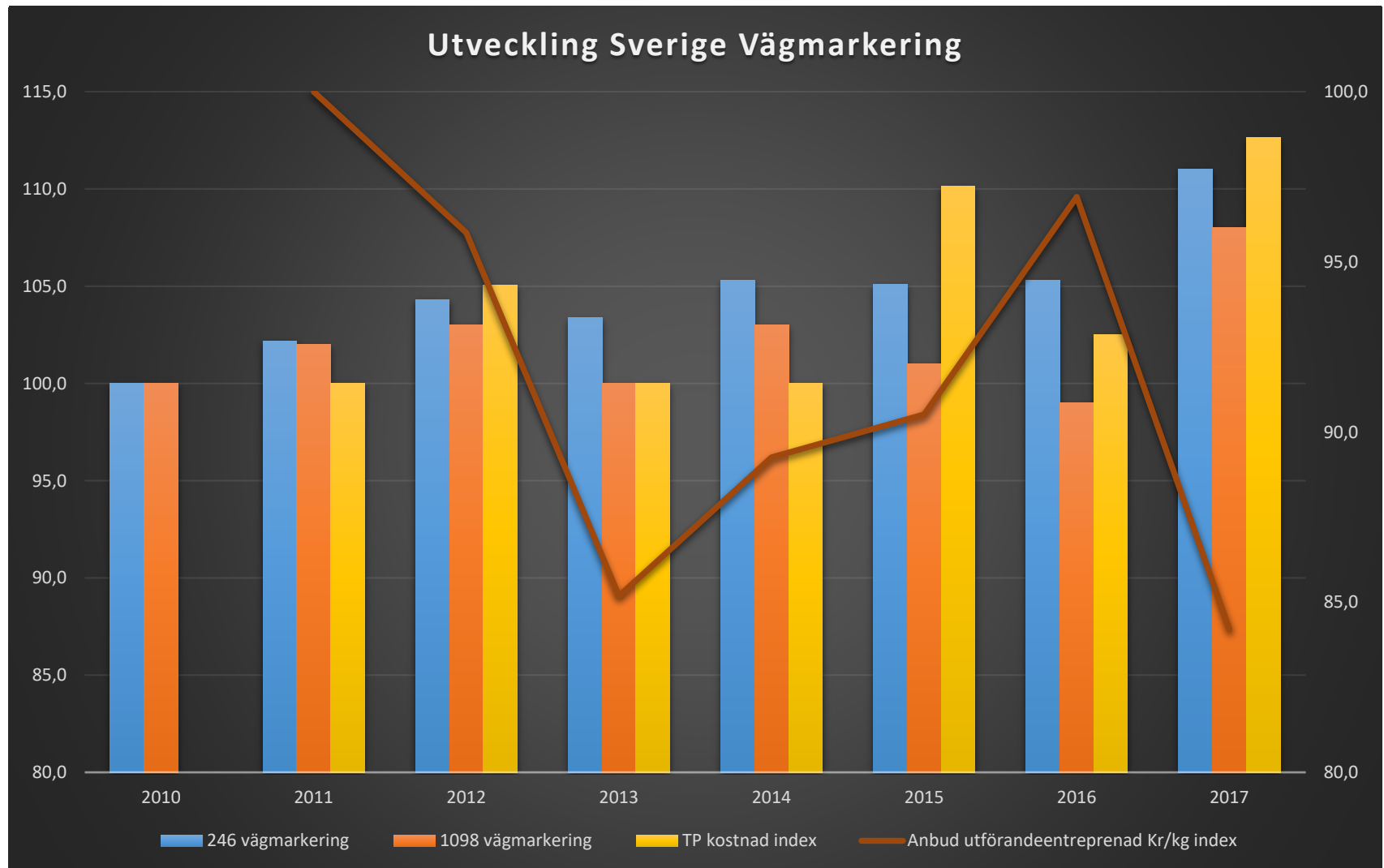
➤ genom att tillvarata medlemmarnas gemensamma intressen och företräda dem inför myndigheter samt övriga organ i samhället

➤ genom forskning och annat utvecklingsarbete

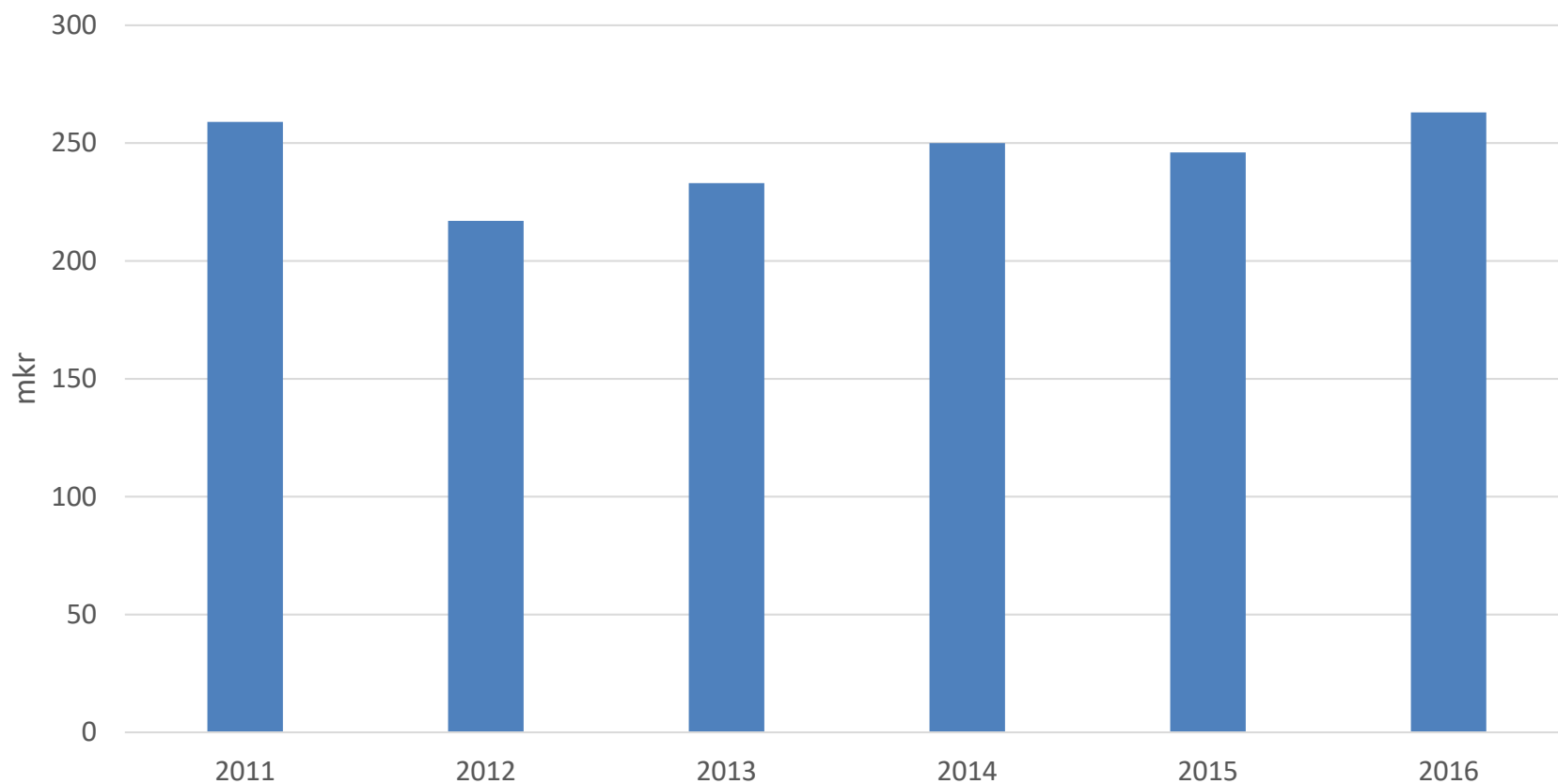


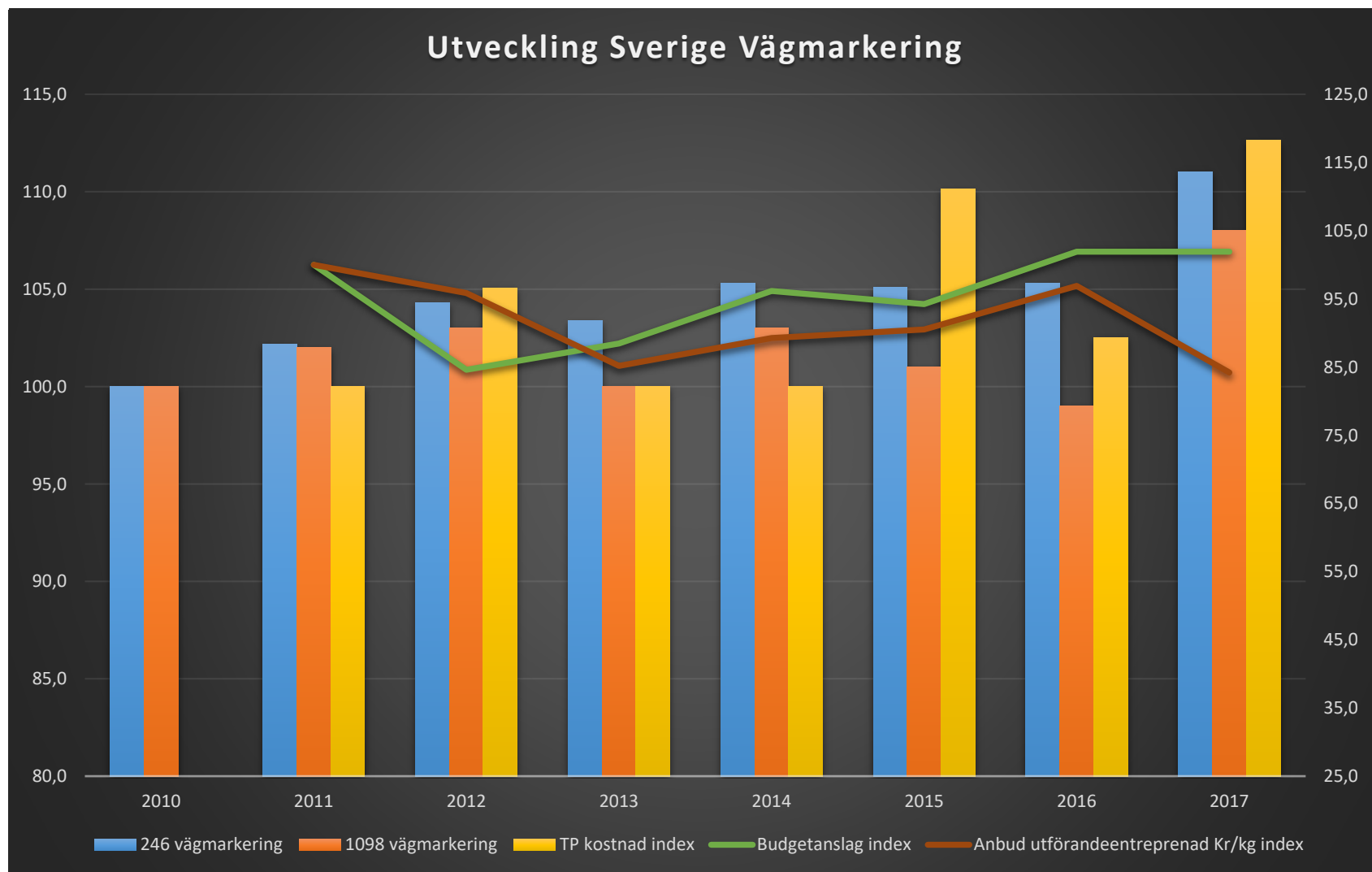


Anbud Index 2011

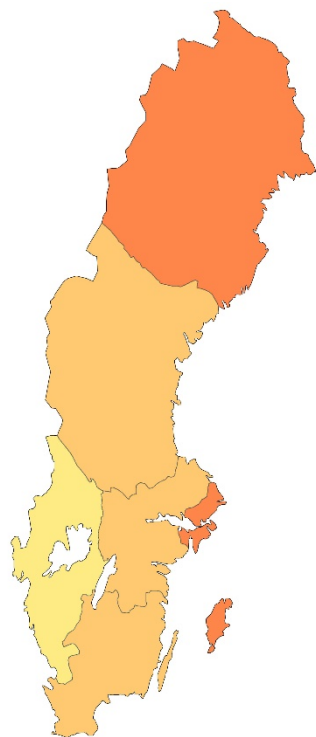


Utfall 2011 – 2016 - Underhåll

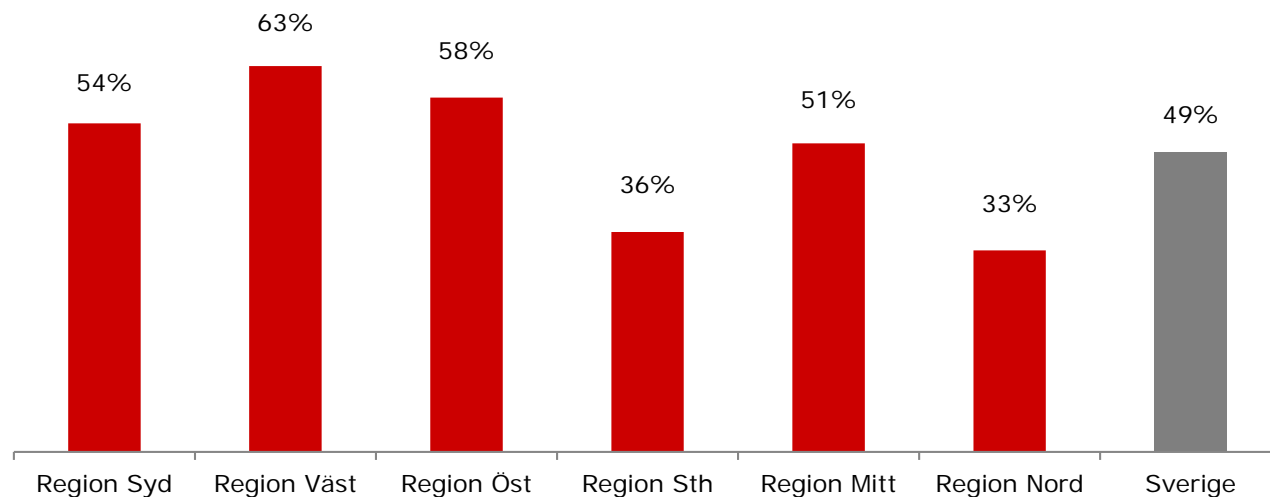




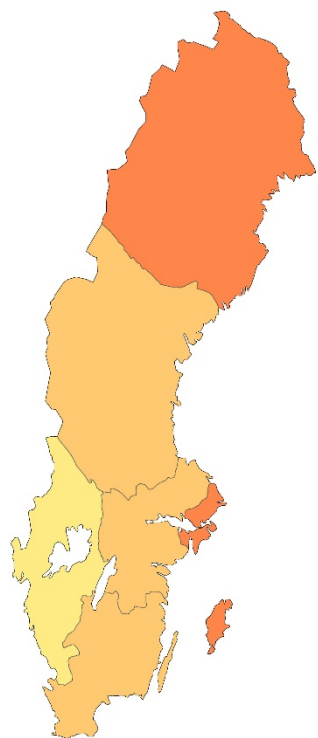
Resultat 2017



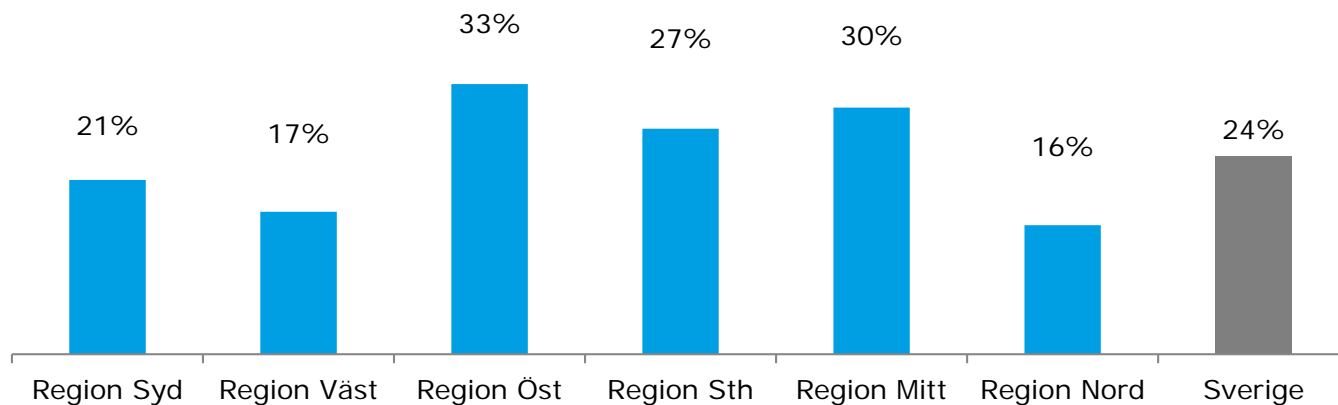
Andel vägmarkeringslängd som uppfyller kraven, torr retroreflektion. Medelvärde av vägklass A-D



Resultat 2017

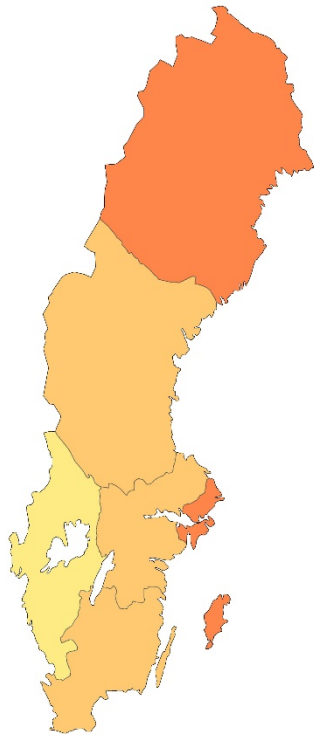


Andel vägmarkeringslängd som uppfyller kraven, våt retroreflektion. Medelvärde av vägklass A-D

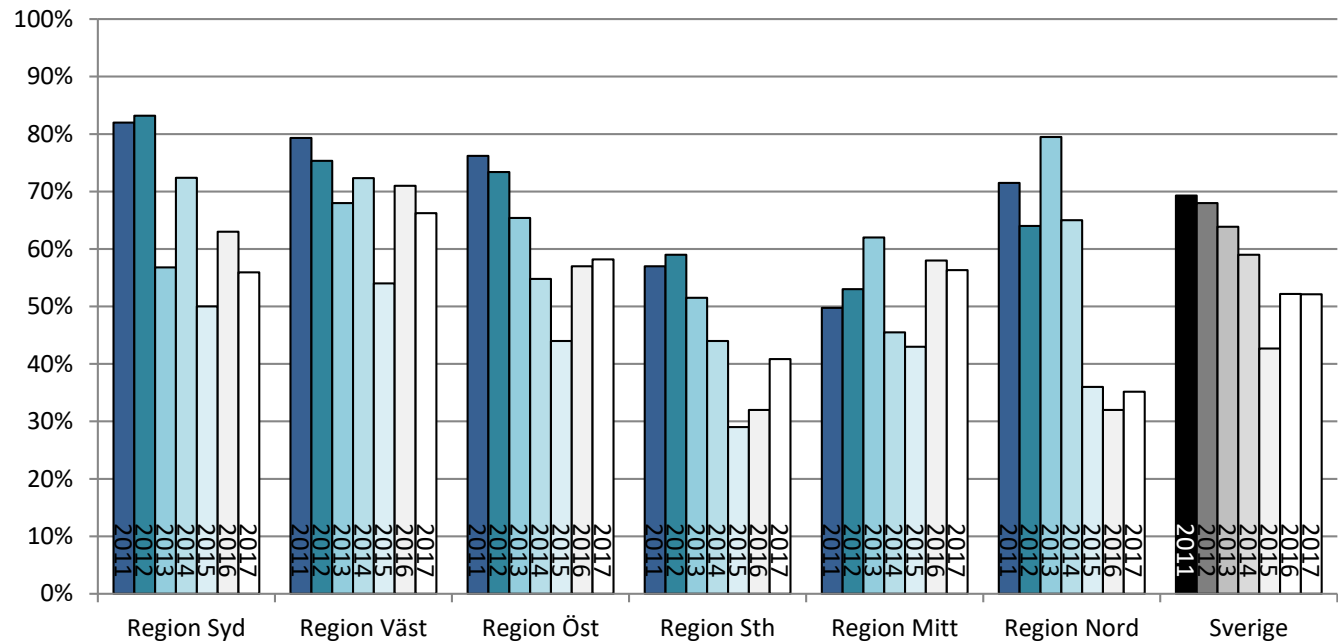




Utveckling sedan 2011

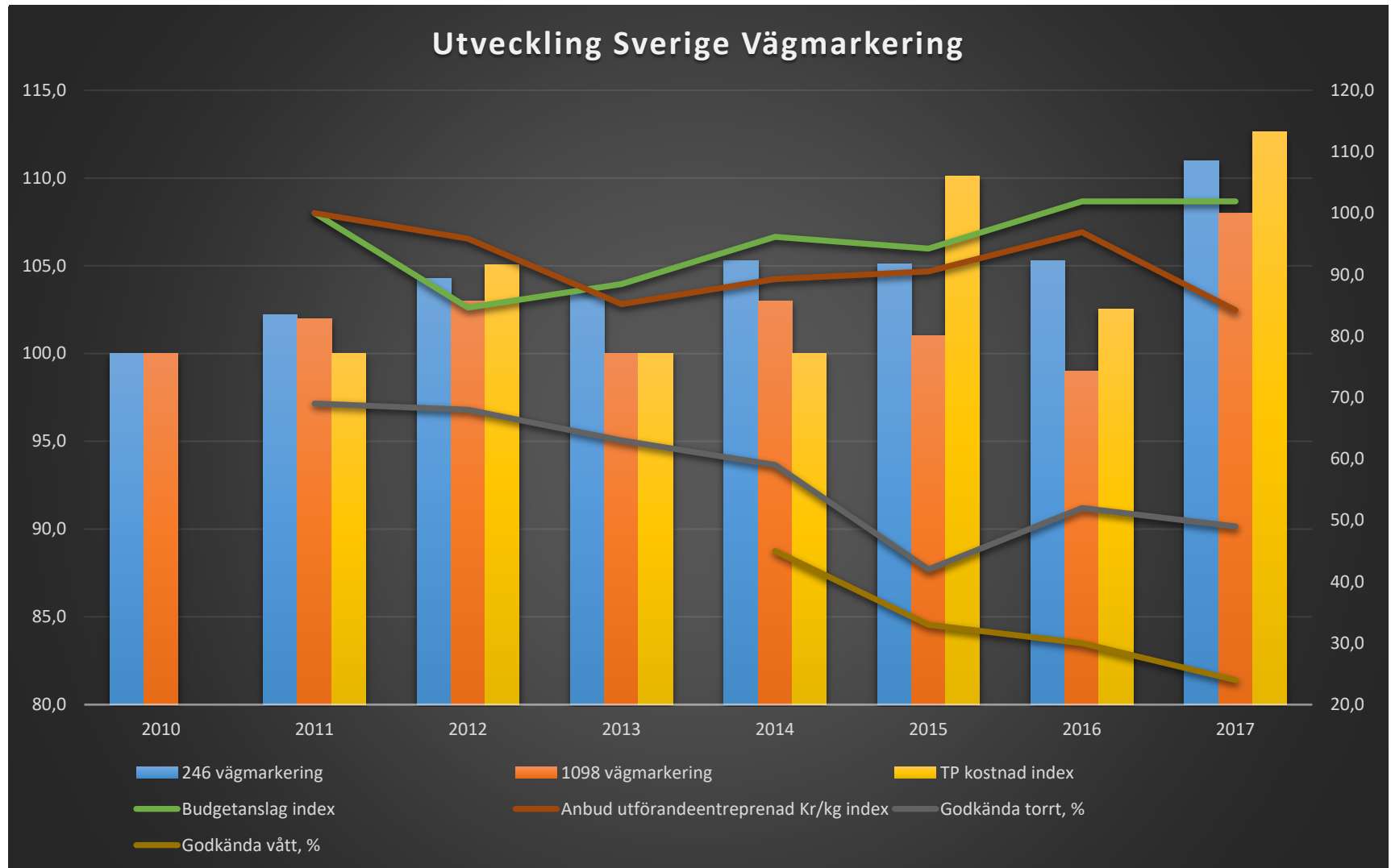


Andel vägmarkeringslängd som uppfyller kraven, 2011-2017
Medelvärde vägklass A-C





Med tillståndsmätning 2017





COST 331

1. A complete review of the state of the art by means of a litterature survey and a questionnaire answered by 15 European countries.
2. An investigation of the visibility distance of road markings, in a driving experiment involving a number of test persons and variable conditions (concerning road marking pattern and reflectivity, and headlamp intensity).
3. An investigation of the driver need for visibility distance, carried out in a driving simulator, involving a number of test persons and variable conditions concerning driving speed, visibility distance and road curvature.
4. Monitoring driver behavior in real traffic conditions throughout different road sections in Finland, Portugal and Switzerland (built up with different designs and quality of road markings), by using an unobtrusive instrumented car and involving a statistically selected number of test persons.

European Co-operation in the Field of Scientific and
Technical Research



COST 331 Requirements for Horizontal Road Marking

Final Report of the Action

"The shortest visibility distance or limit of road markings that the driver need in order to handle the car in a safe and controlled way"

Preview time equal to Sight distance divided by Speed

Minimum preview time of 2,2s

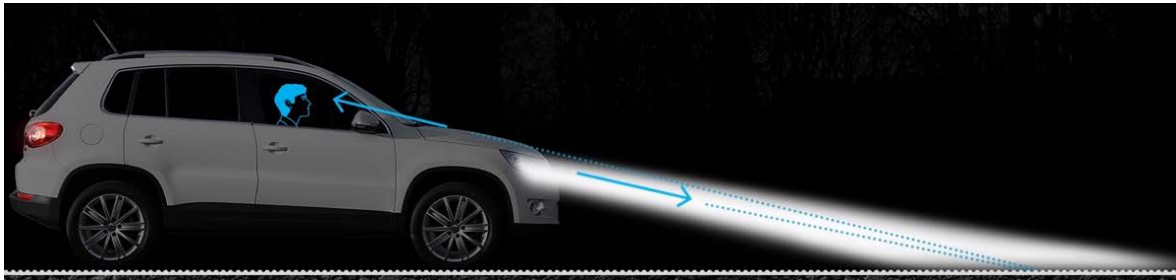


Night time visibility Retroreflection



Svenska Vägmarkeringsföreningen

https://youtu.be/_KaHbbVxJWE?t=390



Night time visibility as described in EN 1436

- In dry condition (Type I marking)
- In wet condition (Type II marking)
- In rainy condition (Type II marking)



Night time visibility

Preview time 2,2 s



	Speed, km/h	Visibility distance	30 cm marking	15 cm marking
Motorway	120	>75m	150 mcd	300 mcd
Secondary road	90	>55m		150 mcd
City	50	>30m		100 mcd

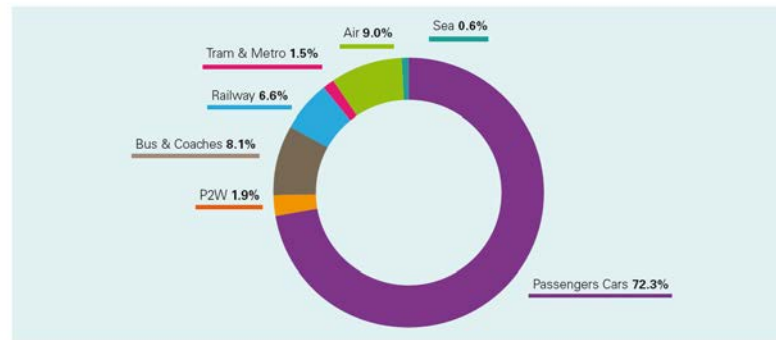
Various countries have implemented requirements based on European standard and the research of COST 331



Transportation way in EU

6.3 Passenger transport modal split in EU 28, 2013 (pkm in %)

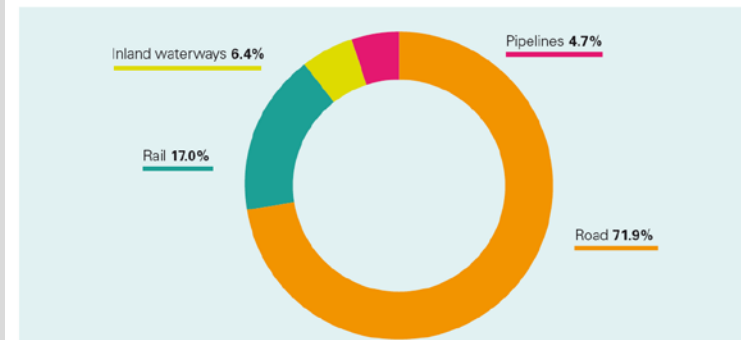
Source: EC



Air and Sea: only domestic and intra-EU 28 transport; provisional estimates
P2W: Powered two-wheelers

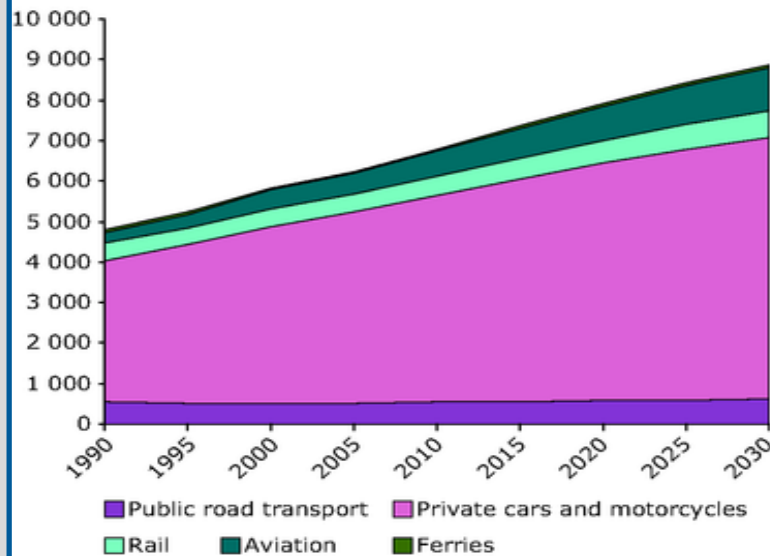
5.4 Inland transport modal split in EU 28, 2013 (% of tkm)

Source: EC

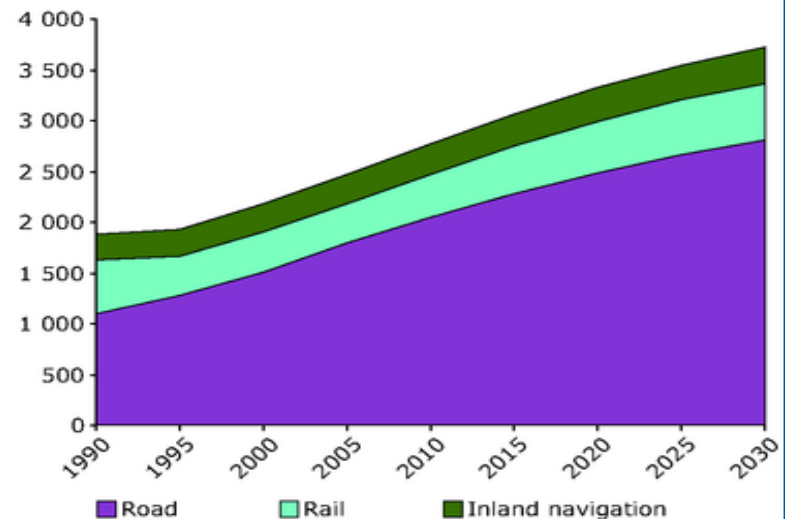


Road: national and international haulage by vehicles registered in the EU 28

Gpkm (passenger transport activity)



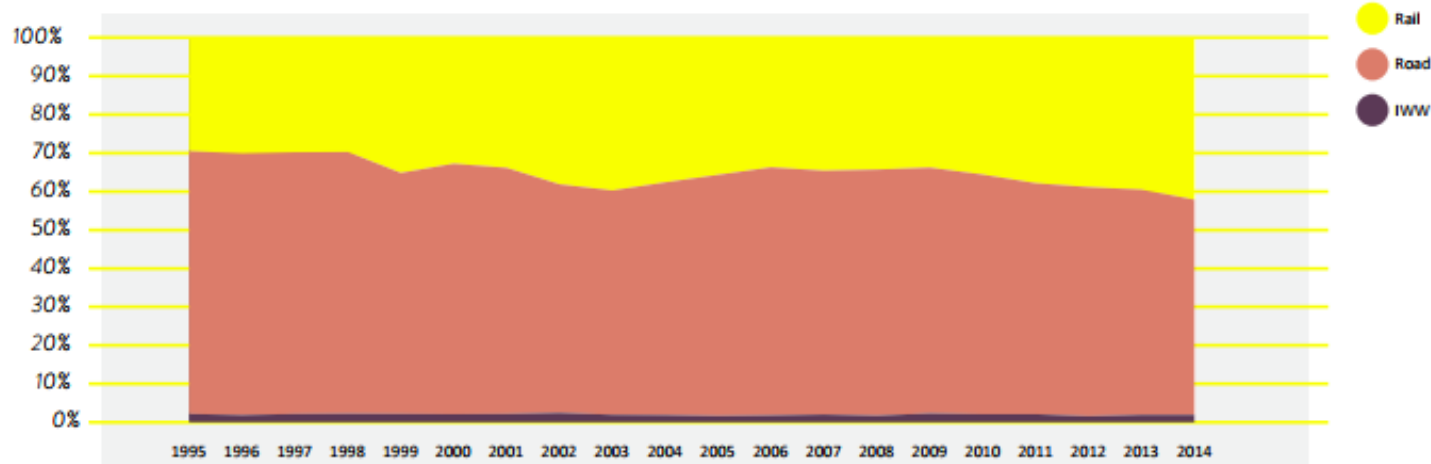
Gtkm (freight transport activity)





Investment in infrastructure

Distribution of infrastructure investment between modes in EU 28, 1995-2014 (Euros, current prices, current exchange rates)



Source: ITF
Note: No data for CY

Maintenance expenditures in road infrastructure in selected countries, 2010-2014 (at current prices and exchange rates - million Euros)

	2010	2011	2012	2013	2014	
AT	559	494	517	559	667	AT
BE	184	156	145	147	206	BE
BG	100	71	103	96	93	BG
HR	195	212	187	209	257	HR
CZ	670	570	571	513	587	CZ
DK	1,058	881	945	920	796	DK
EE	38	39	44	47	45	EE
FI	667	658	574	585	506	FI
FR	2,431	2,746	2,851	2,904	2,760	FR
HU	328	256	296	412	357	HU
IE	164	161	139	128	85	IE
IT	6,437	6,220	7,195	9,134	9,564	IT
LV	85	90	93	100	154	LV
LT	160	153	123	127	143	LT
LU	34	37	34	41	41	LU
MT	25	27	24	25	17	MT
NL	1,209	323	..	..	..	NL
PL	2,636	2,678	428	438	383	PL
PT	102	..	165	174	..	PT
RO	..	..	..	..	..	RO
SK	175	160	193	204	181	SK
SI	137	172	120	123	118	SI
SE	875	856	959	1,044	1,017	SE
UK	3,919	3,552	3,591	3,346	3,229,13	UK
Total EU	22,188	20,462	19,295	21,276	21,206	Total EU
MK	16	15	..	..	..	MK
RS	228	205	208	129	142,98	RS
TR	360	674	600	630	582,14	TR
IS	29	29	29	28	32	IS
NO	1,361	1,615	1,747	1,841	1,997,63	NO

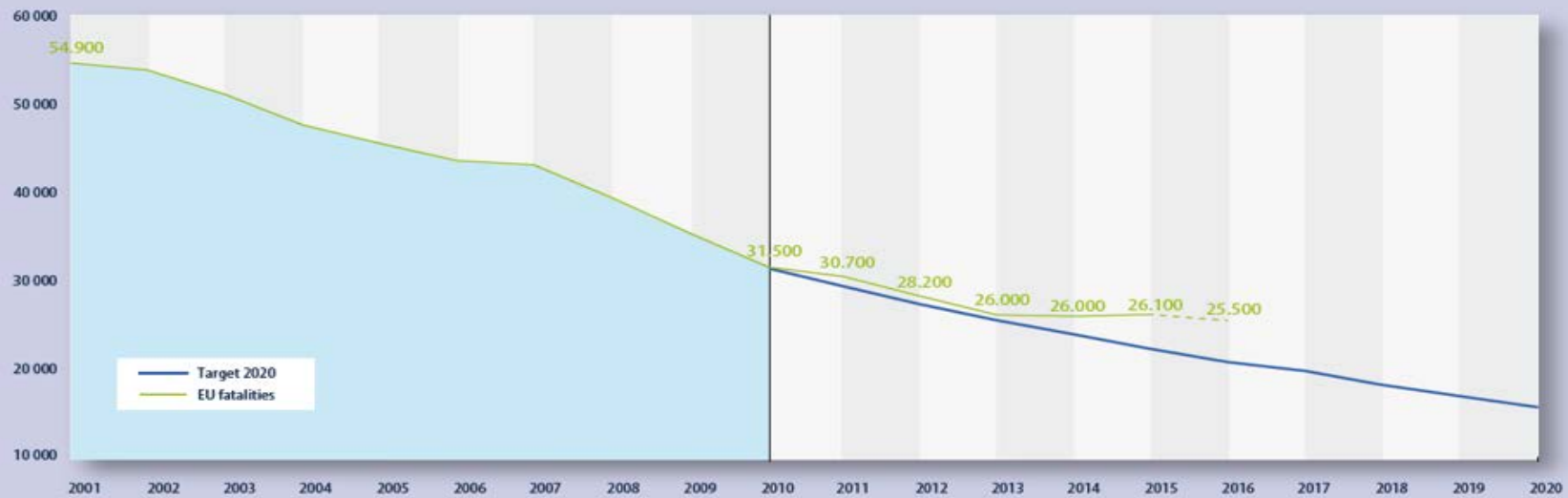


Road fatalities

- Since 2013, progress in reducing fatalities has been marginal
- EU reduction in fatalities 2010-2016 = 19%
- Huge efforts need to put to reach targets of 50% by 2020
- Reasons for slow down:
 - Growing number of elderly drivers
 - Growing number of VRU in cities
 - Less resources dedicated to road maintenance due to cutbacks
 - Increase in traffic volumes



Road fatalities in the EU since 2001



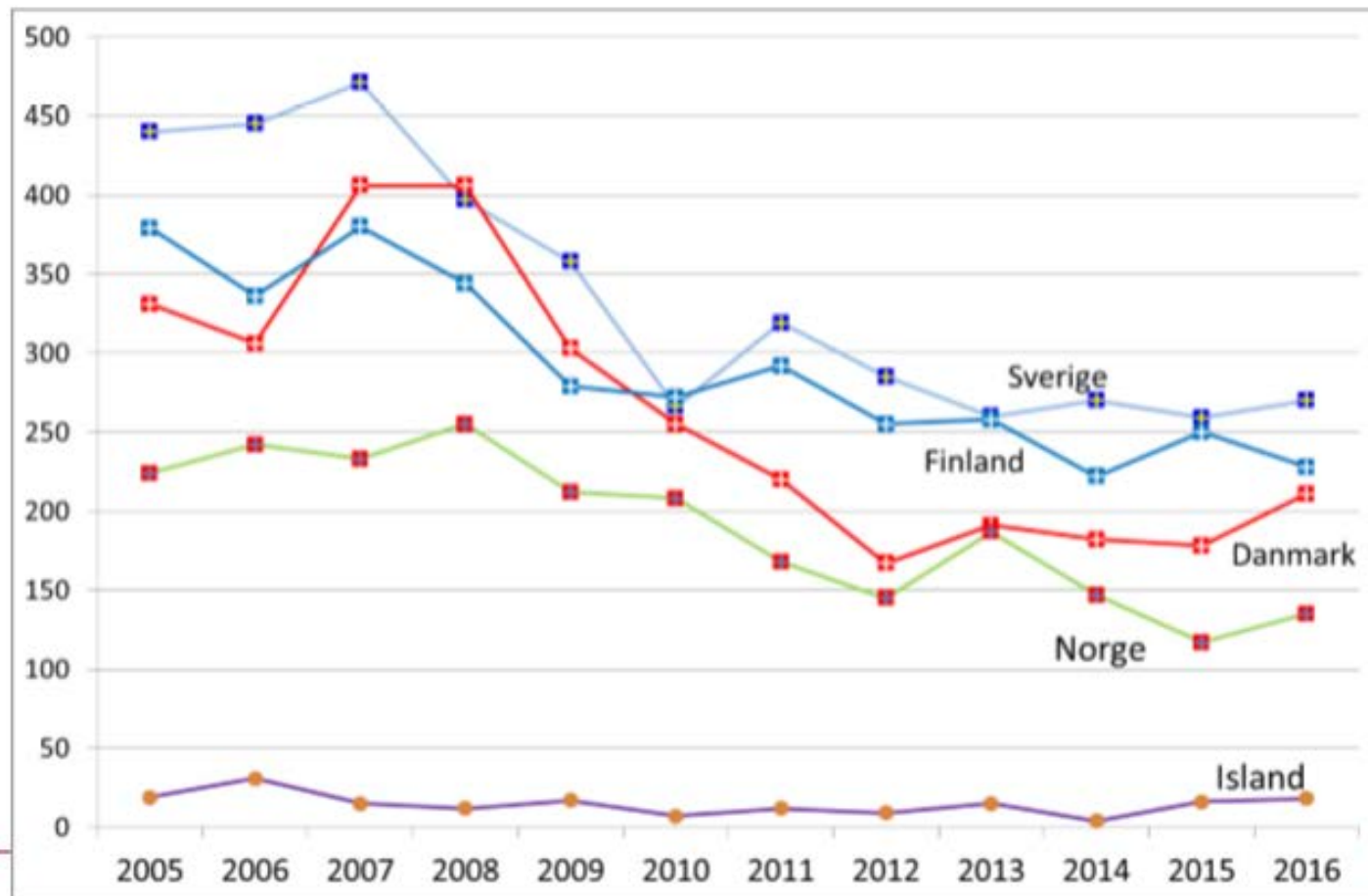
Source: - CARE (EU road accidents database)



Nordic 11 years



Udvikling i de senere år



How to change the negative trend?



Svenska Vägmarkeringsföreningen

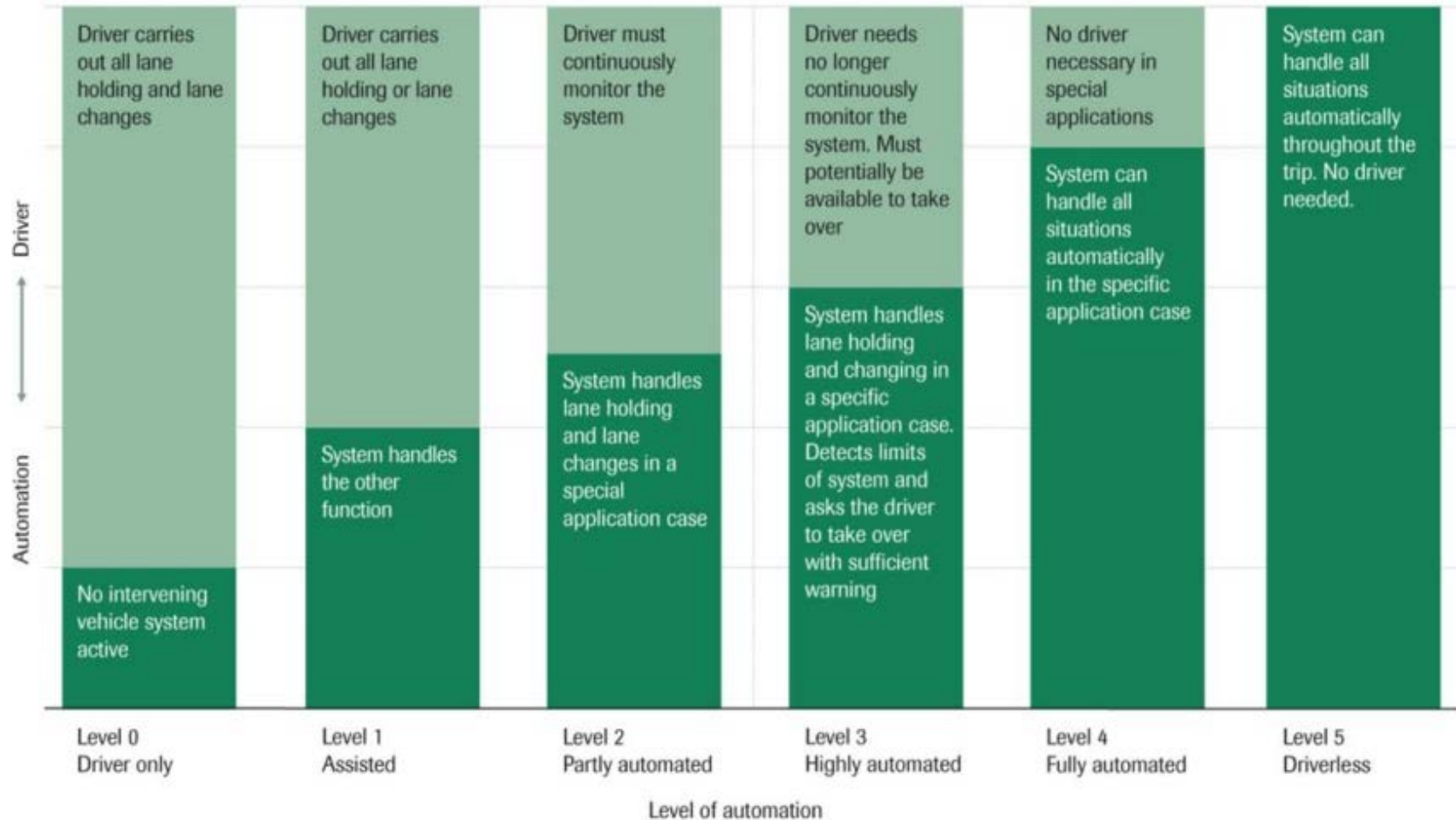
- Sustained reduction in fatalities will require looking beyond 'traditional tools'
- Need to look to new measures that can provide high added value in the short to medium term
- Assisted and connected driving holds great promise
- Given the penetration of connected/autonomous vehicles will be gradual, next generation of driving will be characterised by hybrid traffic conditions requiring **hybrid infrastructure**





SAE classification

Levels of automated driving



SAE International is a global association of more than 128,000 engineers and related technical experts in the aerospace, automotive and commercial-vehicle industries.

- [EC Report: Saving Lives: Boosting Car Safety in the EU \(December 2016\)](#)
- Identified 19 life-saving technologies that should be considered for the revision of General Safety Regulation
- Three technologies deal directly with infrastructure:
 - Lane Support Systems (LSS)
 - Intelligent Speed Adaptation (ISA)
 - Automatic Emergency Breaking (AEB)
- Proposal is to make these technologies mandatory for all new vehicles as of
 - September 2022 for LSS, ISA
 - September 2024 for AEB





- 45% of fatal accidents are single vehicle accidents, typically RoR ([CEDR report on Forgiven Road Sides](#))
- According to WHO ([Managing Speed, 2017](#)), speed contributes to about 1/3 of accidents in high-income countries
- As such, the life-saving potential of Lane Support Systems and Intelligent Speed Adaptation can be significant



ADAS Safety Potential

- Lane Departure Warning (LDW) can reduce up to 9,020 fatal crashes or 29% of all fatal crashes.
- Forward Collision Warning (FCW) can reduce up to 800,000 crashes or 14% of all crashes (750 fatal crashes).
- Blind Spot Monitoring (BSM) can reduce up to 267,000 crashes and 280 fatal crashes.
- *Harper, C. D., Hendrickson, C. T., Samaras, C. Cost and benefit estimates of partially-automated vehicle collision avoidance technologies. Accident Analysis & Prevention, 95, 104–115. 2016.*

Sammanfattning

- En **halvering** av mötes- och singelolyckor där vägmarkeringarna är synliga och skyltad hastighet är 70 km/tim och över
- Effekten motsvarar **ca 30 liv årligen** och många fler skadade
- **Lane Departure Warning** har utvecklats av fordonsindustrin för att hjälpa föraren att inte lämna sitt körfält oavsiktligt på grund av exempelvis distraktion eller trötthet





Ongoing research studies

- CEN / TC 226 / ADAS Autonomous vehicles
 - Better understanding of sensors
 - Syntheses of projects
 - Focus on the work zones and toll gates
 - Supply road databases and protocols
- ERF / CEDR / ADAS
 - Field testing of various pavement markings
- TTI / TRB NHCRP 20-102(06) Pavement Markings for machine vision systems
 - Practical studies on an airfield in Texas utilizing Mobileye 590 (IQ2) sensor with other equipment
 - Develop information on performance of pavement markings to be recognized by machine vision
 - Give recommendation to AASHTO/SAE to develop guidelines and criterias



- NCHRP 20-102(06) Road Markings for Machine Vision
 - Draft final report to be submitted within a week
- ATSSA sponsored project to expand NCHRP data collection to include 6-inch pavement markings
 - Draft final report submitted
- NCHRP 20-102(06) Road Markings for Machine Vision Phase 2
 - Currently in the planning stages

Utilized technology



Cameras



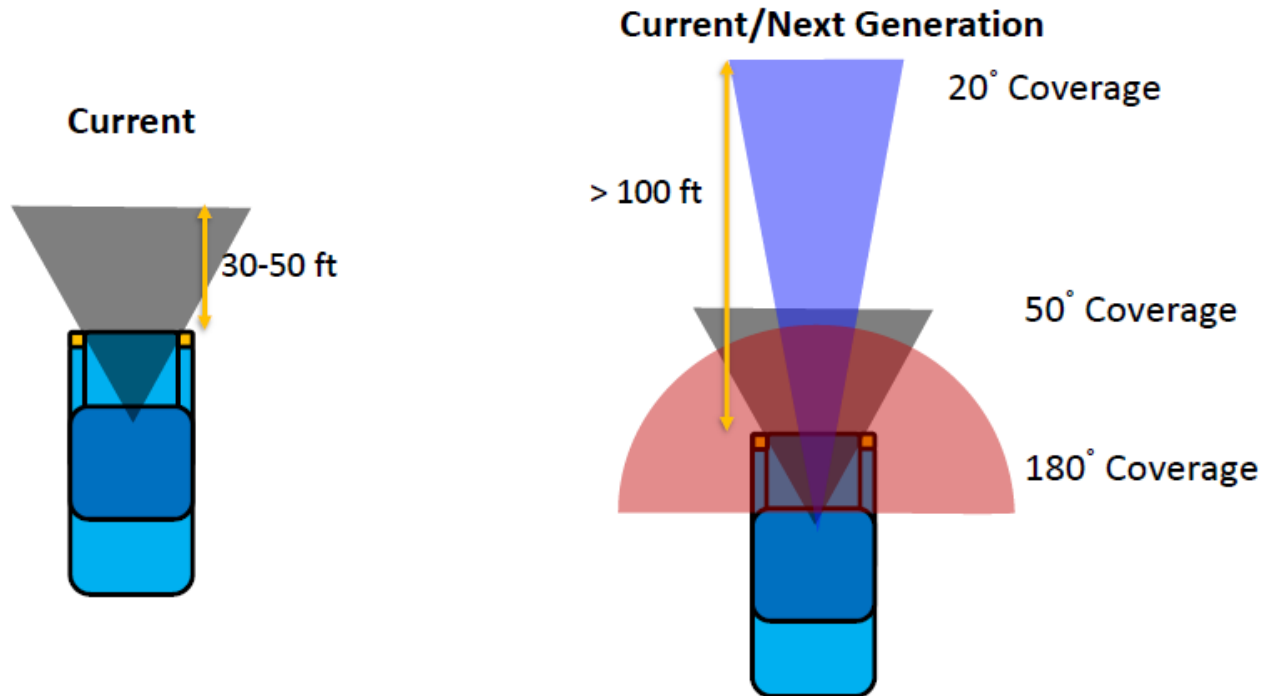
MV Camera

Video Camera

MV Camera Specifics

- MobilEye 590
 - 1 MP camera
 - 50 degree field of view
 - Most common ADAS camera on the market
 - Testing indicated marking detection at 10-15 meters

Autonomous Vehicle Technologies





Marking characterization

- **Night**
 - 30-m retroreflectivity (dry and wet recovery)
 - 15-m retroreflectivity (dry and wet recovery)
 - Luminance of markings and road surface at distances of 45, 85, 125, and 165 ft (dry and wet recovery)
 - **Day**
 - Color
 - Luminance coefficient (dry)
 - Luminance of markings and road surface at distances of 45, 85, 125, and 165 ft (dry and wet recovery)
 - **Road surface also evaluated to evaluate contrast**
-



Preliminary findings

- Contrast ratio of 2:1 results in confidence levels >2 most of the time when there is no glare
 - Nighttime dry / wet
 - Need ~ 50 mcd (without glare*)
 - Evaluate R_L or luminance
 - Long range (>30 m range) machine vision needs may differ
 - Daytime dry
 - Need contrast between marking and pavement
 - Evaluate Q_D or luminance
 - Daytime wet
 - Need contrast between marking and pavement
 - Evaluate Q_D or luminance
-



Next step

- Submit draft final report (Jan 2018)
 - Review/revise Q1 2018
 - NCHRP to publish Phase 1 report
 - Further develop NCHRP Phase 2 work plan
 - Evaluate contrast markings
 - Evaluate glare (from oncoming vehicles)
 - Evaluate other technologies (long range viewing)
 - Incorporate other testing into initial report
 - 4in vs 6in wide marking testing
 - Testing in rain conditions
 - Additional data collection with non-standard camera system
-



Mobileye (Intel) - ADAS

If you can't see the markings, the camera can't either

Single camera 1-2 megapixels IQ2, IQ3 and IQ4

- 2017: 18 out of 43 5 star cars utilize Mobileye technology
- 25 million cars on the market utilizing technology

Main comments on pavement markings:

- Maintenance of markings
 - Sharp edges on lane markings
 - Visible arrows
- Robust markings visible in all weather conditions and variable light condition
- Uniformity of markings (arrows, startin points on new lanes (exits), speed humps, bicycle lanes)
- Crack sealing



Continental (member in ASC)

Characteristics of pavement marking for optimal detection by ADAS

- Higher luminance over lightning conditions means more light is available to each pixel on visible camera to enable detection
- Higher contrast over all lightning conditions improves differentiation between marking and pavement substrate and detection of marking by visible cameras
- Wet retroreflective markings improve light return to visible camera in nighttime and low-light wet conditions, improving detection of pavement markings



Wishes from auto makers

- Maintain markings to a higher standard
 - Re-application
 - Crisp edges (no worn out markings)
 - Remove conflicts with previous markings
 - Eliminate Bott's dots (RPMS)
 - Modify 10-30 gap on lane lines (uniform lane lines)
 - Improve national uniformity on exit and entrance ramps
 - Use one standard contrast marking pattern (important on concrete roads)
 - Reduce crack seal conflicts (ghost marks)
-



Quotes in the media

„The car can't find the lane markings! You need to paint the bloody roads here!“

Lex Kerssemakers
CEO Volvo Nordamerika

„Like the human eye, the technology can't work effectively if it can't see the road markings if they are worn out or hidden, or if they are confusing.“

EuroRAP, EuroNCAP

„Lane markings are the rails for the self-steering car.“

EuroRAP, EuroNCAP

„We really need better lane markings. This is crazy.“

Elon Musk
CEO Tesla

„We need to increase the time, distance, weather range and durability so that a machine or camera can 'see' the pavement markings.“

Tom Hedblom
3M

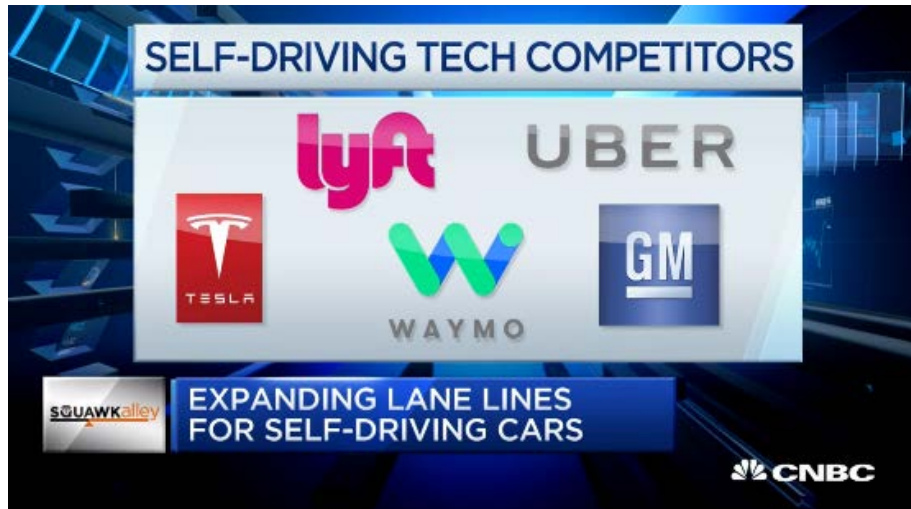
„They (self-driving car companies) actually said make sure you have really good paint lines. So, where there are lines, we have to make sure they're really good.“

Kirk Steudle
Director of Michigan's Department of Transportation

New practice in California



- Better maintainance
- Clearer markings
- Wider lane lines
- To support autonomous driving as well as conventional driving



Permit to 36 companies for autonomous driving

ROADS THAT CARS CAN READ

A Quality Standard for Road Markings and Traffic Signs on Major Rural Roads

BOX 1 - ADVANCED VEHICLE TECHNOLOGIES

- **Advanced Driver Assistance Systems (ADAS):** Now common in many vehicles, eg: SatNav, traffic information, Adaptive Cruise Control, Collision Avoidance, Intelligent Speed Adaptation, Night Vision
- **Lane Keeping Assistance (LKA) and Lane Departure Warning (LDW):** The systems read the road markings and give a visual, acoustic or tactile warning if the vehicle crosses the lane markings without signalling. For the driver, it can feel like running over a rumble strip even though no such strip exists. Lane Keeping Assistance, as well as warning, also gives the driver some steering support
- **Traffic Sign Recognition (TSR):** In-car systems that can read and interpret a range of traffic signs, including speed limits

Source: EuroNCAP/EuroRAP



BOX 2 - THE ROAD MARKING STANDARDS REQUIRED

Based on a collection of data of intervention and maintenance standards from a number of European countries², the ERF has determined a good road marking to be one whose **minimum performance level under dry conditions is 150 mcd/lux/m² and which has a minimum width of 150 mm for all roads; for wet conditions, the minimum performance level should be 35 (RW2)**. Given that these requirements are already in place in some EU member states; the ERF believe this proposal is realistic, technically feasible and cost-effective



European Union Road Federation

ERF Position Paper on Road Markings

THE ERF PROPOSAL:

- Minimum intervention and maintenance policies
- Guarantee of visible horizontal signage all year round
- Minimum marking width: **150 mm**
- Minimum Performance under dry conditions: **150 mcd/lux/m²**
- Minimum performance under wet conditions: **35 mcd/lux/m²**



Nordic certification



vti



**Nordic certification system
for road marking materials**

Version 4:2017



**Carina Fors
Trond Cato Johansen
Sven-Olof Lundkvist
Sara Nygårdhs**



NORDIC CERTIFICATION ROAD MARKING
2017-10-14



Brussels, 20.12.2017
SWD(2017) 484 final

COMMISSION STAFF WORKING DOCUMENT

EU green public procurement criteria for paints, varnishes and road marking

The tenderer shall demonstrate professional competencies in the following areas, as relevant to the nature of the contract being let:

- Method statements for the efficient use of road marking on-site, including the preparation of estimates and the use of specialist equipment;
- Method statements for the preparation of substrates (including, where appropriate, safety procedures for removal of road markings which may have been made with lead pigment and are considered hazardous; or high pressure removal of road markings);
- Method statements for the preparation of road marking formulations and their handling during their application;
- The application of environmentally improved products, including those with reduced VOC content;
- The application of durable and high specification finishes, with reference to relevant EN standards or their equivalent;
- Policies and supporting management systems to minimise road markings waste, maximise the reuse or recycling of waste and unused road marking and to ensure their safe disposal and safe disposal of other chemicals such as road marking stripping agents.

Verification:

The tenderer shall provide evidence in the form of information and references related to relevant contracts in the previous 5 years in which the above elements have been carried out.

TECHNICAL SPECIFICATIONS

1. Use of road markings meeting the EU GPP criteria

(same for core and comprehensive criteria)

All work contracts shall be performed using road marking products that comply with the EU Green Public Procurement requirements as specified in Technical specifications for core criteria of EU GPP – Section 4.3 Road markings.

3.3 Road markings

Core criteria	Comprehensive criteria
SUBJECT MATTER	
The purchase of road markings with a reduced environmental impact	
TECHNICAL SPECIFICATIONS	

3. Quality and durability of road marking system

(same for core and comprehensive criteria)

The tenderer shall demonstrate that the road marking maintains the minimum performance requirements, namely for night time visibility, day time visibility, skid resistance and erosion, after a defined number of wheel passages¹, as specified by the procurer in the call for tender.

¹ *Indicatively, a reasonable performance could be considered as 500.000 wheel passages, according to standards EN 1824 and EN 13197. If a higher level of performance is desired, then a higher number of wheel passages should be specified.*

Verification:

The tenderer shall provide a test report or the approval of a national test facility demonstrating compliance of the road marking system under the conditions appropriate to the contract and according to EN 1824, EN 13197 or equivalent. To ensure comparability, the contracting authority shall specify in the call for tender the test method to be used by all tenderers.



Recommendations

- Create Nordic group for ADAS and road markings – SVMF will be happy to take a leading role to bridge various interest from the industry
- Emphasize requirements on visibility, especially for Type II markings (wet condition) for all roads (meet the need for both human and machine driving)
- Utilize tools like Nordic certification and Green public procurements in public tenders to enhance quality
- Establish control, penalties and/or payment systems to verify performance in various contracts
- Schedule re-application in accordance with the functional lifetime of the roadmarkings
- Increase road marking budget for maintainance



Additional resources spent on road markings:

- **will result in cost savings for the society due to reduced cost related to accidents**
- **will make an infrastructure giving support for ADAS technology**



Toni Ogemark

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- WG2 delegate in CEN
- Member in European road federation
- Chairman of SVMF

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