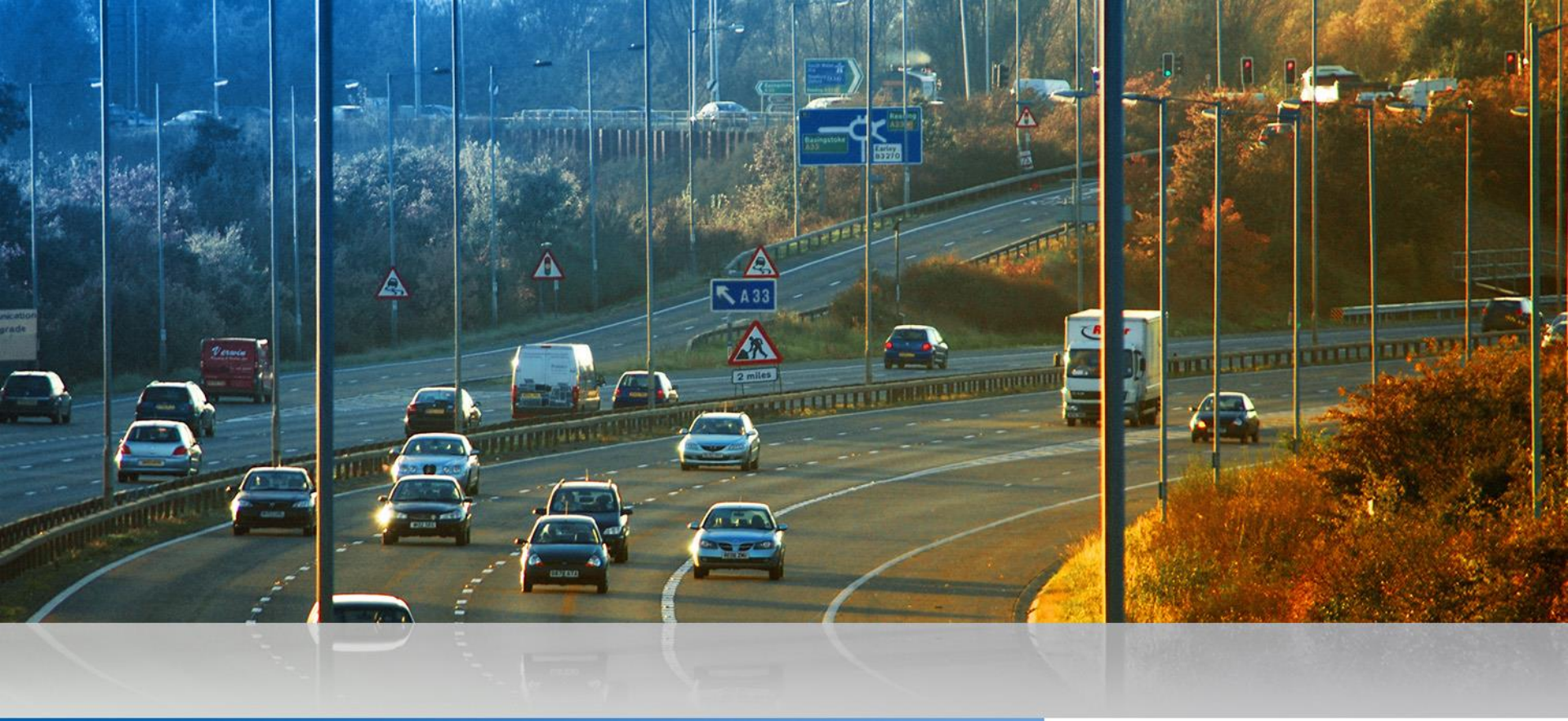



# Potential Benefit of Lane Departure Warning Systems and Lane Keep Assistance

Richard Cuerden

9th March 2015

# Agenda

Potential Benefit of LDWS and LKA

1. **TRL & TRF**
2. **General & Pedestrian Safety Regulation review**
3. **LDWS & LKA – Potential benefits & feasibilty**
4. **LDWS & LKA – Benefit:Cost Ratio**
5. **Summary & future**

# Transport Research Laboratory

*- known as 'TRL'*

- Established 1933; transport research for UK Government
- Privatised in 1996
- 340 staff, including world experts
- Head Office in Berkshire, with UK regional offices and growing international presence
- Market-leading products & services used across 145 countries, by over 1000 clients

# Transport Research Foundation
*- parent company of TRL*

- Created in 1996 as impartial & commercially independent business
- Company Limited by Guarantee; 80+ sector members, no shareholders
- Non-profit distributing, profits re-invested back into original research

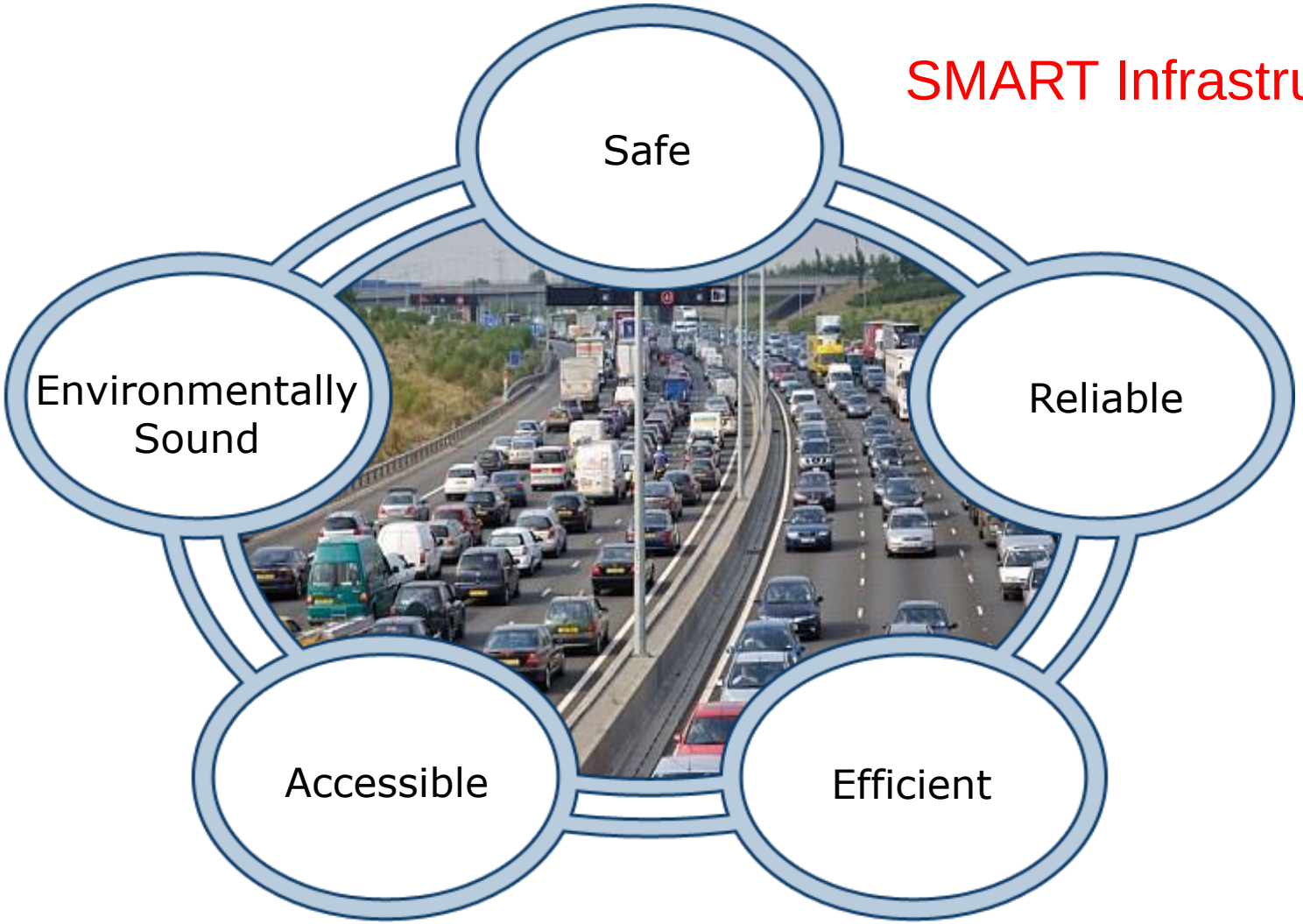
# Strategic View, 3-5 Years

*- What is the future of transport?*

Autonomous Vehicles

LCV Technologies

SMART Infrastructure




| Travellers | Businesses | Governments | Communities | Operators |


BARCLAYS
indigO2
THE ENTERTAINMENT VENUE AT
The O2
adidas
Coca-Cola
100%
DRIVERLESS
100%
ELECTRIC

# Potential Benefit of LDWS and LKA

## General and Pedestrian Safety Regulation
## Benefit and Feasibility of Potential Measures

- General Safety Regulation (GSR) EC 661/2009 published 2009
  - Type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units
  - Includes
    - Implementation of UN Regulations
    - DRL, ESC, tyre pressure monitors (cars)
    - LDW and AEBS (trucks and buses)

- Pedestrian Safety Regulation (PSR) EC 78/2009 published 2009
  - Type-approval of motor vehicles with regard to the protection of pedestrians and other vulnerable road users
  - Includes the following VRU passive safety requirements
    - Legform to front of car
    - Adult and child headform to bonnet
    - Monitoring of upper legform and adult head to windscreen tests

# Potential Benefit of LDWS and LKA

## General and Pedestrian Safety Regulation
## Benefit and Feasibility of Potential Measures

- Both GSR and PSR require the Commission to **report on potential new measures**
  - Monitoring of technical developments in passive safety
  - Consideration of new and enhanced safety features
  - Enhanced active safety technologies

  - TRL study is part of the input to that reporting

# Potential Benefit of LDWS and LKA

## General and Pedestrian Safety Regulation
## Benefit and Feasibility of Potential Measures

The TRL study …

- Provided advice to the Commission regarding the **feasibility, costs and benefits of 50 potential measures** that could be included in the GSR or PSR
- **The investigation was based on existing evidence** identified in a review of the literature and through stakeholder consultation
- The output is **indicative cost-benefits, which differentiate those measures** that are likely, moderately likely or unlikely to provide a benefit consistent with the cost of implementation
- Helped the Commission to **prioritise possible future amendments** to the GSR and PSR to improve vehicle safety

# Potential Benefit of LDWS and LKA

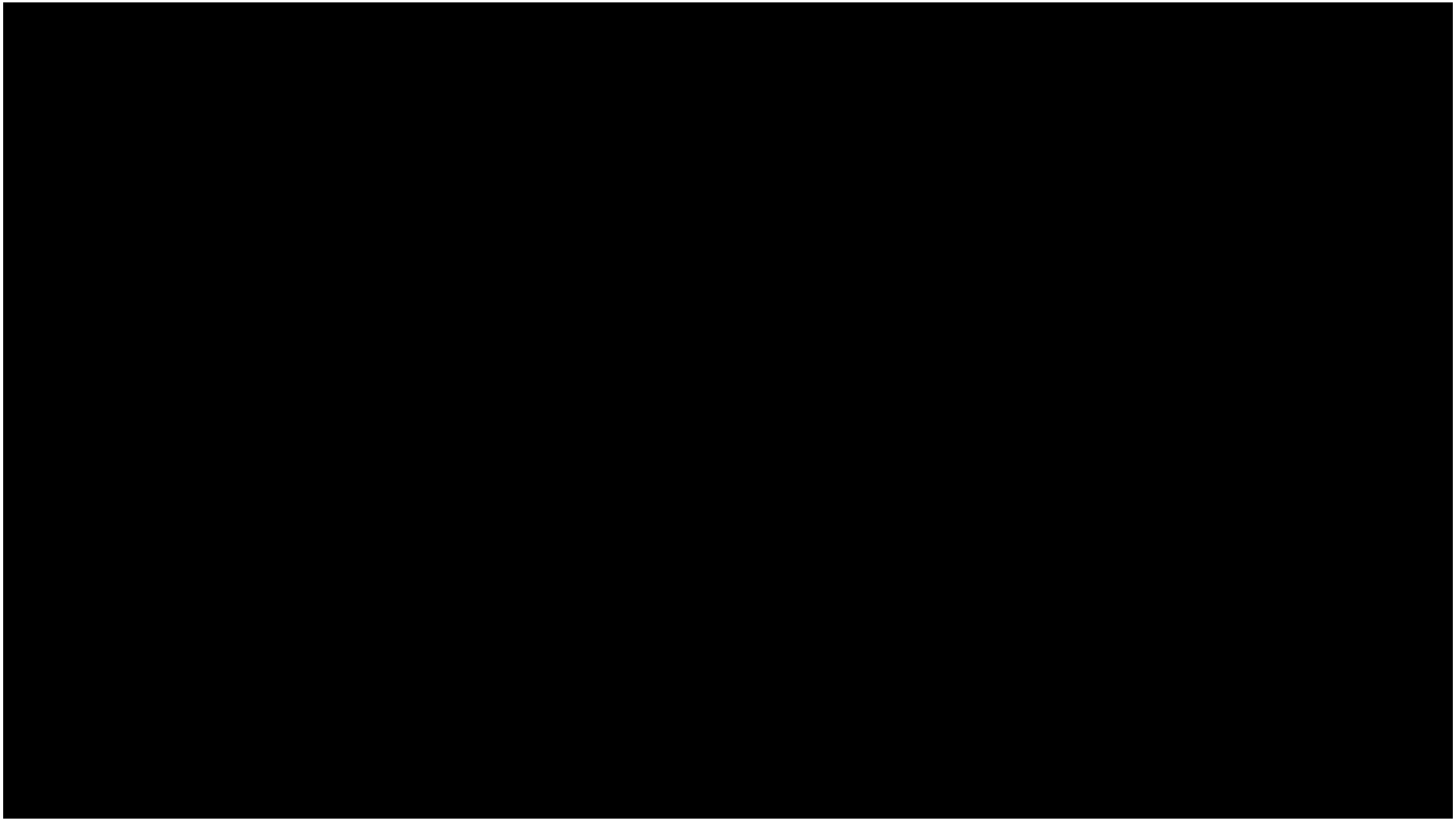
## Lane Departure Warning System (LDWS)

System to assist the driver to remain safely within the lane boundary and issues a warning in the case that lateral deviations take the vehicle towards, or over, the lane boundary.

## Lane Keeping Assistance (LKA)

LKA monitors the position of the vehicle with respect to the lane boundary and applies a torque to the steering wheel, or pressure to the brakes, when a lane departure is about to occur.

# Potential Benefit of LDWS and LKA



*(Courtesy of Volvo)*

# Potential Benefit of LDWS and LKA

## Lane Departure Accidents

These comprise accidents in which a vehicle leaves the lane unintentionally.

This is usually because of **driver distraction or fatigue** and can result in a range of accident configurations:

- **Head-on collisions**
- **Leaving roadway collisions**
- **Side-swipe collisions**

# Potential Benefit of LDWS and LKA

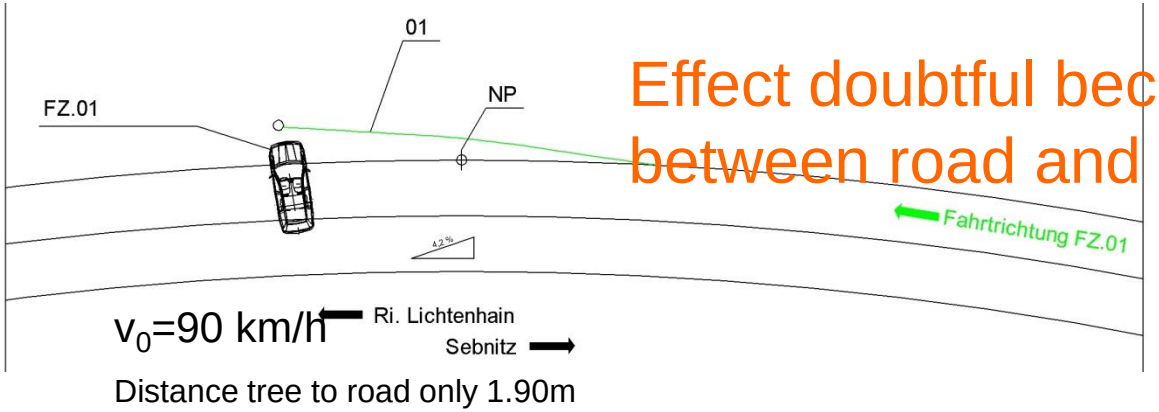
**Target population** – Head on/Leaving road/Side swipe

EU27: Target population based on GB and German national and in-depth data (Visvikis et al., 2008)

| Equipped vehicle type | Casualty severity | Equipped vehicle | | Other vehicle | | VRU | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max | Min | Max |
| M1/N1 | Fatal | 903 | 5,949 | 67 | 612 | 64 | 620 | 1,034 | 7,181 |
| | Serious | 5,773 | 31,539 | 1,026 | 7,530 | 249 | 3,197 | 7,048 | 42,266 |
| | Slight | 21,867 | 64,838 | 7,028 | 19,549 | 459 | 1,361 | 29,354 | 85,748 |
| M2/M3 | Fatal | 7 | 189 | 0 | 7 | 0 | 5 | 7 | 201 |
| | Serious | 51 | 1,045 | 0 | 21 | 0 | 0 | 51 | 1,066 |
| | Slight | 338 | 1,000 | 27 | 82 | 8 | 23 | 373 | 1,105 |
| N2/N3 | Fatal | 23 | 111 | 0 | 65 | 0 | 5 | 23 | 181 |
| | Serious | 135 | 615 | 19 | 213 | 3 | 315 | 157 | 1,143 |
| | Slight | 404 | 1,413 | 184 | 693 | 9 | 42 | 597 | 2,148 |

# Potential Benefit of LDWS and LKA

## LDWS Example: Inattentive female driver, car leaves the road




Distance tree to road only 1.90m

Effect doubtful because of the distance between road and tree (reaction time)

*(Courtesy of Ford)*

# Potential Benefit of LDWS and LKA

## Casualty benefits – Head on/Leaving road/Side swipe

EU27: Estimated casualty benefit (Visvikis et al., 2008)

| Equipped vehicle type | Casualty severity | Estimated benefit – number of casualties | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Equipped vehicle | | Other vehicle | | VRU | | Total | |
| | | Min | Max | Min | Max | Min | Max | Min | Max |
| **M1/N1** | Fatal | 144 | 2,856 | 11 | 294 | 10 | 298 | 166 | 3,447 |
| | Serious | 693 | 12,249 | 123 | 3,391 | 30 | 1,468 | 846 | 17,108 |
| | Slight | 1,531 | 15,232 | 492 | 6,718 | 32 | 359 | 2,055 | 22,309 |
| **M2/M3** | Fatal | 1 | 91 | 0 | 3 | 0 | 3 | 1 | 96 |
| | Serious | 6 | 399 | 0 | 9 | 0 | 0 | 6 | 408 |
| | Slight | 24 | 222 | 2 | 27 | 1 | 6 | 26 | 255 |
| **N2/N3** | Fatal | 4 | 53 | 0 | 31 | 0 | 3 | 4 | 87 |
| | Serious | 16 | 233 | 2 | 88 | 0 | 147 | 19 | 468 |
| | Slight | 28 | 300 | 13 | 181 | 1 | 9 | 42 | 490 |
| | | | | | | | | | |
| **All vehicles** | **Fatal** | 149 | 3000 | 11 | 328 | 10 | 304 | **171** | **3,630** |
| | **Serious** | 715 | 12881 | 125 | 3488 | 30 | 1615 | **871** | **17984** |
| | **Slight** | 1583 | 15754 | 507 | 6926 | 34 | 374 | **2123** | **23054** |

# Potential Benefit of LDWS and LKA

## Feasibility - LWDS

- There are a range of systems currently on the market. The **majority of systems use a forward-looking video camera** mounted behind the windscreen. Other systems use infrared sensors or laser scanning technologies
- Current systems utilise a range of different types of warning: **visual, audible or haptic**, or a combination of these
- ISO Test assessment procedure (ISO 17361:2007) for LDWS
- Acceptability – System voluntary. General lack of data on system use (**system can be turned off**)

# Potential Benefit of LDWS and LKA

## Feasibility – LKA

- The European **market penetration of Lane Keeping Assistance systems is currently low**, because it is typically only offered as an optional extra on limited vehicle models.
- However, systems are offered currently by many of the major manufacturers: e.g. Audi, BMW, Ford, Toyota, VW, Skoda, Honda, Lexus etc., but the actual uptake of the optional extras is unknown ~ it is assumed to be low because the **optional packages that contain this feature are expensive**
- Acceptability – System voluntary. **General lack of data on system use**

# Potential Benefit of LDWS and LKA

## Benefit:Cost Ratio – LDWS

- Quality/quantity of evidence
  - Multiple specific studies and insurance data
- Benefits (EU)
  - Large range of effectiveness estimates = wide range in predicted benefits
- Costs
  - System **costs for LDWS difficult to isolate from other systems** as often packaged - Some estimates for cost between €366 to €600
- BCR
  - Large range in estimate:
  - **US insurance data shows neutral or low effect**, suggesting that BCR at the lower range; however, whether the system was active is not recorded in the claims data.
  - **TRL consider that BCR for LDW is likely to be less than 1**, although the functionality is an important 'stepping stone' to lane keeping systems and the BCR may tend towards 1 as system costs reduce

# Potential Benefit of LDWS and LKA

## Benefit:Cost Ratio – LKA

- Quality/quantity of evidence
  - Multiple specific studies and US insurance data
- Benefits (EU)
  - **Towards upper end of estimate for LDWS** (Same TP; greater system effectiveness)
- Costs
  - **LKA is typically optional and packaged with other related systems**. For example, Audi offer LDW functionality as part of Lane Assist (which also includes LKA) for approximately €480 cost to the consumer
- BCR
  - Benefit:cost ratio; wide range of estimates (for LDW):
  - **1.7-2.1 predicted by European studies** (COWI and Abele et al.)
  - M1/N1: 0.13-4.18 (Visvikis *et al*., 2008); 0.25-2.12 (Robinson *et al*., 2011)
  - **TRL consider that BCR for LKA likely to be above 1** and is toward the upper end of the BCR range predicted by Robinson et al. (2011) and possibly as high as the upper range predicted by Visvikis *et al*. (2008)

# Potential Benefit of LDWS and LKA

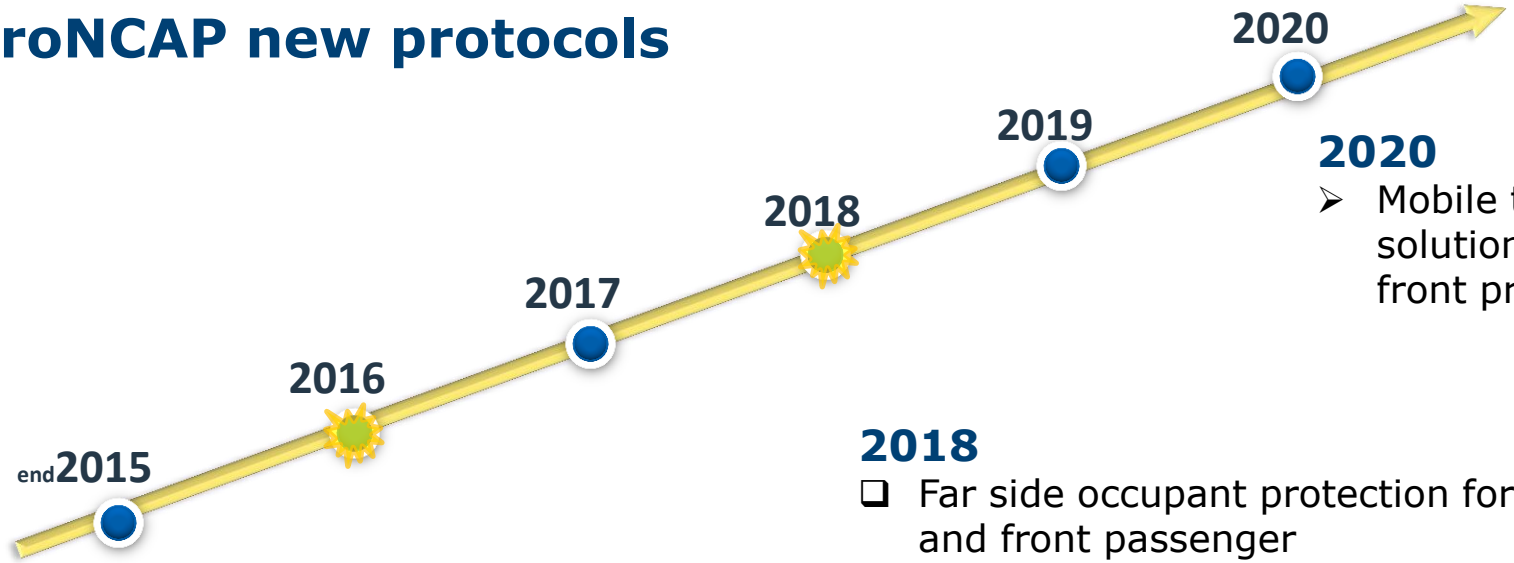
## Summary & Recommendation for GSR

| Potential new measure for GSR | Feasible? | BCR | Candidate for Legislation? |
|---|---|---|---|
| LDWS | ✓ | <1 |  |
| LKA | ✓ | >1 |  |

- Sophisticated lane guidance systems already in production
  - Mercedes E class, Infiniti Q50, Subaru Levorg…
  - Interpret and react to solid and dashed markings, overtaking and oncoming traffic etc.
- 2015 Volvo XC90 to preview advanced Run-Off-Road system

# Potential Benefit of LDWS and LKA

## EuroNCAP new protocols




### 2020

- Mobile test solution to offset front protection

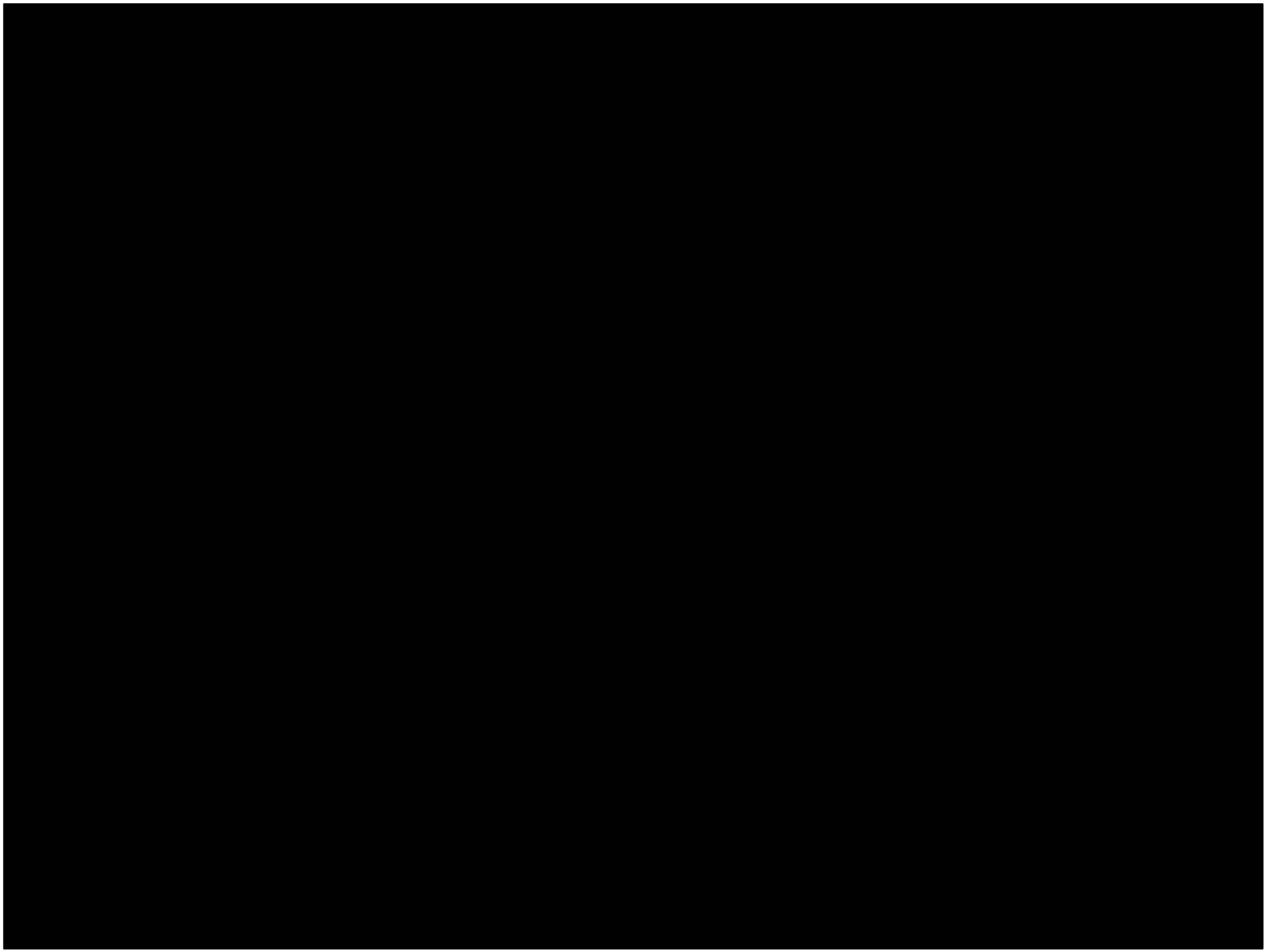
### 2018

- Far side occupant protection for driver and front passenger
- Updated AEB CCR – Offsets and New Barrier
- AEB for pedestrians and pedal cyclists in daylight, darkness
- **Lane Keeping Run Off Road Test Procedure**
- Junction Protection
- Safety critical HMI guidelines

### 2016

- Rear seat occupancy & CRS detection
- Whiplash Test Revision
- Update to Speed Assistance Systems
- 6 and 10 year old child in frontal and side
- **Lane Keep Assist Assessment**

# Potential Benefit of LDWS and LKA



*(Courtesy of Thatcham)*

# Thank you
# Any questions?

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