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Agenda item 2(b)

Overview of LDW / AEBS research for the EC

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Introduction

- Definitions
- Objectives and limitations of the studies
- AEBS
  - System functions
  - Technical requirements
  - Assessing the benefits
- LDW
  - Technical requirements
  - Costs and benefits

Definitions used in the research

- Lane Departure Warning (LDW) systems monitor the position of the vehicle with respect to the lane boundary. When the vehicle is in danger of leaving the lane unintentionally, the system delivers a warning to the driver
- Lane Change Assist (LCA) monitors the areas to the side and rear of the subject vehicle and warn the driver if a change of lane is commenced that could cause a collision with a vehicle in the blind spot
- Lane Keeping Assistance (LKA) is a LDW that takes additional action (e.g. active steering, braking corrections) to help the driver avoid leaving the lane unintentionally
- Automated Emergency Braking System (AEBS) is a generic name for any system that can apply emergency braking independent of driver control
- Collision Mitigation Braking System (CMBS) is a system that can autonomously apply emergency braking in order to mitigate the severity of a collision that has become unavoidable
- Collision Avoidance Braking System (CABS) is a system that can autonomously apply emergency braking in order to fully avoid a collision.

Objectives of the studies

- To gather and evaluate information regarding the technical requirements, costs and benefits of the systems, with respect to application to different vehicle types:
  - Light vehicles (M1 and N1);
  - Heavy goods vehicles (N2 and N3)
  - Large passenger vehicles (M2 and M3)
  - Considering the benefits to:
    - Occupants of the equipped vehicle;
    - Occupants of vehicles in collision with the equipped vehicle; and
    - Vulnerable road users (VRU) i.e pedestrians, pedal cyclists and motorcyclists
- Both studies were desk-based, limited to analysis of existing literature, consultation with industry and accident data analysis

Key characteristics of LDW systems

What requirements are needed in the following areas?

Sensor technology	▪ Should there be specific requirements for the types of sensor that can be used?
System behaviour	▪ What speed should the system function at? ▪ What road curvature should the system function on? ▪ Where should the warning threshold be?
System capability	▪ What type of boundaries are detectable ▪ What Weather/environmental conditions should the system function in?
Human-machine interface	▪ How should the warning be presented? ▪ What status information should be indicated to the driver and how? ▪ How much driver control and adjustment of the system should be permitted?

Existing technical requirements (LDW)

Two technical standards for LDW identified

ISO 17361:2007	FMCSA-MCRR-05-005

▪ Specifications, requirements and test methods for passenger cars, commercial vehicles and buses
▪ Functional elements:
  ▪ Lateral position detection
  ▪ Warning
  ▪ Status indication
  ▪ *Suppression request*
  ▪ *Vehicle speed detection*
  ▪ *Driver preference*
	▪ The Federal Motor Carrier Safety Administration Concept of Operations and Voluntary Operational Requirements (USA)
	▪ Large trucks >10,000lbs
	▪ Main functional elements same as ISO 17361 (different terminology)

Questions for consideration (LDW)

- ISO 17361:2007 has different performance limits for commercial vehicle and cars, is this appropriate?
- Current performance specifications do not include function in adverse weather conditions. Is this necessary/feasible?
- Two classes of LDW are permitted, based on minimum radii and speed for which they are functional. Should both be permitted?
- Warning can occur before or after lane boundary crossed. Effectiveness vs false alarm balance? Where should the regulation draw the line?
- Lane boundaries in tests must be “in good conditions and in accordance with applicable national standards for lane marking design and materials” i.e. one type in good condition per country. How should this be assessed given a single approval for multiple regions and possible diversity within a region?

Relevant accidents (LDW)

Three groups of accidents identified

Head-on (A)	Leaving road (B)	Side-swipe (C)
▪ Accidents on single carriageway roads where the VOI has drifted out of the lane of travel into an oncoming lane, where a collision has occurred.	▪ Accidents where the VOI leaves the lane in which they are travelling, resulting in the vehicle leaving the road or colliding with roadside barriers. ▪ These accidents tend to be single vehicle, but can also involve VRU	▪ Accidents on carriageways with multiple lanes in the same direction. The VOI leaves the lane and there is a collision between the VOI and a vehicle in the adjacent lane (either side to side or front to rear of VOI).

- Target population data for GB and Germany extrapolated to EU
- Effectiveness data taken from literature and applied to target population
- Variation in GB/Germany data combined with wide range of effectiveness in literature led to wide range of predicted effects

Estimating benefits (LDW)

Annual casualty benefit – LDW on N2/N3 vehicles

Casualty severity	Target Population (A+B+C)	Effectiveness (% of target population)			Total Benefit
		A	B	C	
Fatal	23-181	16-48	48	16-48	4-87
Serious	157-1143	12-36	36	12-36	19-468
Slight	597-2148	7-20	20	7-20	42-490

Annual casualty benefit – LDW on M2/M3 vehicles

Casualty severity	Target Population (A+B+C)	Effectiveness (% of target population)			Total Benefit
		A	B	C	
Fatal	7-201	16-48	48	16-48	1-96
Serious	51-1066	12-36	36	12-36	6-408
Slight	373-1105	7-20	20	7-20	26-255

Casualty valuations

Fatal €1,000,000
Serious €135,000
Slight €15,000

Costs

Only retail costs identified

Retail prices	Unit cost used in analysis
€384 - €448 from various manufacturers information	€200-€448
€300 Abele et al (2005) for 2010	
€200 Abele et al. (2005) for 2020	
€200 COWI used €400 for combined system	

Benefit-cost ratios (BCR)

Assuming mandatory fitment in 2013

Vehicle type	Limit	BCR
N2/N3	Min	0.18
N2/N3	Max	6.56
M2/M3	Min	0.47
M2/M3	Max	23.97

Characteristics of AEBS

- Current systems (2006)
  - Mitigation systems
    - Front to rear shunt collisions with other vehicles and some fixed objects
    - No operation at very low or very high speeds/relative speeds
    - Limited function in adverse weather conditions
    - Curve function limited to line of sight
    - Varying strategies – partial braking applied early to full braking applied late
  - Avoidance systems
    - Low speed function (<20 km/h) only
    - Other characteristics as for mitigation systems
- Future systems
  - Expanded functionality e.g.
    - Pedestrian, junction & head on collisions (latter two may require V-V/V-I communication

Technical requirements

- In 2006, only one set of Technical requirements in existence (MLIT guidelines – Japan)
  - Prescribed activation thresholds based on TTC, steering and braking capability
  - Defined minimum levels of automated braking
  - Not all EU models would have complied
  - Good basis but further development required
- ISO standard under development but not available for review
- No published data identified to assess whether a risk of sensor interference in situations where multiple equipped vehicles were present

Assessing the benefits - CMBS

- Two extreme sets of 1st generation CMBS characteristics were defined
  - Partial braking applied late
  - Full braking applied early
  - Neither system expected on market but all realistic systems will fall between the two.
- UK in-depth fatal accident data analysed to predict potential effect of the two “extreme” systems fitted to HVs.
  - Total number of fatal accidents on database >1,800
  - 70 cases met selection criteria (e.g. front of HV to rear of other vehicle, not snowing, speed information present etc.)
  - Collision speeds re-calculated according to system characteristics
  - Estimated 25%-75% of fatalities in front to rear shunts could be mitigated
- Similar approach undertaken for light vehicles but insufficient cases on in-depth database for conclusive result.

Scoping the potential future benefits - AEBS

- "what if" scoping study undertaken to assess the future potential of more developed systems.
  - Based on target population data from GB STATS19 extrapolated to EU using EuroSTAT. Divided by
    - Vehicle class fitted to (M1,2,3; N1,2,3; L)
    - Accident configuration
      - Front to rear of other vehicle
      - Head on collisions
      - Collisions with fixed objects on/off the carriageway
      - Collisions with pedestrians
      - Front to side collisions
  - Casualty estimates reflect the potential ***IF*** systems could be as effective as 1st generation (HV) systems when fitted to other vehicles and when involved in different collision types (i.e. 25%-75%)

Benefits and break-even costs

Vehicle class AEBS fitted to.		System class		
		Current	**Near future**	**Longer term**
M1	**Fatality reduction**	313 – 1,149	2,043 – 7,489	1,349 – 4,946
	Break even cost (€)	26 – 216	136 – 966	96 – 703
M2/3	**Fatality reduction**	4 – 14	96 – 351	55 – 202
	Break even cost (€)	197 – 1,731	1,732 – 12,324	871 – 6,217
N1	**Fatality reduction**	44 – 160	148 – 543	185 – 681
	Break even cost (€)	26 – 182	68 – 443	76 – 500
N2/3	**Fatality reduction**	102 – 372	180 - 659	319 – 1,170
	Break even cost (€)	314 – 1,475	432 – 1,938	773 – 3,481
L	**Fatality reduction**			618 – 2,265
	Break even cost (€)			1,322 – 5,704

- Positive BCR more likely for heavy vehicles
  - Front to rear shunt accidents much more severe with HVs than with light vehicles
  - Costs applied to c.1/50th of the number of vehicles

Conclusions

- For both LDW and AEBS casualty benefits greater if fitted to cars but BCRs greater when fitted to heavy vehicles
- Considerable diversity in technical specifications and performance
- Particularly for AEBS, future developments have more casualty reduction potential than 1st generation ***if*** they can be developed effectively
- Technical requirements are more developed for LDW than for AEBS but further development likely to be needed for both

Examples of areas for further consideration

- Generations
  - Both concepts are likely to be developed in different “generations”
  - Varying performance capabilities already exist (e.g. different classes in LDW ISO, LKA, mitigation or low speed avoidance for AEBS)
  - What functions/generations should be considered in scope?
  - What should the performance limits for those functions be?
  - How can the requirements best be implemented without stifling future development of the next generation?
- In service performance