Conférence Européenne des Directeurs des Routes

Conference of European Directors of Roads

Incident management and safety at road work locations

CEDR Project Report 2023-01

June 2023

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CEDR Project Report 2023-01 is an output that is authored by **Jan Van Hattem, Senior Consultant at Rijkswaterstaat** which is the executive agency of the Dutch Ministry of Infrastructure and Water Management together with CEDR's Working Group 3.1 Road Safety. The Working Group's main goal is to develop and share knowledge among European NRAs and develop coordinated activities on the improvement of safety of road networks.

The Working Group consists of technical experts on road safety from more than 25 European NRAs. The Working Group Chairs are: **Jeremy Phillips, National Highways, England** and **Alastair de Beer, TII, Ireland**.

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Executive summary

Incidents with road workers and incident responders have enormous consequences not only for those involved but also for their family and organisations. Road authorities and emergency organisations strive to improve the workers' safety within their influence where possible. By doing so they have reached the conclusion that cooperation with the car industry is a necessity for further improvement on issues outside their influence like AEBs. Preceded by tests, a feasibility study and work within the UNECE HGV taskforce, an event in Lelystad in October 2022 was meant to be the start of a dialogue between industry and road authorities.

The demonstrations at the event illustrated the issues and possible solution directions. These have been discussed in detail by the participants. The discussion has led to more understanding and respect of each other's responsibilities, opportunities and challenges. It is up to the participants to actually follow up the event and to improve safety for all on our roads.

Vehicle automation will not stop but needs more steering. Road authorities need to take an active role in this and interact with the vehicle industry.

1 In brief

The international event on the safety of road workers and emergency personnel took place on the 5th and 6th October 2022.
The event was organised to address the growing road safety concerns caused by driver behaviour, unsafe use of support systems and possible risks of automated vehicles. Individual Road Authorities have little options to cope with these developments. They need to work together and reach out to other parties, the automotive industry in particular to increase the safety for both the workers on the road and the road users.
More than 70 attendants participated in the event among which Road authorities, Automotive industry, delegates from European Commission, Contractors and equipment manufacturers.
Demonstrated and discussed were the uniformity of the equipment and vehicles, enhancement of the detectability by using extra reflectors on existing objects or separate objects, communication like C-ITS and other innovations as well as other situations where AEBS could be relevant.
The discussions and the workshop took place at the RDW Test centrum in Lelystad in an atmosphere of mutual respect and resulted in more understanding of the urgency of the issue.
Suggestions made at the workshop are added to each subject. These are the basis for the proposed next steps mentioned in the final chapter. These have been drafted after the event for further discussion.
Incident data provided by road authorities and the discussion on how to deal with those as well as human factors and use of procedures like Fend-off are discussed in a separate report.
Effects of disturbing lights at road works were investigated in the nightly program. The light measurements made at the event are also reported separately.

1.1. Reasons for the event

Increasing road use and aging infrastructure increase the number of necessary road works. Inattentive drivers are a real and growing danger to emergency personnel and road workers alike. To warn drivers and to provide road worker safety the road operators developed procedures and also made their equipment stand out using bright patterns of reflective materials, warning lights-, flashers, road signs and special structures.
The equipment and procedures have been designed with the human driver in mind. Their effectiveness depends on the driver to be attentive. As drivers are tempted to be distracted by smartphone and rely more and more on the support and safety new vehicle systems offer it is vital that these systems are able to detect road works and emergency workers. The detection has to be robust and initiate appropriate action. In case a collision is eminent the AEB system should be triggered.

1.2. Previous tests by Rijkswaterstaat

For better understanding the response of current AEB systems (on trucks) toward various objects, RWS performed several tests with both trucks and passenger cars equipped with an AEB system[1][2][3]. Tests in 2020 in cooperation with RDW[4] showed it is concluded that the tested vehicles generally respond well to the European Vehicle Target (EVT), the Jetta soft target and a flat foam target. The trucks tested responded well to a truck-trailer. A less consistent AEB response was found for the other test objects, such as road inspector vehicles (so called WIS cars and motorcycles), collision absorbers and mobile road signs. Tests performed also showed inconsistent AEB responses towards more common passenger cars. The tests performed by RWS did not provide conclusions on the origin of the inconsistent performance. For safety reasons the earlier experiments, were performed in such a manner that mainly the Forward Collision Warning (FCW) could be activated, and not yet an AEB activation. The latter experiments in 2019 and 2020 did involve tests up to impact.
Adding a corner reflector to the road work equipment to make it look like the crash cushion leads to recognition as a car by the AEB system and triggers the braking action. However as camera's are added to the AEB systems and as the systems are further refined to halt for more categories like bikes and crossing pedestrians and to prevent unjustified braking attaching of corner reflectors is no longer effective. The industry even warms that ill-considered placement of such reflectors might provoke unjustified alarms on adjacent traffic lanes.
This led to the question whether a more robust solution to trigger an AEBS reaction was feasible.

1.3. Feasibility study AEB system smart marker

In 2021 Rijkswaterstaat and RDW requested TNO to investigate the feasibility of the development and usage of a so-called smart marker. This project analyzed the potential effect of an additional marker on roadworks to decrease the number of trucks crashing into them. An expert workshop with 29 experts provided the project with input from the industry. Based on the feedback from the workshop it was decided to perform the feasibility study and effect analysis not only for a standardized AEB marker, but also consider other solutions to improve performance of AEB systems at road works. The final report was shared with the UNECE. The feasibility study was input for this event.

1.4. UNECE HGV Informal working group

The UNECE working group 29 is the World Forum for the regulatory framework to make vehicles safer and more environmentally sound.[5] This is where technological developments are debated and decided upon. New vehicle regulations have to be accepted by each country (or contracted party in UNECE terms). The EU operates as one country. The acceptance of new vehicle regulations lies with the European Parliament

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[1] Practical Test of the Detection of Trucks for the Advanced Emergency Braking System, Klem, E., et al, Royal Haskoning DHV, Dec 2017.

[2] Field Test to the visibility of traffic control measures for Autonomous Emergency Braking Systems, Hattem, J. van, et al, Rijkswaterstaat, Klem, E., et al Royal Haskoning DHV, Dec 2017.

[3] AEBS and Traffic Measures 2", Gorter, M., et al, Royal Haskoning DHV, Feb 2019.

[4] AEBS marker testing, Michel van Laarhoven, RDW 2019.

[5] Vehicle Regulations | UNECE

and European Council. Road Authorities can reach out to their policy department or to the national organisation that represents them in the UNECE Working group or contact the Task force directly. Acting in unity within CEDR would be most effective.
Within Working Group 29 special interest groups dealing with specific topics. One of these is the Informal working group (IWG) on Advanced Emergency Braking System for Heavy Duty Vehicles

AEBs had as original focus prevention or mitigation of the collision of trucks shunting into a traffic jam. The changes in the regulation are summarized in the annual report of BASt[6]. (also part of the background information supplied to the participants prior to the event)

The terms of reference of the IWG included: “Investigate the feasibility of a generic marker triggering AEBS reaction with the purpose to increase safety in road servicing areas and at railroad crossings.” The result of the feasibility study has been discussed in the Taskforce in March 2022.
The IWG expressed its doubt about the choice for the smart marker in the feasibility study and missed the input form the industry.

Other comments were:

- Missing data and root cause analysis on incidents.
- Adding reflector: effect on object separation and object classification, could hinder working AEB system or result in false triggering. Precautions for misuse, temporary solution.
- Training recognition existing systems: the huge variety and little existence of training data of service vehicles may be an obstacle.
- Needed list of specific object to be considered, relevant features for different sensors.

To discuss these doubts and to exchange information the suggestion for a dialog was welcomed by the industry. Experts from the industry have actively contributed to the event.

1.5. CEDR

CEDR is an organisation of European national road administrations[7], it is the platform for Road Directors and National Road Administrations that facilitates, reliably and effectively:

- Benchmarking and sharing of knowledge and best practices,
- Collaborations and sharing of resources in joint projects,
- Professional networking and competence building.

The event was organized in close cooperation with the CEDR safety working group. Working Groups within the CEDR organization are groups of experts working together on specific subject areas relevant for National Road Administrations (NRAs). The groups are domain-specific and focus on concrete tasks and deliverables with the aim to achieve specified goals.

The CEDR road safety working group facilitated a webinar on this subject on 24 June 2022. At this occasion Rijkswaterstaat presented the findings from the TNO feasibility

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[6] Emergency Braking system for Heavy-duty vehicles – adapting international regulations, Dr. Patrick Seiniger, Daniel Sander, BASt annual report 2021.
[7] CEDR

study and the comments from the UNECE HGV IWG. The Members of the CEDR safety working group expressed their concern and agreed on the need for a dialog with the industry on the safety of road workers and emergency personnel. The event reported here was organized by Rijkswaterstaat with support from CEDR, RDW and TNO.

1.6 Information provided prior to the event

The following information was prepared for the event:

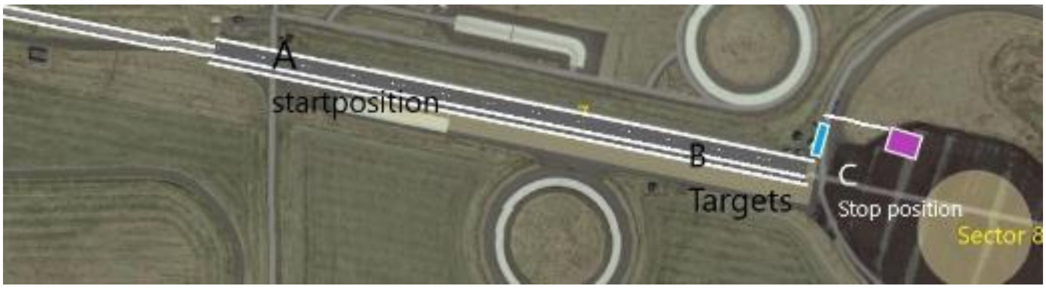
- Webinar to the CEDR working group on 24th June 2022. Recording available at CEDR member website and a PowerPoint-presentation from Rijkswaterstaat.
- Booklet with background information on:
  - road works and procedures,
  - incident data provided by members,
  - information on AEBS
  - the draft program of the event.

Original available from Rijkswaterstaat, Incident data gathered also in a separate report by Michel Lambers. Human Factor Safety Consultants.

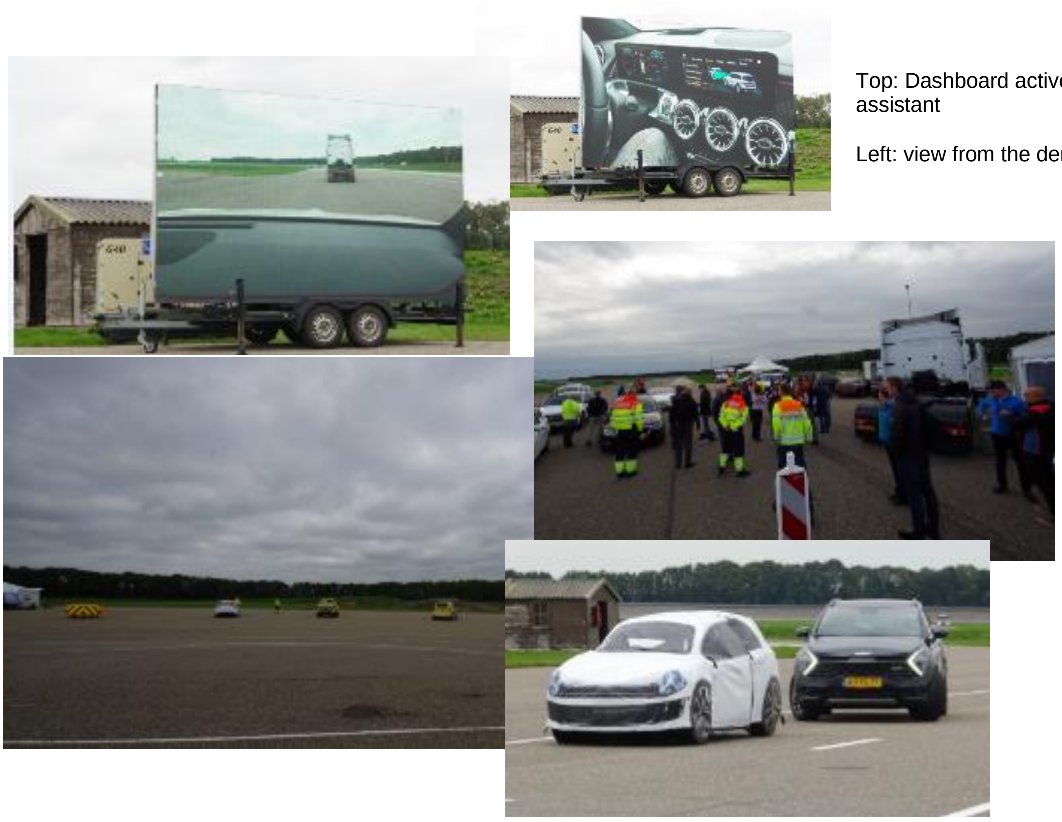
videoverslag AEBS en verkeersmaatregelen
https://youtu.be/qyeyUd7ayYk

2 The event in pictures

Overview



A large screen provided a view inside the demonstration car.

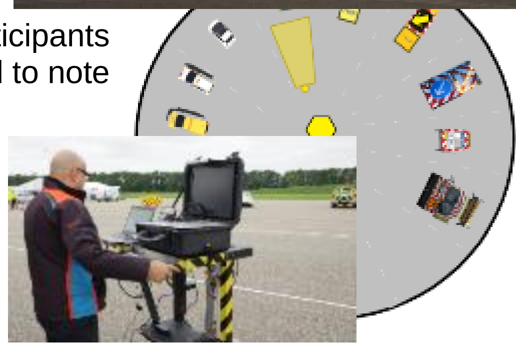


Top: Dashboard active brake assistant

Left: view from the demonstration car

3 Demonstration of vehicles and equipment

Uniform properties of vehicles and road equipment facilitates fast and reliable automatic recognition.



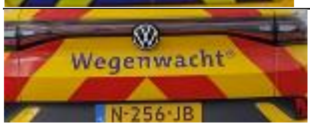
The visual and radar properties of the vehicles in use at incident and road work locations were compared. The vehicles were placed in a circle with the backsides towards the middle. Participants could observe from the middle and walk around to note the common characteristics and differences.

Also three posters with various Truck Mounted Absorber (TMA) models were available as reference and are part of this paragraph.

3.1. Visual variation

One of the solution directions analysed in the feasibility study is the explicit inclusion of road work objects into the AEB development and testing, assuring that these types of objects are detected correctly and classified accordingly by the AEBS. In this part we investigate the challenge of further standardization. The aspects of image recognition that could be relevant are described in chapter 3 of the feasibility study.

3.1.1. Striping vans and cars

Cars and vans	Some observations on striping (vehicles present at the event)
	Direction of the striping can be ////\\\\ or \\\\V////
	Colour: orange, blue, red, combination red/blue
	License plate inside the striping or beneath, car lights always visible.
	Width: small variation in width.
	Striping surface differs considerably between vehicles Remark: Car transporters have hardly any room for striping

3.1.2. Messages signs

Vans and cars:
message signs, arrows

Observation: Large variation in messages, light sources used, signs, sizes and position.
(first and last pictures marked with *were present at the event, others are added from Internet)

 *

*

*

*

3.1.3. TMA’s and arrow cars

TMA and arrow cars


*


*

*

Cushion/ lower part.

Direction of striping ///\\\

Colour striping red or orange

Format of striping and width: a wide variety

Alternative: squares; yellow on red, red on white.

Background colour: yellow, red, light red, white

License plate: different positions not always visible

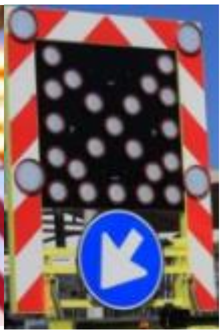
Specials like skids do not have any striping

The extra panel visually blocks the adjacent lane.

*= Vehicles present at event other pictures are excerpts from posters at the event

Directions and signs on TMA and arrow cars






Pictures are excerpts from posters at the event

Observations

The arrow consists of separate lamps. These can be part of the frame. The frame itself can be open or closed with a black background. Extra flashers can be added for visibility from a longer distance.

Only in some cases there is a red/white frame around the back.

The direction sign (arrow) varies considerably in size. In one example it is replaced by the more general warning sign. The road works warning sign is sometimes added.

3.1.4. Work vehicles

On the back side of various road work vehicles a smaller version (of the arrows/warning signage) consisting of a frame with four alternating lights is used.


Pictures are from Internet and not present at the event, included for completeness of the overview.

3.1.5. Vehicles on site in Lelystad

Various brands: Wagenaar, Nissen, Scorpion, Tesla, several test cushions representing these models from Moshon Data.
The radar reflection and classification is discussed in the next paragraph.


30/- dbm^2
Point


35/-dbm^2
Point


32/- dbm^2
Point


15/- dbm^2
Point


33/13
Car


26/15
Car/Point

22 / 13dbm^2
Point


33/17
Car

23,5/ 14,5dbm^2
Point


. dbm^2
Car


.
Car

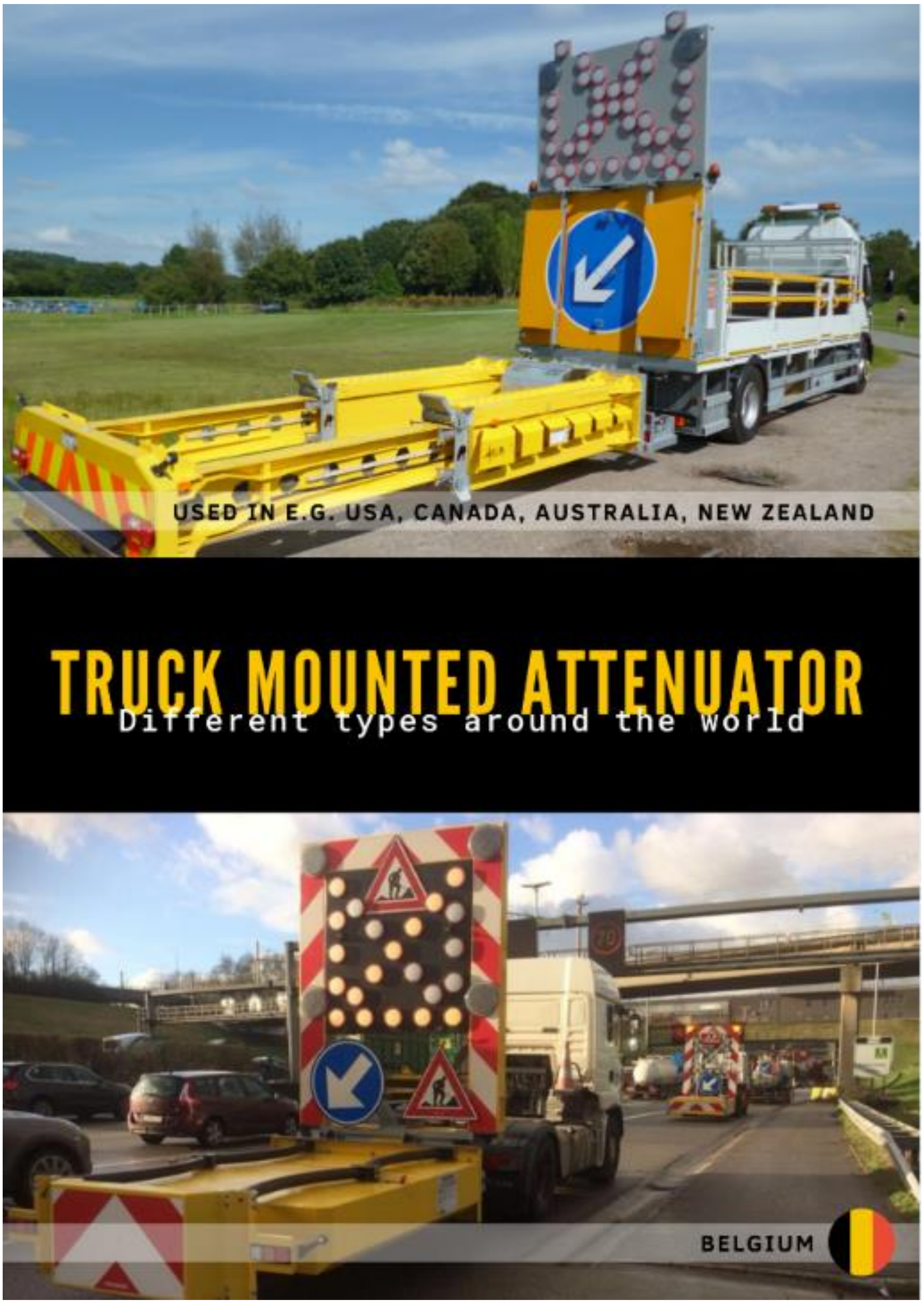

36/- dbm^2
Car/Point

Numbers show the RCS straight/fend-off in dbm2

In several cases the radar could not classify the vehicle as a vehicle. Please note that both the vehicle and the radar were stationary which makes classification more difficult.

Posters displayed at the event for reference with TMA's supplied by Verdegro


QATAR
SWEDEN (FIRE DEPARTMENT)
OLYCKA
DENMARK
HUNGARY
CONVOY VEHICLE NO OVERTAKING


USED IN E.G. USA, CANADA, AUSTRALIA, NEW ZEALAND
TRUCK MOUNTED ATTENUATOR
Different types around the world
BELGIUM

3.2. Vehicles at the event in-fend off visual

Striping varied in several ways: design Batenburg (blocks) or lines, angle /// or \\\, colour. No classification as a vehicle was made (see previous remarks).

3.3. Conclusions and visual assessment

The variation in visual appearance is quite large for all objects. As discussed in the feasibility study this increases the effort needed to for camera recognition. Standardization or the adding of specific identifying features could help to decrease development time.

To know what would make the road work objects to be detected by camera based sensor systems easier requires knowledge from experts in that particular field.

Is more uniformity necessary?
The largest variation is seen with cars and vans used by first responders. As they operate in live traffic they are exposed to high risk.
Even when placed within the driving lane it is unclear to what extent the extra striping, signs and lights renders recognition by a camera sensor as a car or van more difficult. Extra research is needed to find out how much uniformity is needed and how standardisation can be realized.

3.4. Radar properties

Cars, vans and TMA's
At the event the radar reflection of the various vehicles was measured. This is expressed in the Radar Cross Section (RCS)[8]. The reflection and the classification are both added to the pictures of the vehicles on display. The reflection shows a large variation. This can be heavily influenced by the measurement angle, particularly on a large flat surface like a TMA.
The outcome illustrates that the radar used does get a reflection but it is not able to classify it as a "known object". It should be noted that more advanced systems not only use RCS for classification.
It should also be noted that both the object and the radar were stationary which makes it harder for the radar to do correct classification. Under more realistic conditions – driving in live situations - the classification with radar and or car moving classification should be considerably better.

Other road work objects
Objects like cones, rumble strips or beacons are made of plastics. These have a low RCS value to keep the data manageable stationary object with a low RCS might be dropped. Camera and LiDAR should be able to properly detect them.

Illustration: 2017 high speed incident on beacon.

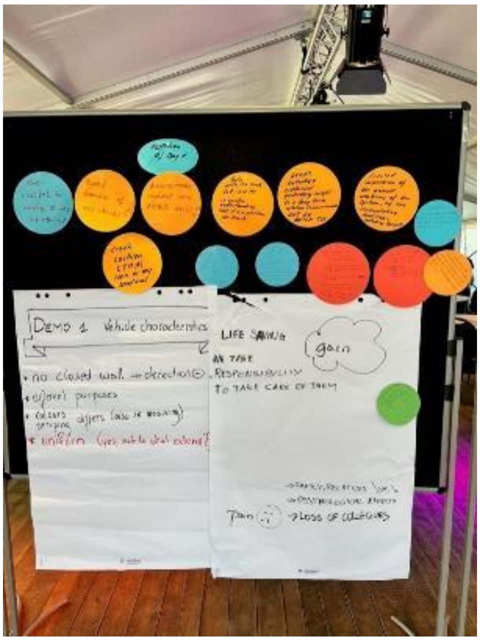
[8] Radar cross-section - Wikipedia

3.5 Observations from participants

The observations and remarks were gathered in a lively discussion during the workshop. As shown on the picture some remarks were quite short. e

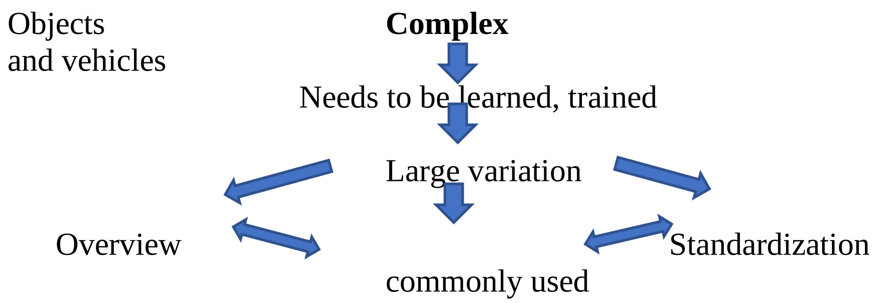
Remarks given on vehicle characteristics:
- No closed wall (canvas) behind the arrow hinders detection
- The different purposes increase the variation
- Differences in colours and striping
- How much uniformity is needed
- The crash cushion on the TMA is seen as very beneficial
- The Crash properties are defined in European standards
- Awareness is needed on how AEBS actually works
- Uniform Road services and emergency procedures
- Standardization of striping of vehicles
- Uniformity of the road work vehicles should be improved.
- We need to start from accidentology, using a feed back loop/ information sharing to co-develop a TMA with road worker safety as a central objective.
- Do not forget to take into account all users.

Some observations overlap with the ones on fend-off.

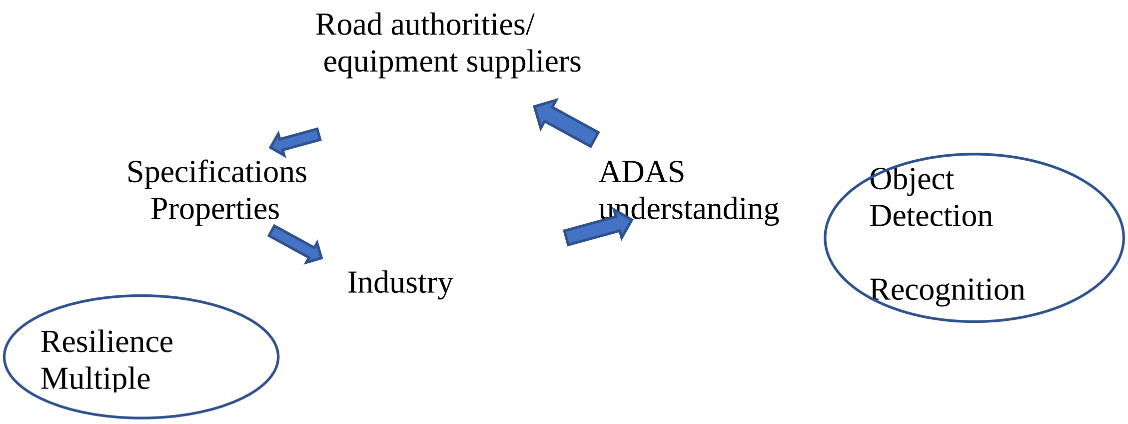


These schemes resulted from the discussions:

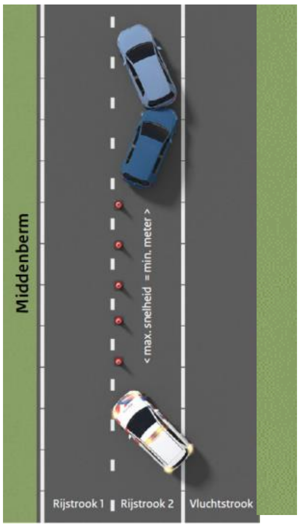
Improve object detection by learning specific objects and situations like fend off
The systems can learn to detect the complex situation only the large variation makes this more difficult. Standardisation of the most commonly used objects would contribute.



Information Sharing
How the automotive systems works and what would be needed to make objects better detected is not known by Road Authorities and equipment suppliers. On the other hand what objects are used by them is not known by the industry. Information sharing is needed.



4 AEB reaction on Fend-off



Introduction

Placing of an emergency vehicle under an angle has several functions:
It functions as a buffer and in case of being hit by an vehicle from the back it will be pushed sideward instead of into the direction of the incident. It also signals to oncoming drivers that it is in a stand still position.

In the fend-off position the surfaces reflecting the radar are also under an angle. This results in a much smaller reflection surface which is gravely influenced by the angle. The shape of the reflection surface differs also from a standard tail end of a car.

4.1. Demonstration

At the demonstration the Balloon car was placed in three positions:

- in-lane,
- fend-off at a small angle within the lane boundaries
- fend-off at a larger angle on the lane boundary, blocking two lanes.

The Balloon car was approached by the test vehicles several times at low speed (<40km/hr). In a number of runs the driver was in full control which might have resulted in disarming the AEB system. The demonstrations should be seen as illustrations as only one of the drivers was a professional test driver and the setup was less controlled than at regular tests. The runs during which the human driver interfered with the controls are excluded from the results, as small input can “switch-off” the AEB.

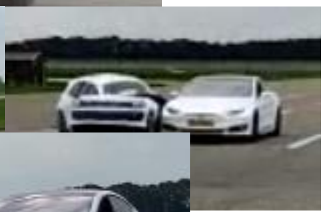
Vehicle	Target Balloon car straight	Fend-off in lane	Fend-off on lane markings – not fully blocking the lane
Car 1	Stop at low speed,	Hit	Hit
Car 2	Stop	Stop	Hit
Car 3	Stop	Hit	Hit
Car 3, LKS and ACC on	Stop	Stop	Hit with reduced speed
Truck	Stop	Hit	Hit
Truck, LKS ACC	Stop	Stop	Hit
Car 4	Stop	stop	Hit
Car4, LKS, ACC on	Stop	Stop	Hit
Car 5	Stop	Stop but with a slight hit	Hit

Car 5, LKS, ACC	Stop	Stop	Slow down and Stop

Photographs


Fend-off in lane: stopped with a slight hit.

Fend-off on lane markings: hit

Fend-off in lane: stopped with a slight hit.
On lane markings: hit

Fend-off on lane marking with LKS, ACC engaged: slow down and stopped.


Fend-off in lane: stopped
Fend-off on lane markings: hit

Fend-off in lane: stopped

Conclusion from the demonstrations

When placed straight all AEB equipped vehicles stop. When the target is placed under an angle vehicles most versions of AEB hit it. More advanced types with LKS and ACC stopped in time or only hit at low speed.
When the vehicle was placed on the lane marking, it was hit even by the most advanced types. However with all automated functions on the Tesla stopped even when the lane was partially blocked. As the speed during the demonstrations was below 40km/hr there is no certainty that the systems show the same behaviour at higher (highway) speeds.

4.2. Observations of participants

During the discussion notes were taken and participants wrote down their observations on each subject. Their input is summarized below. Please not that these can be individual opinions that are not always widely held.

On the test setup:

- The demonstrations use 1 truck and 4 passenger cars, earlier understanding was that running into road works is a specific truck problem.[9]
- Of the vehicles used only the truck has a mandatory AEB system.
- It is difficult to understand what happens when you do not know what happens if the brake was hit by the driver or the car. The information must be clear.
- The briefing of test drivers: they should not have interfered with the control systems of the car.
- The target did not meet all requirements defined in the ISO vehicle standard.
- AEBS is designed for specific test cases: rear-end collision, pedestrian crossing, bicycle on road.

General:

- Systems react not for cars in fend-off and others.
- Fend-off should be avoided.
- What angles are used in fend-off, how much fend-off before it crashed?
- Fend-off is a challenge for radar only systems -> define usage
- The most hazardous situation is when an emergency vehicle is pulled over at the hard shoulder partly occupying the ego's vehicle driving lane. We didn't test such cases.
- Next generation vehicle do not know of road services or measures without standards.
- Created impression of the overall weakness of the system, by non-representative conditions including target.
- Test demonstrates that many cases are not detected, is the target the Balloon car and did all the vehicles stop for the rear end collision –JvH yes all vehicles in the demonstration did first stop for the rear of the test object-

Remarks made at the discussion:

- Truck manufacturers operate in an extremely competitive market.
  Safety features present in passenger cars like airbags are hardly purchased in the truck market.
- Incidents with road works or emergency personnel are relatively less frequent than other incident types. Other safety area's like pedestrian and bike recognition have a larger safety impact in numbers. The resources of the industry are scare and used where they have the most benefit.
- Road works and fend-off position are not part of the Euro NCAP safety rating.

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[9] comment JvH: Both passenger cars and trucks are effected; trucks are seen as the largest safety risk because they are hard to stop and have a large impact. It was not feasible to have more trucks at the event.

- How the systems work is part of the intellectual property of the manufacturers. This makes sharing of technical knowledge of sensor and vehicle systems more difficult.

5 Adding radar reflectors

Due to the windy conditions during the days at the test site several demonstrations had to be cancelled but instead these topics were presented at the meeting.

5.1. Adding a corner reflector to existing equipment

The Feasibility study[10] provides an adequate description of this solution direction:

" Placing a marker on the roadworks objects to make it more easily detected has several aspects to be considered. The marker should be relatively small in terms of the output generated in order to not hide the key features for detection of the roadworks object itself. For camera systems this could be a high contrast marker (like a QR code) to be placed on the roadworks object. The best estimate is that it should be a similar size as other key features camera systems use to detect objects, which include number plates, lighting units and wheels.

[10] TNO report | TNO-2021-R11992 | final v3 21 / 42

For radar systems a corner reflector could be used. This reflector will send the transmitted radio waves by the radar directly back to the receiver, where it will be picked up as a point like image. This will greatly increase the roadworks object's radar reflectivity and therefore its potential visibility. A similar reflector, based on light instead of radio waves, can be used for lidar systems."

- Existing and older AEB systems are known to react to a larger reflection caused by the corner reflector.
- Newer AEB systems require that the reflected radar profile represents an actual object to prevent false positives. Increasing the radar reflection could in this case have a negative effect on recognition.
- The industry warns that potentially extra reflections could result in false alarms on adjacent lanes. Ewe have not been able to reproduce this on the test track.

Based on the effect on the older AEB systems corner reflectors are placed on road work vehicles by contractors in the United Kingdom and the Netherlands.
Due to the conditions at the test track the effect could not be demonstrated at the event.

5.2. Remarks by participants

- Be careful to modify existing object f.i. using reflectors
- Risk of making things worse blinding radar recognition.
- Contractor: Do something/ anything now TMA "should" be simpler.
- Travel to site- relocation of use "like blue lights"
- Prioritise cases, risks, dangers, TMA is information not just protection.
- Systems should not confuse drivers
- "magic a TMA into a car"

Opportunities:

- Fleet penetration of AEBS most km's with modern truck
- Digital twins of NRA.

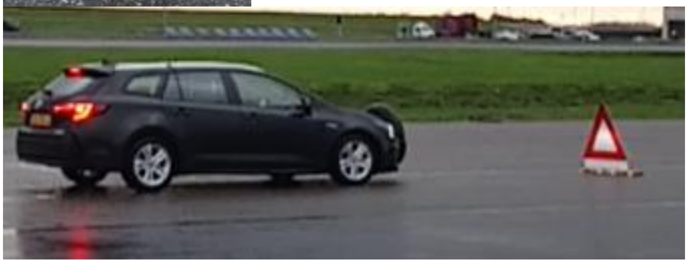
5.3. Prototype Smart Marker

A stand-alone marker is positioned at a distance f.i. 50 meter from the road works. It should be detectable by radar, camera, lidar and fused systems. It should also be clearly visible and recognizable for human drivers. When accidentally hit this should result in minimal damage and not cause any flying objects.
In the past several objects have been tried and failed[11][12]. The experience was used to produce a prototype smart marker for this demonstration.
This consists of a slab test target with two extra corner reflectors at a distance behind it. On some AEBS this will trigger a reaction comparable to a full size test object like the Balloon car. As it still is a prototype it didn't fulfil the requirement of wind resistance. This made it impossible to demonstrate at the RDW Test centrum. Instead the back of the balloon car was used. This object is not yet the smart marker but has some of the properties to trigger the AEB system of a car coming straight behind.

[11] AEBS marker testing, Michel van Laarhoven, RDW 2019
[12] AEBS reaction on road works, Rijkswaterstaat, 2017, 2018.

Radar reflector on pole

Car approaching slab target



Reflector placed on warning triangle on previous tests

On transport fixed to the vehicle

5.4. Remarks made the participants on the stand alone smart marker

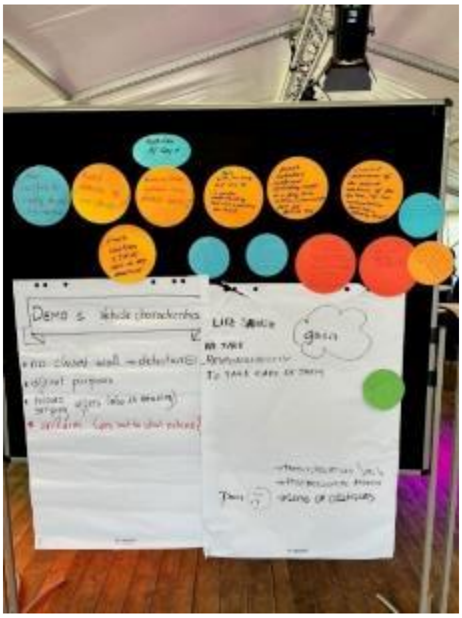
During the workshops remarks were gathered, these served as input for the discussions and may not always represent widely shared views.

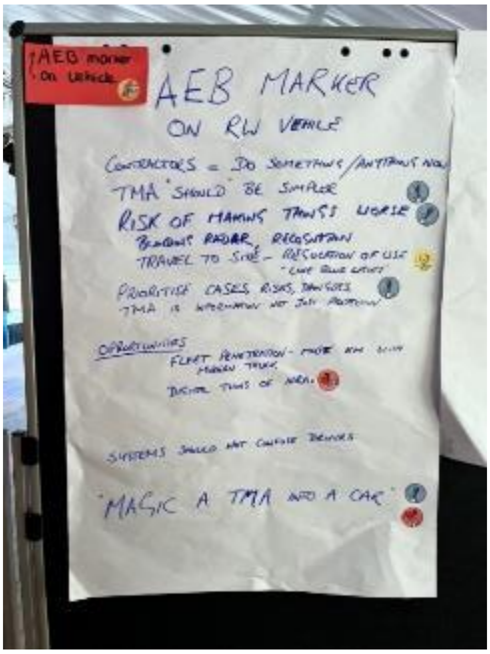
- Redo the design and integrate existing means like cones, rumble strips. (illustrated with a drawing at the workshop and suggests evaluation of the set up at road works and objects used)
- Keep in mind the needed stopping distance.
- Avoid false positives and miss-use.
- Investigate the effect of a possible off-set.
- Avoid other reflections.
- Fear of using undocumented features
- Standardization

General remarks

- Classification of objects with a radar is complex
- We can't expect AEB to work in every single situation. Test cases are defined in alignment with industry (OEM/Tier1) and it's a thorough process that ensures reaction when they should (i.e. true positives) and prevent undesired interactions (i.e. false positives).
- Placing a corner reflector in a trailer does not ensure (proper) system reaction.
- Vehicle safety systems rely on fusion of many sensors to achieve effective operation. Loss of any of these systems degrades performance of the safety system. Rader on its own has limited safety benefit.
- Manufacturer implementation of radar system greatly effect performance.

- Scope for enhancing effectiveness of radar by enhancing visibility of target.
- Smart marker has limited usage unless target can be uniquely identified.
- Resilient safety will require multiple methods of detection and identification.
- It is important that the work with regulations is done side by side with the development. Changing of regulations take a lot of time.





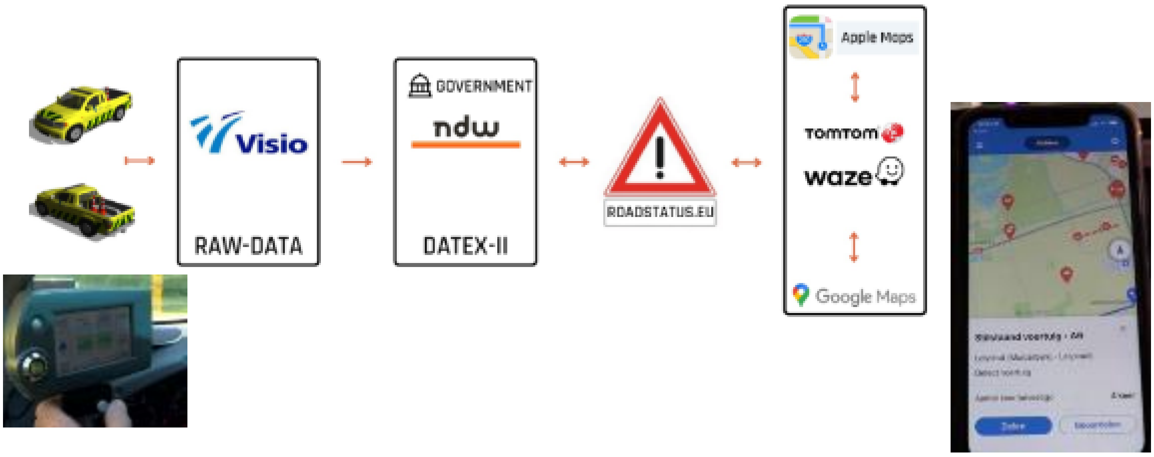
6 Communication

Communication to the vehicle or directly to the driver of the presence of incidents or road works is one of the possible solutions to improve AEBS performance mentioned in the feasibility report. At the event communication is interpreted in a wide sense.
Informing the driver (traffic information channels like radio, app) that there are road works going or an incident occurred on his planned trip could result in changing departure time or route. It could also raise his awareness and warn him in short distance.
C-ITS could provide much greater detail by sending data to the car on what to expect the actual speed limit and the exact position of the road works / the incident at lane detail. The car can inform the driver but in advanced scenario's it could also use the information to evaluate its reaction in relation to sensor input.
To maximise use of this information in/by the vehicle should know its own exact position on the road. The information could then be used to help interpret sensor data gathered by the car at that specific time and location.
Line of sight communication - like the active radar reflector, infrared or the optical communication between backlights and car camera[13] - would have the advantage that sender and receiver have a known relative position. The camera could further add lane information and object classification.

[13] Intelligent transport systems- ISO/TC 204- localized communications- optical camera communication – ISO/DIS 22738

6.1. Traffic information

The demonstration consisted of a road officer placing his vehicle on the road A6. The vehicle then sends a notification to a central database. (SRTI database[14] as required by EU regulation). This database contains essential safety data that can be used by service providers in their applications. These applications provide in-car and pre-trip information towards road users.



Hurdles as experienced by Rijkswaterstaat:

- Organizational, technical and financial issues prevent that all road inspectors, TMA's , and emergency vehicles use this service.
- Discussions on data definition and quality result in some providers not using the available data.

6.2. Reaction from participants

- Make full use of ISA to reduce the speed at work and incident locations. speed limit.

6.3. C-ITS

After receiving an incident notification the traffic centre dispatches a road officer to that location On arrival the road officer sends out a message to the beacons and drivers on the road whilst the National Datawarehouse (NDW) is also informed. At the NDW the information is processed and made available to the service providers, they inform the other drivers.

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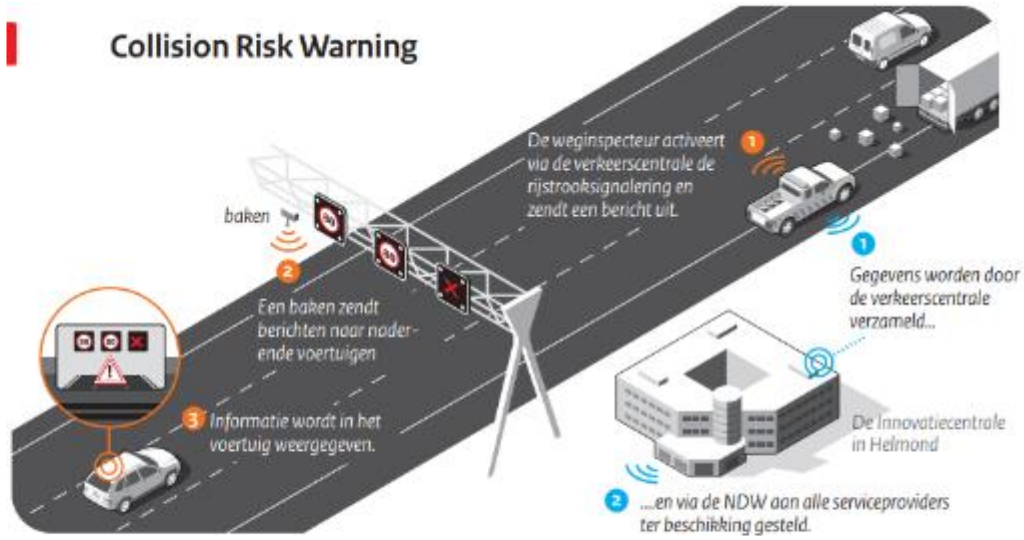
1 [14] **Safety-Related Traffic Information (SRTI) & Real-Time Traffic Information (RTTI), Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 , [Safety-Related Traffic Information (SRTI) & Real-Time Traffic Information (RTTI) (europa.eu)](#)**



In the Cooperative ITS corridor road operators of Germany, Austria and the Netherlands have worked together with industry partners towards the introduction of C-its services in Europe. Other important projects in this area are InterCor and C-roads.
At this moment Volkswagen and the German Road authority are the most active in this field.
Although the promised services could be very effective the take up seems to be hindered by discussions on security and authorization.

6.4. Remarks by participants on C-ITS

Aspects to be taken into account:

- Human factor
- Technology
- Different road lay-outs

Challenges

- improve language: create common codes,
- improve technology: compatibility/interoperability (HW/SW, 4G vs 5G),
- create standards/ protocols (road signs, road workers),
- collect data and learn -> KPI (speed, etc)

Findings

- active communication- warnings/detection not general information
- no false communication - 2/3 errors mean no trust
- positive communication – road workers are there to help, they are not the enemies

6.5. Active radar

An radar is an intelligent send/receive device. A prototype of an active reflector was demonstrated that can communicate the unique identity and the distance to the object. The active reflector listens to the approaching AEB radar and then sends back its identity and distance to the sender. This requires modification to the AEB radar that would have to be accepted by the manufacturer.

The modification consists of extra software provided to the OEM by start-up company R4DAR[15].

At the event an active reflector was placed on a TMS. The ID and distance were decoded by a modified radar and displayed on a laptop screen.

Passive reflector
The Passive reflector does not need an external power source. Instead the reflected signal is manipulated in such a way that with extra software it can get a unique identifier as well as the distance. If this would result in a workable product the safety benefit would be extraordinary.
The picture below illustrates how a bicyclist would be detected in a difficult backlight situation (from product promotion R4DAR).

6.6. Remarks by participants on the active radar

The R4Dar technology as explained might be a long term solution for communication, but is not a quick fix.
Some expressed doubts on the possible need for hardware changes as well as software changes.

6.7. Dynamic signals

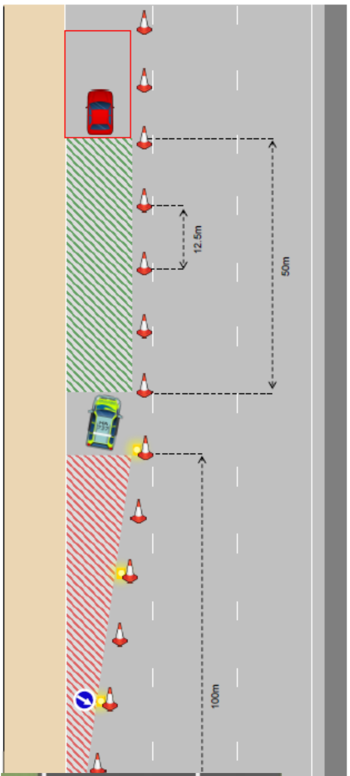
[15] R4DAR Technologies – Seeing is Believing

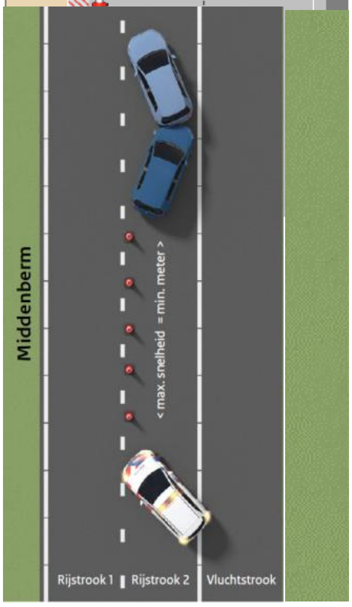
The information on overhead gantries and roadside VMS is difficult to interpret for Automotive camera systems. Most systems can handle the standard speed limits signs with red circles. Non-standard signs are much harder this can be illustrated with the example on the Rijkswaterstaat gantry on the right.
The in-car information screen indicates traffic lights instead of the dynamic panels.
As dynamic signalling is important to inform drivers for road works ahead we invited ASAM to present their initiative on the event. Due to Covid this presentation had to be cancelled. Because of the relevance of the subject it is mentioned here and participation to the ASAM project could be considered during follow up discussions.
More information on ASAM can be found on: ASAM.net[16]

[16] ASAM. (Association for Standardization of Automation and Measuring Systems). This is a non-profit organization that promotes standardization of tool chains in automotive development and testing. Members are international car manufacturers, suppliers, tool vendors, engineering service providers, and research institutes. ASAM standards are developed by experts from its members.

7 Differences in Work processes across Europe

The Traffic Officers from National Highways UK showed the safety measures taken in case of a vehicle breakdown. The vehicle with flashers and dynamic panel together with the cones and warning signs warn and guide oncoming traffic.





If a vehicle should hit the cones the driver will be alarmed. Also the Traffic Officer will be alerted by the sound. Having a low radar reflectivity cones and traffic signs generally do not trigger an AEBS reaction. An oncoming car equipped with AEBS will very likely stop or mitigate a possible collision on the vehicle of the Traffic Officer.

The demonstration started a lively discussion on the procedures prescribed by European Road Authorities. Fend-off is not practiced in all countries, also the use of cones and signs differs considerably.

For instance in the Dutch situation the vehicle is used as a buffer. With cones placed only between the Road Inspector Vehicle and the incident.

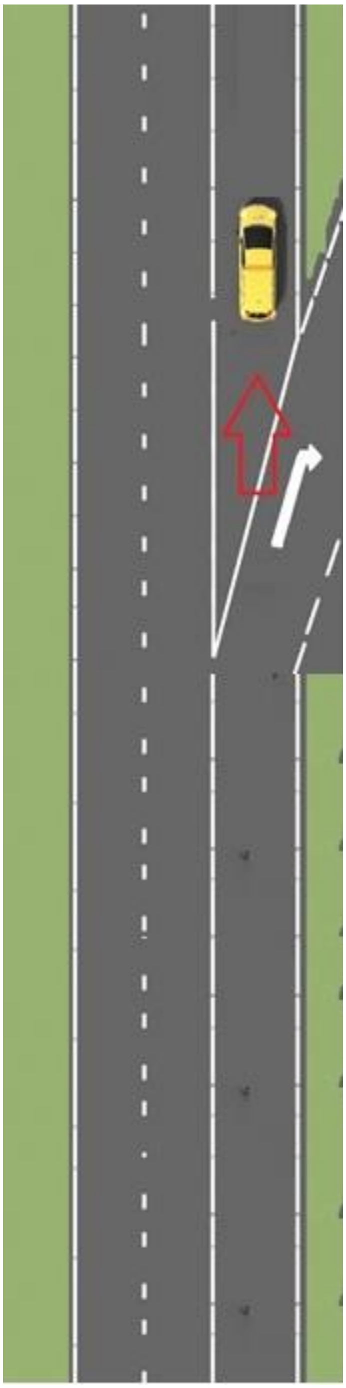
An incoming vehicle would push the Road Inspectors vehicle sidewards. As demonstrated the fend-off position could influence the correct working of the AEBS. This is especially the case at large angles were parts of the vehicle block the adjacent lane. If the vehicle in fend-off fully blocks the lane some AEBS systems still react as demonstrated earlier.

The procedures are part of a way of operating in each country and are the result of years of practical experience. Human drivers adopt to the different procedures across countries. This might be less simple for automated driving functions.

8 AEBS and lane markings, barriers and pedestrians

8.1. Lane markings

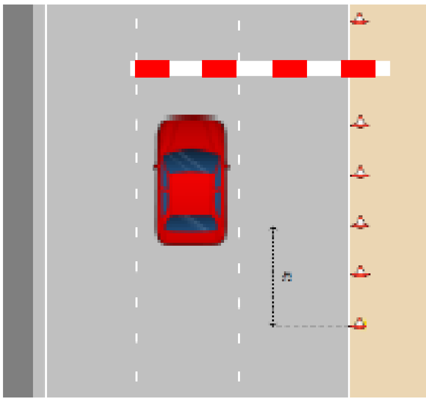
The issue addressed here is the possible negative effect on EAB triggering when crossing a lane marking. This is a possible effect of the some of the precautions taken by manufactures to prevent false triggering by the AEBS. This requires to be certain that detected object is in the same lane as the ego vehicle. Experience of the RDW learned that after crossing a lane marking some AEB systems do not react until the position in the lane is clear. This could mean imminent danger to a Road officers vehicle as shown in the figure.



Set up
To demonstrate this temporally road marking was made on the test track. Vehicles equipped with LKS and AEB were driven at the Balloon car across this marking. For practical reasons the length and the angle of the marking on the road were considerably smaller than in the real world, also the demonstration was executed at low speed.

Result
The vehicles showed a standard AEBS stop.
The demonstration showed that in this situation crossing the lane marking did not have any influence on functioning of the AEBS.
Final conclusions cannot be made on basis of the demonstration. Because of the differences the advice is to repeat the demonstration in a real road environment.

8.2. Barriers



Barriers are used at train crossings, bridges and tunnels. Barriers are mentioned in the terms of reference of the UNECE HGV taskforce and were therefore included in the program of the event.
The size and form make detection by camera and radar a challenge. As they are hit by cars on a regularly basis recognition by AEBS would mean a large improvement.
Planned was to test the recognition of barriers by AEB systems and to demonstrate possible effect of changes to facilitate recognition.

The event did have the world premiere of the first soft target to test the EABS reaction.
Due to the weather conditions this test had to be cancelled.

First Barrier for test purposes:

8.3. Pedestrian detection

The new regulations for AEB systems require that a vehicle can detect and stop or mitigate a collision with a crossing pedestrian[17][18]. As pedestrians are hard to detect and their movements can be erratic this is a difficult task.
To develop and test the functionality of these systems standard test set-ups have been defined. The objects used and their movements are defined in ISO 19206-2:2018 Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 2: Requirements for pedestrian targets[19].
The robustness of detection is an important topic as the clothing of the test target: black sweater, blue pants differs considerably from the safety vest used by emergency personnel and road workers or the standard safety vests as required in private cars.

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[17] UN Regulation No 152 - Uniform provisions concerning the approval of motor vehicles with regard to the Advanced Emergency Braking System (AEBS) for M1 and N1 vehicles
[18] (IWG on AEBS-HDV) Proposal for a supplement to the 02 series of amendments to UN Regulation No. 131 (Advanced Emergency Braking System) | UNECE
[19] ISO 19206-2:2018 - Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 2: Requirements for pedestrian targets

9 Night tests

While preparing the event Rijkswaterstaat received feedback on issues with the functioning of LKS in the presence of strong backlights. As lane information could play a role in functioning of the AEB system this led to the question if strong flashers could cause a similar effect on LKS and possibly have an effect on AEBS.
As we could not find any information on the functioning of support systems in a night situation we decided to add the question on the effect of strong flashers and work lights on the performance of support systems.

Observations

During the night test the functioning of lane support systems was tested on a dark road and while passing flashers mounted on road work vehicles.
During these test the lane support systems didn't show any different behaviour.
With the LKS seemingly fully functional we decided - after discussion with the vehicle suppliers - to skip an AEB test in the night situation.

Lane markings displayed on the dashboard in presence of strong flashers.

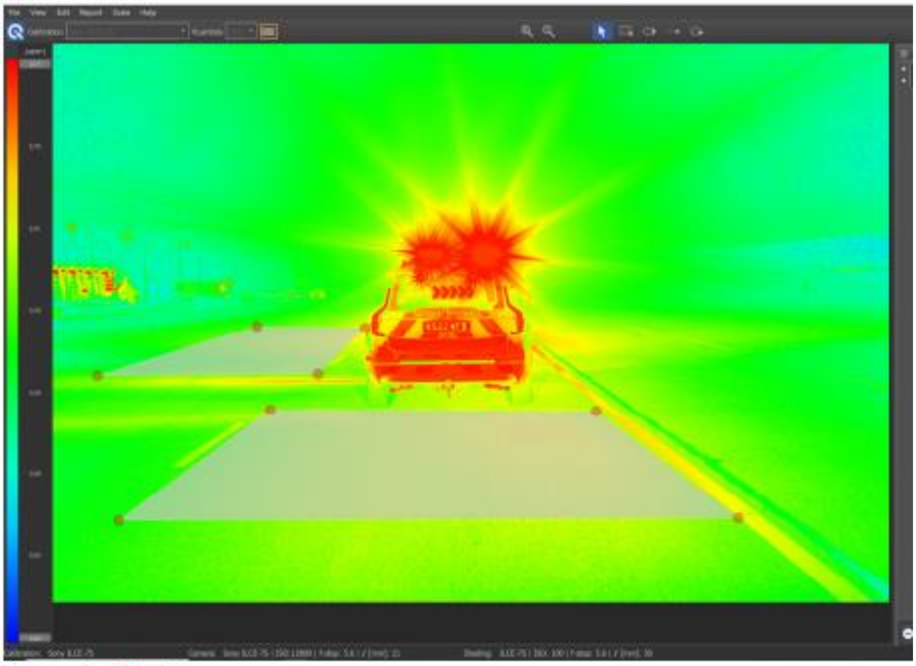
Reaction at the event

- The lane keeping system appears not to be effected by blinding of bright flashers.
- Euro NCAP has been testing VRU at night for already several years. Some systems show lower performance at night compared to day-time

Measurements

During previous tests involving human drivers' reactions on flashers and bright light in night conditions we had trouble to determine the actual light levels and contrast differences. This might also influence the camera function and any following sensor fusion. A specialized firm "de Kruijter Public Lighting" provided light measurements reported separately and available to all participants. Below a picture from the report. In the report the measurements are compared with earlier work from the joint Nordic project on "Disturbing lights at road works during night time"[20]

[20] Disturbing lights at road works during night time, Anita His, NordFoU 2005-2008



Second vehicle
road luminance in front of obstacle 1.59 cd/m2
road luminance next to obstacle 0.92 cd/m2

Picture from the report
De Kruijter

Please refer to the separate report Light Measurement, De Kruijter Public Lighting.

10 Accidentology

The incident data as received from the participating road authorities was presented and discussed in a special session with the title Accidentology. In this discussion various related subjects were discussed like causes, missing information, registration issues, involved parties, GDPR, responsibilities. This has led to a separate report. The remarks made as gathered represent individual opinions and might not always be widely shared.

Incident statistics and research:

I

- What incident data do we need
- Current CEDR questionnaire is difficult to answer
- OEM knows very well what his fleet is involved in.

II

- Project Browser CEDR –project 2013 “standardize dataset for road work accidents” contractors reports.
- Cause of incidents not 100% clear
- Driver condition unknown and if known subject to GDPR

III

- Browser uniform definition while TMA is different per country
- Rethink, update the browser project.

Other remarks:

- Incident statistics and incident investigation is very important.
- How can traffic engineering devices help to automated cars, what can we do from a road authority’s perspective?
- What can be the role of the RISM Directive 2019 on Road infrastructure safety management?
- We need data to make a point.
- Testing and track effects in real traffic – (find out how systems perform in real conditions)

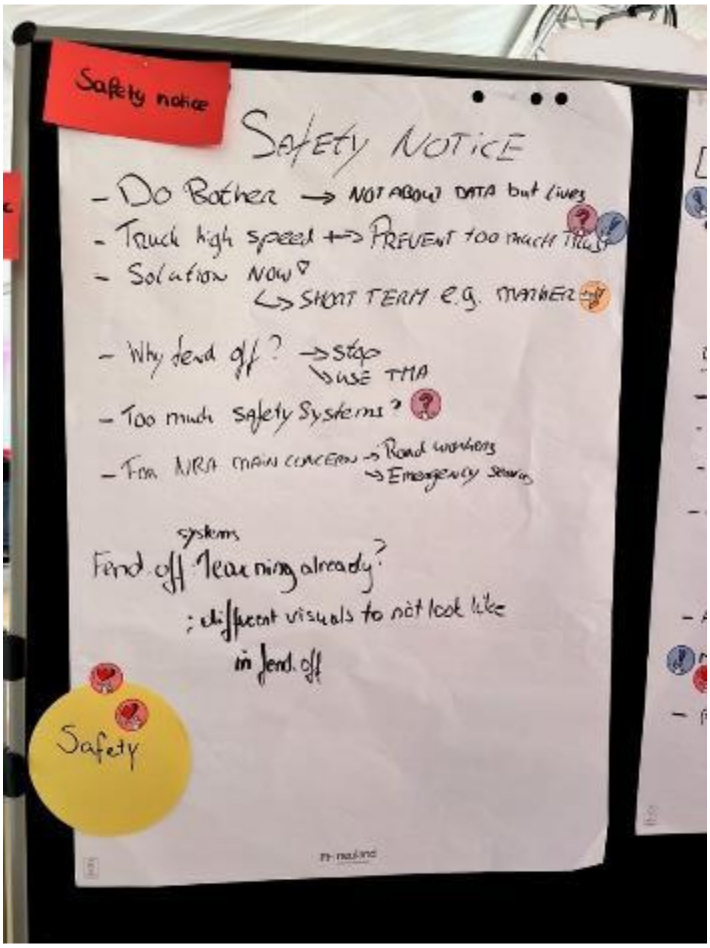
On the role of the driver:

- Distracted driving is the real issue here, and there are ways to ensure that driver is kept in the loop.
- I started texting in traffic jams since my car has ACC (never did it before)

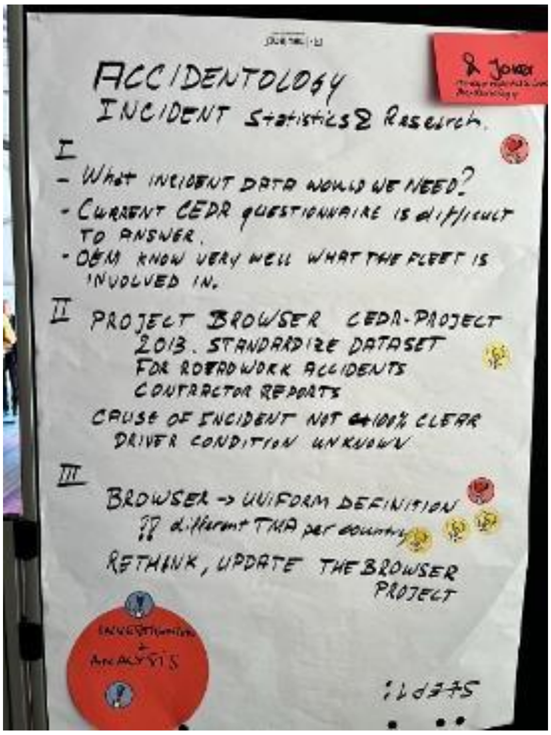
Interaction between driver and support system

- However automation is a great support but the systems are not made to fully rely on it, as the responsibility remains exclusively with the driver.
- Important to know the capabilities of the vehicle.
- Awareness needed how AEB works.
- Balance between a supportive or a stupid/over bothered support system. (system warning can cause driver irritation resulting in him switching it off)

Also the moral dimension was discussed at the meeting: can an incident with a first responder or a road worker be compared with a regular incident with a road user?



Safety notice
SAFETY NOTICE
- Do Bother → NOT ABOUT DATA but lives
- Truck high speed ↔ PREVENT TOO MUCH TRUST
- Solution NOW?
↳ SHORT TERM e.g. MARKER
- Why fend off? → stop
↳ USE TMA
- Too much safety systems?
- For NRA MAIN CONCERN → Road workers
→ Emergency services
systems
Fend off learning already?
: different visuals to not look like
in fend. off
Safety



ACCIDENTOLOGY
INCIDENT Statistics & Research.
I
- What INCIDENT DATA WOULD WE NEED?
- CURRENT CEDR QUESTIONNAIRE IS DIFFICULT TO ANSWER.
- OEM KNOW VERY WELL WHAT THE FLEET IS INVOLVED IN.
II PROJECT BROWSER CEDR-PROJECT 2013. STANDARDIZE DATASET FOR ROADWORK ACCIDENTS CONTRACTOR REPORTS
CAUSE OF INCIDENT NOT 100% CLEAR
DRIVER CONDITION UNKNOWN
III
BROWSER → UNIFORM DEFINITION
?? different TMA per country
RETHINK, UPDATE THE BROWSER PROJECT
INVESTIGATION & ANALYSIS

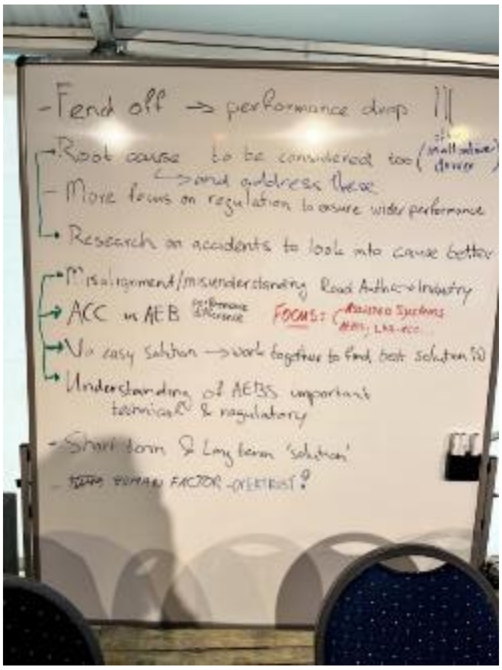
11 Conclusions and next steps

The event brought together relevant stakeholders like Road Authorities, equipment builders, Automotive Experts, Sensor suppliers, European Commission, Policy makers, Euro NCAP, Police, Breakdown services, contractors. It has succeeded in exchanging views and getting more understanding of the positions of all involved. Issues like uniformity of equipment and vehicles, visual and radar recognition, knowledge of AEBS development were discussed in detail.

At the event it became clear that there is no easy fix to improve the safety of emergency personnel and road workers for temporally non-attentive drivers. The Road Authority perspective is that systems like AEBS should include road works and emergency vehicles. Also it became apparent that it is up to the Road Authorities to put this subject on the agenda of Policy makers and the UNECE and to initiate the change needed. The other stakeholders showed a genuine interest to support initiatives or to provide feedback.

The event focused on the present situation, with little attention to new ways of automation of driving tasks like ALKS. For safe operation the relevant regulation imposes a great responsibility on the car manufacturer who has to ensure the safe operation of the ALKS functionality. In case of an incident during ALKS within the operational domain (real live traffic) the car and thus the manufacturer is responsible. How incidents locations and road works are handled within the operational domain was not a topic at the event but could be a relevant area for cooperation between Road operator and Car manufacturer.

11.1. Concluding remarks



In the two days of the event many relevant road safety and vehicle aspects were discussed in detail. The concluding remarks made at the event are shown in the picture below.

The next paragraph drafted after the event is an effort to come to
a starting point for further work.

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11.2. Next steps

After the event the results have been processed into suggested next steps and possible specific actions. Further discussion and detailing is needed.

Next step 1:
For Road Authorities it is essential to get more protection against inattentive drivers and the way assisted driving functions are used: Advanced Emergency Braking Systems should have provisions to detect road works and emergency vehicles in order to handle these situations in a safe way.

- The CEDR members should use their influence they to get this on the agenda of their Policy department and their representatives in the UNECE:
    - Include detection of Road works and emergency vehicles in the type approval.
    - Include detection of Road works and emergency vehicles in the Digital test suites used by the automotive industry.
    - Request Euro NCAP to include it in their rating.

This step requires Automotive and Road Authorities to work together. Also it will stimulate steps towards more uniform equipment, vehicles and procedures.

Next step 2:
Road Authorities do the ground work for step 1!

- Do what is possible now to increase the detectability of equipment and vehicles in use without creating new issues like false triggering. Also find out how much uniformity in HW and SW is needed.
- Utilize existing means like traffic information and C-its to inform drivers,
- Investigate and understand issues with the present vehicle assistance and coming functions like ISA, lane marking, backlights, barriers, safety vests, drivers training, dynamic signalling.
- Stimulate innovation in a broad sense targeted on the safety of road workers and emergency personnel.

11.3. Detailed actions

11.3.1. National Road Authorities and emergency services be heard

Traditionally the Road Authorities are not directly involved in vehicle regulation. As vehicles can no longer be seen only as a mechanical means of transport this has to change. Safe operation of (partly) automated vehicles and automated functions requires involvement of the Road Authorities. The safety of the personnel working on the road like road workers, emergency and service personnel must be a first priority when working on new vehicle regulations.
Automated functions like AEBS shall in the future include detection and recognition or road works and emergency vehicles in order to in order to handle these situations in a safe way. This will require automotive industry and Road Authorities to work together. Needed here are clear definitions to have a goal automotive parties can work to and that creates a level playing field. Once part of the vehicle regulation testing is a necessity.

11.3.2. Be part of Automotive test suites

Include detection of Road works and emergency vehicles into the testing suites as used by the automotive industry and in type approval.

As tests on public road are time and money consuming most testing is done in a computer environment. Scenarios that involve incidents, road works and maintenance should be part of the test suites. This will require action by multiple actors. To get to realistic scenarios that would include road works and emergency vehicles representative for all situations across countries Road Authorities have to take action. Uniformity will evidently be one of these.

11.3.3. Euro NCAP for road works and incident locations

Inclusion of road works and emergency vehicles in Euro NCAP safety tests would make best practices stand out as an example for others. It requires a clear definition of common practices and objects used by Road Authorities. Accidentology could contribute to the design of a possible test scenario. In its Vision 2030 Euro NCAP will put a larger focus on the robustness in real world circumstances of the crash avoidance technology[21]. This includes lighting and weather changes, target appearance and interaction with other road objects and infrastructure.

11.3.4. Strive to visual uniformity

Uniform properties for sensors
The way vehicles and equipment look is based on experience and best effort of each individual Road Authority. This has resulted in a variety across countries making detection and recognition by automated functions harder. Road Authorities and equipment builders should strive to reduce this variation. To find out how to improve, what and how much changes are needed action is needed. This will also include improvement of the detectability of existing equipment and vehicles. Changing the radar or visual properties without causing false triggering will be part of this.

The cost of changes to existing equipment cannot yet be estimated. Uniformity of new equipment will most likely have a positive effect on the cost while increasing the lifespan. At the event is was mentioned that the lifespan of vehicles and equipment is shortened by the percentage involved in collisions.

As technical knowledge is an important factor in the competition between OEMs they have restrictions in sharing this. Therefore it is needed to invite parties from other industry sectors and Universities.

For instance camera recognition is a feature that can be found in many applications. A smart-phone with Google lens gives an perfect example of the power of image recognition. In a car the recognition has to be direct and reliable without the enormous computing power available in the network.

The suggestion is to initiate a small targeted project and invite experts from universities, computer vision companies, LiDAR, radar and camera suppliers plus automotive experts to come up with suggestions on the sensor properties of road work equipment and emergency vehicles.
The result of this step should be a proposal covering the if and how to have the equipment and vehicles easier to recognize for sensors.

[21] Euro NCAP Vision 2030: a safer future for mobility, page 12

This as the start of a possible standardization effort, within CEN or any other standardization organization.

11.3.5. Build upon the present communication options

As demonstrated and discussed on the event there are a number of communication channels available. Although even the combination of all options will not guarantee that all drivers/vehicles will receive the information or that adequate reaction will follow these option will have an important effect on safety. Full utilisation is therefore a requirement.

<u>Make full use of traffic information and SRTI messages</u>
Traffic information makes use of mature technology, it is feasible to have it working on all Road works and all incident locations. It requires a constant effort to keep the information chain working and make sure that all drivers can have access to traffic information that includes relevant dangers like road works and incidents.
As process, equipment, platform and EU ITS regulation are the same across all CEDR members exchange of information between them could help to increase the quality and to lower the cost of platforms and equipment used. As a first step the present situation and methods used across CEDR members could be compared. This should lead to a more uniform approach and economy of scale.

<u>ISA in temporarily situations</u>
Intelligent Speed Adaption (ISA) is obligated in every new type approved car from July 2022. Utilize the full potential of ISA by communicating the temporarily speed limit at road works and incident locations to vehicles.

<u>Realisation of C-ITS</u>
At the event it turned out to be extremely complex and costly to demonstrate the working of C-its on site. The number and type of remarks of the participants showed doubt and uncertainty on the C-its introduction strategy among the participants.
As introduction of C-its is already a priority on European- and National level it is it can be expected that this will be addressed at these levels.

11.3.6. Investigate and evaluate the present safety practices

Vehicle functions and driver behaviour change this makes it relevant to investigate and evaluate the safety barriers that are in use by Road Authorities and emergency services to find out if they are still adequate or need improvement. Therefore the present program that looks at the match between sensors and vehicle and lane markings, backlights, barriers, safety vests, driver education, dynamic signalling. These are detailed below.

- Investigate barrier issue
  At present the safety issue with barriers at tunnels, bridges, and railway crossings has not been clearly defined. It would be the first step to underpin the necessity for automatic recognition. Possible remedies could be part of a broader action on improvement of automatic recognition of road (side) objects.
  The action proposed is that to collect the data and motivations for this from Road Authorities and Automotive Industry.

- Verify the influence of safety vests
  Pedestrian detection can contribute to the safety of road workers and emergency personnel. It should be verified that it is also works when wearing a safety vest or uniform.
  The clothing of the test target black sweater, blue pants differs considerably from the safety vest used by emergency personnel or the standard safety vests as required in private cars. As Euro NCAP strives towards more robustness of crash avoidance systems this could possibly fit in their Vision 2030 mentioned earlier.

- Verify the influence of lane markings
  If AEBS would be less functional directly after diagonal crossing lane markings this could have serious safety implications for emergency services and occupants of broken down vehicles standing there. The action proposed is that a number of countries work together to verify this and report on it.

- Participate in ASAM initiative on dynamic signalling.
  On this subject the industry seems to take the lead. It would be most beneficial if one or two CEDR members would participate in this initiative and report back to the Safety Working group.

- Organise a seminar on lights on road works
  Correct lights on road works is a concern of Road Authorities, Automotive industry, equipment constructers, human factor and lighting specialists. The proposal is to invite these parties to exchange research and experiences and review the last developments. To start of this could be a webinar to be succeeded by a work conference with a night program.

- Educate
  Traffic safety starts with responsible capable drivers. Apart from fit to drive they should understand that vehicle can be a last resort but have their limitations. This should help to prevent over trust. Educational programs in the UK targeted on truck drivers provide an example.

- Evaluate
  Expert knowledge and years of experience have resulted in various approaches all meant to achieve maximum safety at incident and work locations. Where possible compare and evaluate existing practices across NRA's interview road users, measure behaviour, lane changes, speed, passing distance.

- Use TMA’s equipped with radar (UK, NL) and floating car date to find out what works and what doesn’t.

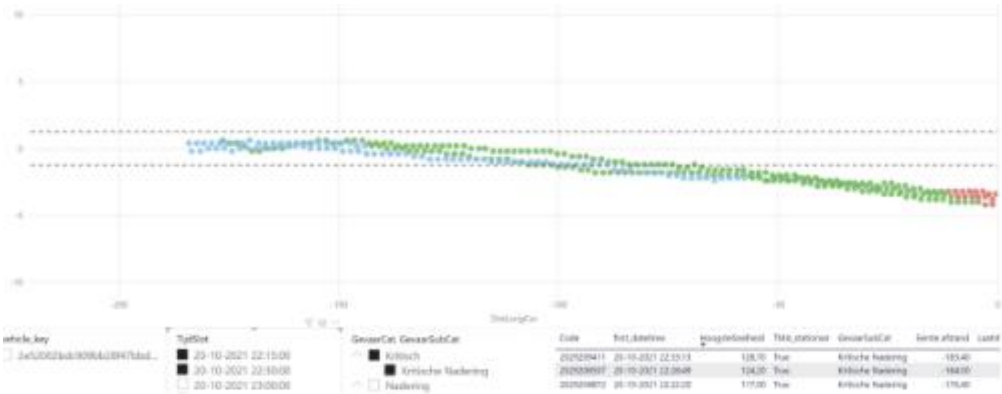

Figure shows vehicles approaching an TMA with high speed >120km/u and changing lanes at less than 100meter.

11.3.7. Stimulate innovation

Next to improvement of the present practices, equipment, vehicles innovation can lead to different ways of thinking and operating.
Stimulate alternative solutions and start initiatives, give room to innovative ideas and help innovators to identify the important hurdles.
Examples of innovations are the active and passive radar reflector and Optical camera communication like ISO/DIS 22738 (see appendix). This could well fit in the EU agenda of making Europe more competitive.
Support from established organizations like CEDR, ACEA, Clepa and the EC could really make the difference for innovative approaches.
In all this do not forget to use the innovation potential of the individual NRA’s. Welcome idea’s from the own organisation and try to connect these with others.

Abbreviations

Organisations	
ACEA	ACEA - European Automobile Manufacturers' Association
ASAM	Home (asam.net) Association for Standardization of Automation and Measuring Systems
BASt	BASt - The BASt Federal Highway Research Institute (BASt)
CEDR	CEDR CEDR is an organisation of European national road administrations
CEN	About CEN - CEN-CENELEC (cencenelec.eu) European Committee for Standardization
CLEPA	- CLEPA – European Association of Automotive Suppliers
EC	Directoraat-generaal Vervoer (MOVE) - Mobility and Transport (europa.eu)
Euro NCAP	Euro NCAP | The European New Car Assessment Programme
TNO	Innovation for life | TNO
UNECE	Vehicle Regulations | UNECE World Forum for the harmonization of vehicle regulations (WP.29)
Other	
AEBS	Advanced Emergency Braking Systems
C-its	Cooperative intelligent transport systems (C-ITS), which enable vehicles to interact directly with each other and the surrounding road infrastructure. L_2010207EN.01000101.xml (europa.eu)
ISA	Intelligent Speed Adaption
GDPR	General Data Protection Regulation (GDPR) Compliance Guidelines
HDV	Heavy Duty Vehicles
LiDar	LIght Detection And Ranging of Laser Imaging Detection And Ranging , method for determining ranges (variable distance) by targeting an object or a surface with a laser and measuring the time for the reflected light
NDW	Nationaal Dataportaal Wegverkeer | Nationaal Dataportaal Wegverkeer (ndw.nu) Dutch National Datawarehouse (NDW)
NRA	National Road Administration
OCC	Optical Camera Communication
OEM	Original Equipment Manufacturer
Radar	Radar - Wikipedia detection system that uses radio waves to determine the distance (*ranging*), angle, and radial velocity of objects relative to the site
RCS	Radar Cross Section
RISM Directive 2019	L_2019305EN.01000101.xml (europa.eu) **Directive 2008/96/EC.** This Directive requires the establishment and implementation of procedures relating to road safety impact assessments, road safety audits, road safety inspections and network-wide road safety assessments by the Member States.
SRTI	Safety-Related Traffic Information (SRTI) & Real-Time Traffic Information (RTTI) (europa.eu)
TMA	Truck Mounted Attenuator

Appendix 1: Optical Camera Communication

DRAFT INTERNATIONAL STANDARD
ISO/DIS 22738

ISO/TC 204 Secretariat: ANSI
Voting begins on: 2019-12-17 Voting terminates on: 2020-03-10

Intelligent transport systems — Localized communications — Optical camera communication

What ever happened to:

OCC is considered for usage in:

c) roadside ITS station units (ITS-SUs), and

d) vehicle ITS-SUs.

OCC is intended to provide information to vehicles, see Figure 2.

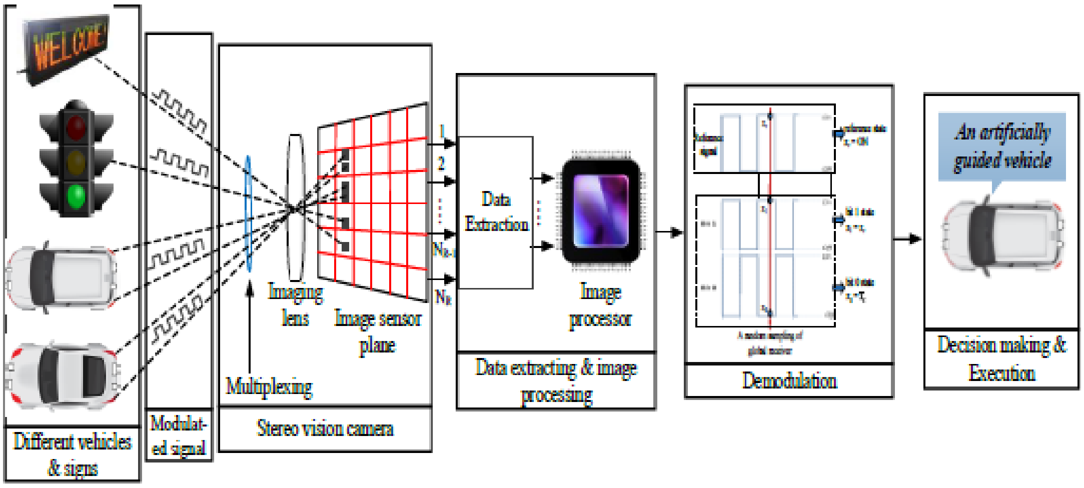

Figure 2 — Vehicle-centric data flow in OCC

OCC uses LEDs as transmitter and cameras as receivers with visible light or near IR (NIR). Characteristics of OCC are:

Figure 3 shows the basic operation of OCC. OCC supports ITS applications for vehicular scenarios such as already proposed by universities and companies [8, 9, 10].

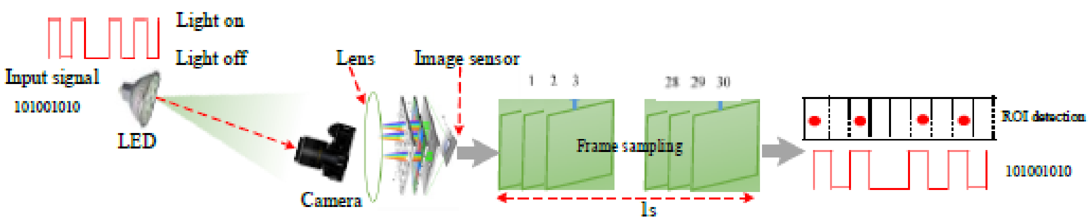

Figure 3 — Basic OCC operation

Appendix 2: C-ITS details

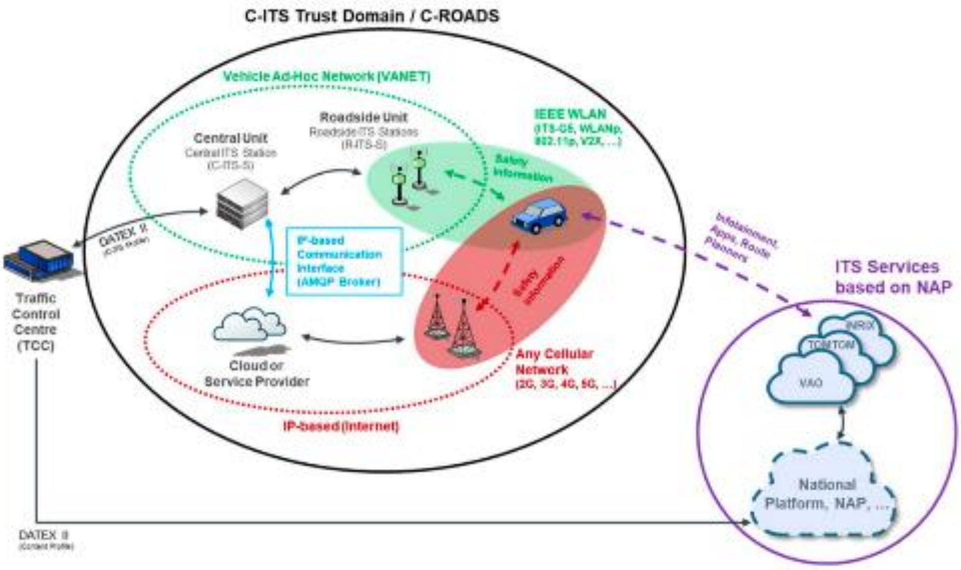

Table 2: PKI sy

C-Roads Member State	TLM							
Austria	EU							
Belgium (Flanders and Wallonia)	EU							
Czech Republic	EU							
Denmark	EU							
Finland	EU							
France	EU							
Germany	EU							
Greece	EU							
Hungary	EU							
Ireland	EU	EU	National	National	National	ALL	TBD	TBD
Italy	EU	EU	Contract/EU	Contract/EU	Contract/EU	ALL		TBD
Netherlands	EU	EU	TBD	TBD	TBD	TBD	TBD	TBD
Norway	EU	EU	TBD	TBD	TBD	TBD		TBD
Portugal	EU	EU	TBD	TBD	TBD	TBD	TBD	TBD
Slovenia	EU	EU	National	TBD	TBD	TBD	TBD	TBD
Spain	EU	EU	National	National	National	All		TBD
Sweden	EU	EU	TBD	TBD	TBD	TBD		TBD
UK	EU	EU	TBD	TBD	TBD	TBD	TBD	TBD
EC DG JRC	EU	EU	EU	EU	EU	All	TBD	2020 TBC

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