

Acceptance & Experience of a Vulnerable Road User Detection System among Heavy Vehicle Operators: A year-long Multi-City Field Trial

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TRANSPORT CANADA

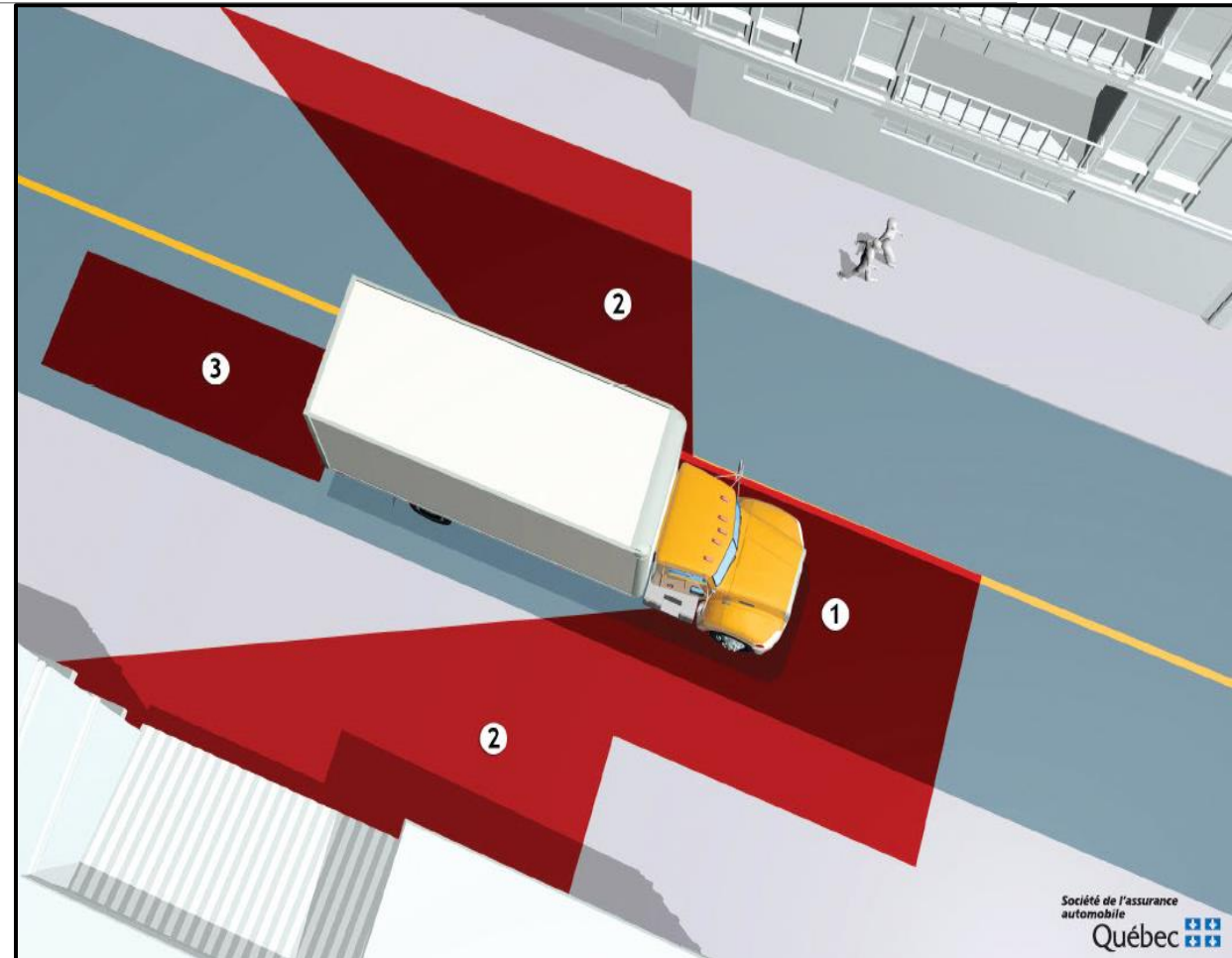
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Outline

- **Heavy vehicles & Vulnerable Road Users (VRUs)**
 - *Relation between heavy vehicles & VRUs?*
 - *Countermeasures proposed to address this issue?*
- **Track Testing of VRU detection systems**
 - *Which VRU detection system performs best on track?*
- **Field Operational Test (FOT) of VRU detection system**
 - *What is a FOT?*
 - *Benefits of an FOT?*
- **Challenges of technology designed to aid drivers**
- **Results from the FOT**
 - *What were the operators' experience using the system?*
 - *What were the main benefits and concerns of using the system?*

Heavy Vehicles & VRUs

- **Heavy vehicles are often involved in fatal collisions with Vulnerable Road Users (VRUs) (e.g., pedestrians and cyclists)**
 - Design flaw of heavy vehicles
 - Creates blind spots that make it difficult for operators to detect nearby VRUs
- **Proposed countermeasure**
 - VRU detection system – assist drivers by monitoring blind spots & warning them of VRUs nearby [1-2]

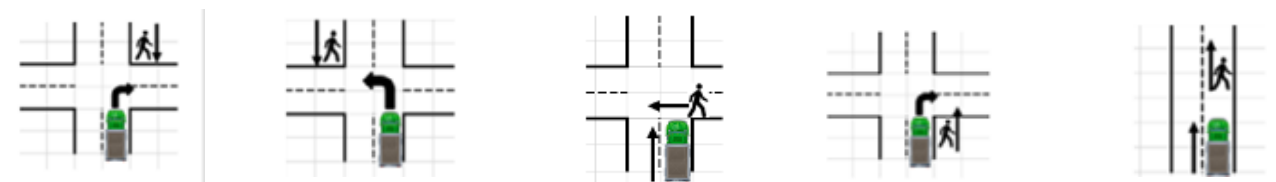


Track Testing of VRU detection systems

- Closed-track test to identify best VRU detection systems on the market [3]



- Scenarios used to evaluate VRU detection system



- Multi-smart image recognition system performed best

VRU Detection System

- **Mobileye Shield+ Smart Camera VRU Detection System**

- collects distance and relative speeds to assess risk and issues warnings to driver of imminent collisions
- Two-staged alert system using visual and audio

- **Visual alerts turned from:**

- **Green** (OK) -> **Amber** (VRU detected) -> **Red** (VRU imminent danger)

- **Other Advanced Driver Assistance Systems (ADAS)**

- Forward Collision Warning and Lane Departure Warning

- **Installed on heavy vehicles for FOT for further testing**



PEDESTRIAN & CYCLIST COLLISION WARNING
(MOBILEYE PCW)



FORWARD COLLISION WARNING (MOBILEYE FCW)



LANE DEPARTURE WARNING (MOBILEYE LDW)

Field Operational Test (FOT) of VRU Detection System

- **Field Operational Tests (FOT)**

- Evaluate functions of driver support systems under real-world operating conditions
- Year-long and multi-city FOT across Canada

- **Fleet vehicles that met the following criteria:**

- Heavy Trucks
- Difficult to navigate in town
- Naturally operated near VRUs
- Operational year-round
- Expose greatest number of operators for feedback and exposure to the system



Heavy Vehicles used during FOT

- **Differed in:**

- Size and design
- Operated in different road types and conditions

- **14 vocational vehicles selected**

- **System only alerts of a potential risk**

- Operator always remains in full control of the vehicle responsible for taking appropriate actions in response to alerts issued by the VRU detection



Challenges of using systems designed to aid drivers

- **Known challenges when it comes to using systems designed to aid drivers**
 - Important to assess technology on different drivers, vehicles, roads, lighting and weather conditions across Canada
 - Acceptance of technology is exceptionally important given that the performance of the system ultimately depends on drivers using and responding to the assistance system appropriately

Research Questions

- How does VRU detection system perform on extended use under real operating conditions in Canada?
- What is the overall operator impression / experience using such systems while operating heavy vehicles?

Data Collection

- **System (data loggers)**
 - (type and frequency of alerts, GPS locations of where alert was given, speed, vehicle distance driven etc.)
- **Self-report Questionnaires (n = 49)**
 - Vehicle Driven
 - City & Date
 - Workload
 - Road Safety
 - Trust
 - System performance
- **Semi-structure interview post-FOT debriefing**
 - Group teleconferencing conducted separately for each municipality
 - Emphasis on open-ended discussions



Results

- **System data**
- **Self-report Questionnaire data (n=49)**
 - Median, standard deviation, and frequency counts
 - Thematic analysis (identifying common themes in text & categorizing them) [4]
- **Debriefing data**
 - Categorized into positive, negative or dependent

System Data

Distance Driven & Alerts Issued

- **Collectively drove 419,540 km**
 - Average of 389 km / week
- **Visual warnings**
 - Average of 709 times per 1,000 km
- **Red visual + audio warnings**
 - Average of 32 times per 1,000 km
- **Other ADAS warnings (FCW, LDW) via an auditory chime**
 - Average of 328 times per 1,000 km
- **Overall, the system alerted an average of 1,069 times per 1,000 km**



Self-Report Questionnaire

Training

- **Training administered by Dican Inc. on the VRU detection system**
 - majority of operators received training (15 did not)
 - classroom demos with video and system descriptions
 - live demos of the system on-site
 - information sheet for reference
- **Reported training was useful and helpful**



Operator Acceptance & Behaviour

Likert Scale 1 – 10

- No impact on workload
- Mixed responses on how the system improved road safety
- Mixed responses on trust in system – no one completely trusted it
- Mixed responses on preference in driving a vehicle with the system

System Warnings & Operator Response

- **Timing**
 - On-time or delayed
- **Visual and audio alerts**
 - highly effective at capturing attention
- **Majority of operators (n=42) had initial visual response to warning**
 - E.g., looked at warning alert, scan environment to look for VRU etc.

System Performance according to Operators

- **Correct warnings**
 - correctly detected VRUs only half of the time
- **False Alarms**
 - issued warnings even when no VRU was present half the time
- **Misses**
 - the system rarely missed or failed to detect actual VRUs

Overall Experience / Impressions

- **Situations where system did not work**

- Environmental
- Weather
- Physical Location / Road
- Reliability Issues

- **Negative Experiences**

- System not suited for the task
- Warnings were annoying

- **Positive Experiences**

- Safety advantages

Post-FOT Group Debriefing

Collective Group Responses

- System was not beneficial in avoiding a collision
 - System unreliable with increased false alarms
 - Detected road signs as VRUs
- System needed to be integrated better with other on-board technology
- Warnings were a distraction rather than an aid
 - Tone & frequency
- Training session was helpful and useful
 - Liked the hands-on experience with the system and live demos

Discussion

- **System Data showed promise**
 - Issued warnings throughout the FOT
 - Effective at alerting operators of VRUs
 - No collisions during the FOT
- **Overall, negative experience according to Operators**
 - Warnings were a distraction
 - Reliability issues of the system
 - According to naturalistic driving studies, 4 inappropriate warnings per hour rated most annoying
- **Training was not given to all operators**
- **Consider physically redesigning heavy vehicles [5]**



Conclusions

- **Distraction, unreliability and failure** to apply the system to different vehicles and tasks were all common factors that decreased driver acceptance with the VRU detection system
- **Consider user feedback and opinions when assessing new technologies.**
 - Objective system data showed promise, but it was the subjective data collected that gave insight on how ADAS perform in real driving conditions
 - No point in designing the perfect system if drivers are not going to accept and use it
- **Technology continues to improve**
 - Operators are open to using new technology for safety benefits

Thanks!

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