



What happens when a driver doesn't respond to a drowsiness warning? Incorporating microsleeps as a strategy to reduce the risks of drowsy driving

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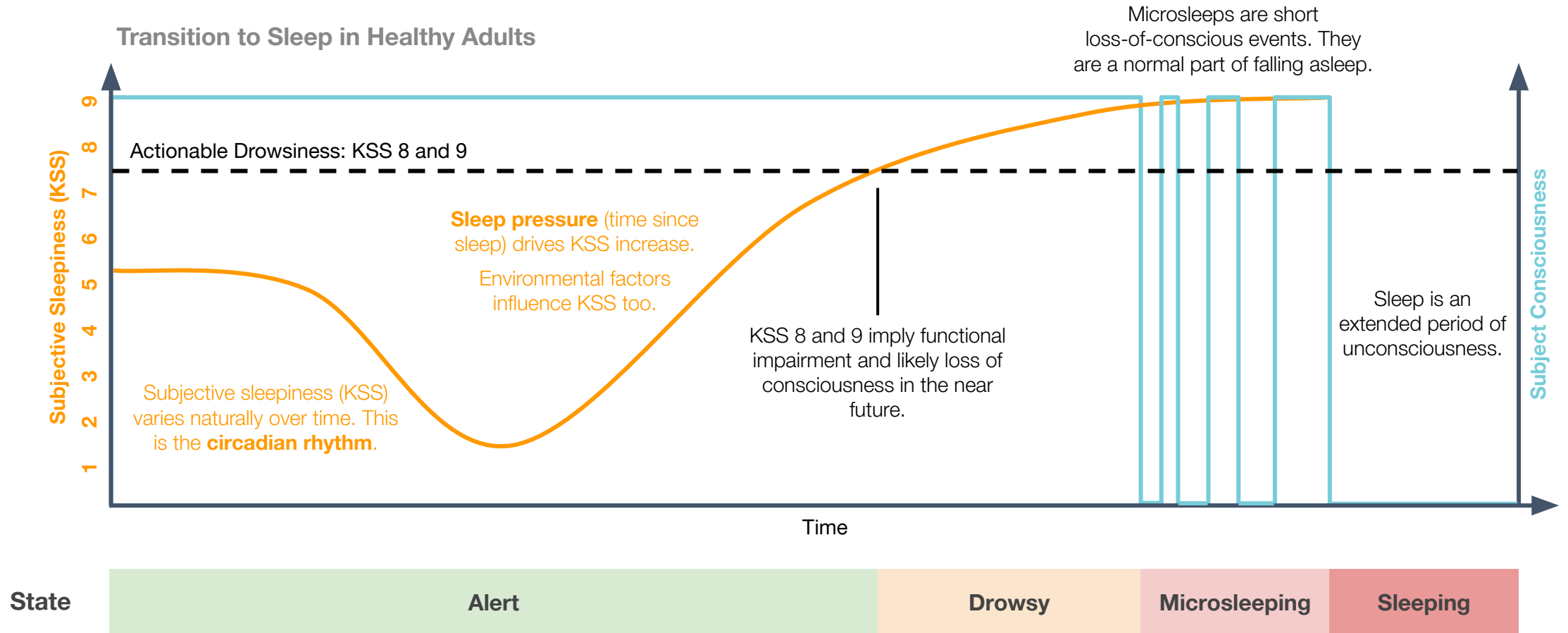
Presentation Context and Objective

- Including microsleep behaviour represents a real opportunity for reducing drowsiness-related crashes while also enhancing driving acceptance
- Discussion here will focus on:
 - The different drowsiness behaviours that occur in the transition from wakefulness to sleep
 - The opportunities to enhance safety outcomes and driver acceptance by expanding the range of drowsiness behaviours included
 - Issues to consider the implementation of microsleep behaviours

Part 1: The transition from wakefulness to sleep

Drowsiness and Microsleeps occur across a spectrum of sleepiness

The transition from wakefulness to sleep

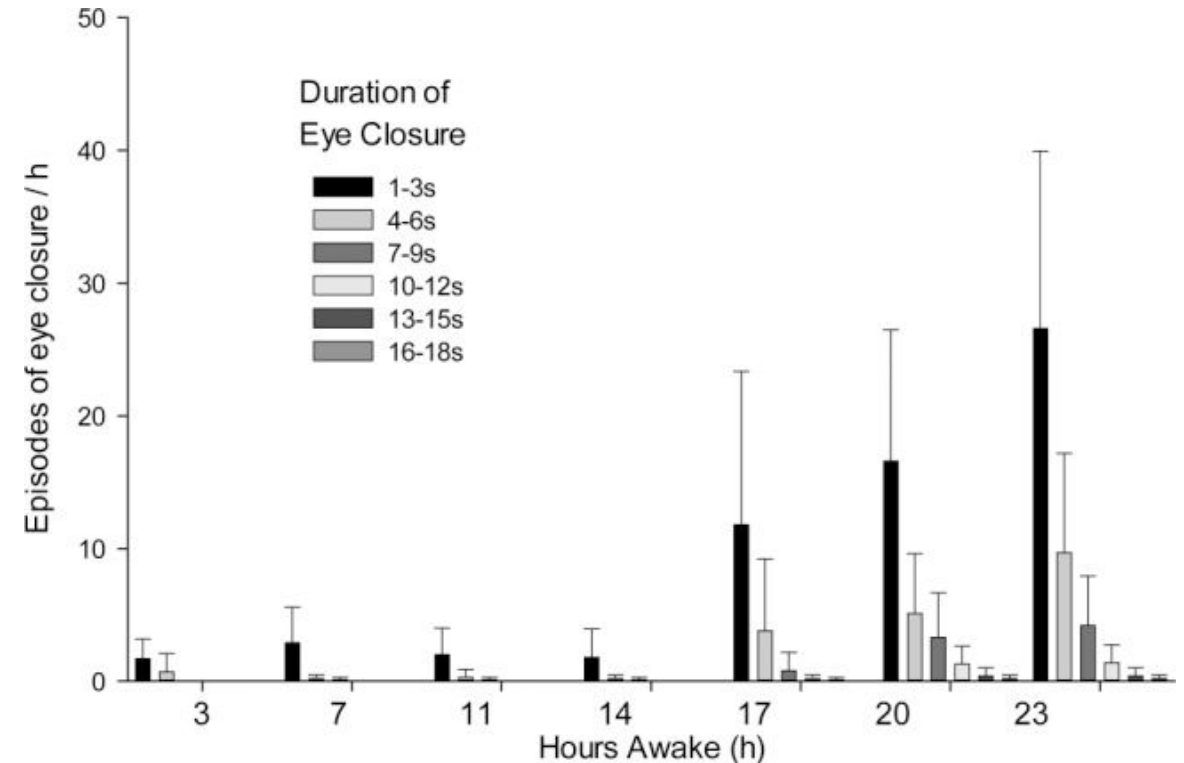


Transitions from wakefulness to sleep

- Microsleep (MS) definitions centre on a temporary loss of consciousness related to severe drowsiness
- Primary visual indicators include:
 - reduction of neck stabilization reflex
 - partial/full long eye closure; fluttering of eyelids; slow eye rolling (Boyle et al., 2008; Heitman et al, 2001)
- While EEG is regarded as the most accurate means of MS measurement, eye-closure behaviour is regarded as the most practical and reliable in the field
- Underpinning measures, such as blink duration, are predictive of microsleep behaviours and subsequent lane departure events (Mulhall et al. 2020)

Sleep pressure and microsleep behaviour

- Being a drowsiness-related behaviour, MS are more evident as sleep pressure increases
- The most prevalent MS are shorter duration eye-closure events (see adjacent figure - discussed later in Section 3)

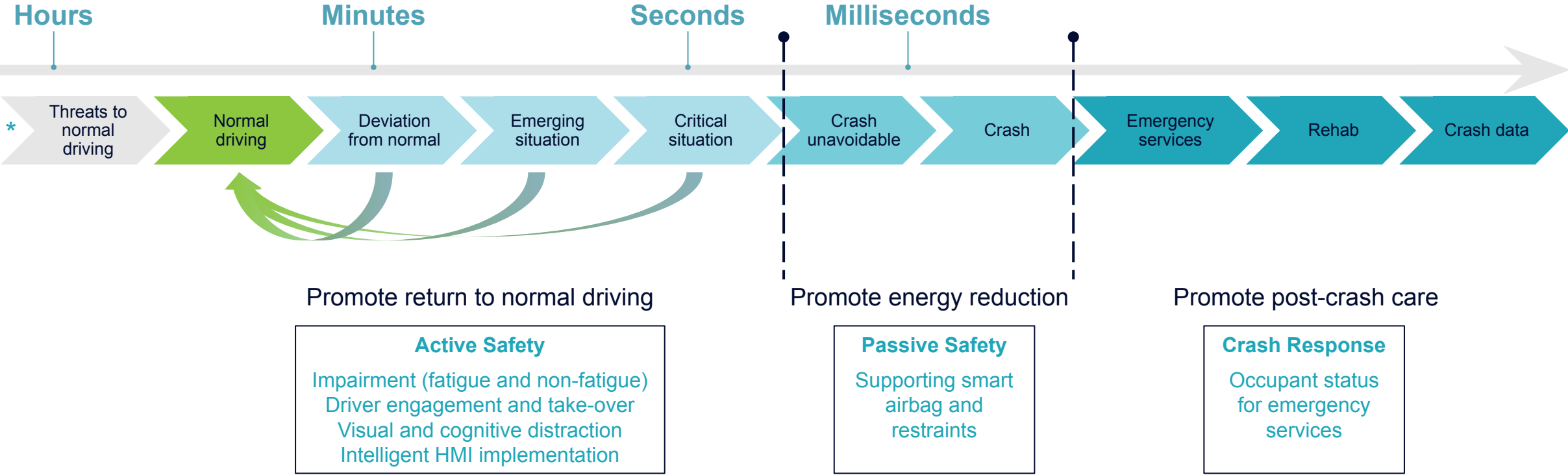


Frequency of long eye closure by duration of time awake
(Adapted from Alvaro et al., 2016)

2. The safety case

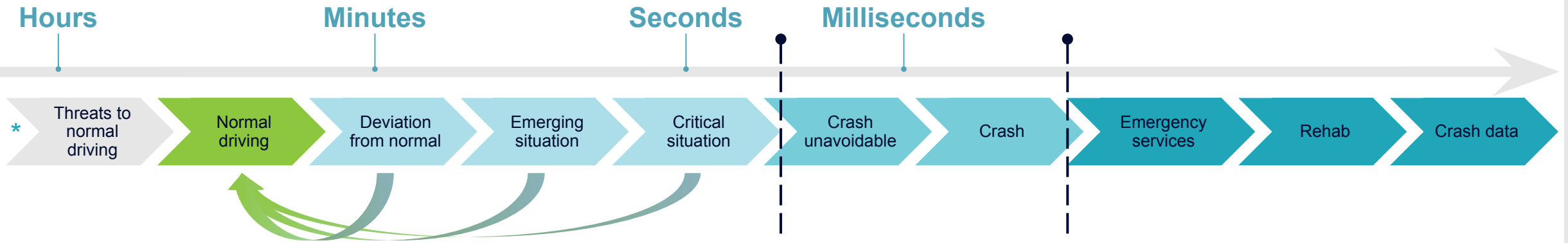
Crash risk and interventions that are likely to generate strong safety outcomes and driver acceptance

Framing The Context: The Integrated Safety Chain

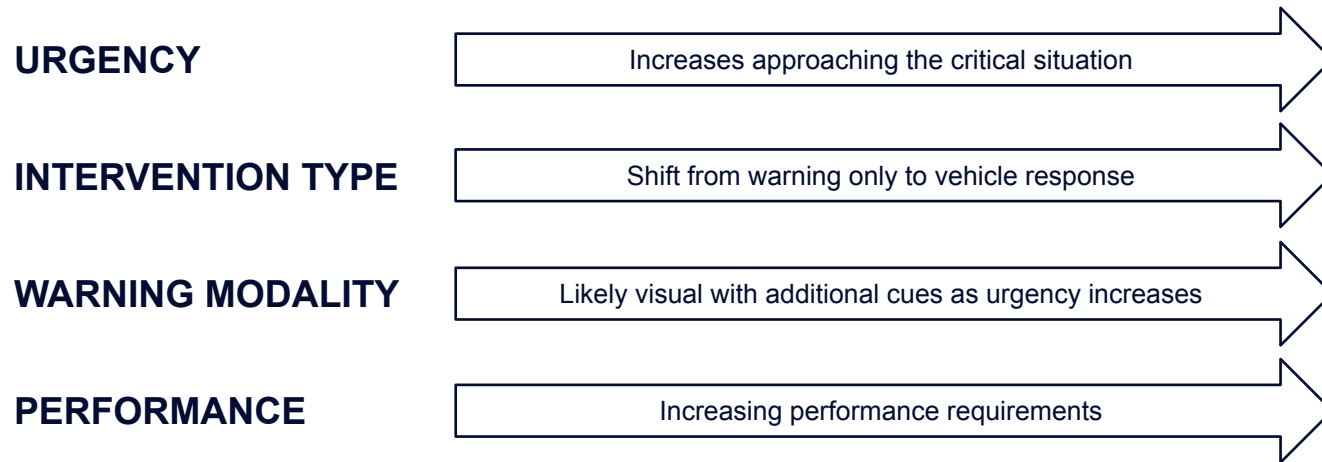


* Adapted from Fitzharris, M., Corben, B., Lenné, M. G. et al. (2022). Understanding Contributing Factors for Serious Injury Crashes Using Crash Chain Analysis: ECIS Report 3 (MUARC Report 345). Available at: <https://www.monash.edu/muarc/research/research-areas/transport-safety/enhanced-crash-investigation-study/ecis-reports>

This framework defines key elements of implementation



This reflects comprehensive safety thinking and introduces discussion of key issues to support OSM uptake

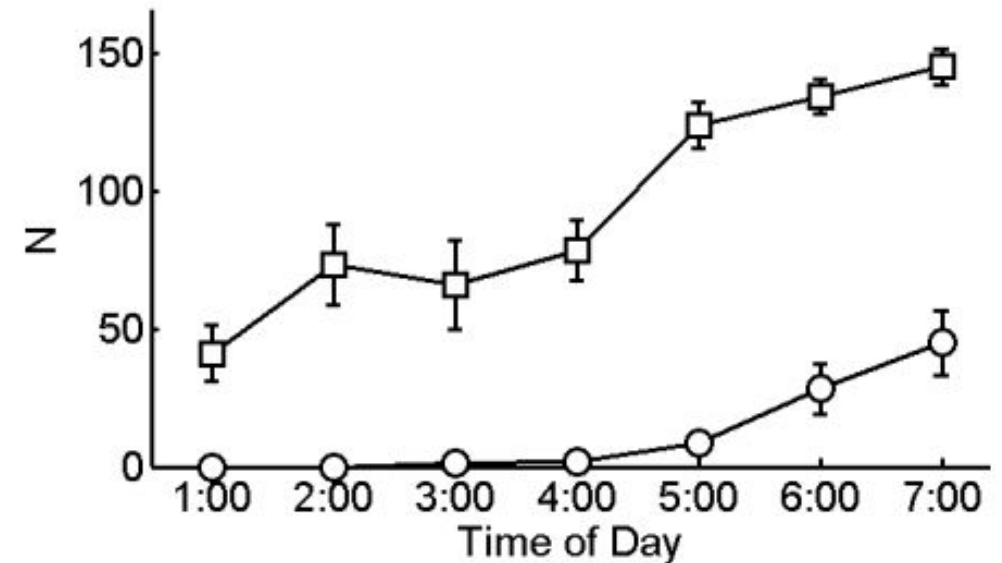


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Evidence for Microsleep Behaviours

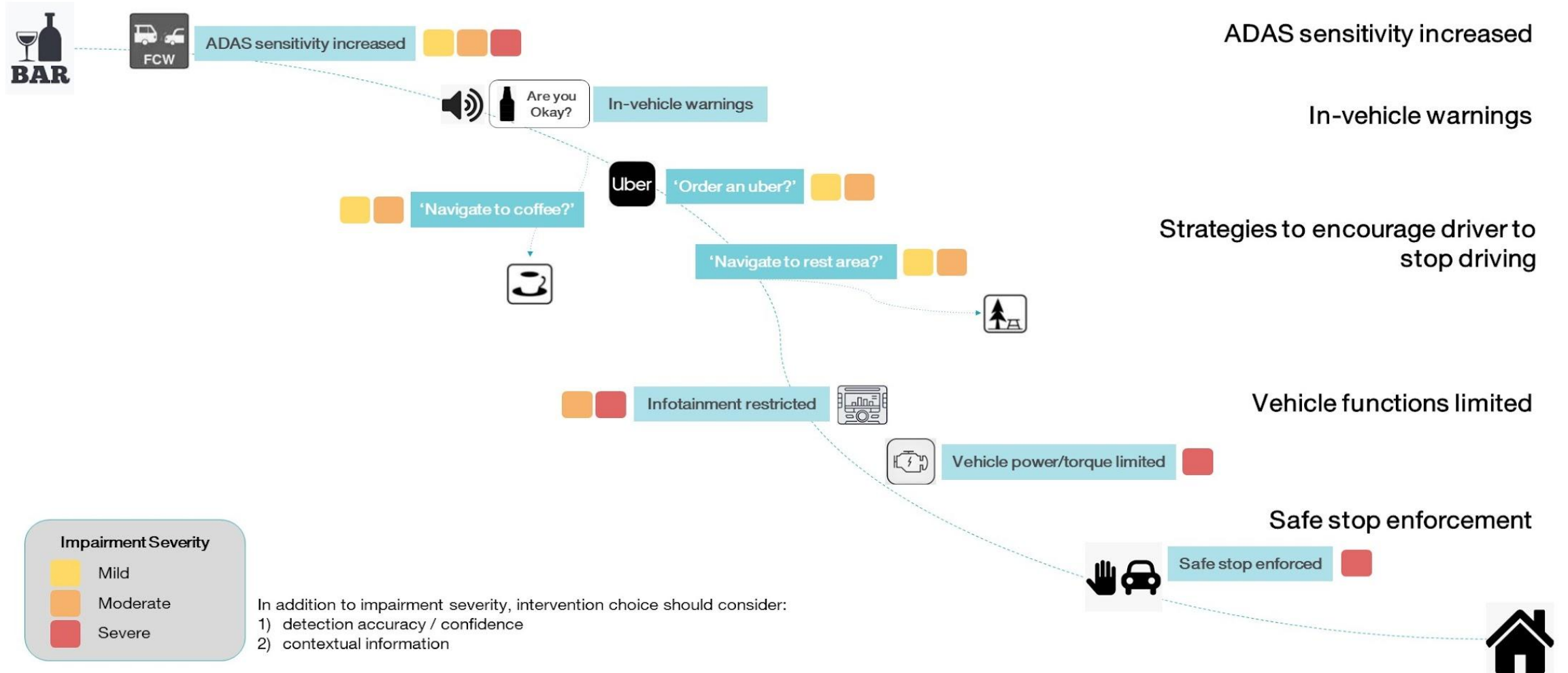
- Drowsiness occurs on a spectrum with changes measured over time
- Microsleeps are discrete events and represent a significant and distinct risk to drivers
- A microsleep precedes an estimated 60-80% of sleep-related crashes (figure adapted from Golz et al, 2011).



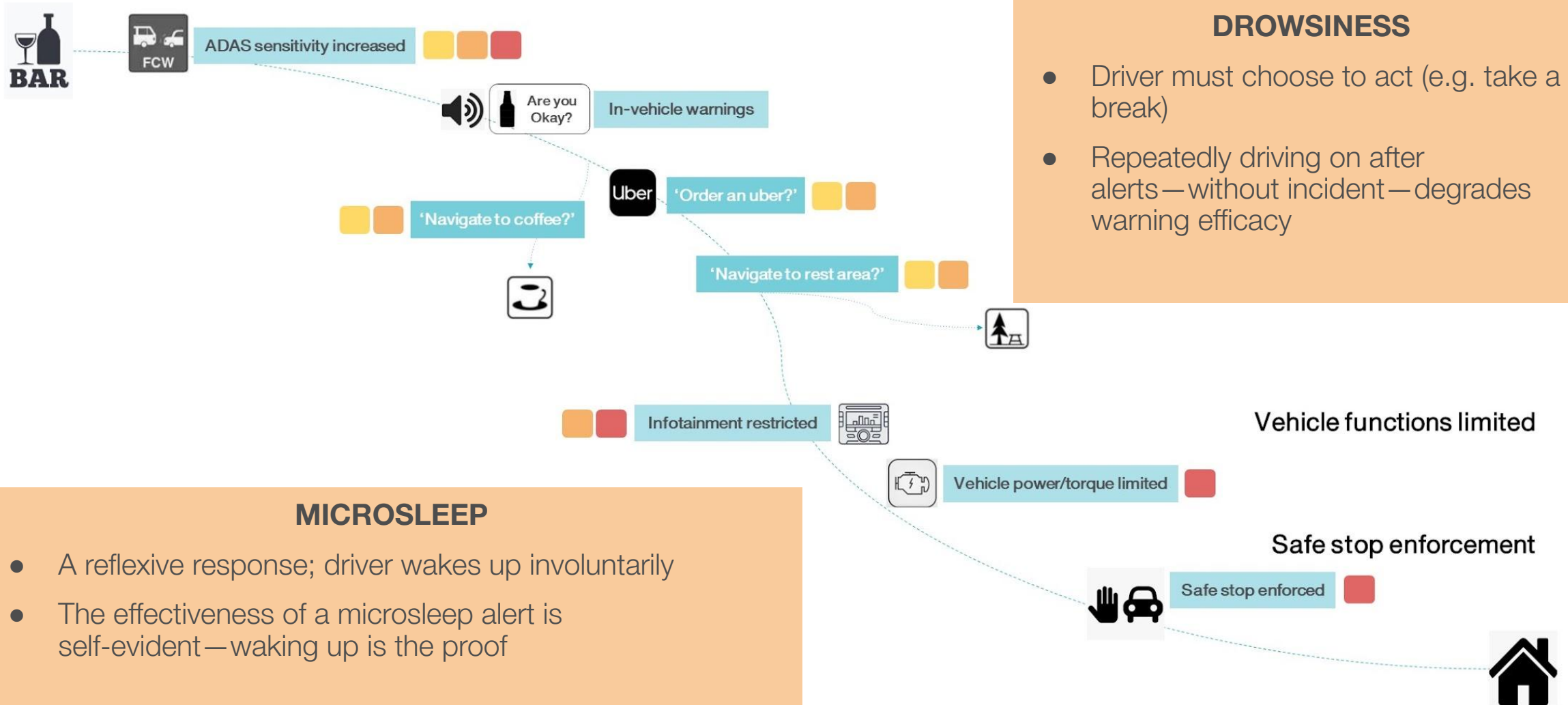
The mean number of MS (squares), of crashes (circles)

Interventions must match actual & perceived risk to be effective

(intoxication example)



Interventions must match actual & perceived risk to be effective



DROWSINESS

- Driver must choose to act (e.g. take a break)
- Repeatedly driving on after alerts — without incident — degrades warning efficacy

MICROSLEEP

- A reflexive response; driver wakes up involuntarily
- The effectiveness of a microsleep alert is self-evident — waking up is the proof

Vehicle functions limited

Safe stop enforcement

The effectiveness of alarms and stronger interventions



Event detected



Alerts activated

66%

When drivers received in-cab alerts, it reduced detected microsleep events by 66% relative to when the monitoring device silently recorded events but didn't alert the driver.



Event detected



Alerts activated



Stronger action

94%

When in-cab alerts were combined with contacting the shift manager, detected microsleep events reduced by 94%.

Fitzharris, M., Liu, S., Stephens, A. N. & Lenné, M. G. (2017). The relative importance of real-time in-cab and external feedback in managing fatigue in real-world commercial transport operations. *Traffic Injury Prevention*, 81(S1), S71-78.

Alerting rates impact safety and experience goals

Detected Microsleep Event Every X Hours



Fitzharris, M., Liu, S., Stephens, A. N. & Lenné, M. G. (2017). The relative importance of real-time in-cab and external feedback in managing fatigue in real-world commercial transport operations. *Traffic Injury Prevention*, 81(S1), S71-78.

Cori, J., Booker, L., Sletten, T., Rajaratnam, S., Singh, B., Stanley, D., ... & Howard, M. (2024, September). Evaluating the effectiveness of camera-based fatigue detection technology in a rural truck driver cohort. In *JOURNAL OF SLEEP RESEARCH* (Vol. 33). 111 RIVER ST, HOBOKEN 07030-5774, NJ USA: WILEY.

Summary: Interventions in the context of the behaviours targeted

	Trigger	Alert Successful If	Consequences of Failing to Act Upon Alert	Compliance Likelihood
Drowsiness	KSS 7+	Driver takes a break	A spectrum of outcomes	Lower / voluntary
Microsleep	Extended Eye Closure	Driver wakes up, takes action	High and often immediate	Higher (due to immediate feedback)

Drowsiness

- Driver must choose to act (e.g. take a break)
- Repeatedly driving on after alerts—without incident—can condition drivers to disregard future warnings, irrespective of true drowsiness level

Microsleep

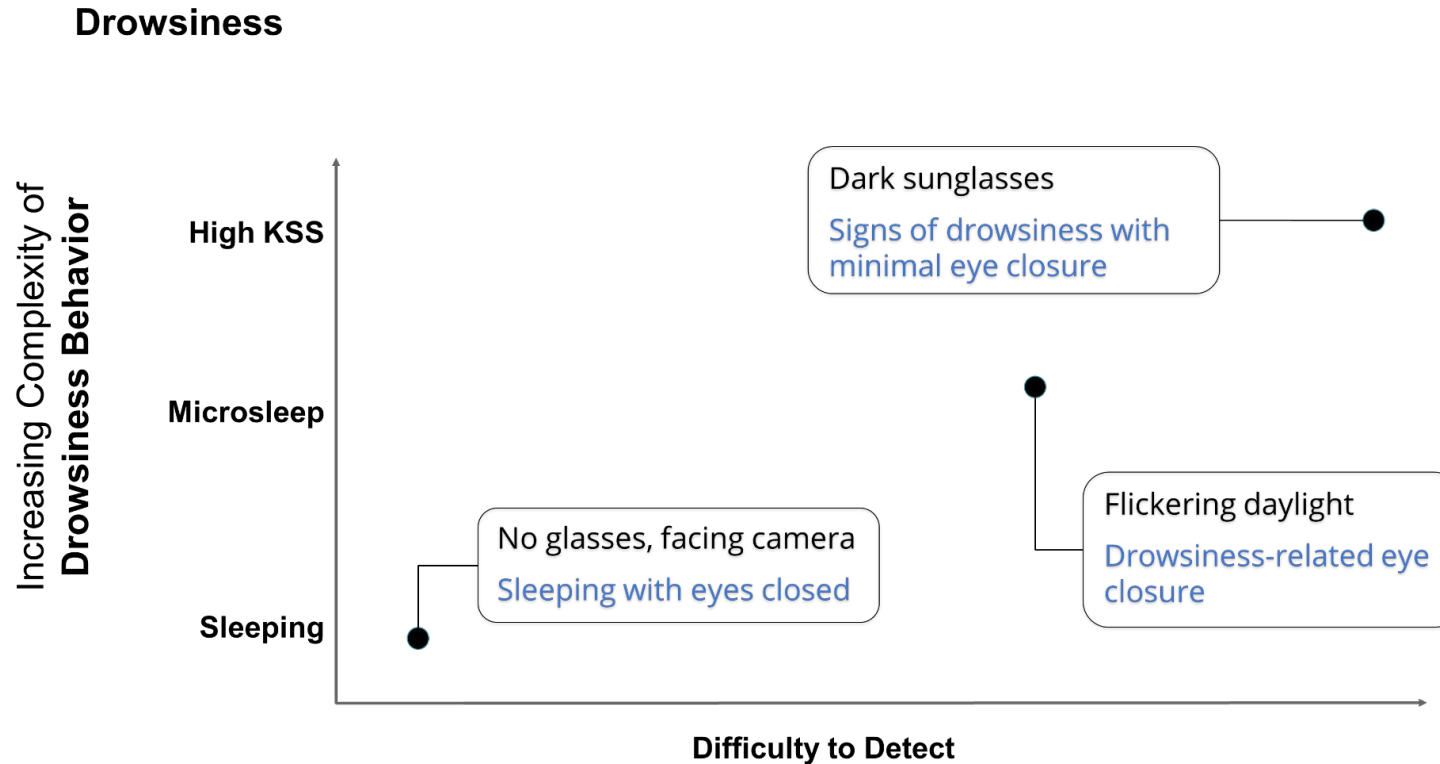
- A reflexive response; driver wakes up involuntarily
- **The effectiveness of a microsleep alert is self-evident—waking up is the proof**

This highlights the importance of detecting microsleeps and focusing drowsiness alerts on high-risk states

3. Implementation considerations

Microsleep behaviour can be measured effectively for certification

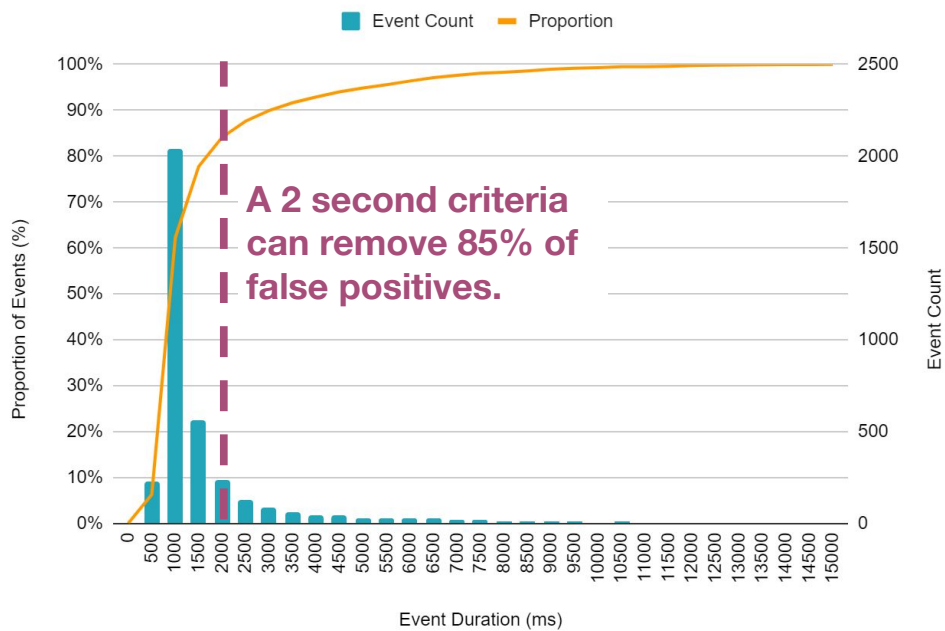
Expanding the range of drowsiness behaviours



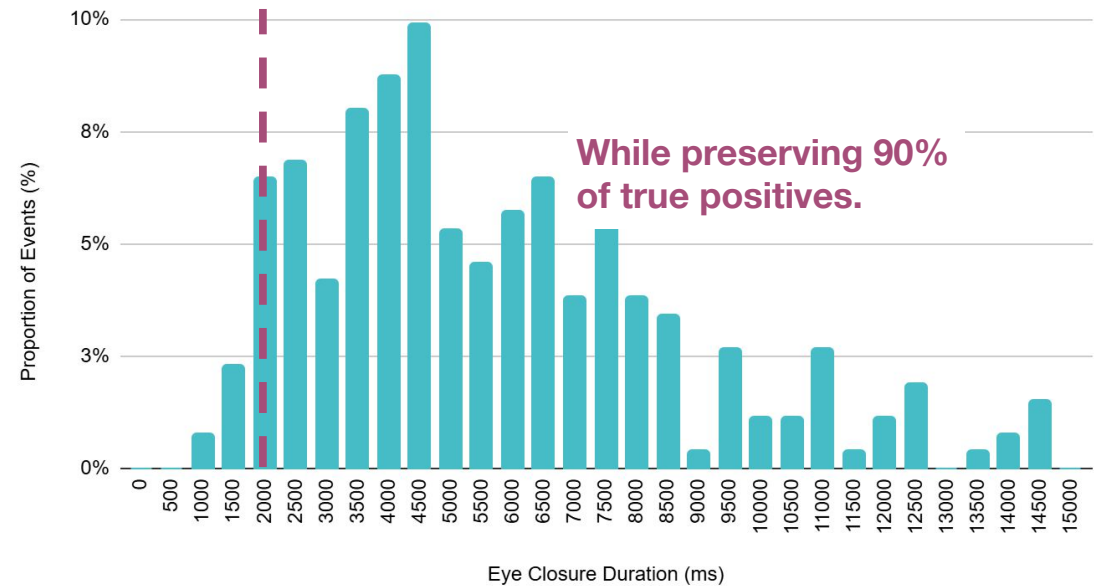
Fredriksson R, Lenné MG, van Montfort S and Grover C (2021) European NCAP Program Developments to Address Driver Distraction, Drowsiness and Sudden Sickness. *Front. Neuroergon.* 2:786674. doi: 10.3389/fnrgo.2021.786674

Eye closure duration and wakefulness

Distribution of Alert Eye Closure Event Duration¹



Distribution of Eye Closure Duration in Microsleep and Sleep Events



1. Excludes blinks. Excludes microsleep and sleep events.

A minimum eye closure duration criteria is effective at minimizing microsleep false positives.
Data from Seeing Machines research partner projects involving test track driving



Operational definitions to reduce false positives

- There are known distributions of alert and drowsy eye closure events by eye closure duration
- Most drowsy-related eye closure durations are > 2 seconds
- Alerting rates for LECs without a drowsiness input will be high
- Given the LEC data presented, implementations that accommodate additional indicators of microsleep (e.g., head nodding) or evidence of prior drowsiness, will to reduce false alarms

Conclusion: The case for including Microsleeps

- It is a more critical safety event
- It occurs before <80% of sleep-related crashes
- Being typically discrete events supports greater detection certainty compared to high KSS drowsiness behaviour over time
- It can be meaningfully tied to a stronger vehicle response
- It is more readily understood and accepted by drivers
- There is strong evidence of efficacy
- It aligns with other regulations and consumer policy
 - China DAMS
 - Euro NCAP

Acknowledgements

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Thank you

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