LEVERAGING EXTERNAL HAZARD DATA TO SAFEGUARD AUTOMATED DRIVING SYSTEMS (ADS)

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Content of the talk

- On-board sensors have limitations
  - ADS can benefit from V2X
- Our proposal to use V2X
  - Early Hazard Processing System (EHPS)
  - A new design: three-state model
- Safety argumentation
- Simulation results

On-board sensors have limitations

Adverse weather

Photo from: Joshua Tree National Park / NPS, Hannah Schwalbe, 2016. Public domain**.** Source: Wikimedia Commons

Roads geometry

Photo from: Mike Butler, Source Adobe Stock

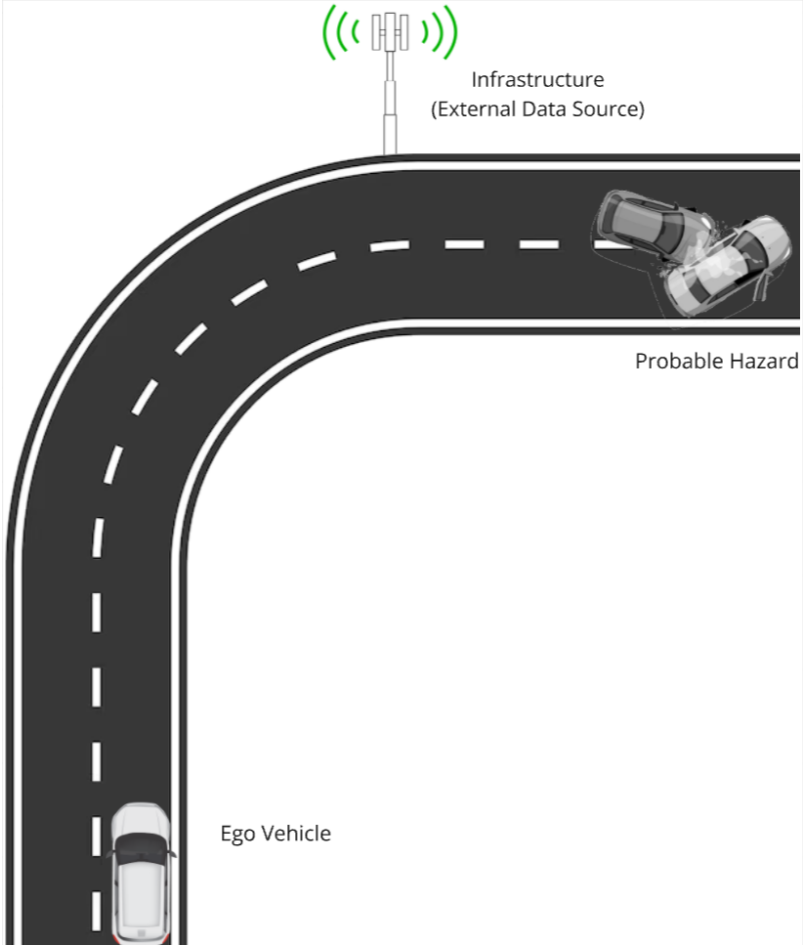
Occlusion by traffic

Photo from: Martin Barraud, Source Getty Images

A concrete scenario
Hazard Beyond Sensor‘s Field of View

On-board sensors may detect hazards too late

- Curved road limits the ADS field of view
- Onboard sensors may not detect the hazard behind the curve
- ADS might react too late



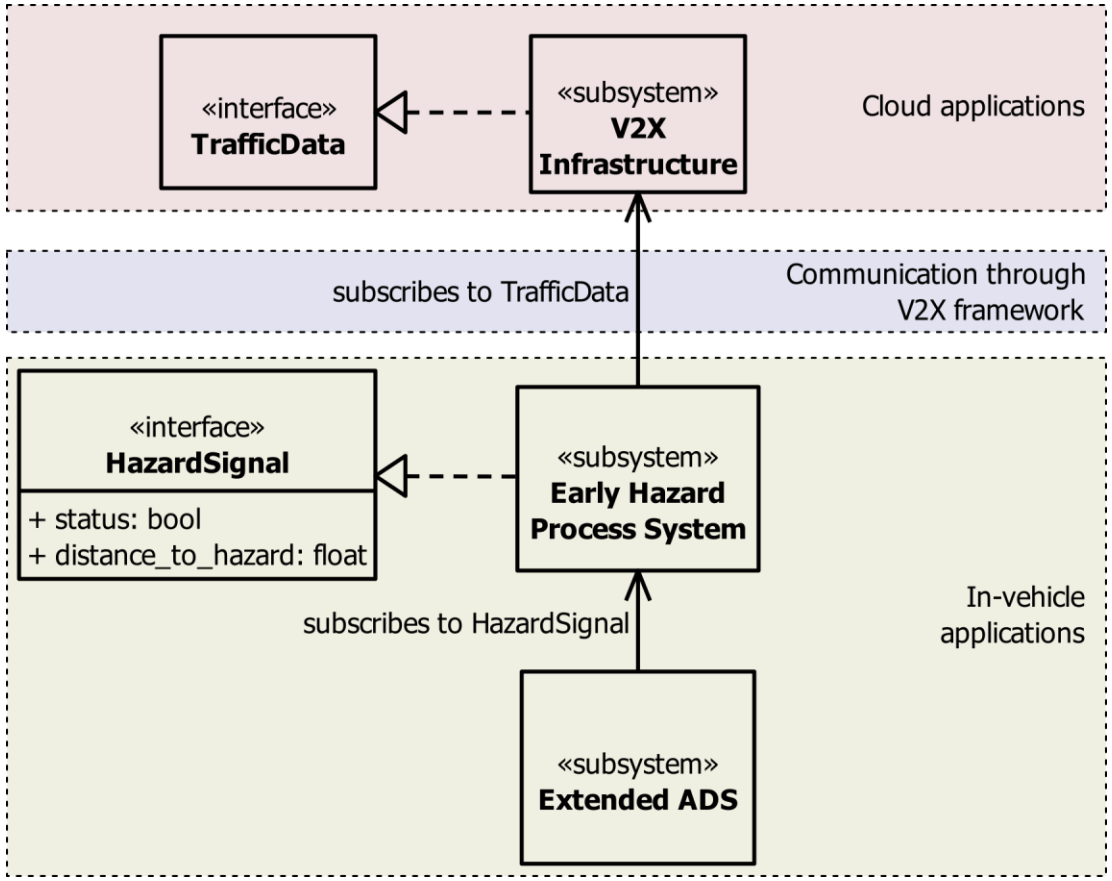
ADS can benefit from V2X

- Vehicle-to-Everything (V2X) communication, offers ways to increase awareness of ADS
  - Example: receiving external hazard data, can improve ADS behavior

- Although, external data is not always reliable
  - How to use them without compromising safety?

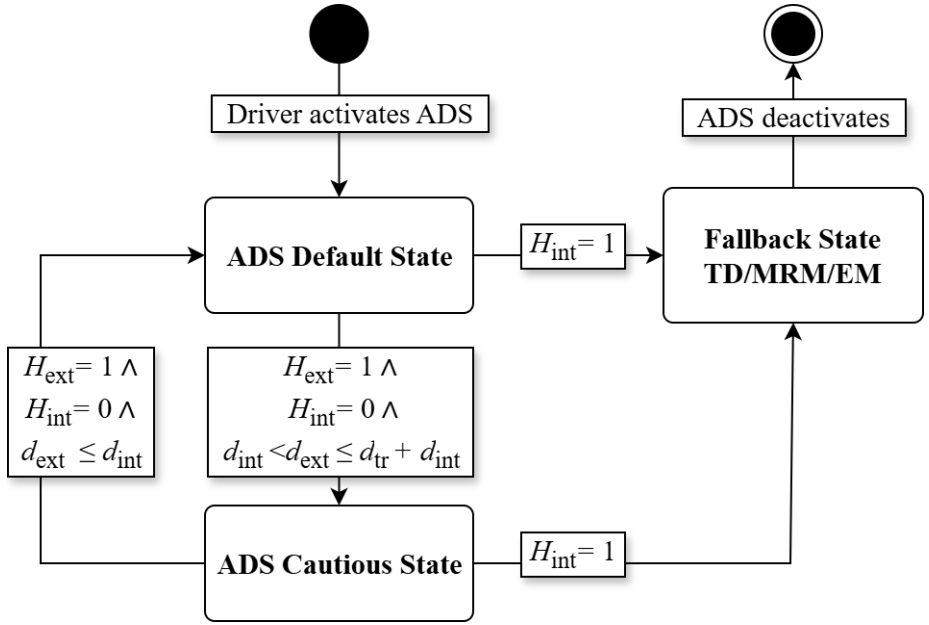
Our proposal

We propose an Early Hazard Processing System (EHPS) together with an extended ADS model, which uses hazard signal from external source to trigger a preparatory state.



The design

- We extend the ADS by introducing a new **Cautious State**.
- The Cautious State is a preparatory state which the ADS transitions into based on external hazard information.
- In this state, ADS behaves more conservatively, e.g. by reducing speed.



Safety argumentation

The EHPS-enabled ADS performs at least as safely as the baseline system

We considered all cases where external hazard data may be uncertain, either in the hazard's reported location or in its existence:

hazard does not exist but is reported by EHPS

- The ADS slows down, verifies with internal sensors that no hazard exists, and returns to the Default state. This prioritizes safety over performance without introducing collision risk.

hazard exists but is not reported by EHPS

- In this case, the ADS behaves like the baseline system, detecting the hazard with on-board sensors while traveling. Its safety performance is therefore identical to the baseline.

hazard is closer to ADS than is reported by EHPS

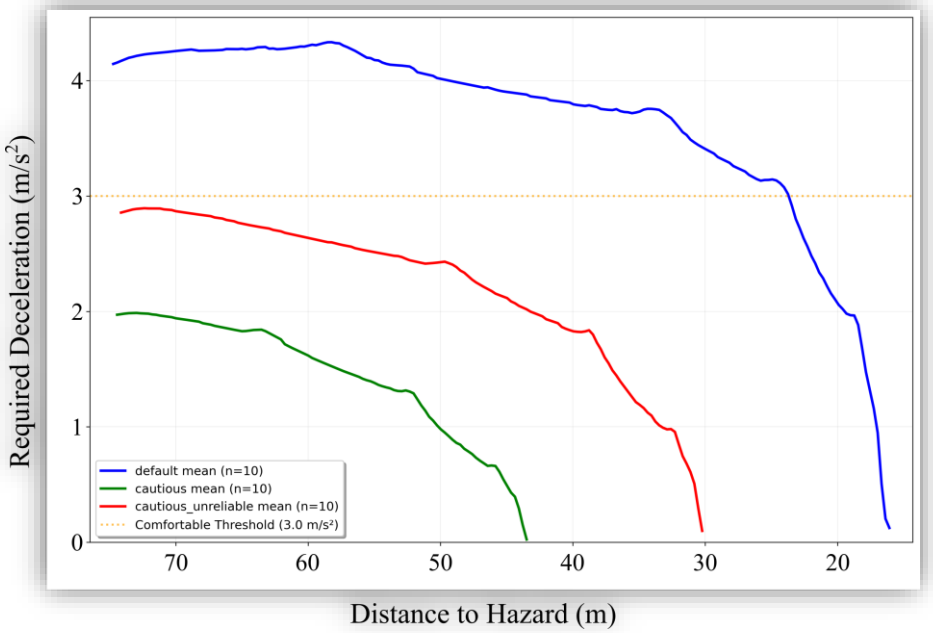
- In this case, the hazard appears earlier than expected, so the ADS cannot fully transition to the Cautious state. However, it detects the hazard at a lower speed, still improving over the baseline.

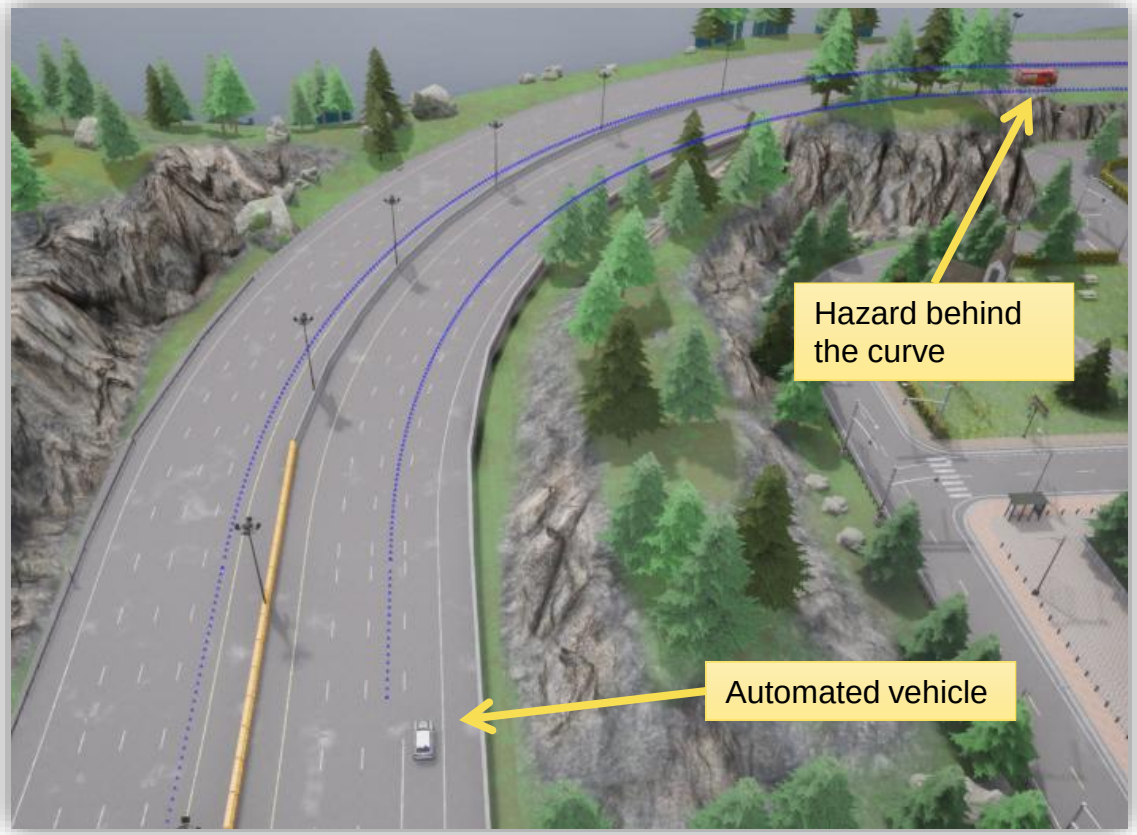
hazard is farther to ADS than is reported by EHPS

- In this case, the hazard is farther than expected, so the vehicle begins transitioning back to the Default state. This is equivalent to the baseline ADS.

Simulation Results

System under test	TTC [s] +/- std	Required Deceleration [m/s^2] +/- std
Baseline ADS	3.102 +/- 0.021	3.306 +/- 0.032
ADS using reliable external data	4.497 +/- 0.018	1.267 +/- 0.001
ADS using unreliable external data	3.730 +/- 0.001	1.957 +/- 0.009





Results show an increase in the time-to-collision (TTC) and reduction in the average required deceleration compared to baseline, even when the external hazard data are unreliable.

Conclusion

- External hazard data can make ADS more prepared
- EHPS enables early awareness before onboard detection
- ADS enters a Cautious State, reducing speed proactively
- Safety-critical actions still rely on onboard sensor confirmation
- Results show higher TTC and lower required deceleration
- Even unreliable external data can improve safety and comfort

Imprint

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