Efficient Injury Risk Assessment for ADSs Using Subset Simulation

2025-09-10: SafeComp2025 – Session 2

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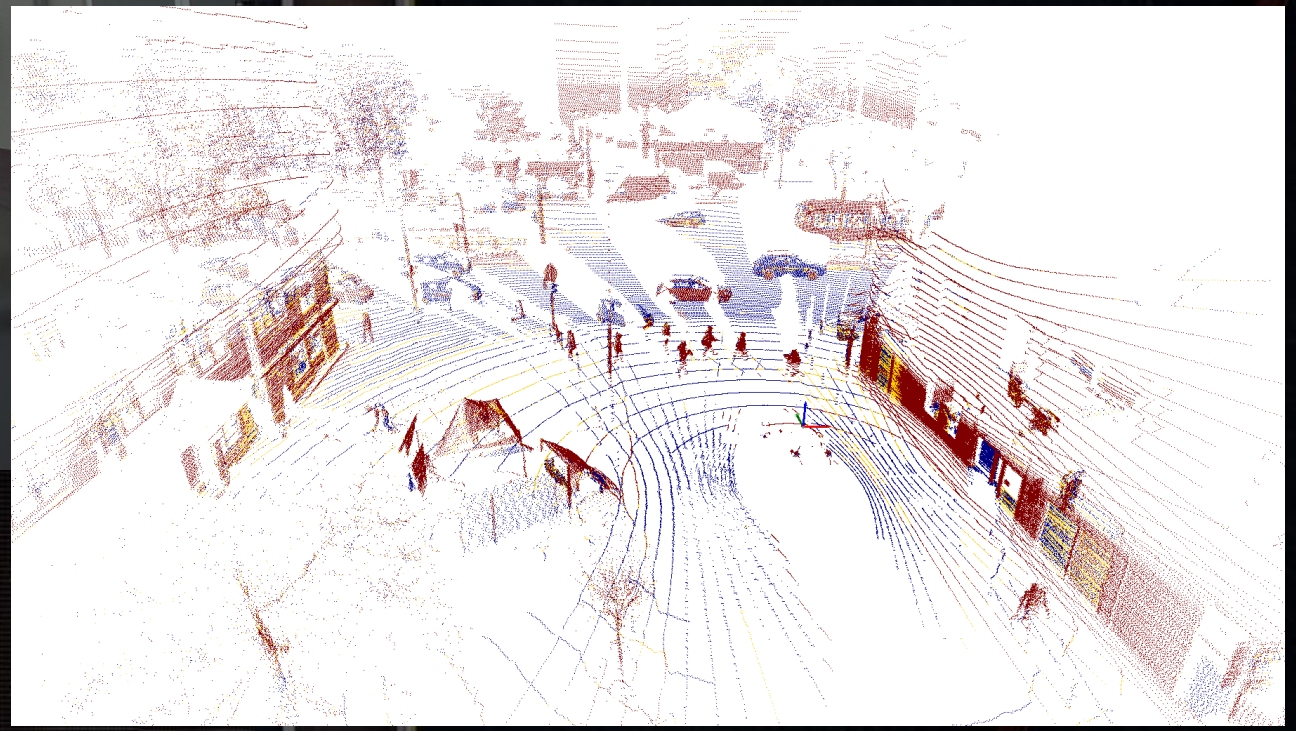
Image: Volvo cars

Complex operational environment

Images: ZOD



Simulation-based risk assessment

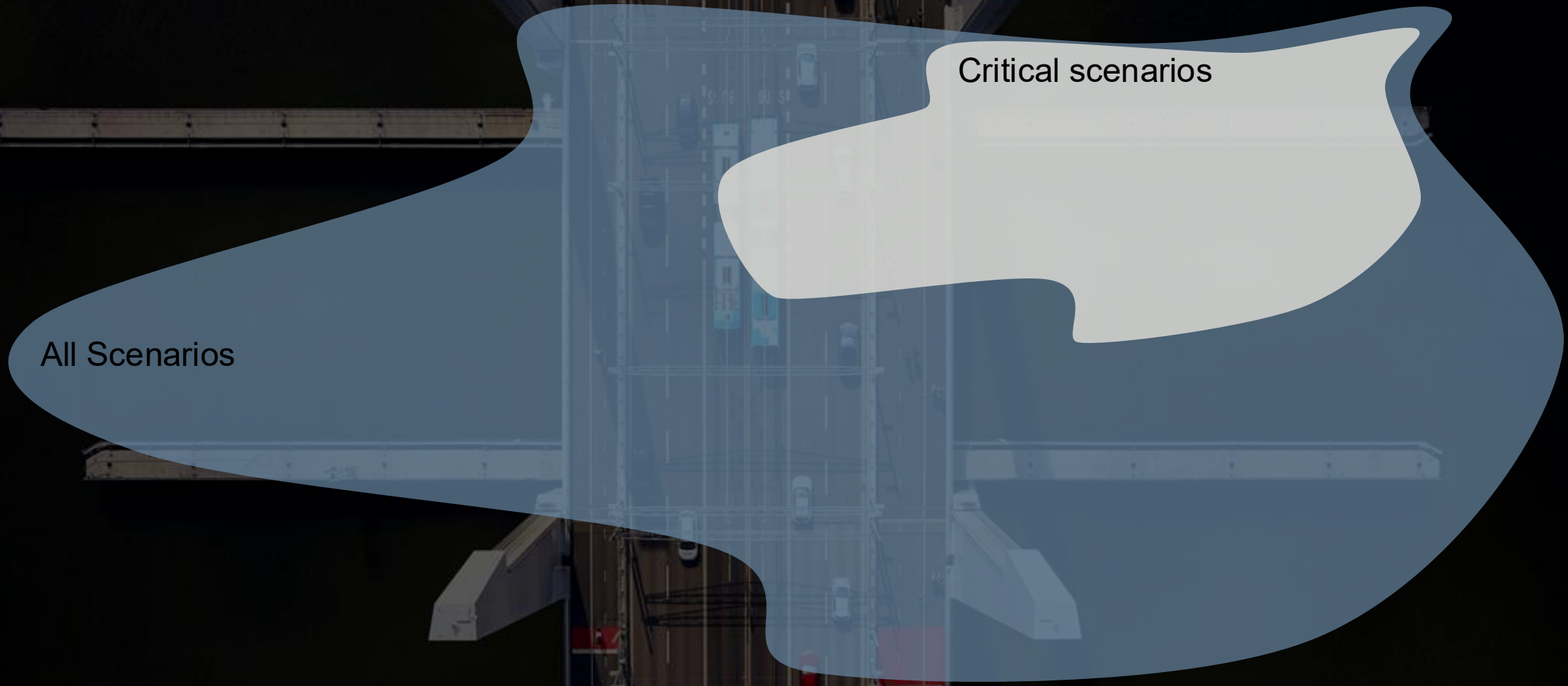
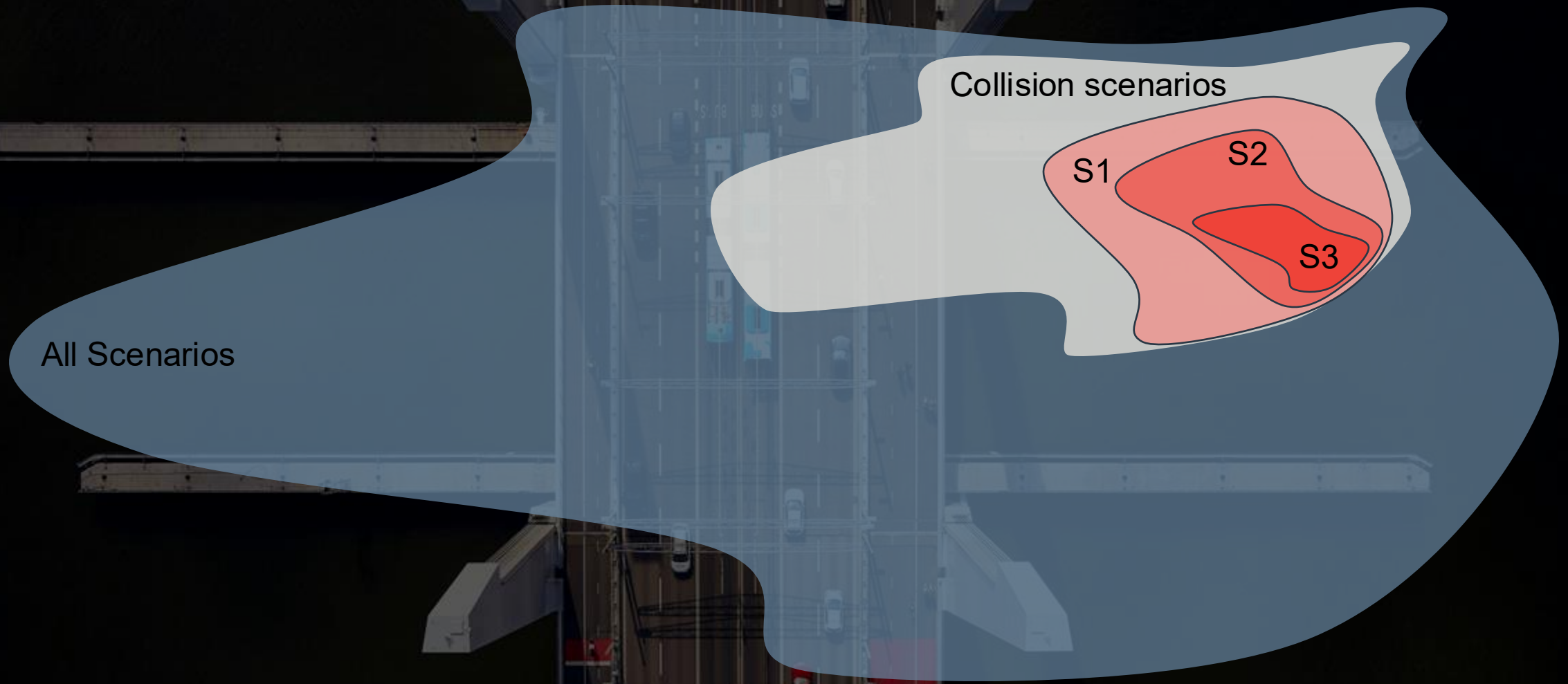


Image credits- Teslarati

Images: Volvo Cars

Considering severity



Find critical scenarios

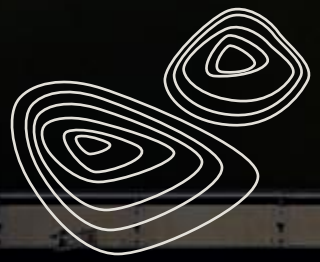
Probability of scenario

Severity of scenario

Risk

SW feature

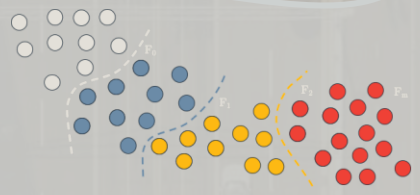
Recorded scenarios



Scenario statistics

Simulation

+



Scenario search

Risk Assessment

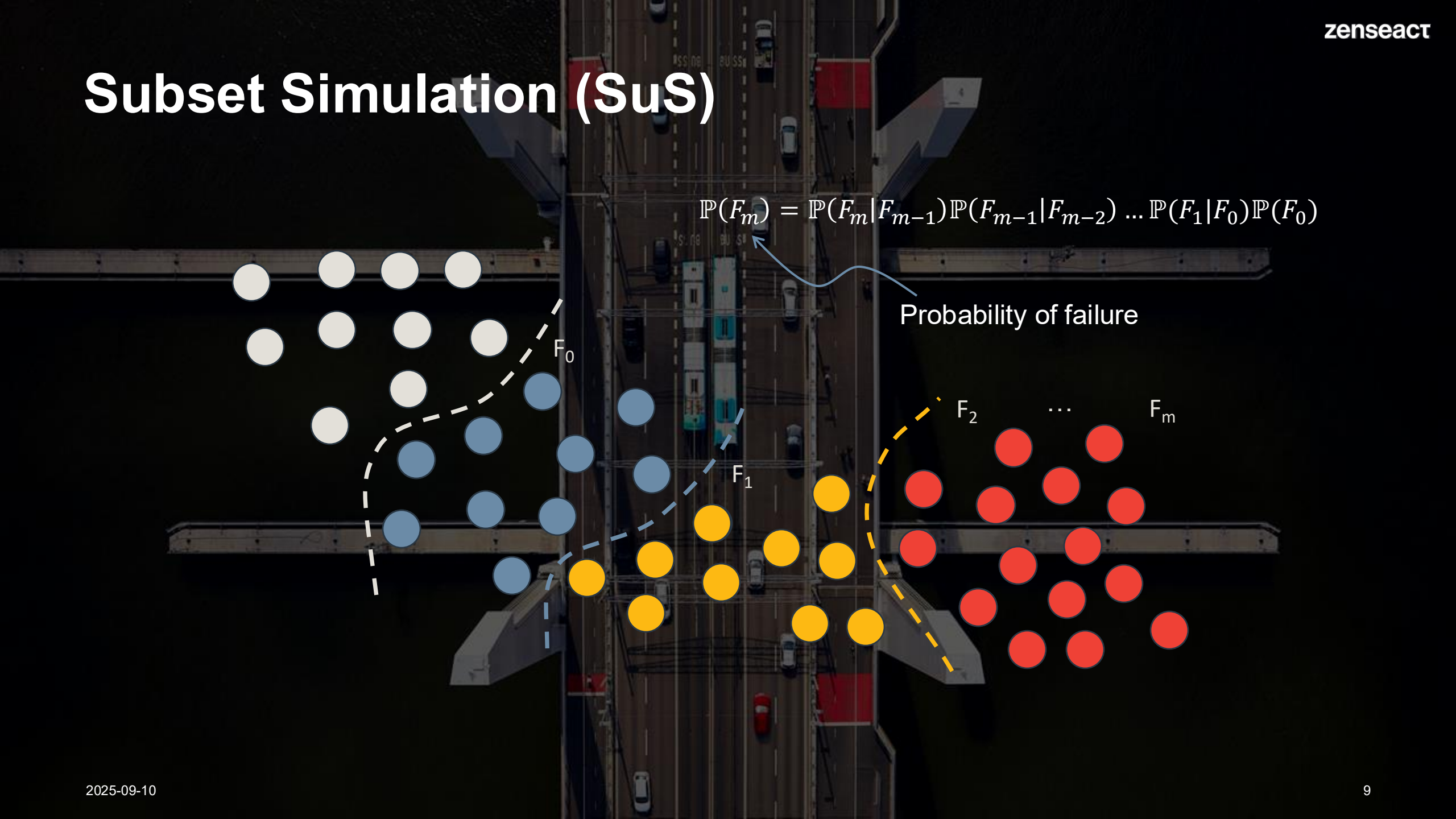
2. Multiple injury levels

1. Severity-guided Subset Simulation

Subset Simulation (SuS)

$$\mathbb{P}(F_m) = \mathbb{P}(F_m|F_{m-1})\mathbb{P}(F_{m-1}|F_{m-2}) \dots \mathbb{P}(F_1|F_0)\mathbb{P}(F_0)$$

Probability of failure



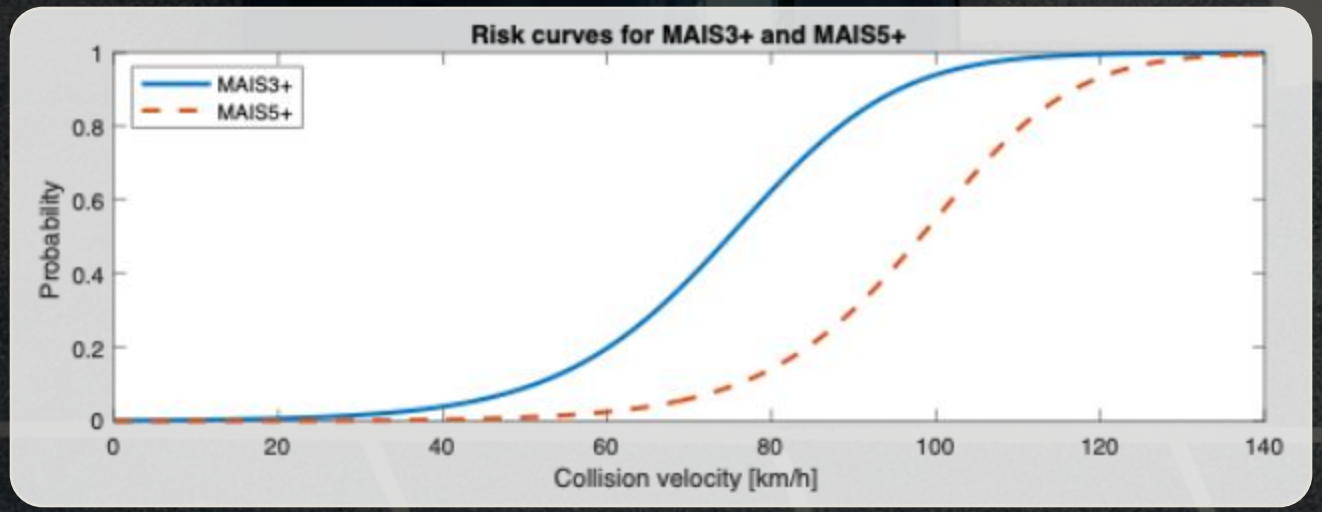
Composite failure metric: SEVBTN

Collisions

Constant

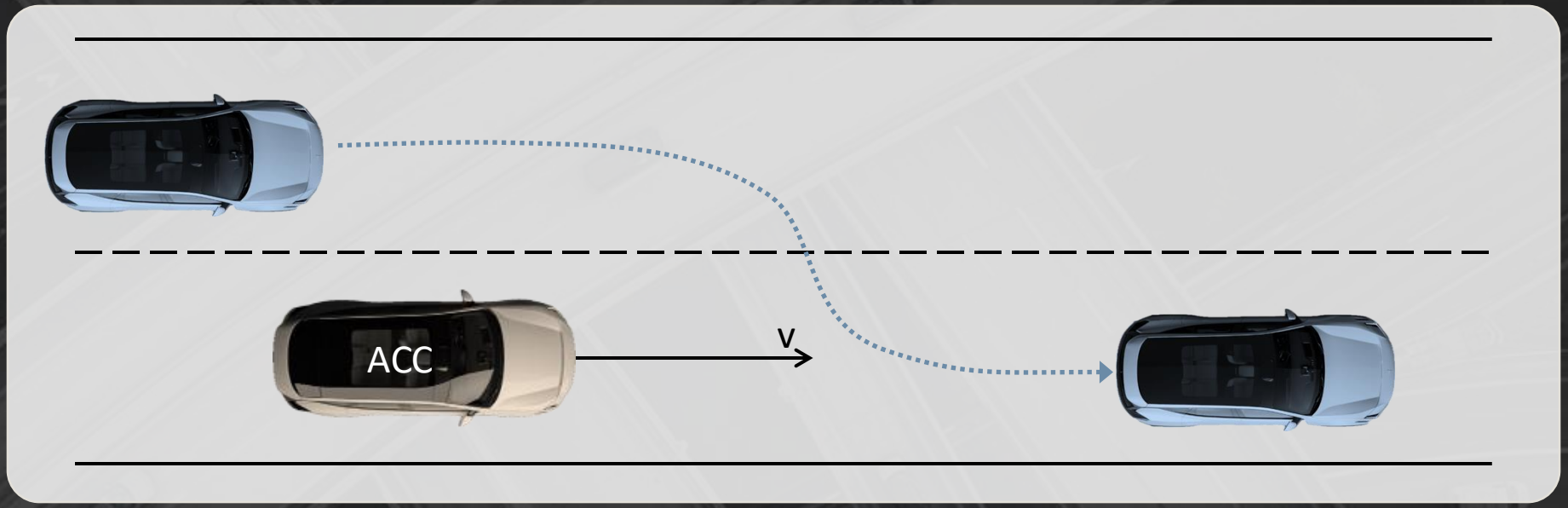
$$g(\theta) = (1 + \tau_{\Delta v}) \cdot (\min(BTN, 1) + \Delta v)$$

Severity

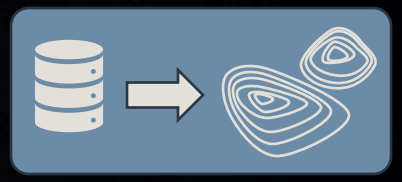


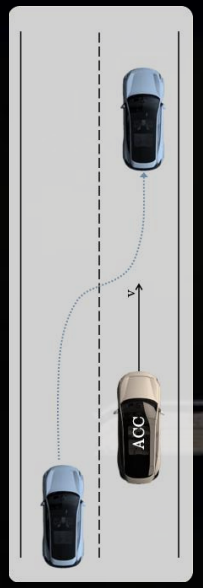
[McMurry et al. (2021)]

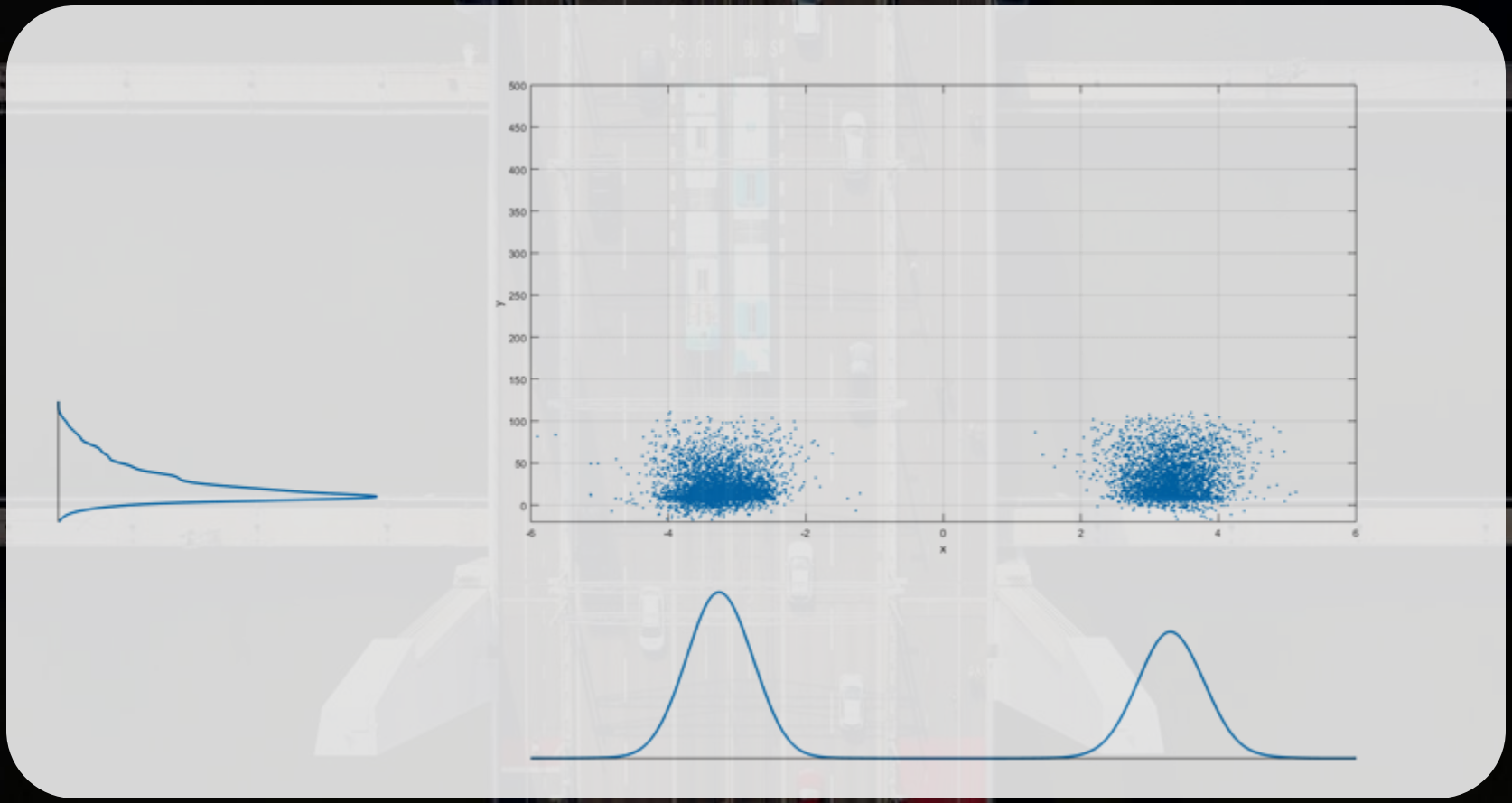
Evaluation: Cut-in Scenario for ACC feature



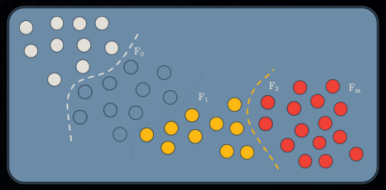
12 443 Recorded Cut-ins

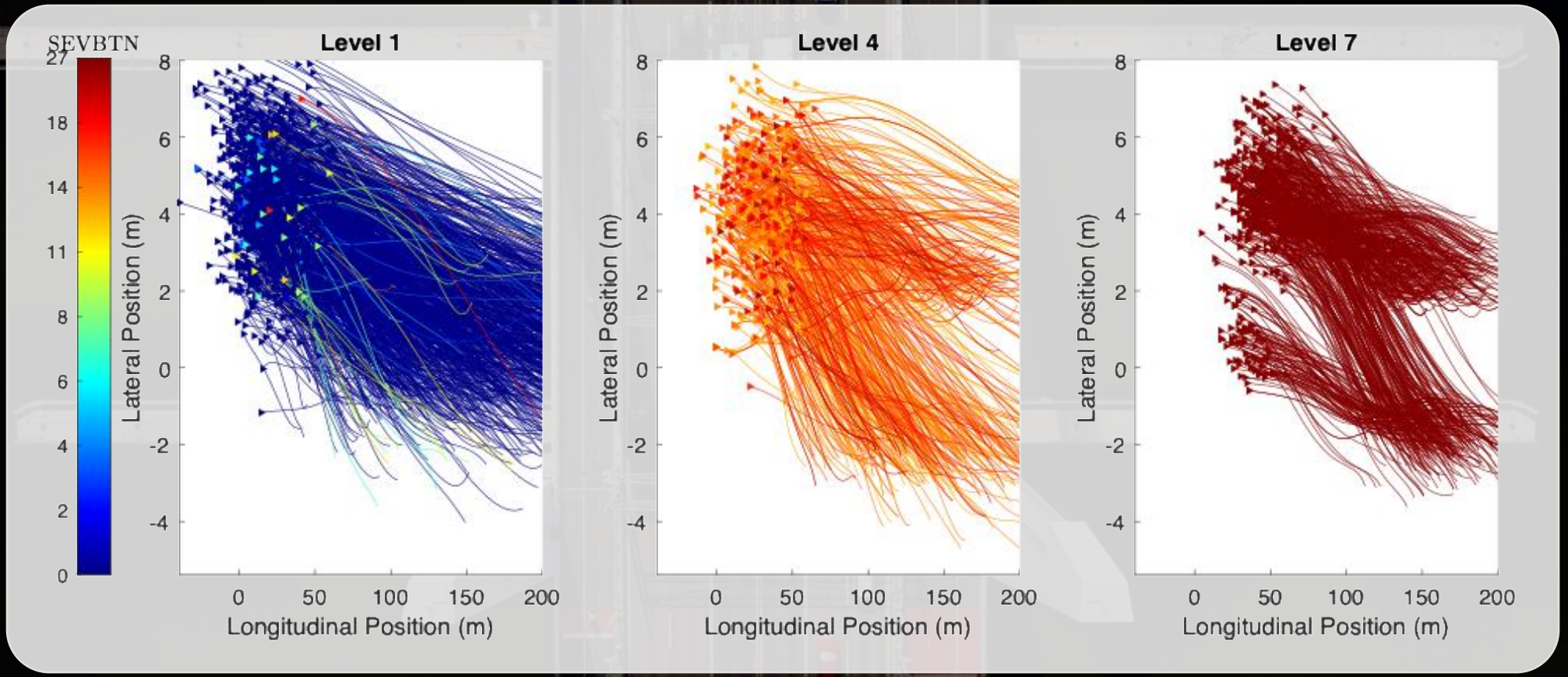




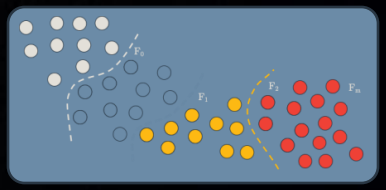


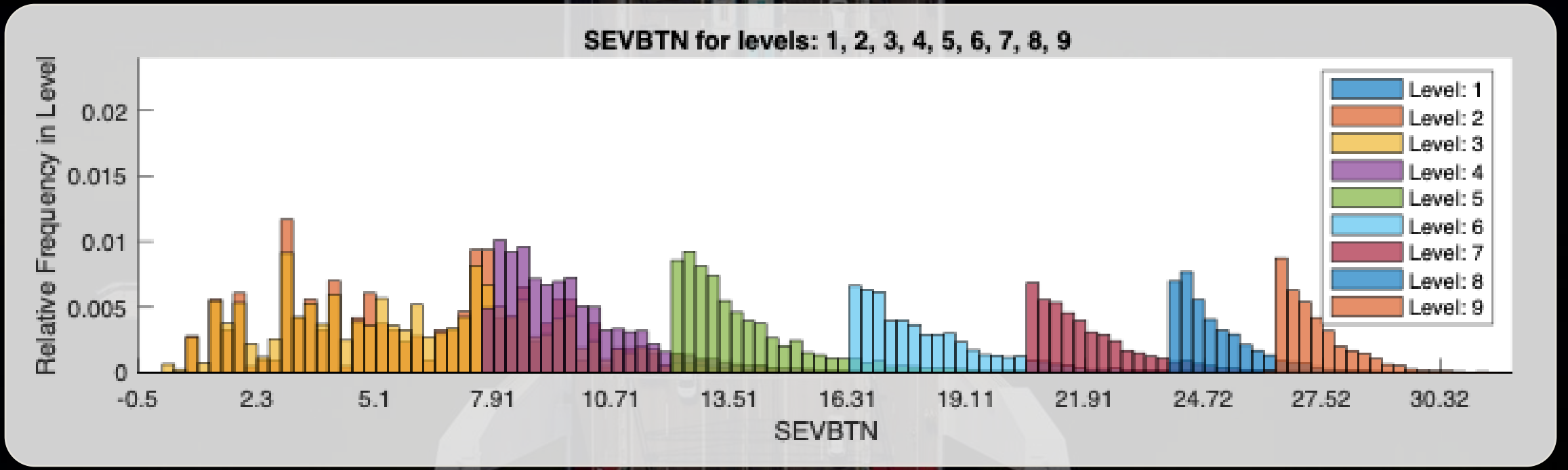
[Note: visualisation not from the used version of the dataset]



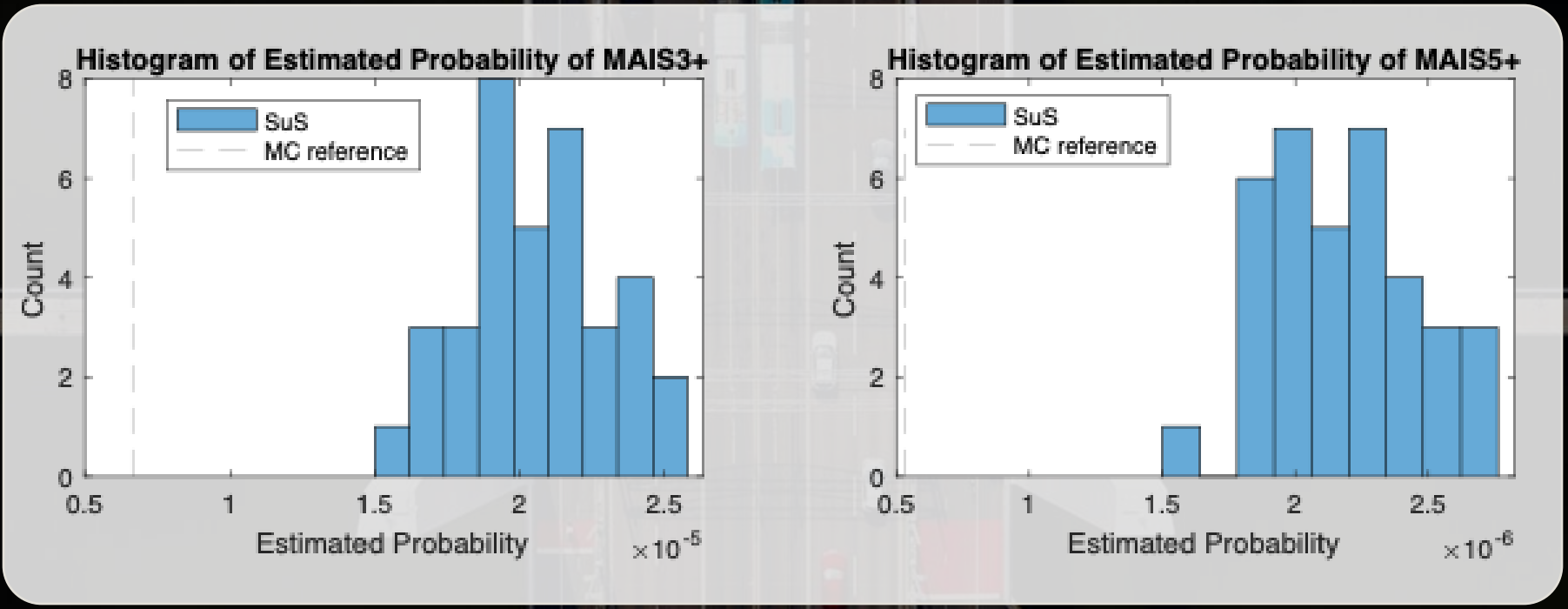

SEVBTN
27
18
14
11
8
6
4
2
0
Level 1
Level 4
Level 7
Lateral Position (m)
Longitudinal Position (m)
8
6
4
2
0
-2
-4
0
50
100
150
200

SuS levels



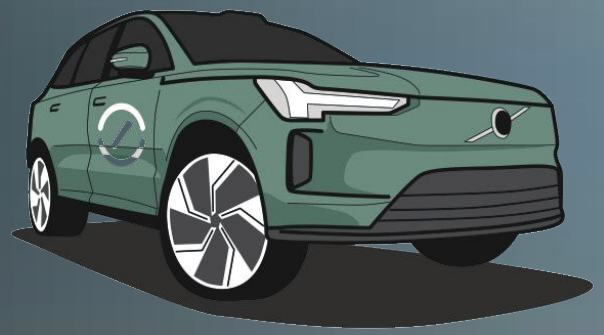

SEVBTN for levels: 1, 2, 3, 4, 5, 6, 7, 8, 9
Relative Frequency in Level
0.02
0.015
0.01
0.005
0
-0.5
2.3
5.1
7.91
10.71
13.51
16.31
19.11
21.91
24.72
27.52
30.32
SEVBTN
Level: 1
Level: 2
Level: 3
Level: 4
Level: 5
Level: 6
Level: 7
Level: 8
Level: 9

	Subset Simulation		Monte-Carlo
	Average	Standard deviation	
Number of samples	0.96×10^6	4 871	193×10^6



Future work

- Explore sources for reducing the over-estimation bias
- Extending simulations and metrics to additional factors, e.g. collision angle
- Use the extended SuS approach to support Dynamic Risk Assessment of ADSs

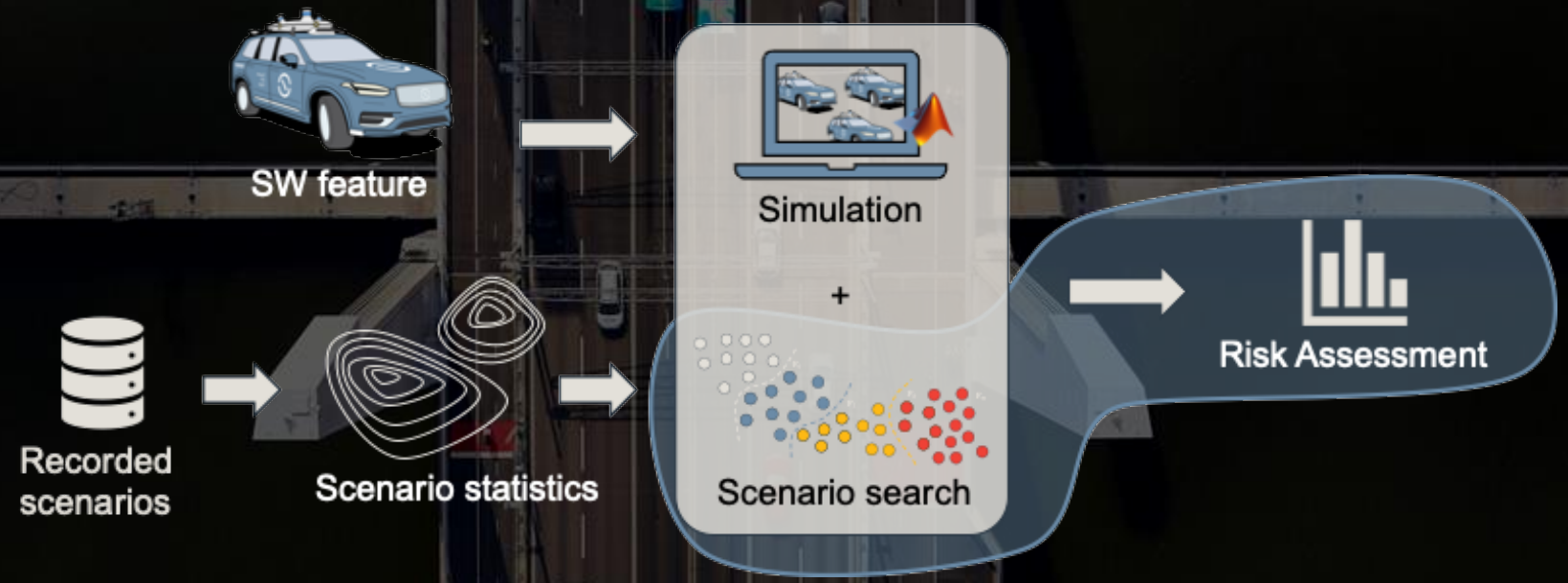


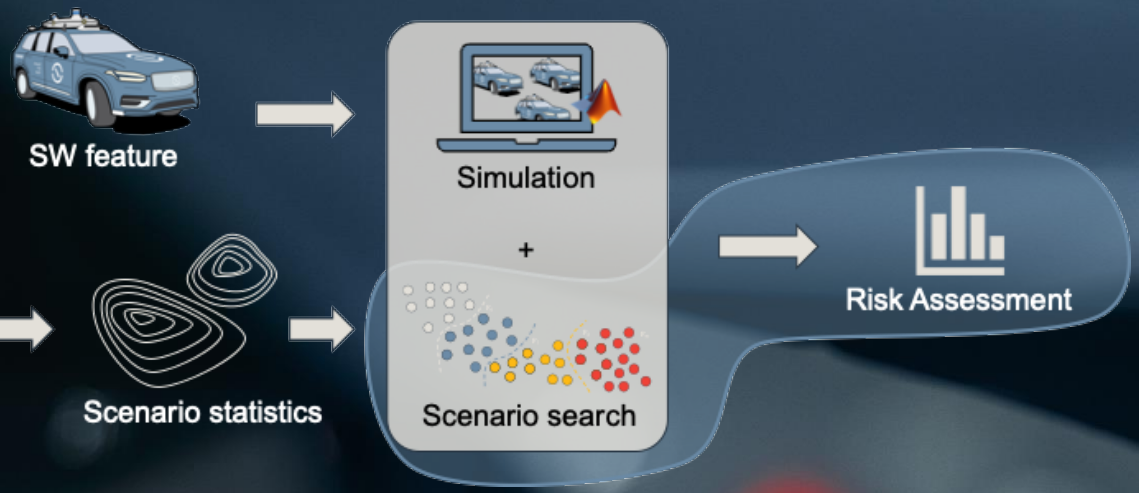
Conclusions

Extending SuS to include severity of collisions

Simultaneous estimation of multiple injury risk levels

Efficient assessment





Link to paper:
https://doi.org/10.1007/978-3-032-01241-8_6

Thanks for listening

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