

Safety Zones & Data Requirements

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Safety Zone Concept

In driving scenarios, not all dynamic objects (e.g. pedestrians) are equally important to be detected by an Automated Emergency Braking (AEB) function. In this example, we can differentiate objects by the risk of a potential collision. This narrows down the test scope on dynamic objects that can reach the ego driving corridor before it passes them. Other objects are out of scope.

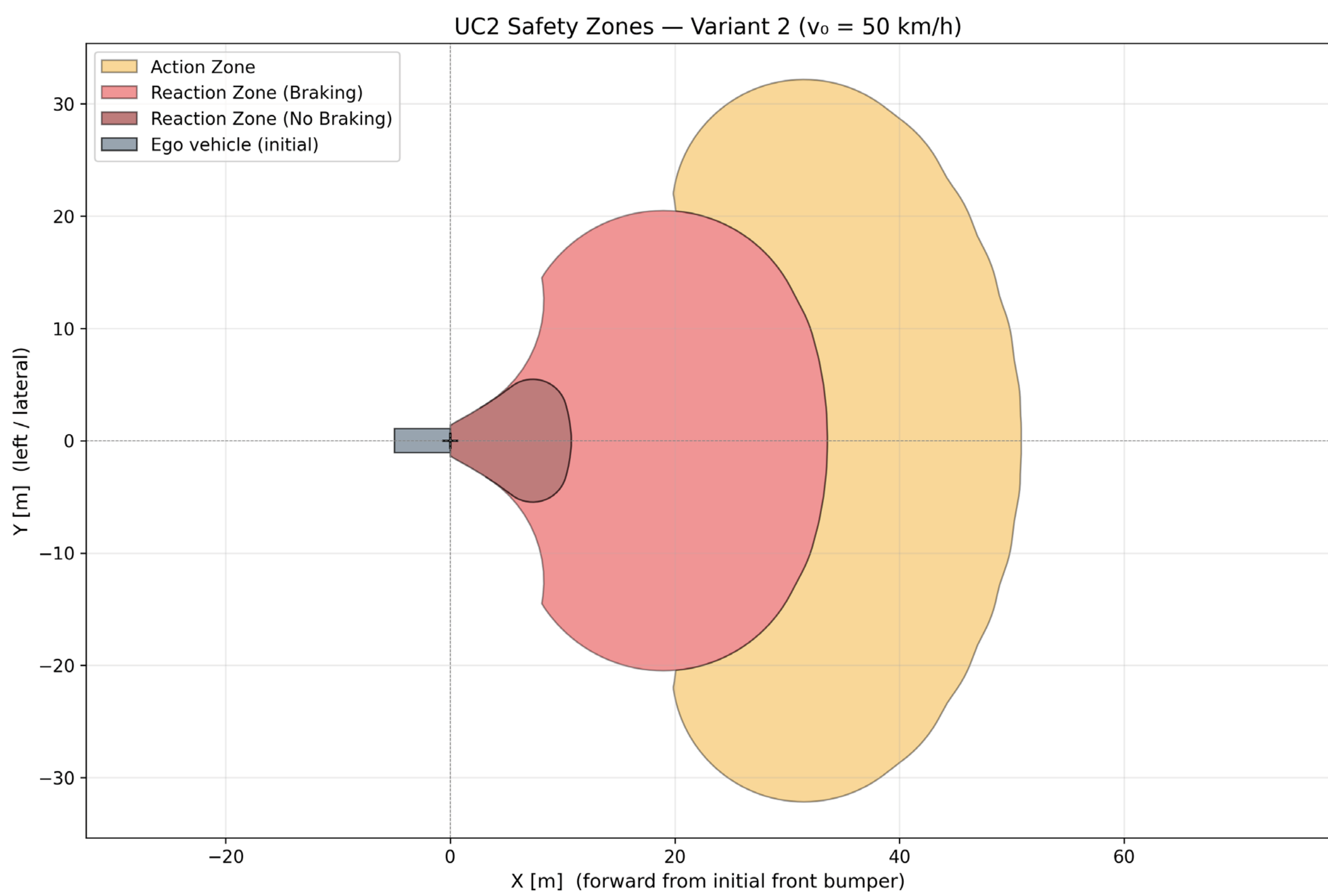


Figure 1: Safety zones for emergency / comfort braking maneuvers with -7 m/s^2 / -3 m/s^2 , an initial ego velocity of $v_0 = 50 \text{ km/h}$ and steering angles between $-4^\circ \dots +4^\circ$, where pedestrians move towards the ego driving corridor at 18 km/h (jogging) / 8 km/h (walking fast) in an angular range of $-120^\circ \dots +120^\circ$ (© Robert Bosch GmbH).

We use Safety Zone masks as shown in Fig. 1 representing reachable sets of object locations to filter for safety-relevant objects in our data. For our AEB example, we model the kinematic ego behavior in longitudinal and lateral direction assuming constant deceleration after a reaction phase with constant velocity (Fig. 2) while ego vehicle drives a curve with constant steering angle (Fig. 3). We merge the reachability sets from multiple simulations with varied steering angles smoothing the enveloping overall contour.

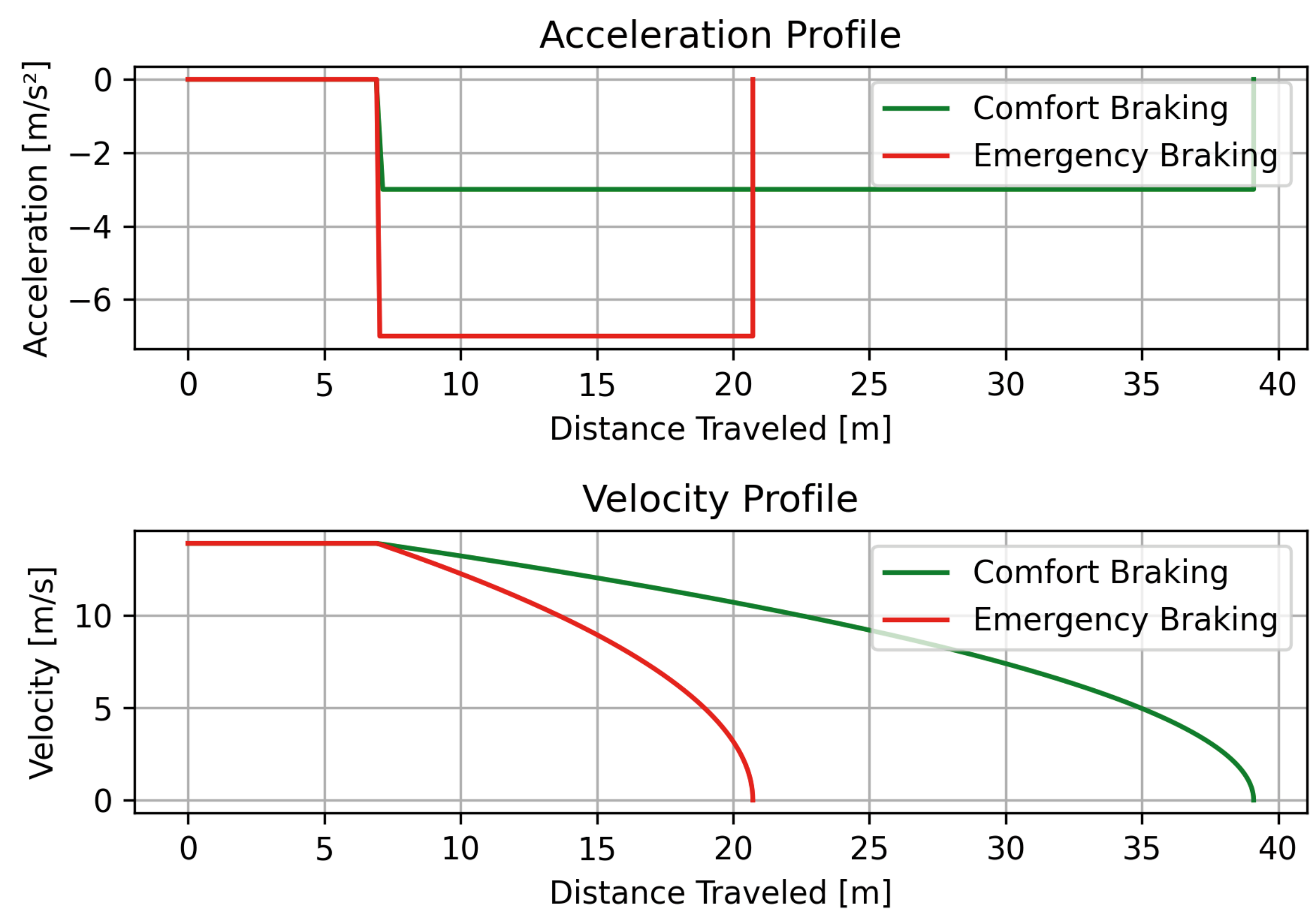


Figure 2: Ego braking behavior (© Robert Bosch GmbH).

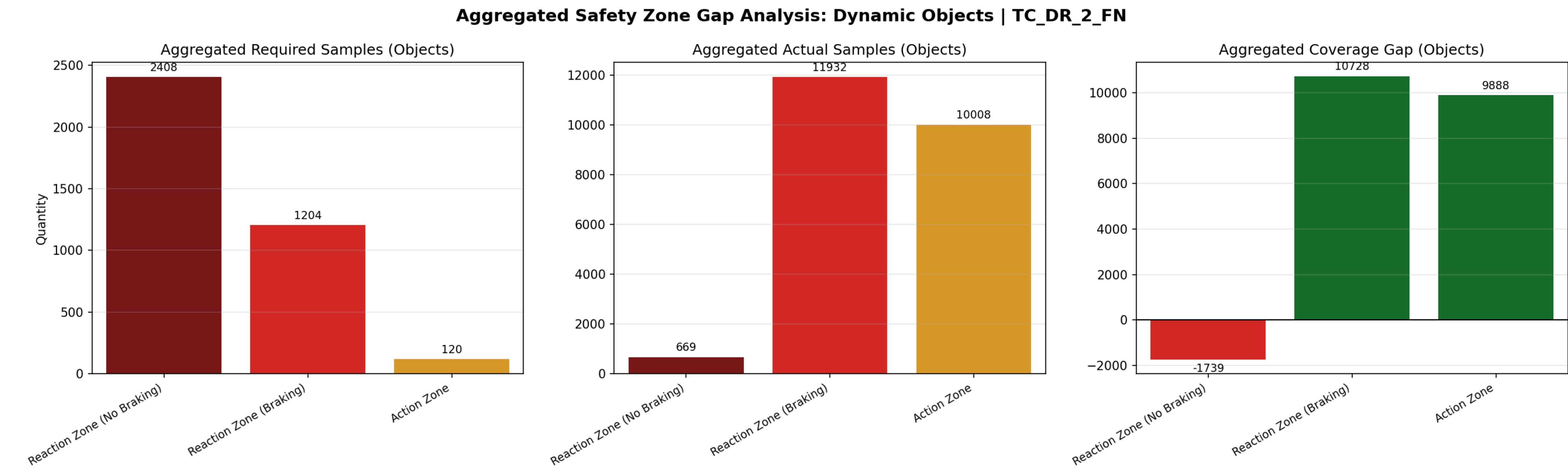


Figure 5: Example dataset requirements addressing the minimal desired coverage by pedestrians in the Safety Zones (left), the evaluated actual coverage of the ZOD dataset [1] (center), and the coverage gaps (right) (© Robert Bosch GmbH).

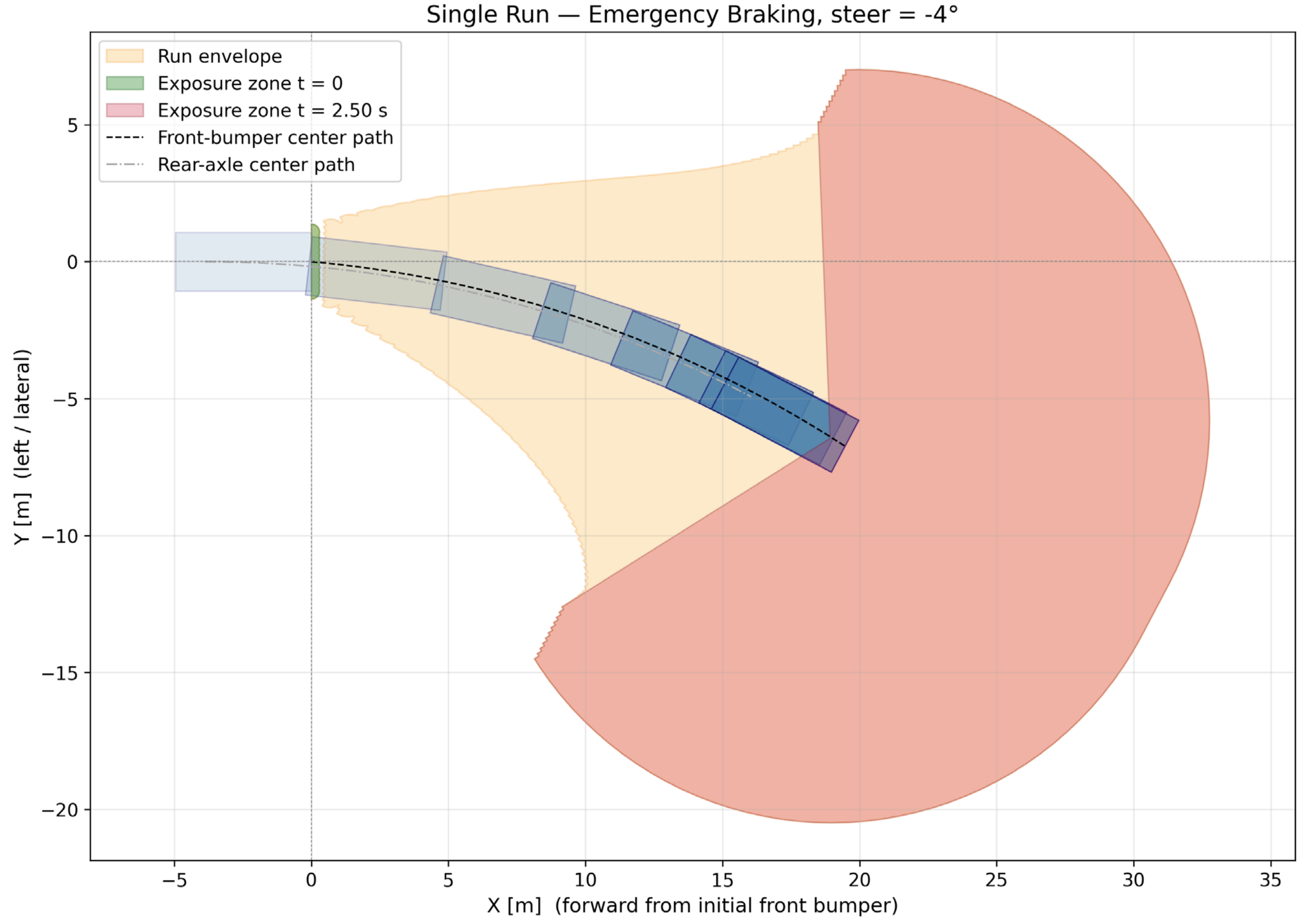


Figure 3: Reachable set for pedestrians walking at constant velocity towards the ego vehicle from different directions, while it brakes and drives a curve (© Robert Bosch GmbH).

Deriving Data Requirements using Safety Zones

Estimating the risk of potential harm, we define target error rates for each Safety Zone section as depicted in Fig. 1 by the colors (red: high risk; yellow: moderate risk). By making assumptions on the occurrence of FN/FP triggering events (for FN: pedestrians in safety zones), we can derive a target error percentage on a curated dataset that only contains potential error stimulating events. Fig. 4 shows pedestrian locations with occlusion ratio in the safety zones as potential triggers.

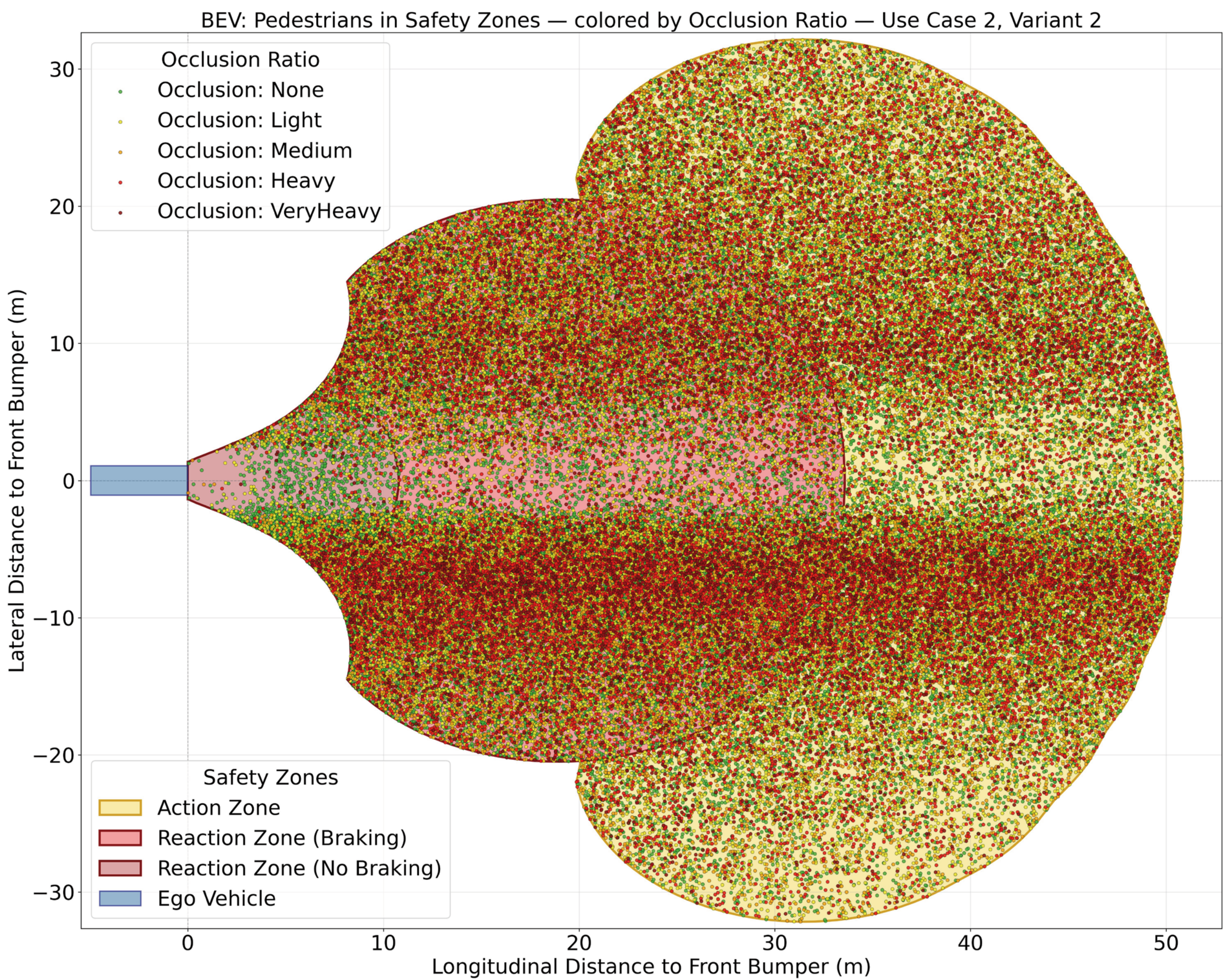


Figure 4: Pedestrian locations from the ZOD dataset [1] associated to the Safety Zones from Fig. 1 colored by their occlusion ratio (© Robert Bosch GmbH).

Assuming Bernoulli-distributed events, we derive a required test coverage as per safety zone and feature class using Null-Hypothesis Significance Testing as basis for deriving data requirements.

References:

[1] Zenseact Open Dataset (ZOD), <https://zod.zenseact.com/>, (CC BY-SA 4.0) license.

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