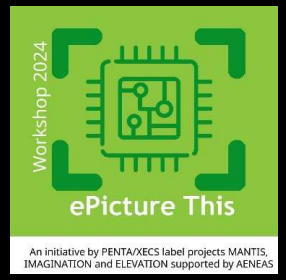
Accidentology & Monitored Deployment

resembler.ai

E-Picture This, Eindhoven, 26-8-2024

Pieter Jonker, Boris Lenseigne,
Serge Lambermont,

info@resembler.ai | www.resembler.ai



Automated Driving is there….. Is it safe?

Serge Lambermont - Expert in Safety Electronics and Automated Driving Robotics.

2013 - 2018, Aptiv's Technical Director Automated Driving (Silicon Valley) responsible for Global automated urban driving technologies and activities. Includìng the urban self-driving vehicle development platforms for the Singapore Automated Mobility on Demand (AMoD) Pilot and urban driving activities in the US and Europe.

2015 Leader of the 3500 miles Coast to Coast Automated drive (San Francisco - New York)
2015-2018 Aptiv's CES urban driving demos.

Pieter Jonker - Expert in Automated Driving and Robotics, RT Image processing and AI.
Professor Emeritus of the Delft University of Technology / Cognitive Robotics Department, and Eindhoven University of Technology / Vision based Control.
With his startup Jonker-Makis Robotics he has built multiple robotic solutions for commercial applications in the automotive, medical and indoor robotic fields.
Pieter realized the WE-pods; autonomous 6 persons Pods (WUR Campus) as well as the Mission; a 12 persons Autonomously Driving shuttle bus (Aldenhove testtrack).

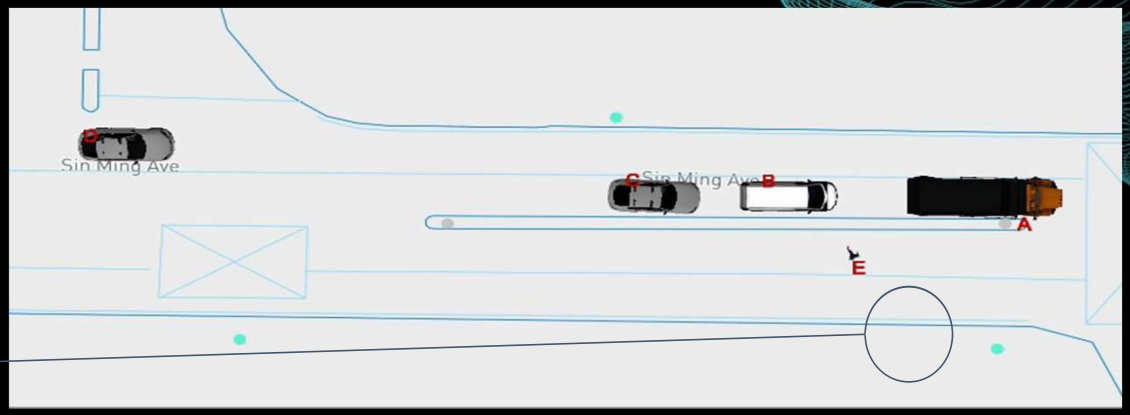
Resembler's Vision on Future Mobility

We aim to create a world where advanced AI systems work seamlessly with road infrastructure and human drivers to improve overall road safety, prevent accidents and learn from near misses

Resembler uses AI for enhancing safety in future mobility, that is: de-risking ADAS and self driving technology with camera based monitored deployment

How to assess an Automated Vehicle?

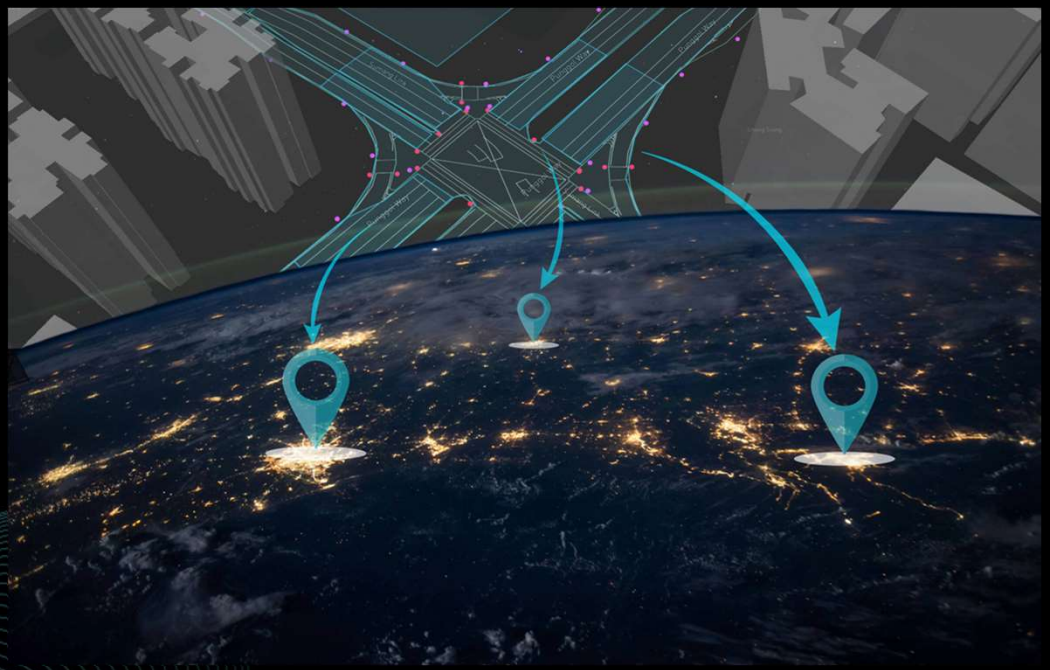
Many accidents are prevented by vigilant drivers who anticipate hazards



Can an Automated / Autonomous Vehicle (AV) do that the same or better?

Resembler generates Replacement Tests from real accidents

How Resembler works

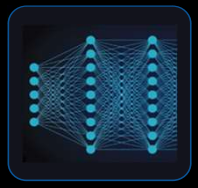


Ingestion

Incidents from roadside and dash cam footage

Anonymizer

GDPR compliant



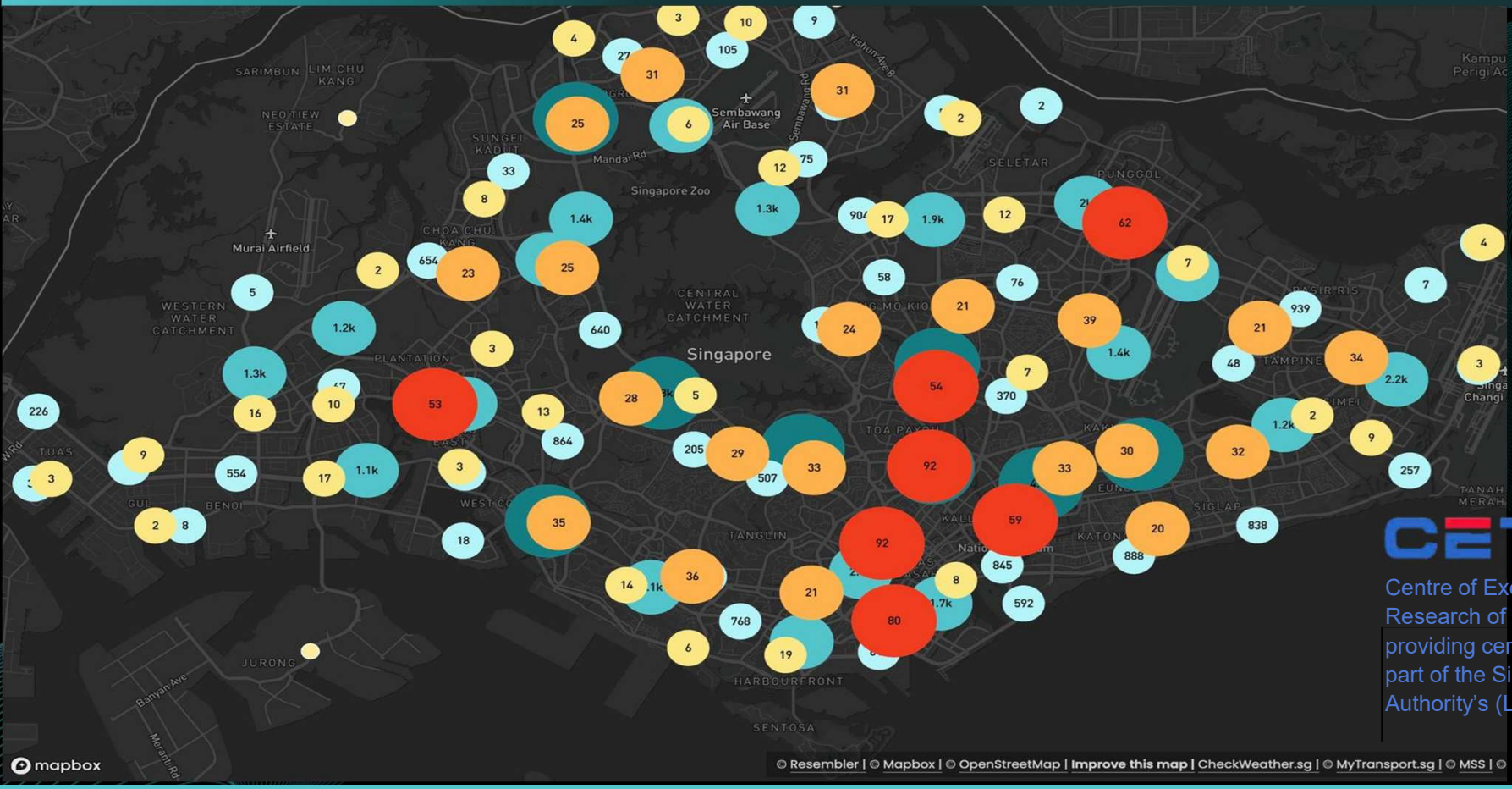
Learning

Deep learning contextual AI

Resemble

Find similarities in attributes surrounding the incidents

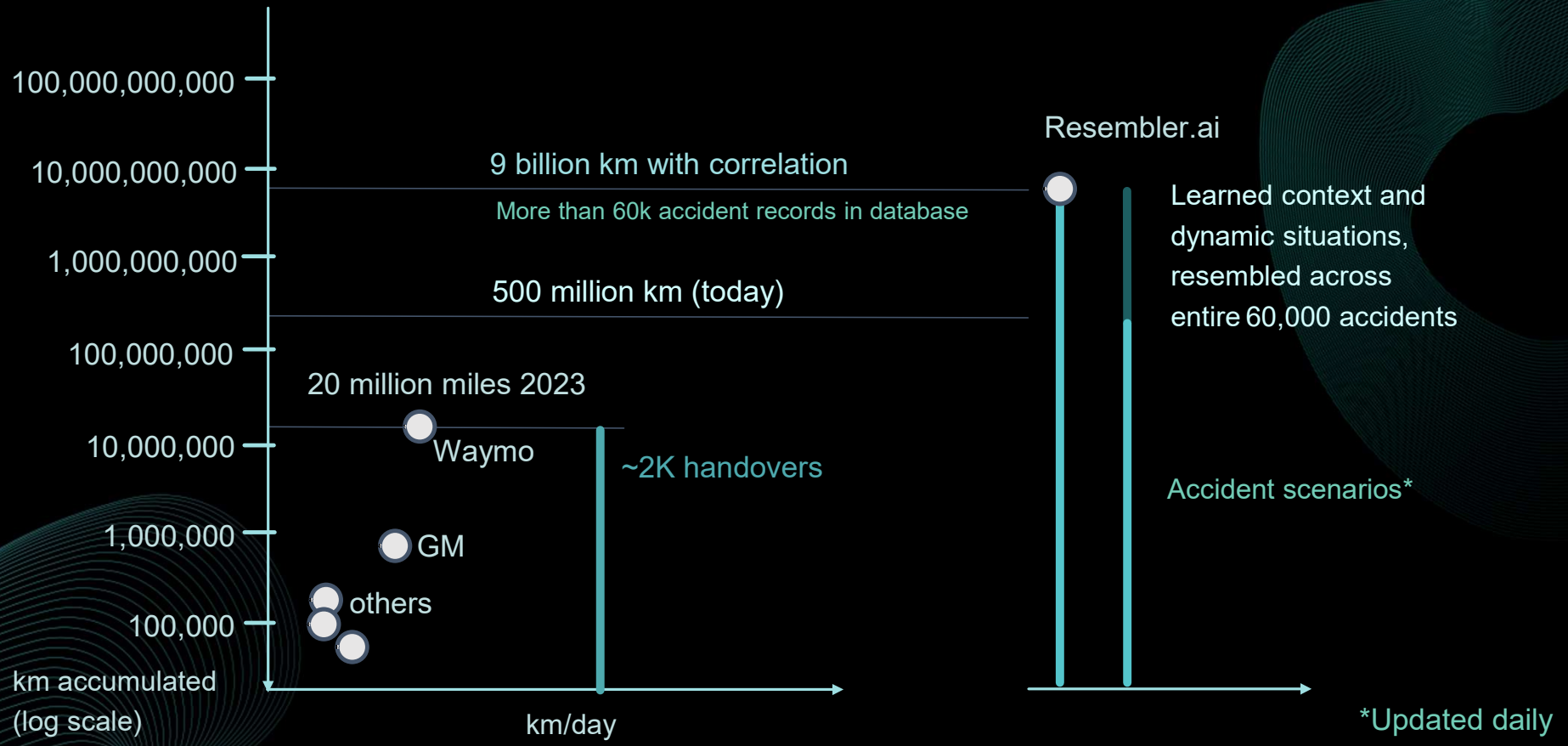
Resembler collaborates with CETRAN (Singapore)



CETRAN

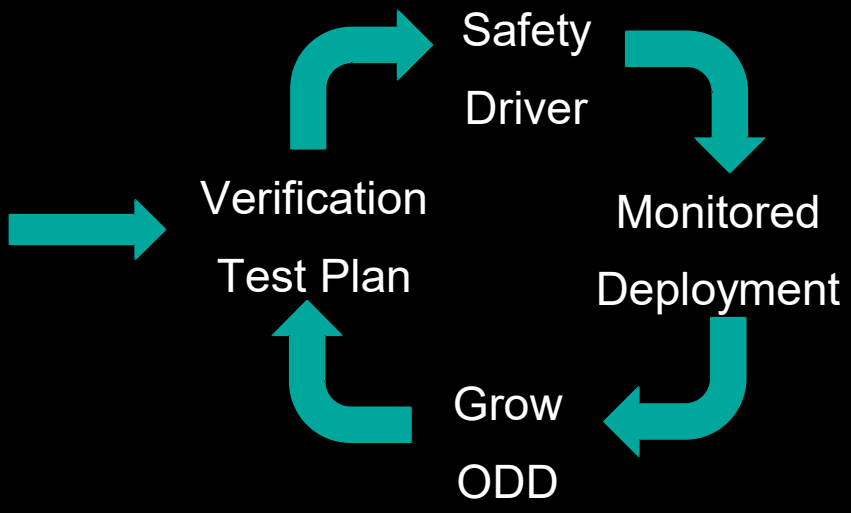
Centre of Excellence for Testing & Research of Autonomous Vehicles providing certification and policy as part of the Singapore Land Transport Authority's (LTA)

500 Million km Edge Cases (9 billion km correlation)



Resembler's Incremental Deployment of AD

Safety Case:
Area (ODD)
AD Vehicle



Automated Driving is a complex task with: technical, infrastructure, ethical, regulatory and societal challenges

Challenges of Incremental Deployment

Infrastructure Challenge

Areas of deployment (ODD) each have unique complexities and the AD system must be tested in the area of deployment

Ethical Challenge

Traffic rule compliance is not sufficient - 90% of accidents result from human error

Regulatory Challenge

Data sharing and privacy makes it difficult for companies to get the information they need to verify the area

Resembler: Data ingestion and database building

footage

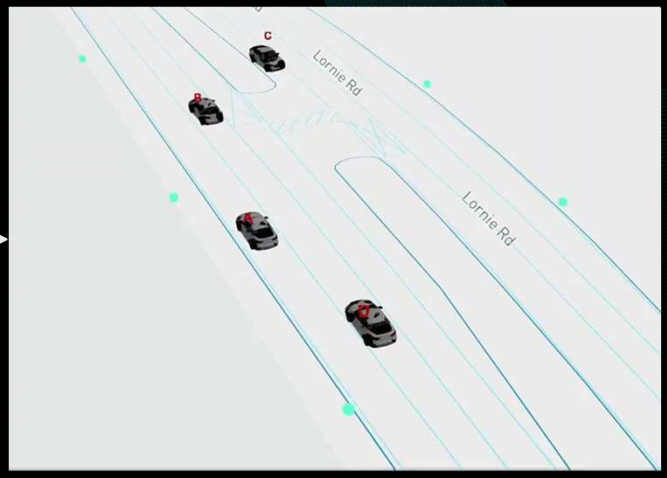
streetmap

satellite

earth

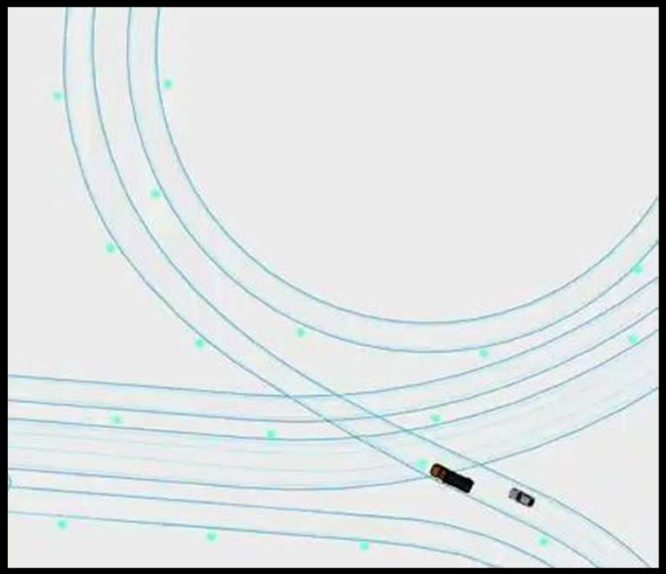
LTA datamall

Video footage



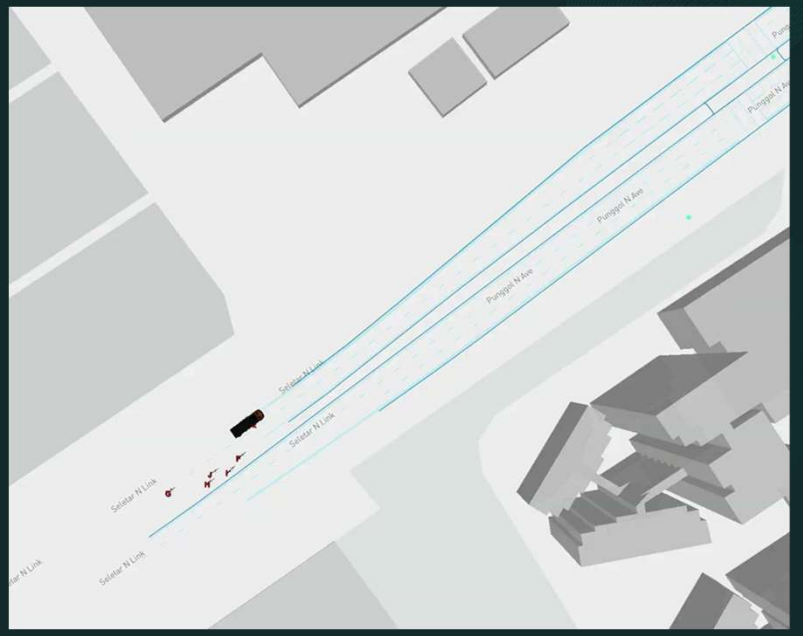
3D Animated Graphics

Resembler: Make abstractions from real accidents



Use Key Performance Indicators (KPIs) to compare A Driving with human driving

Example 1; Archetypical case with bicycles



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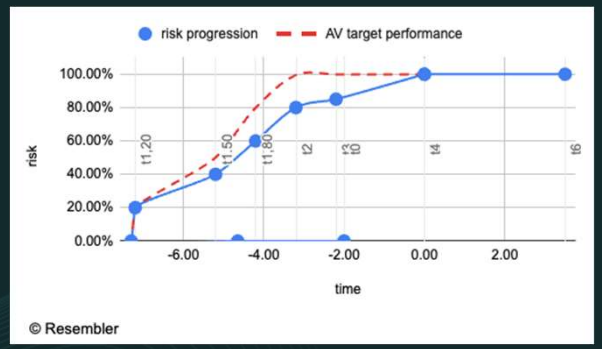
Example 1; Imminent Danger and Risk progression

Imminent Danger KPI

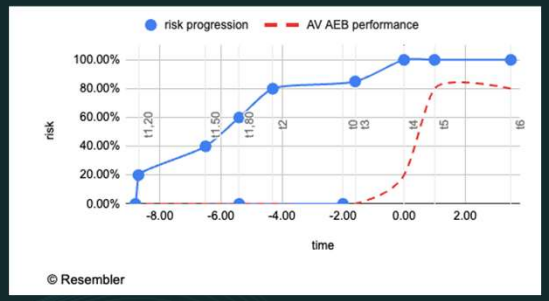


t1,20
multiple cyclists,
cyclist on incorrect lane,
stopped vehicle slow lane

t1,80
cyclist leaning left

Example 2; Imminent Danger and Risk progression

Imminent Danger KPI

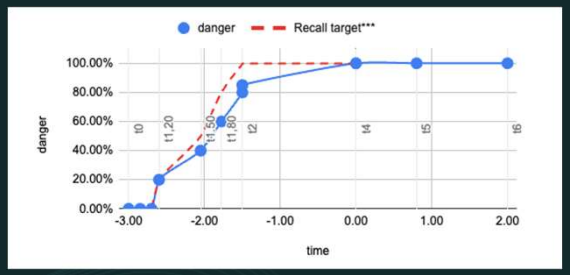


t1,20
truck driving too fast around a bend, cargo starting to tilt

t1,80
Truck falling over

Example 3; Imminent Danger and Risk progression

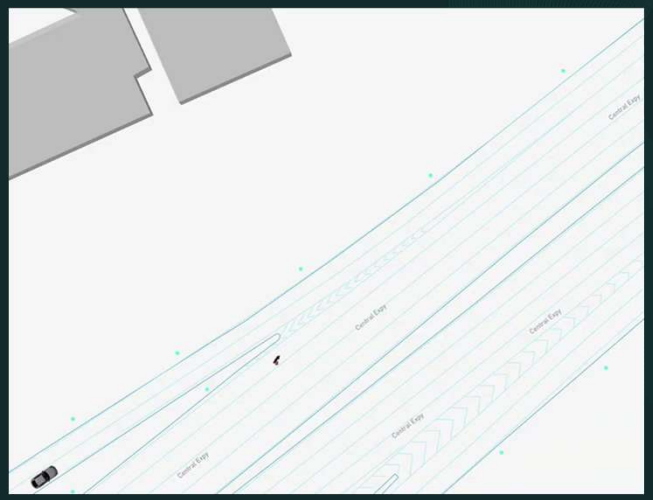
Imminent Danger KPI



t1,20
Pedestrian going into occlusion

t1,80
Stroller in the road, pedestrian appearing out of occlusion

Example 4; An Edge case



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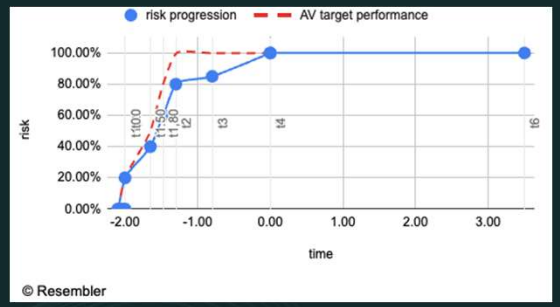
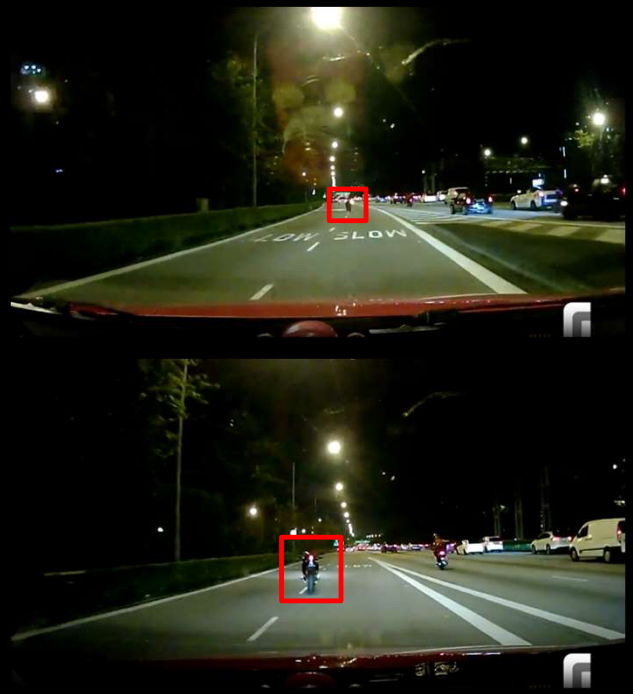
Example 4; Imminent Danger and Risk progression

Imminent Danger KPI

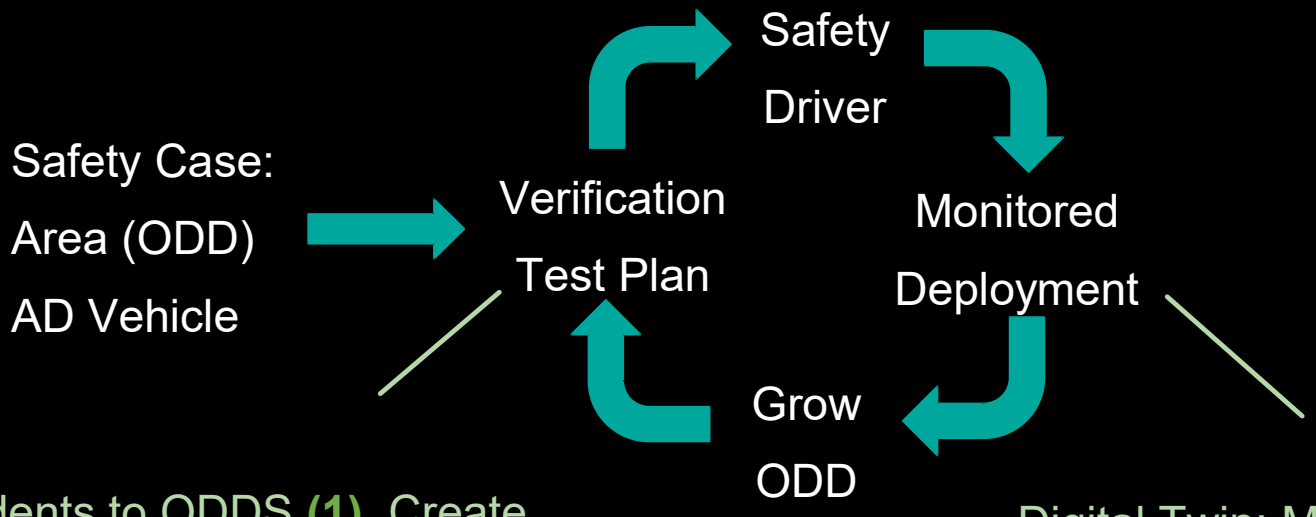




t1,20
Slow moving motorcycle, sudden lane change, illegal lane change, moving erratically

t1,80
No driver on the motorcycle,
Motorcycle moves slowly,
Motorcycle moves erratically

Resembler Products (5x)

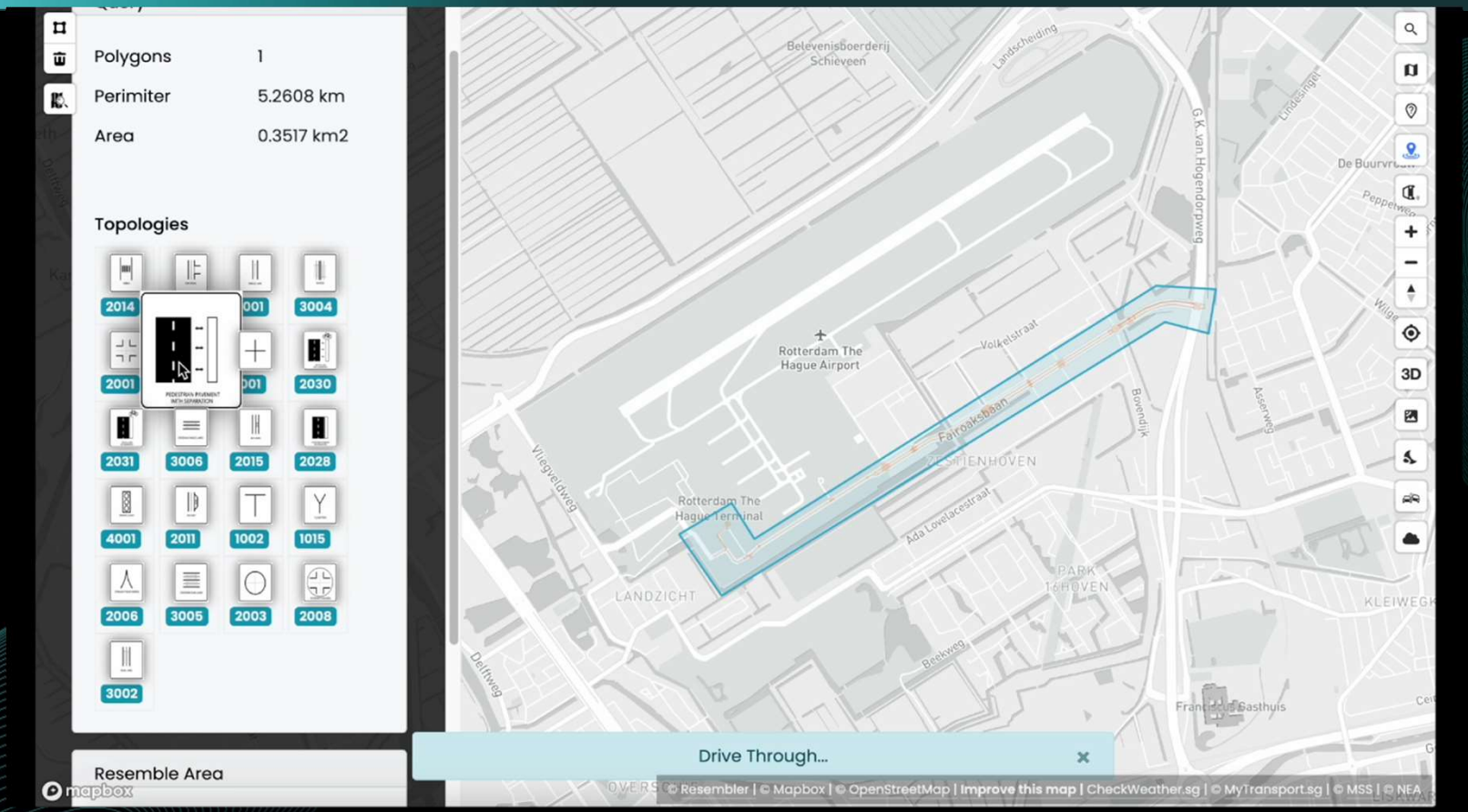


Map accidents to ODDS **(1)**, Create verification test plan(s) and KPIs from an equivalent of 500M km data coverage **(2)**, Generate opendrive/simulator inputs for the replacement tests**(3)**

Compare ODDs **(4)**

Digital Twin: Monitor and compare dash-cam triggers with pre-existing human incidents, accidents and handovers **(5)**

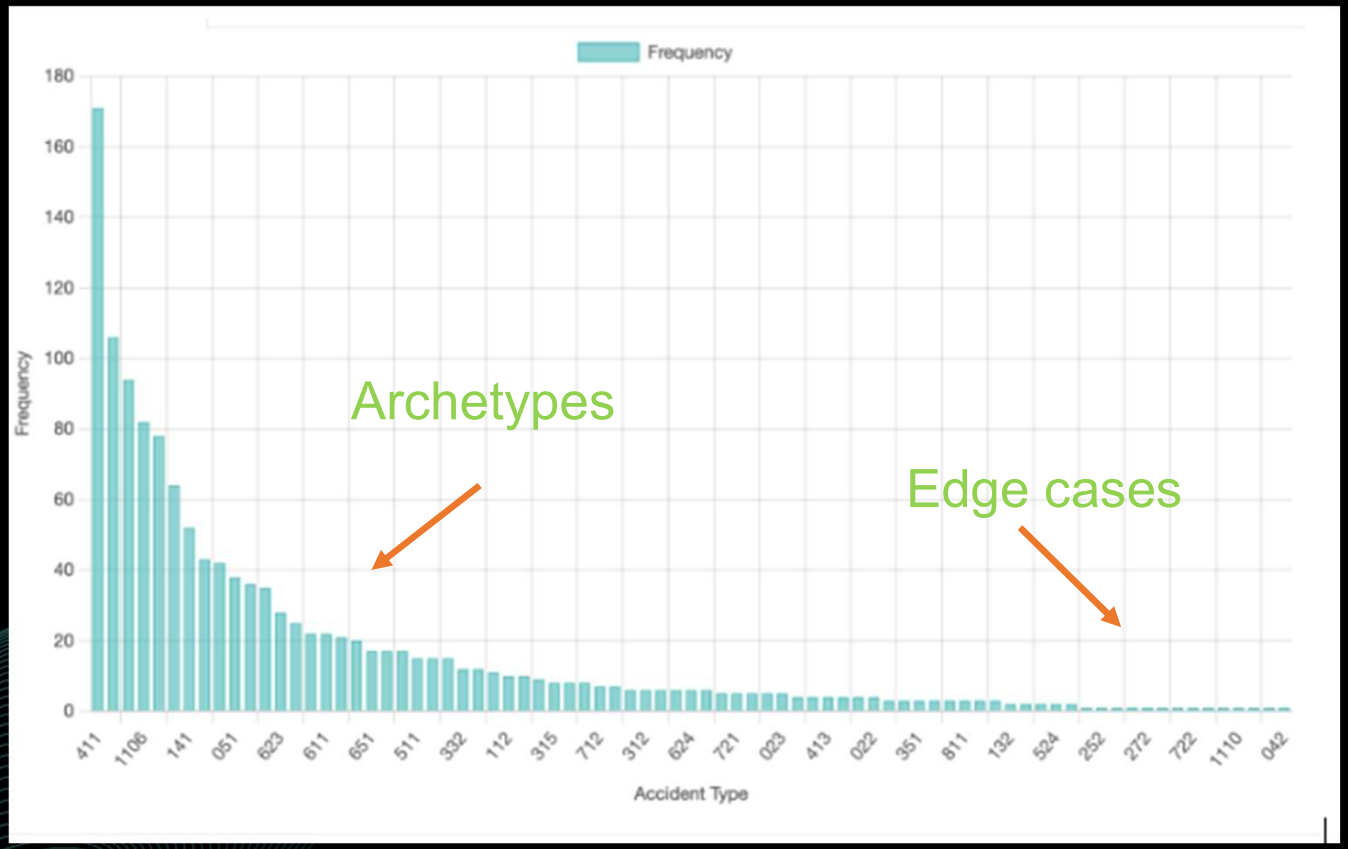
1a - Resemble (re)map accidents / incidents to ODDs



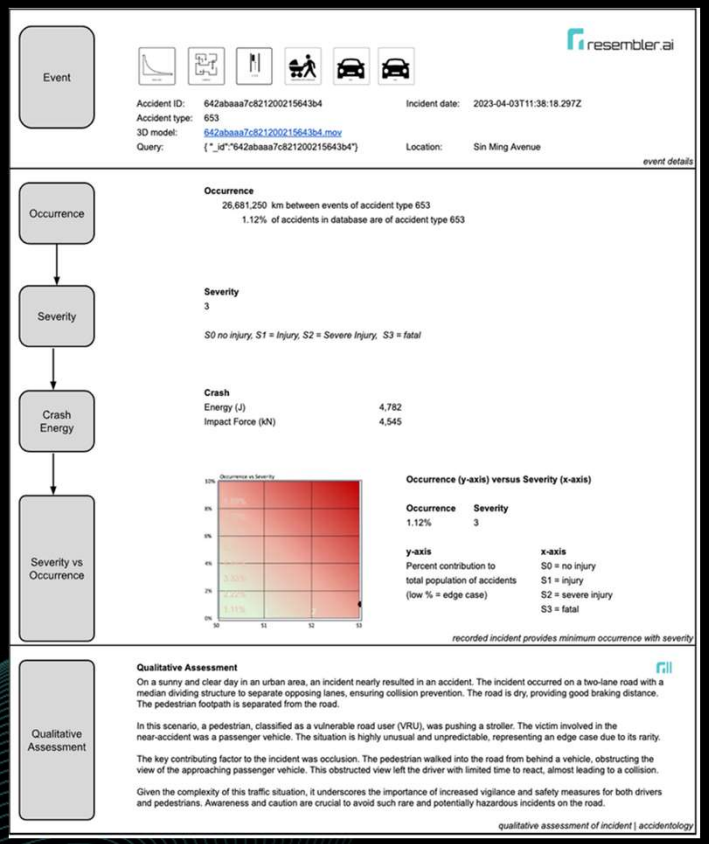
Remapping Singapore accidents to possible accidents at the ODD Rotterdam-The Hague airport <> Metro_Station-Meijersplein

(Normalize) (with AV x)

1b – Select test cases based on occurrence an severity



2 – Generate an ODD Verification & AD Test Report



Event

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Accident ID: 642abaaa7c821200215643b4
Incident date: 2023-04-03T11:38:18.297Z
Accident type: 653
3D model: 642abaaa7c821200215643b4.mov
Query: {"_id":"642abaaa7c821200215643b4"}
Location: Sin Ming Avenue

event details

Occurrence

Occurrence
26,681,250 km between events of accident type 653
1.12% of accidents in database are of accident type 653

Severity

Severity
3

S0 no injury, S1 = Injury, S2 = Severe Injury, S3 = fatal

Crash Energy

Crash
Energy (J) 4,782
Impact Force (kN) 4,545

Severity vs Occurrence

Occurrence (y-axis) versus Severity (x-axis)

Occurrence	Severity
1.12%	3

y-axis	x-axis
Percent contribution to total population of accidents (low % = edge case)	S0 = no injury S1 = injury S2 = severe injury S3 = fatal

recorded incident provides minimum occurrence with severity

Qualitative Assessment

Qualitative Assessment

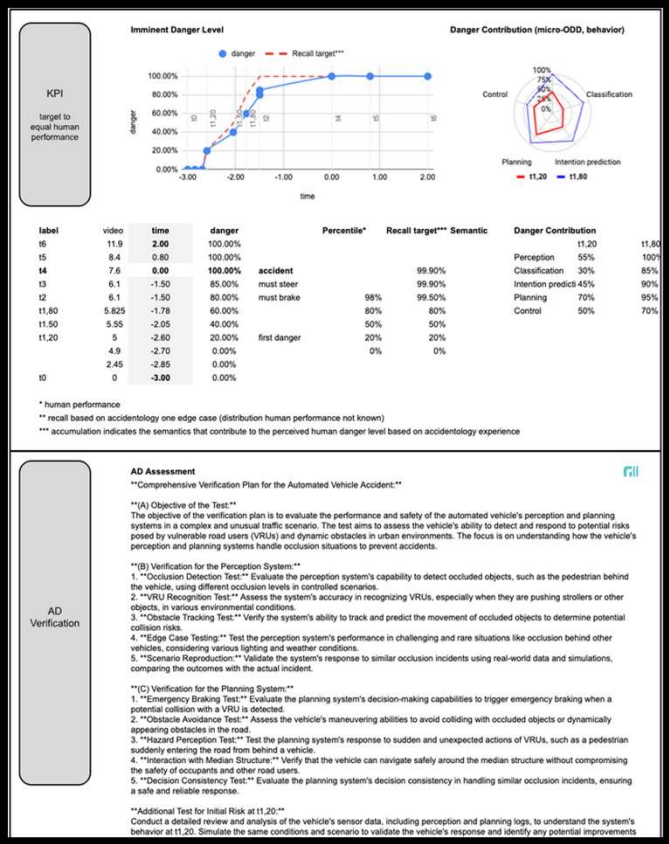
On a sunny and clear day in an urban area, an incident nearly resulted in an accident. The incident occurred on a two-lane road with a median dividing structure to separate opposing lanes, ensuring collision prevention. The road is dry, providing good braking distance. The pedestrian footpath is separated from the road.

In this scenario, a pedestrian, classified as a vulnerable road user (VRU), was pushing a stroller. The victim involved in the near-accident was a passenger vehicle. The situation is highly unusual and unpredictable, representing an edge case due to its rarity.

The key contributing factor to the incident was occlusion. The pedestrian walked into the road from behind a vehicle, obstructing the view of the approaching passenger vehicle. This obstructed view left the driver with limited time to react, almost leading to a collision.

Given the complexity of this traffic situation, it underscores the importance of increased vigilance and safety measures for both drivers and pedestrians. Awareness and caution are crucial to avoid such rare and potentially hazardous incidents on the road.

qualitative assessment of incident | accidentology



KPI

target to equal human performance

Imminent Danger Level

danger — Recall target***

Danger Contribution (micro-ODD, behavior)

Control, Classification, Planning, Intention prediction

t1,20 — t1,80

time

label	video	time	danger		Percentile*	Recall target***	Semantic
t6	11.9	**2.00**	100.00%				
t5	8.4	0.80	100.00%				
t4	7.6	**0.00**	**100.00%**	**accident**		99.90%	
t3	6.1	-1.50	85.00%	must steer		99.90%	
t2	6.1	-1.50	80.00%	must brake	98%	99.50%	
t1,80	5.825	-1.78	60.00%		80%	80%	
t1.50	5.55	-2.05	40.00%		50%	50%	
t1,20	5	-2.60	20.00%	first danger	20%	20%	
	4.9	-2.70	0.00%		0%	0%	
	2.45	-2.85	0.00%				
t0	0	**-3.00**	0.00%				

Danger Contribution	t1,20	t1,80
Perception	55%	100%
Classification	30%	85%
Intention predict	45%	90%
Planning	70%	95%
Control	50%	70%

* human performance
** recall based on accidentology one edge case (distribution human performance not known)
*** accumulation indicates the semantics that contribute to the perceived human danger level based on accidentology experience

AD Verification

AD Assessment

Comprehensive Verification Plan for the Automated Vehicle Accident:

(A) Objective of the Test:
The objective of the verification plan is to evaluate the performance and safety of the automated vehicle's perception and planning systems in a complex and unusual traffic scenario. The test aims to assess the vehicle's ability to detect and respond to potential risks posed by vulnerable road users (VRUs) and dynamic obstacles in urban environments. The focus is on understanding how the vehicle's perception and planning systems handle occlusion situations to prevent accidents.

(B) Verification for the Perception System:
1. **Occlusion Detection Test:** Evaluate the perception system's capability to detect occluded objects, such as the pedestrian behind the vehicle, using different occlusion levels in controlled scenarios.
2. **VRU Recognition Test:** Assess the system's accuracy in recognizing VRUs, especially when they are pushing strollers or other objects, in various environmental conditions.
3. **Obstacle Tracking Test:** Verify the system's ability to track and predict the movement of occluded objects to determine potential collision risks.
4. **Edge Case Testing:** Test the perception system's performance in challenging and rare situations like occlusion behind other vehicles, considering various lighting and weather conditions.
5. **Scenario Reproduction:** Validate the system's response to similar occlusion incidents using real-world data and simulations, comparing the outcomes with the actual incident.

(C) Verification for the Planning System:
1. **Emergency Braking Test:** Evaluate the planning system's decision-making capabilities to trigger emergency braking when a potential collision with a VRU is detected.
2. **Obstacle Avoidance Test:** Assess the vehicle's maneuvering abilities to avoid colliding with occluded objects or dynamically appearing obstacles in the road.
3. **Hazard Perception Test:** Test the planning system's response to sudden and unexpected actions of VRUs, such as a pedestrian suddenly entering the road from behind a vehicle.
4. **Interaction with Median Structure:** Verify that the vehicle can navigate safely around the median structure without compromising the safety of occupants and other road users.
5. **Decision Consistency Test:** Evaluate the planning system's decision consistency in handling similar occlusion incidents, ensuring a safe and reliable response.

Additional Test for Initial Risk at t1,20:
Conduct a detailed review and analysis of the vehicle's sensor data, including perception and planning logs, to understand the system's behavior at t1,20. Simulate the same conditions and scenario to validate the vehicle's response and identify any potential improvements

(Using LLMs)

Specification of:
- Perception Tests
- Action Test
- Behaviour Tests
  i.e. Replacement Tests

Example: Verification Test Plan

3 – Generate (Opendrive) Simulator input

carla_input_resembler.mp4

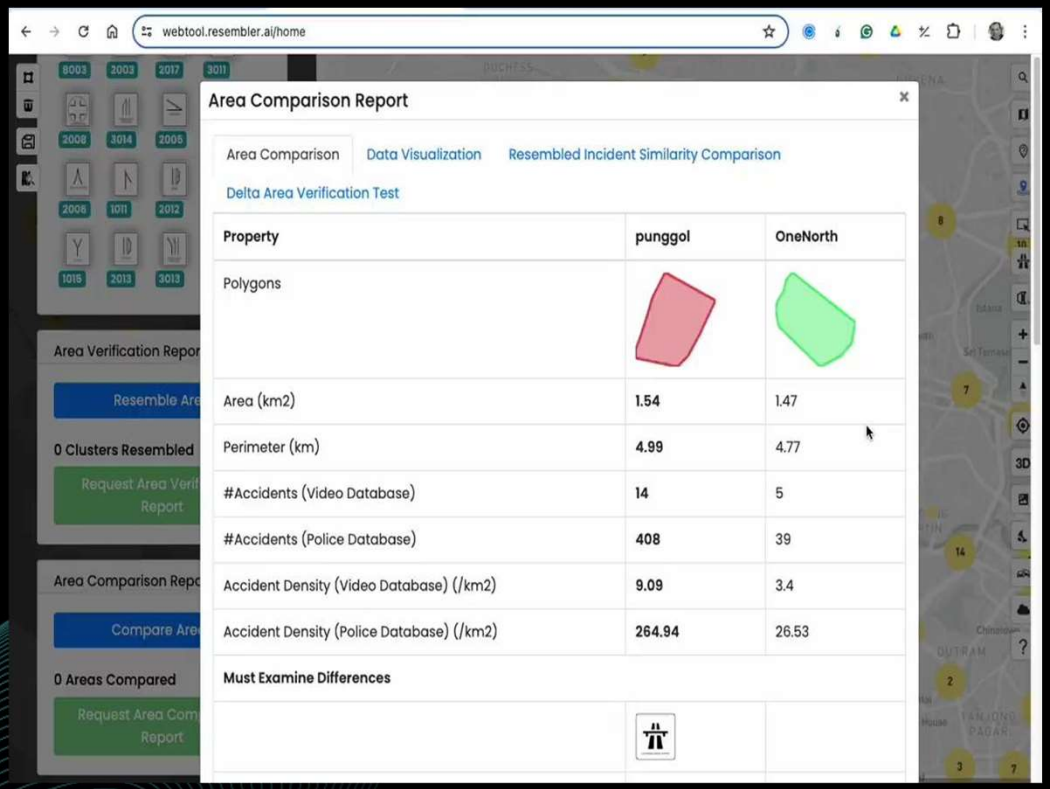
carla_output.mp4

human performance

AD system under test *

* development in collaboration with CETRAN

4 - Compare ODDs to reduce testing or enlarge the ODD



Compares areas of deployment

Creates incremental verification test plans

Works globally, e.g. compares deployment in Singapore with deployment in US or EU

5 – Realise Monitored Deployment

Trigger
Footage + GPS

animation+model,
contextual data

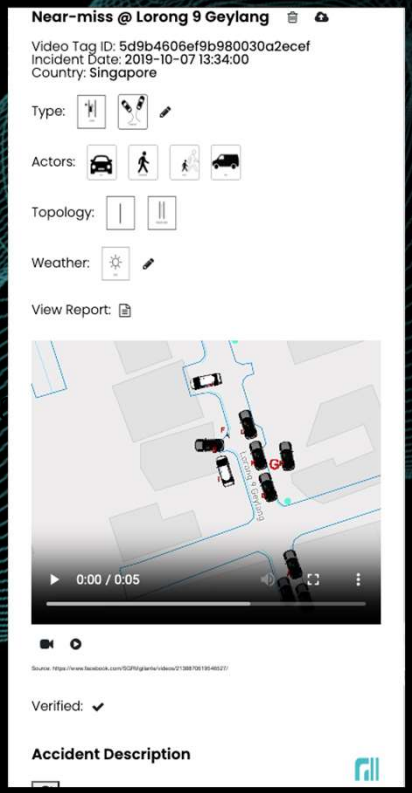
Resembler toolset:
database, area pareto,
ODD compliance, similar
accidents, test plans

anonymized

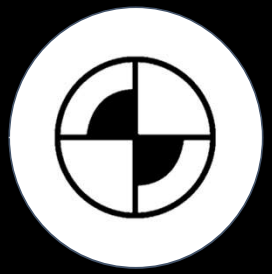
Incident view

GDPR compliant

Control Center View



Auto-Report



Thank You

