ZENUITY

Shape the FUTURE of DRIVING

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Presentation outline

- What is **Zenuity**?
- What is most difficult in designing self-driving vehicles?
- How to prove a self-driving vehicle is sufficiently safe?
- Alternative approaches
- Conclusion

Zenuity's founding fathers

19th April 2017

Volvo Cars, the premium car maker, and Autoliv, the worldwide leader in automotive safety systems, have signed a final agreement to establish a new joint venture called Zenuity to develop software for autonomous driving and driver assistance systems

Zenuity's technology scope

ZENUITY

Cloud

Real-time HD Maps | Connected Safety Functions

Sensor

Sensing | Sensor Fusion | Decision & Control | Vehicle Control

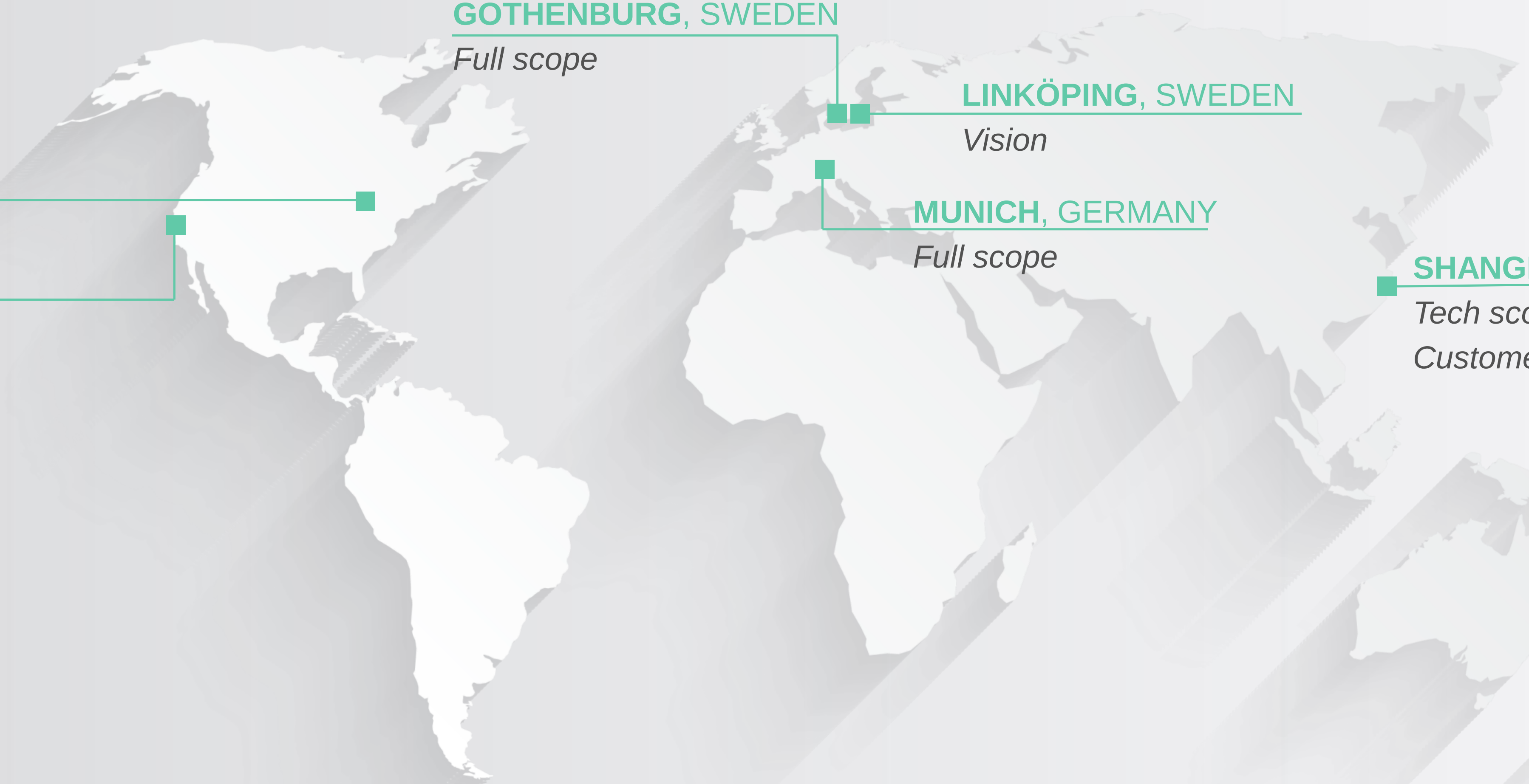
Actuator

Base Tech Software | HW Design | System Design | Technical Safety Concepts

System

Zenuity today

Started April 18th 2017 with 200 employees

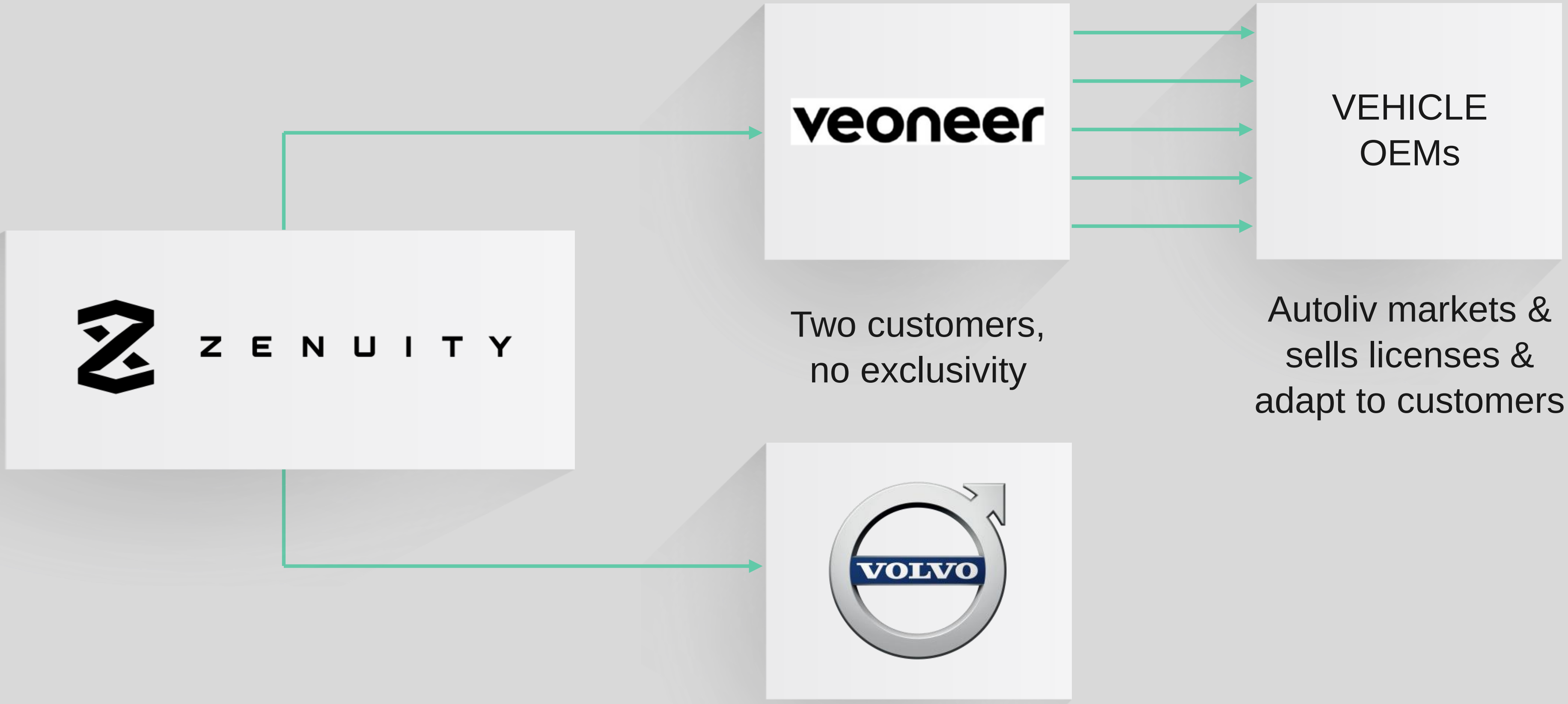


ZENUITY EMPLOYEES

580

Zenuity’s way to market

Developing automotive driver assistance & autonomous driving software, direction hardware-agnostic



Our Product Roadmap

Combining driver support (ADAS) and autonomous driving

ROBOTAXI CAPABILITY

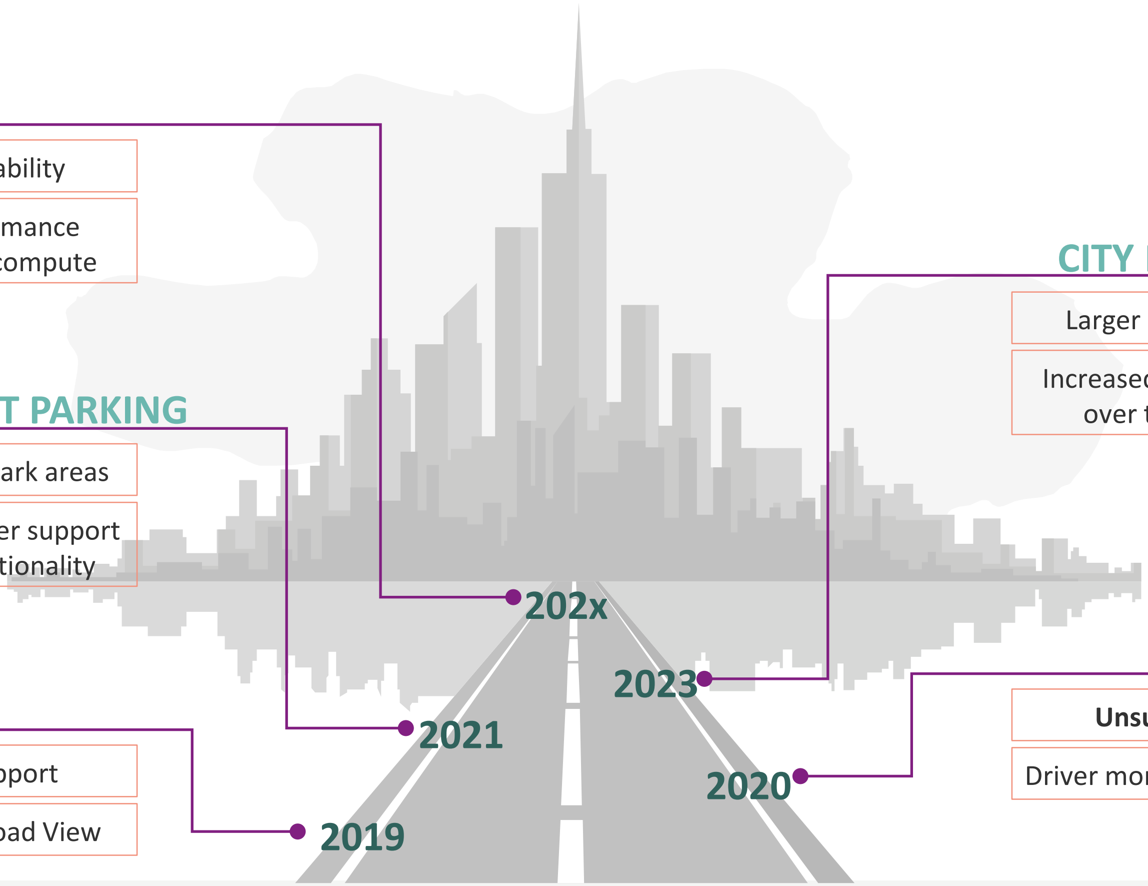
Driverless	High availability
Increased coverage over time (OTA)	High-performance sensing and compute

HIGHWAY PILOT & AUTO VALET PARKING

On highway (<130 km/h)	Driverless in park areas
Increased functionality over time (OTA)	Additional driver support & NCAP functionality

NEXT GEN DRIVER SUPPORT

NCAP 2018 - 2020	Driver Support
Connected Cloud	Connected Road View



CITY PILOT & AUTO VALET PARKING

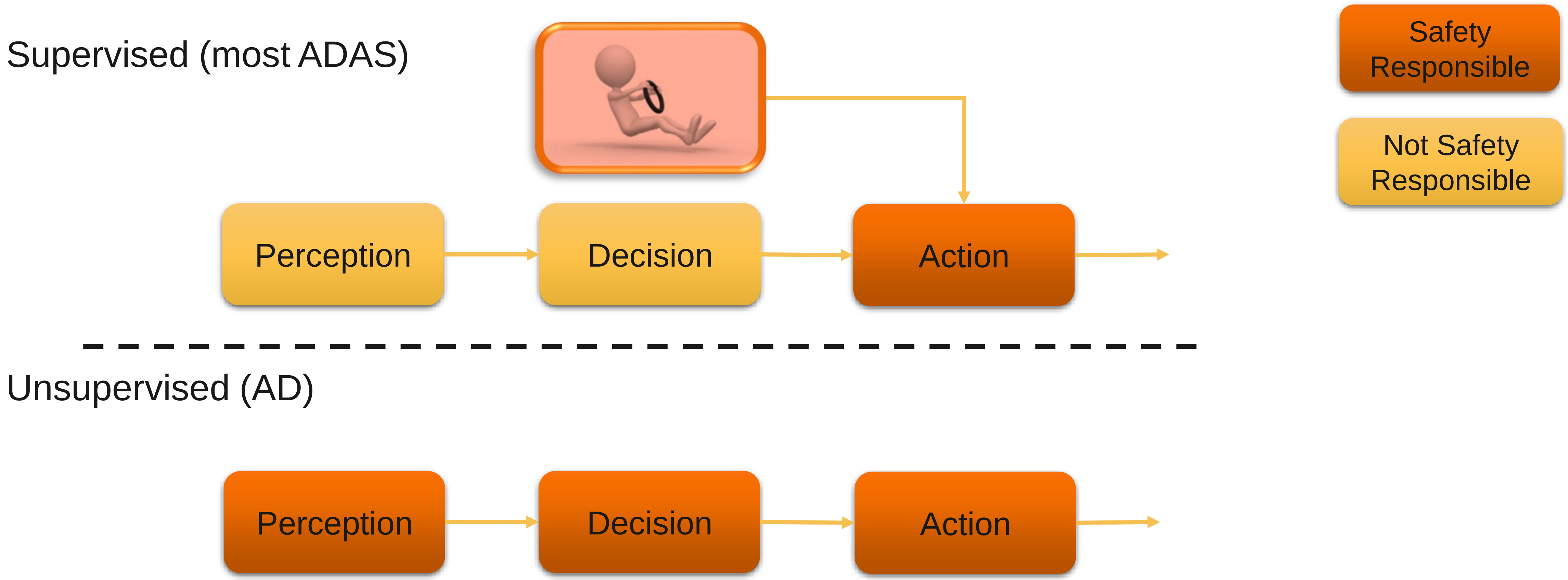
Larger urban roads	Intersection & Traffic light
Increased functionality over time (OTA)	Driverless auto park on public roads

TRAFFIC JAM PILOT

Unsupervised	Boxed-in (<60 km/h)
Driver monitoring camera	Redundant architecture

From Driver Support to Autonomous Driving

Fundamental change for safety concepts



The Challenge

Driver out of the loop

↓

Self-driving vehicles must be able to handle
***all* foresee-able situations of the Operational Design Domain**

(and *prove* that it can!)

This puts unique requirements on the vehicle,
its sensor, actuators and electrical architecture.

Unsupervised driving

Safety Case:

“Structured **argument**, supported by **evidence**, intended to justify that the ***AD functionality*** is acceptably safe for **all relevant traffic situations** and **all relevant environmental conditions**.”

Overall safety requirement: Fewer ***caused*** accidents (by some margin) than human driver

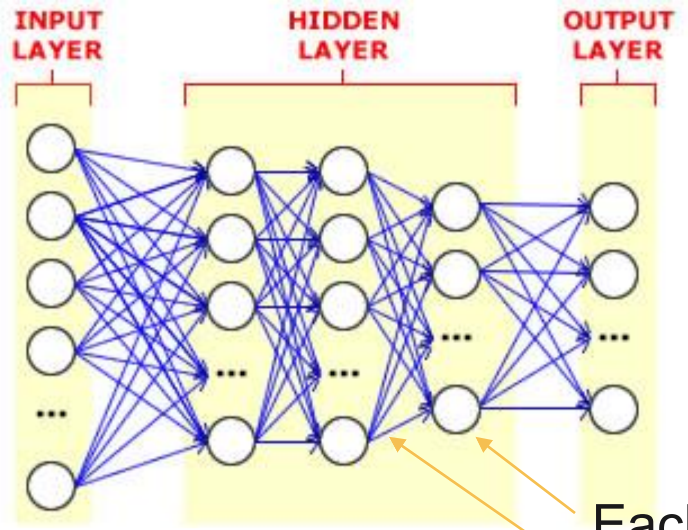
Topic	1/frequency	hours	Market
Road fatalities	150 million km	4 x 10E6 h	U.S.
Rail fatalities	2.5 billion passenger km	4 x 10E7 h	U.K.
Air fatalities	50 billion passenger km	1 x 10E8 h	U.K.
False AEB	0.5 million km	1 x 10E4 h	Global
Safety Driver interventions (High Score 2018)	20 thousand km	7 x 10E2 h	CA

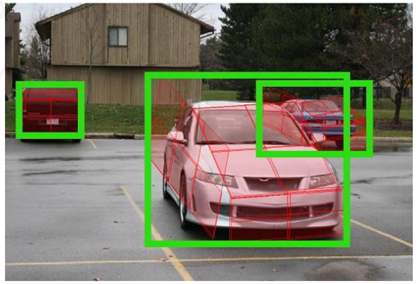
How to design and prove self-driving to be sufficiently safe?

- **Define** the target. The product should be sufficiently safe when used by real customers in the real world.
- **Divide and conquer**, establish testable requirements for components
  - Use sufficient detail; False Negative performance depends on range, illumination, precipitation etc.
  - Reduce Operational Design Domain if needed
  - **Analyzable** vs non-analyzable components

- Use a combination of field testing, simulation, and selected scenarios at test track for verification
- Show that there is enough redundance and independence to reach the overall requirement (worst case scenarios occur less than 10E-8 /h?)
- Done!

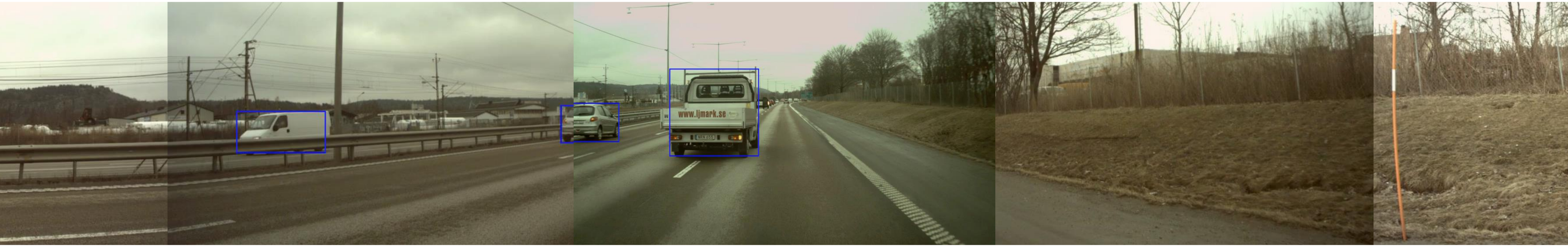
Deep Neural Networks



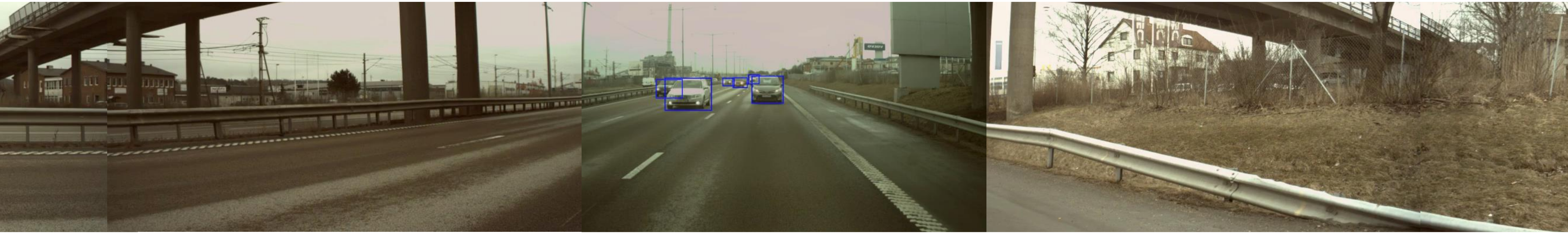


Deep Neural Network

Each neuron has ”trainable” parameters
Each connection has a ”trainable” weight

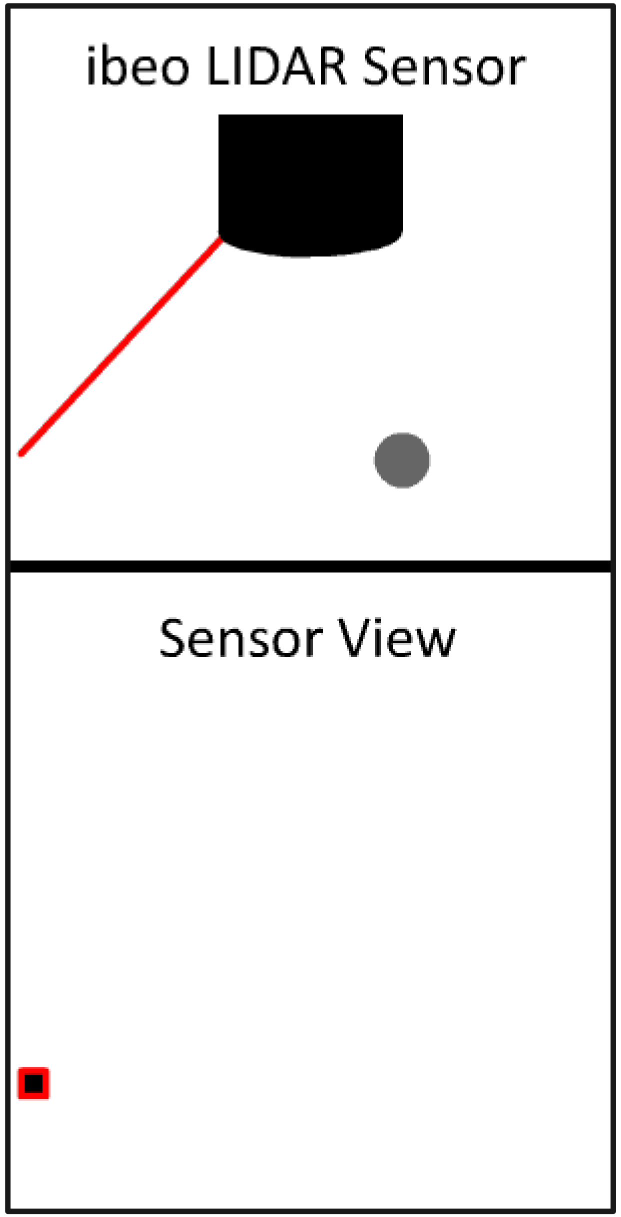


Deep Learning



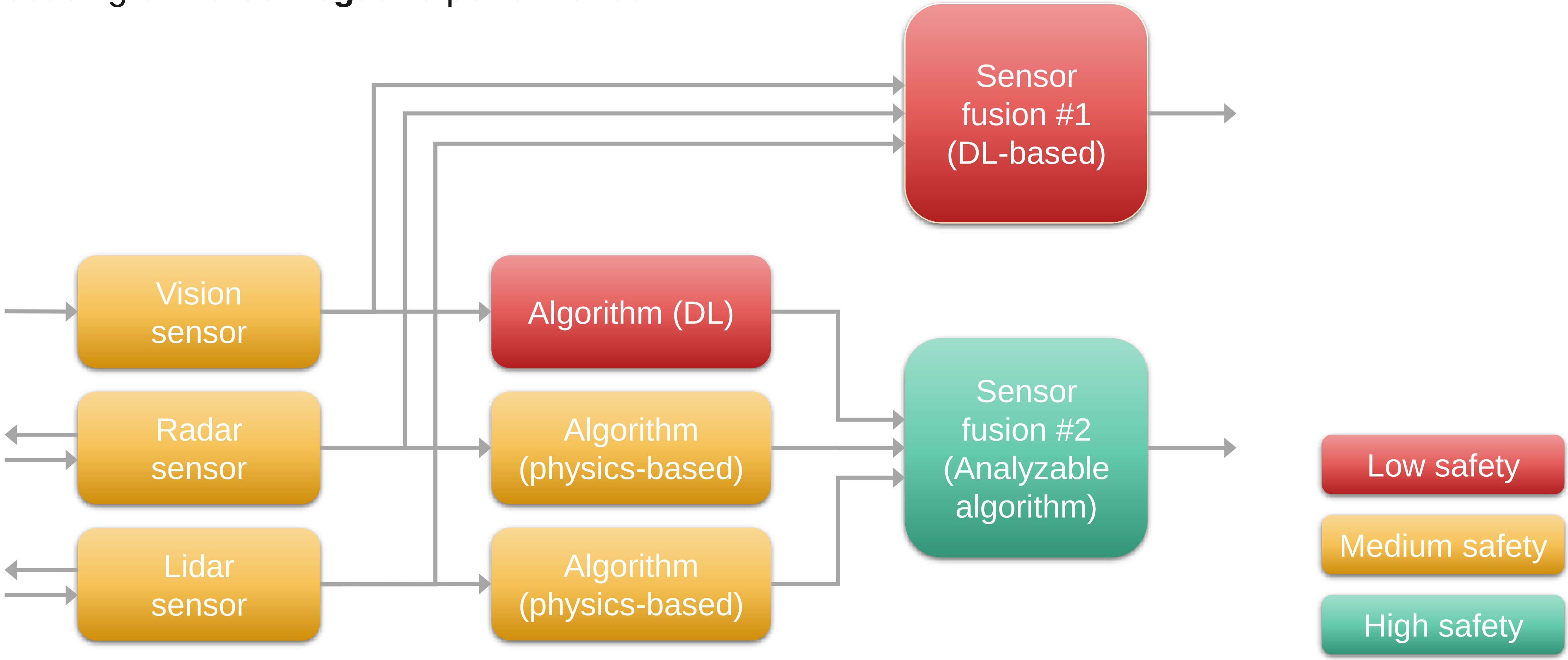
On the other hand...

- Lidar detections are based on well-known physics and relatively simple algorithms
- Performance can be predicted also outside of the tested envelope (to some extent)
- When exposed to real life objects different to those used in verification tests, it is likely to detect them as well.
- Similar reasoning can apply to radar and ultrasonic

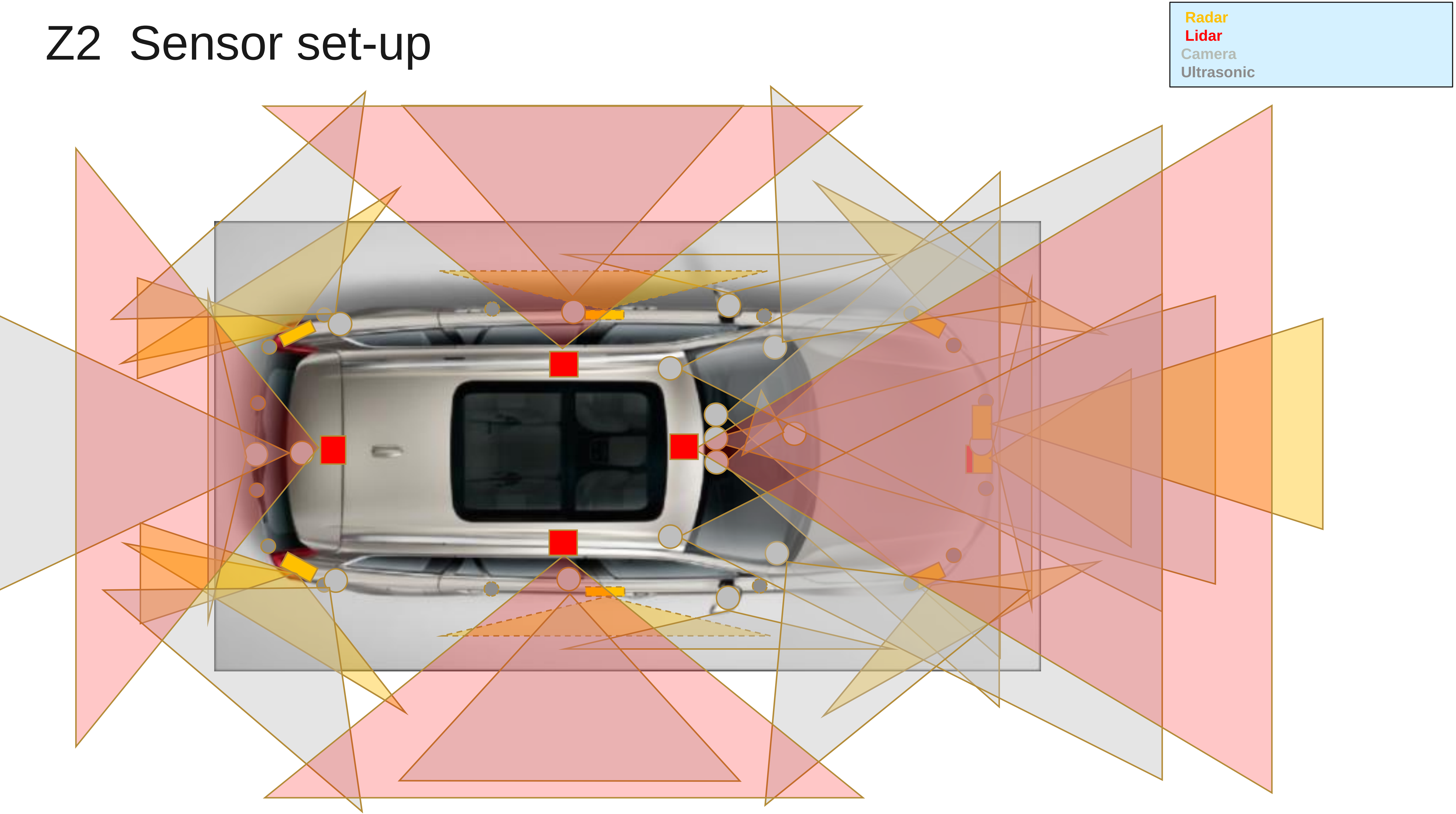


Perception, decomposition example

Focusing on **False Negative** performance



Z2 Sensor set-up



Verification & Validation strategy

Safety verification of ***All major subsystems for All relevant scenarios***

Scenario DB

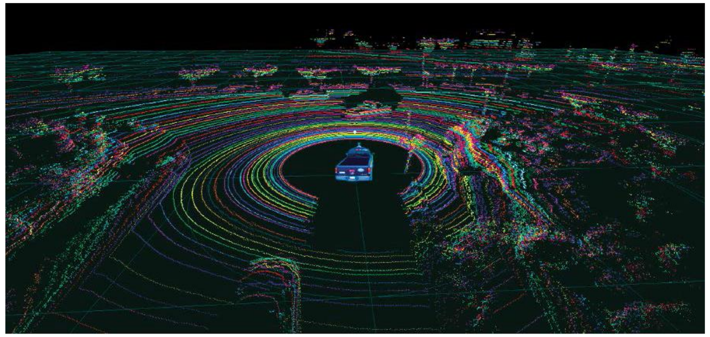
Perception → Objects → Decision-Making → Planned Path → Vehicle Control

Traffic/Test track with Ground Truth

Traffic/Test track with Ground Truth

Resimulation
Augmented/Virtual Data

Formal methods
Closed-loop simulation



Building complete customer features

Highway Pilot

Perception

Decision-Making

Vehicle Control

Conclusions

- Zenuity develops SW for ADAS and unsupervised AD, approaching AD with its safety heritage from Volvo Cars and Autoliv
- Unsupervised Automated Driving is a huge challenge. Super-human performance needed.
- Safety verification by brute-force driving is not feasible
- Deep learning can be utilized safely by
  - parallel, independent channels with reduced functional safety requirements
  - verification by dedicated testing and various forms of simulation of modules

ZENUITY

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