A Conceptual Framework for ADAS/AD Safety

October 20, 2022 | Stuttgart

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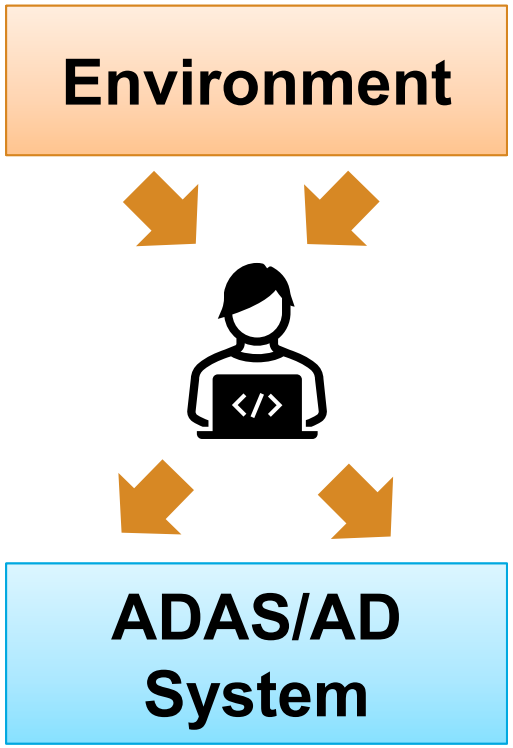
What are you going to learn today?

How the industry is ***learning the unknown*** and ***making it safe***



1) Safety Argumentation:

- Safety Of The Intended Function (*SOTIF*)
- Mileage coverage vs Scenario Coverage

2) Modelling & Simulation:

- *Environment (scenes & scenarios)*
- *System under test* (AD/ADAS)

Have you ever been involved in a car accident?

Internal Environment

Environment

External Environment

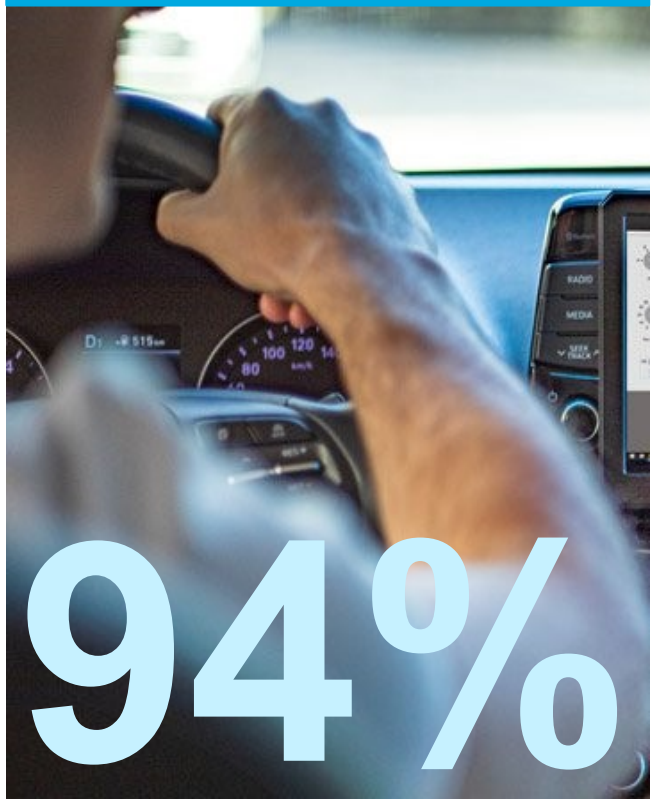
Driver

Vehicle

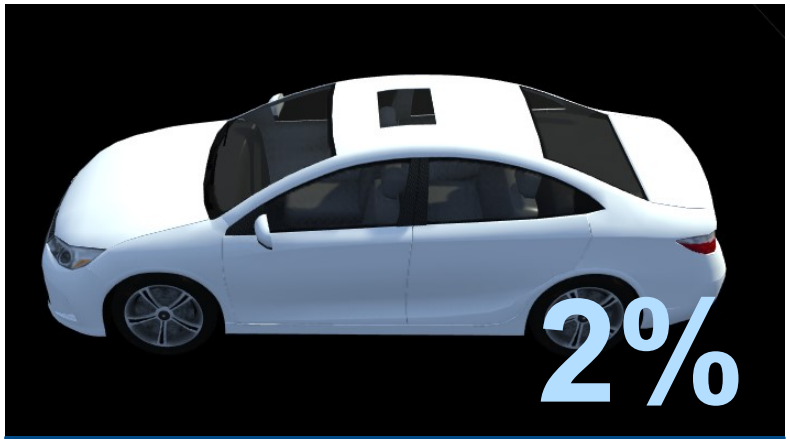
Human beings are prone to errors

See distribution critical reasons pre-crash event (NHTSA)*

Driver



Environment



Vehicle

+ 2% unknown reasons

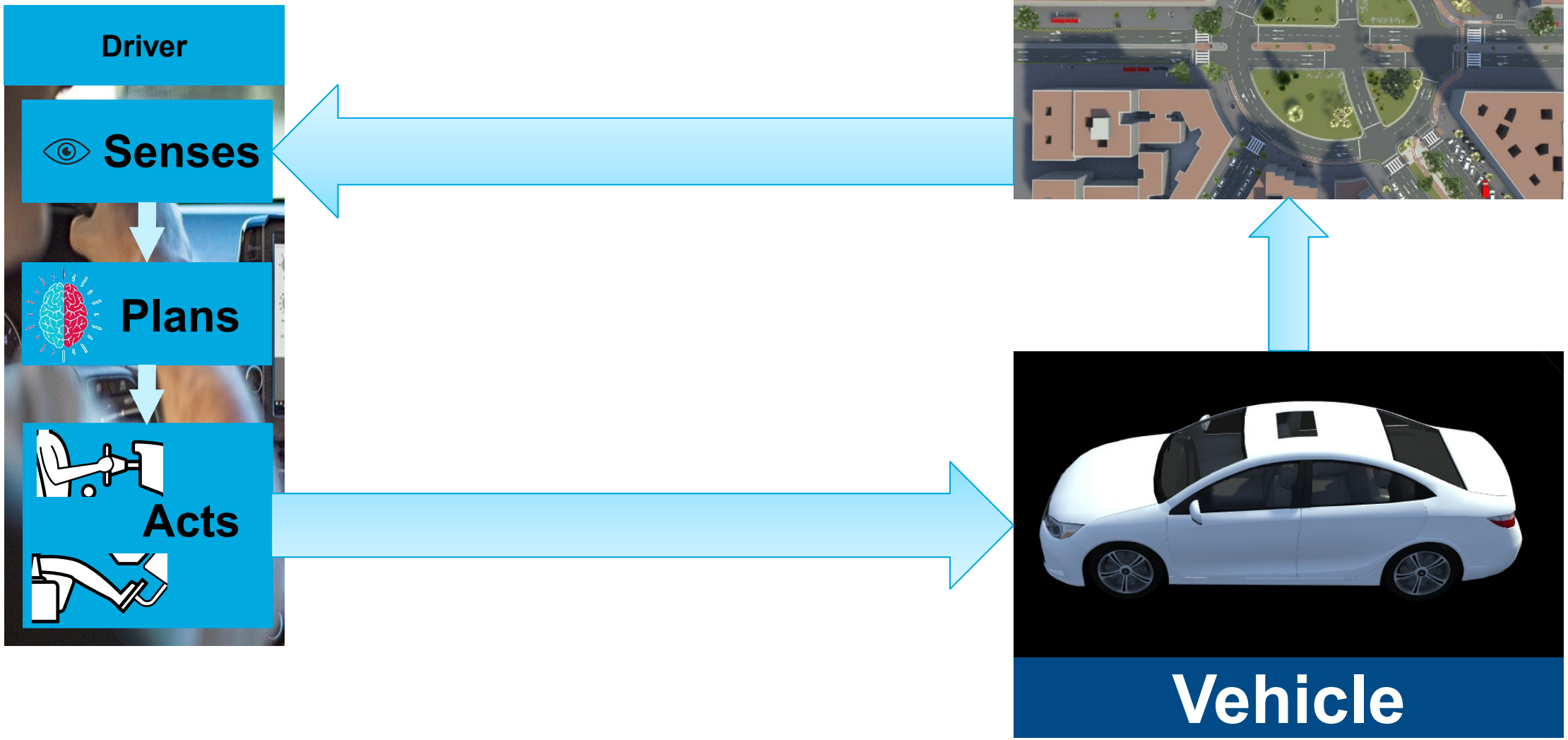
*Singh, S. (2015, February). Critical reasons for crashes investigated in the National Motor Vehicle Crash Causation Survey. (Traffic Safety Facts Crash•Stats. Report No. DOT HS 812 115). Washington, DC: National Highway Traffic Safety Administration.

Worldwide,
approximately 1.3 million
~ 2 x population of Stuttgart
die each year
on road traffic crashes.

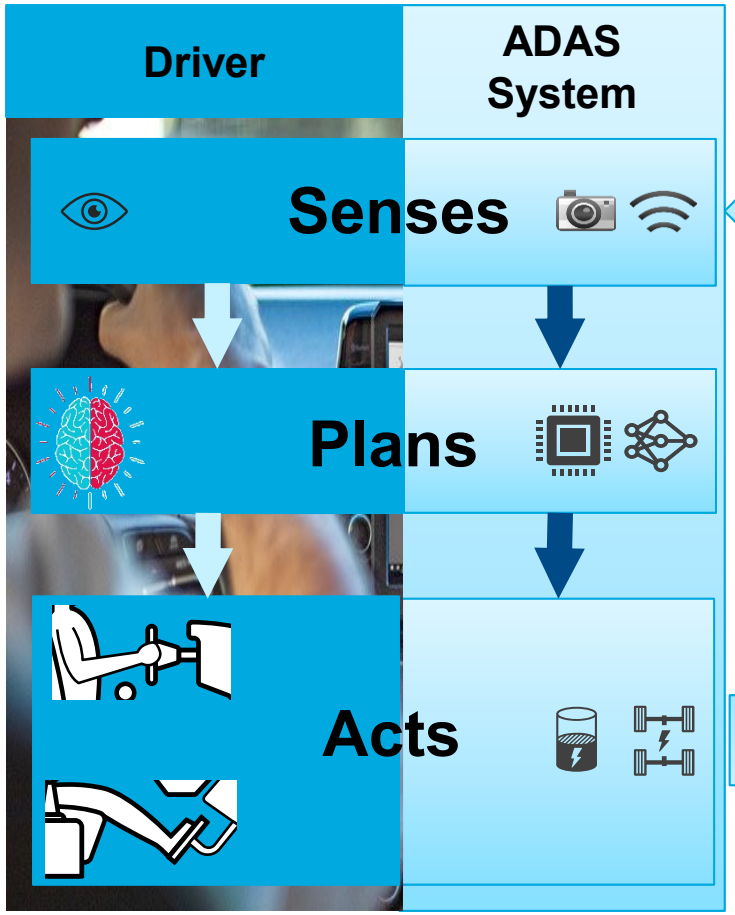
World Health Organization

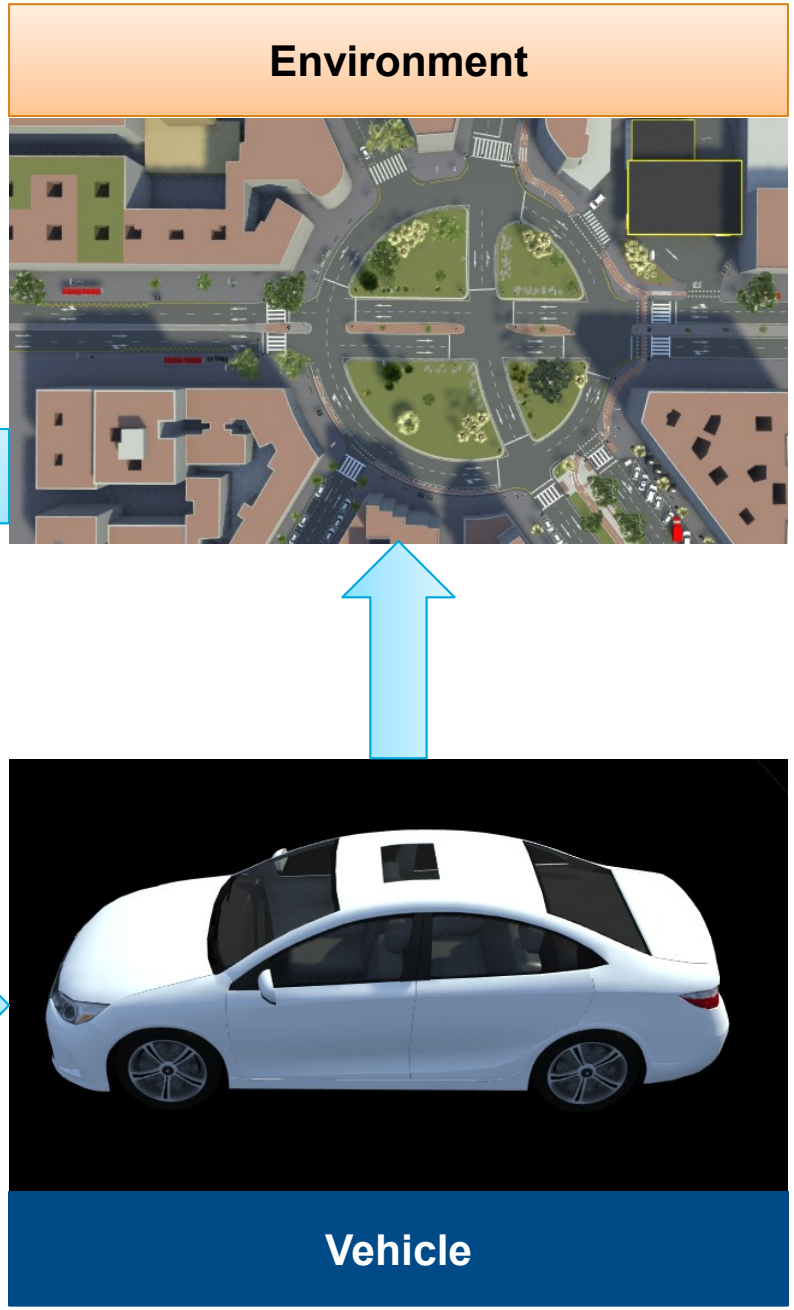
https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries (Accessed April 11, 2022)

How is industry removing human error?



Step 1 - Advanced driver assistance systems (ADAS)





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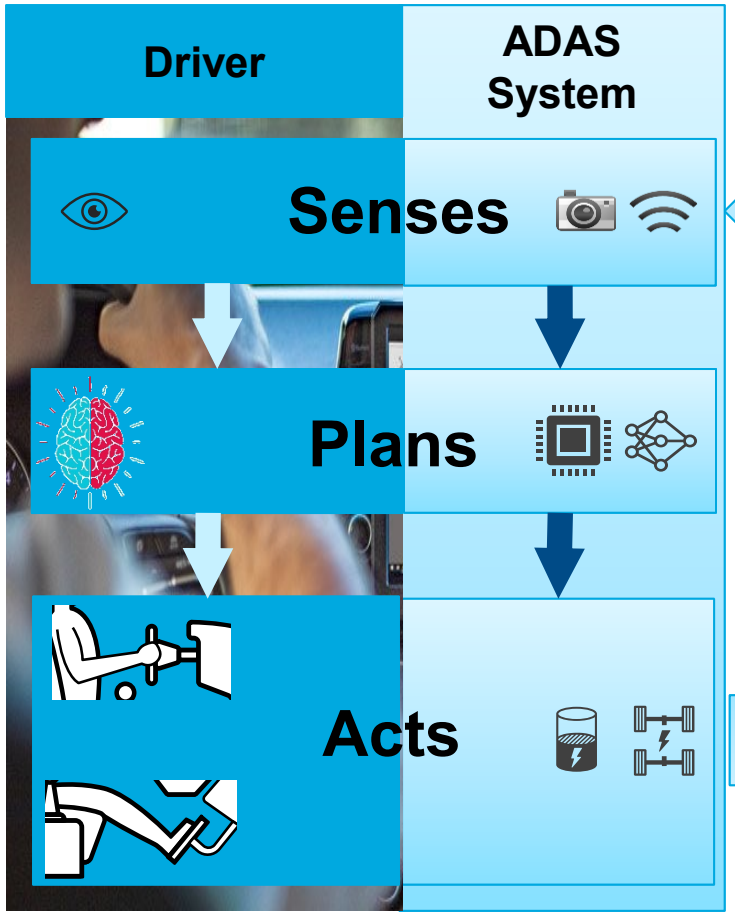
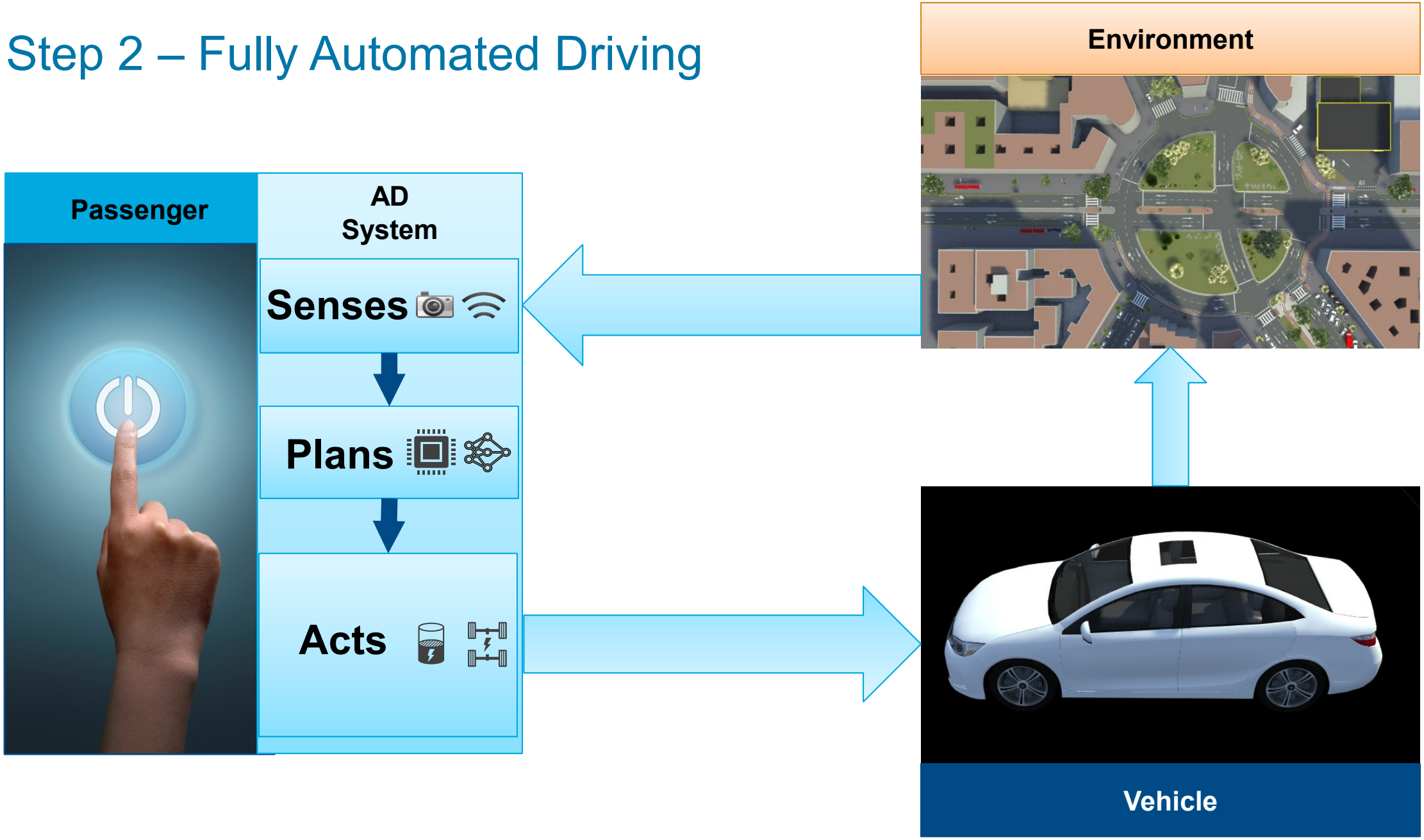


Step 2 – Fully Automated Driving



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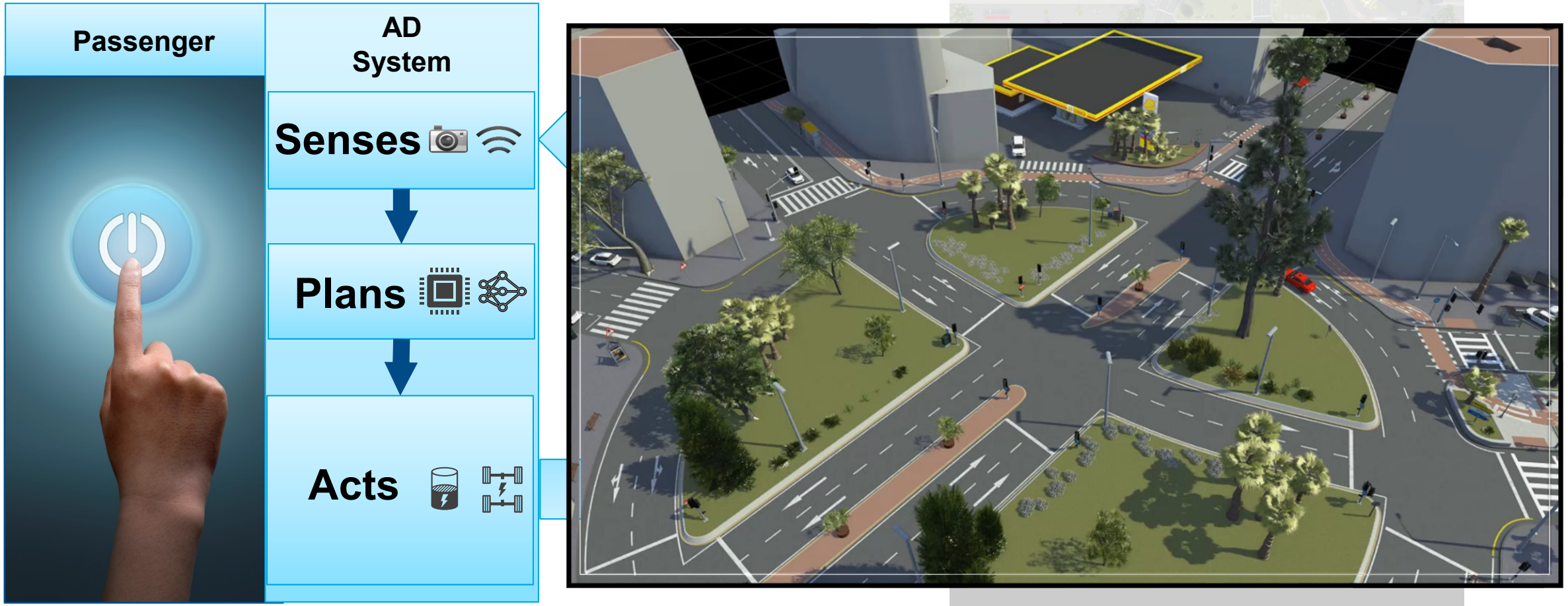
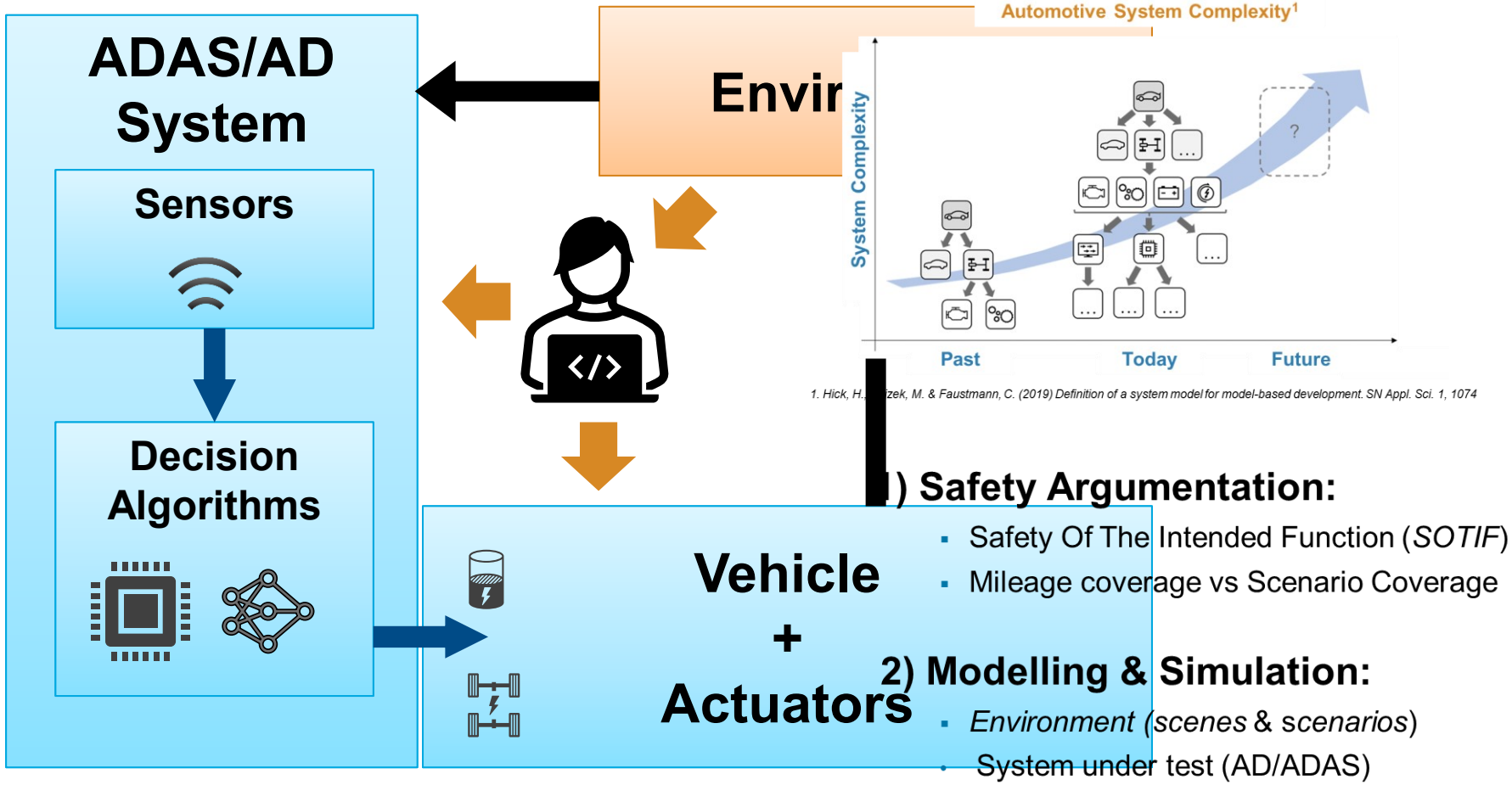


WE are now the human input; WE need to ensure systems are safe



How can we demonstrate AD systems are safer than Human Drivers?

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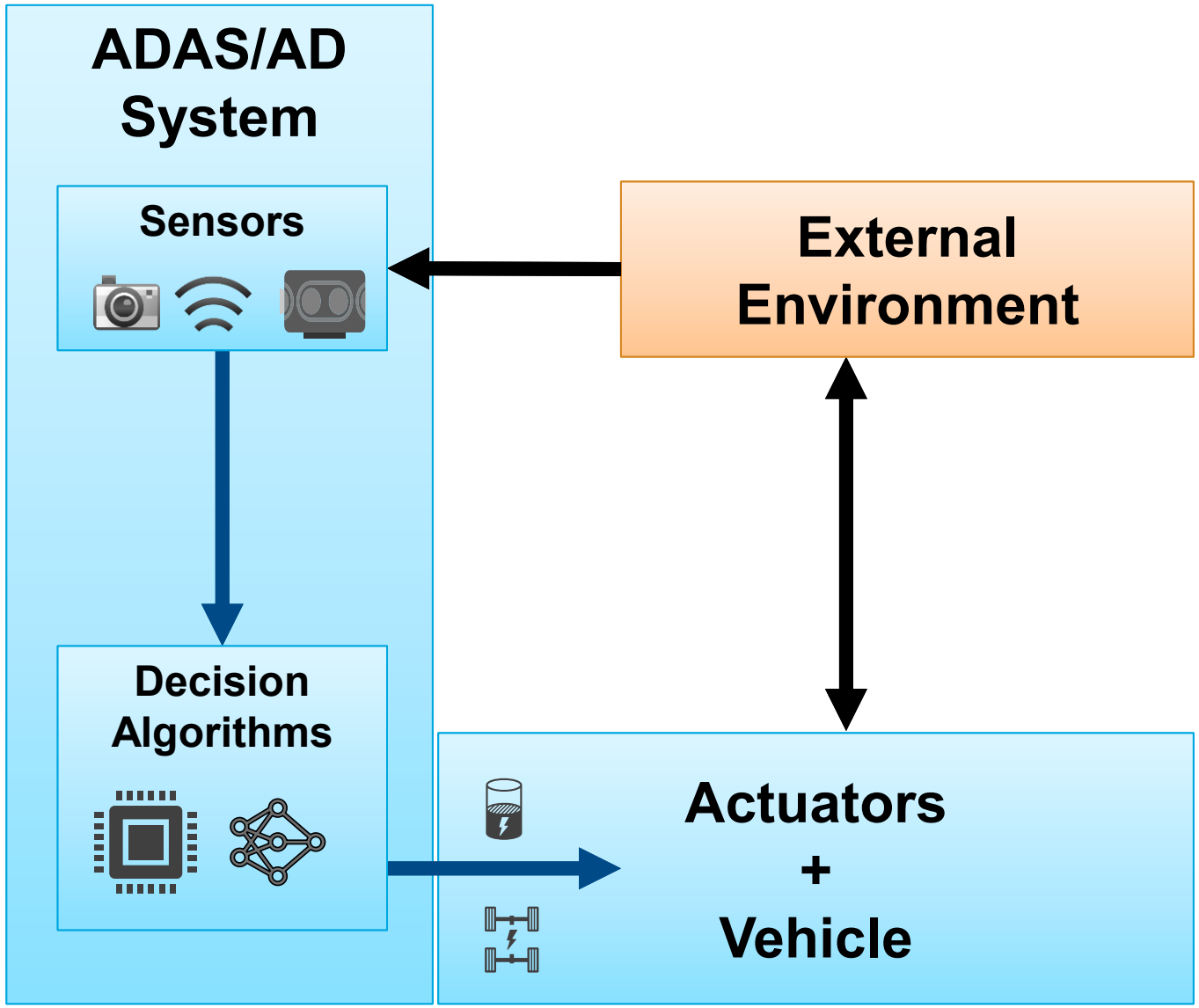
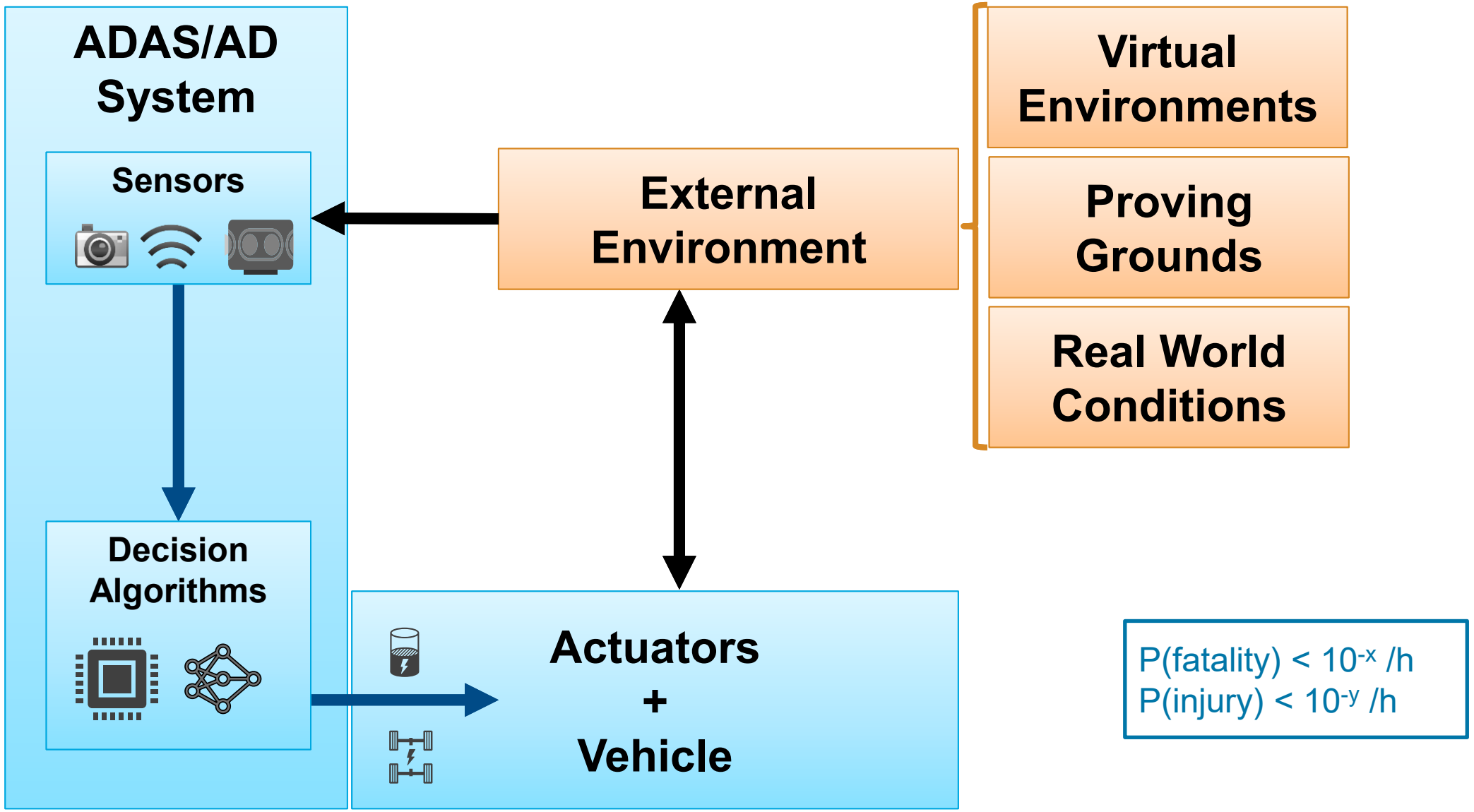


Crash statistics for comparable use cases

Ex: Fatality happens every 10 Million hours (or 700 Million km driven)

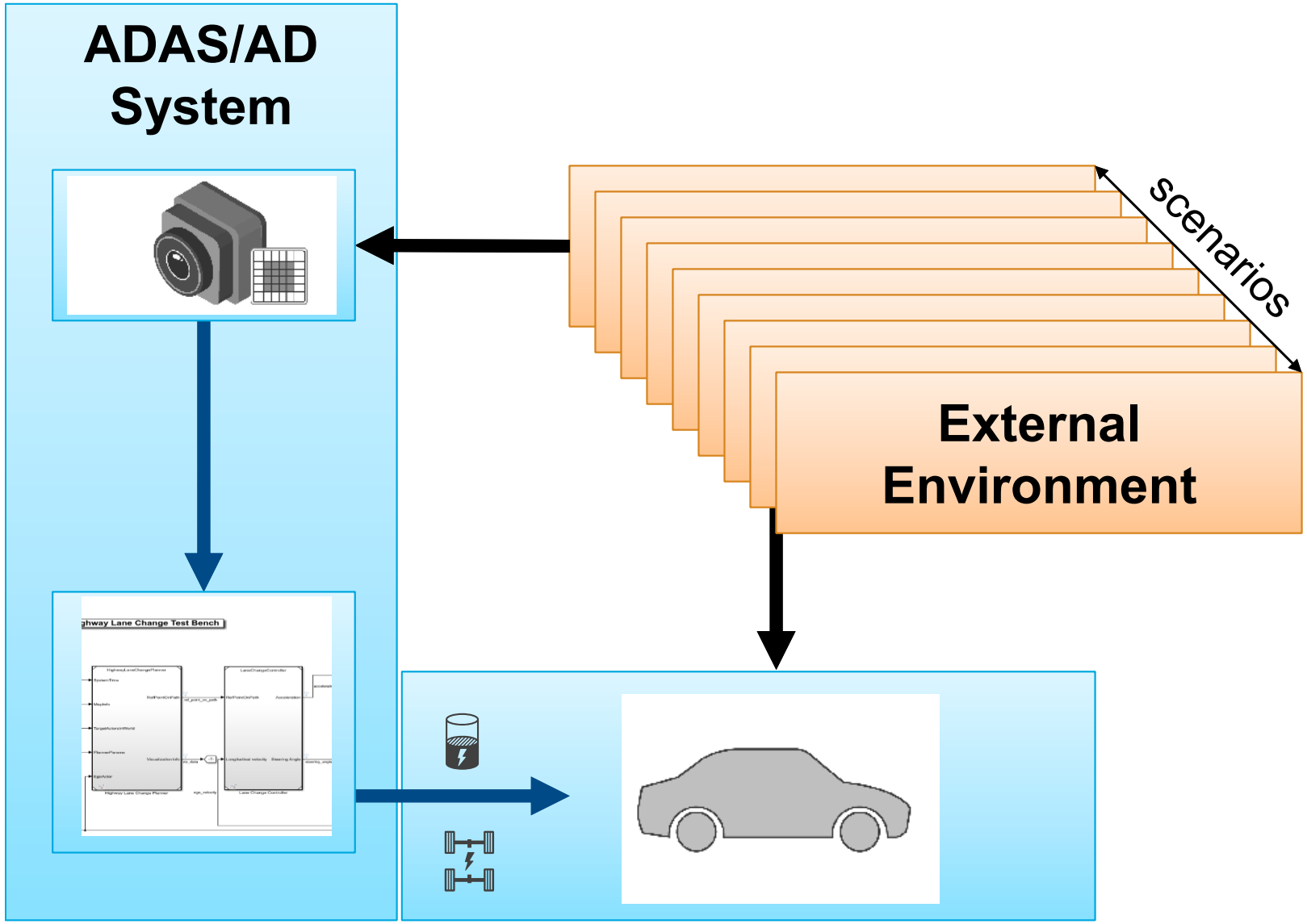
P(fatality) < 10^{-x} /h
P(injury) < 10^{-y} /h

How to demonstrate AD systems are safer than Human Drivers?

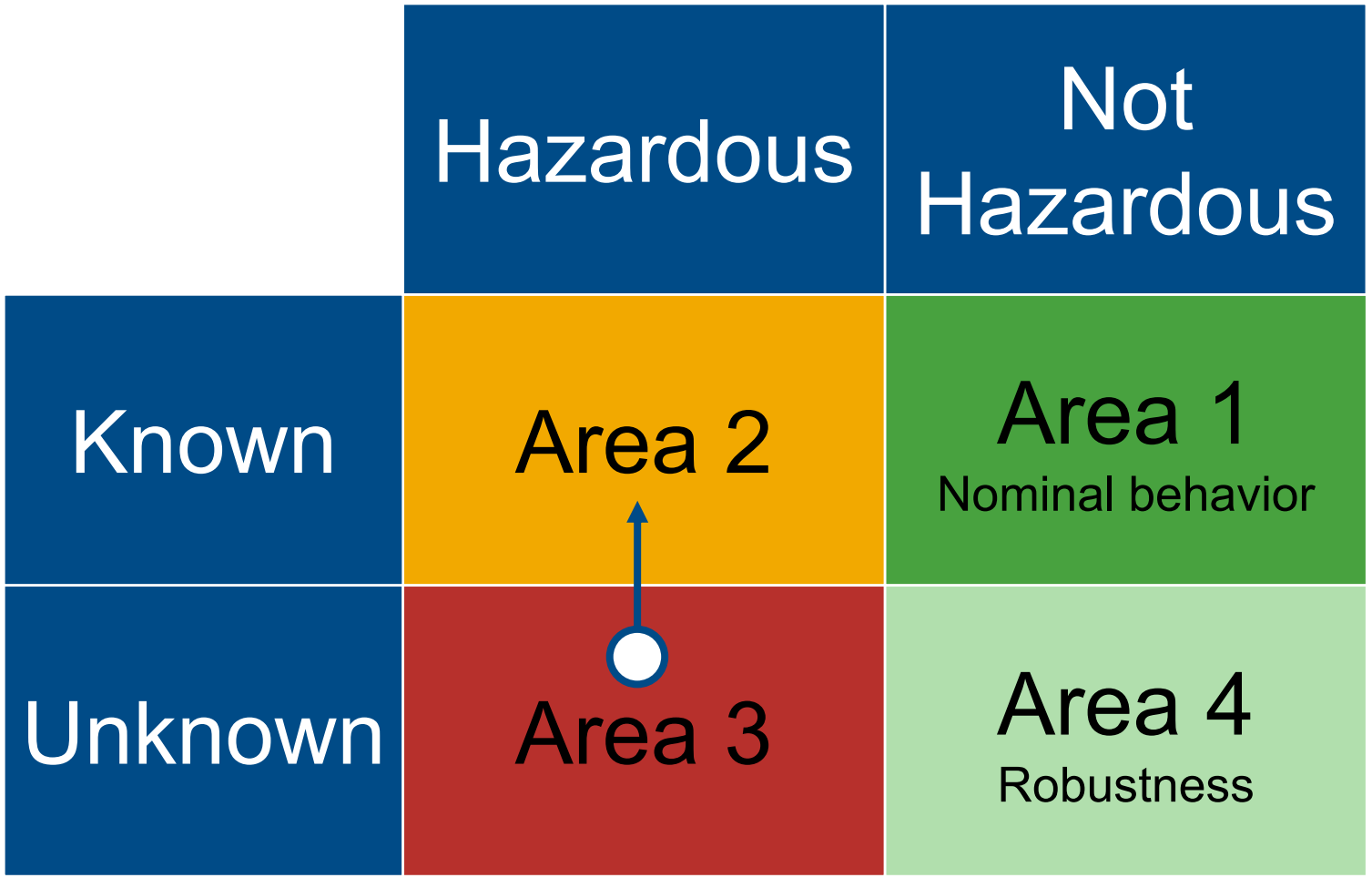


P(fatality) < 10^{-x} /h
P(injury) < 10^{-y} /h

Conceptual Framework for Verification and Validation of ADAS/AD



How to gain confidence in the safety of the intended function?



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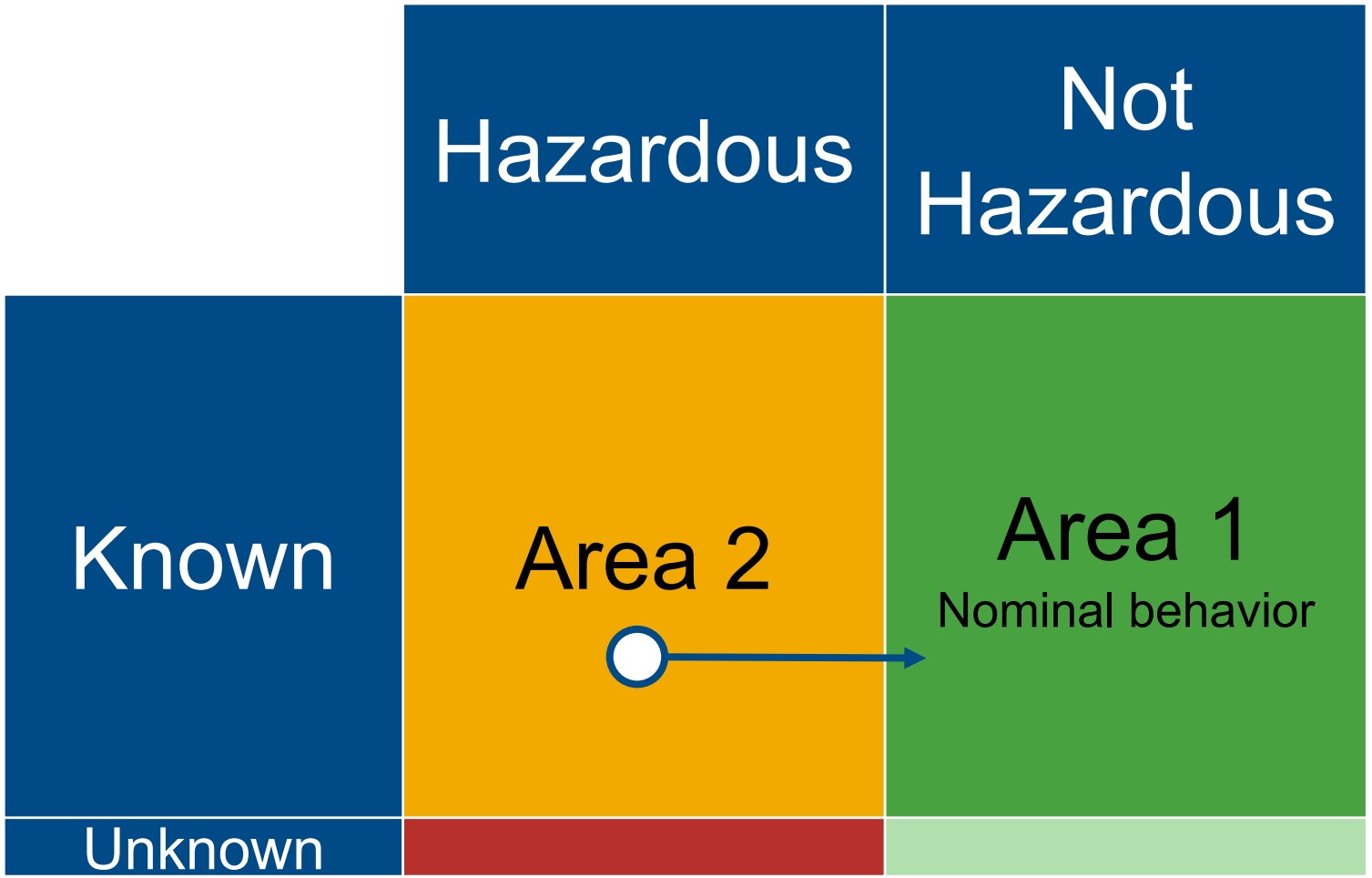

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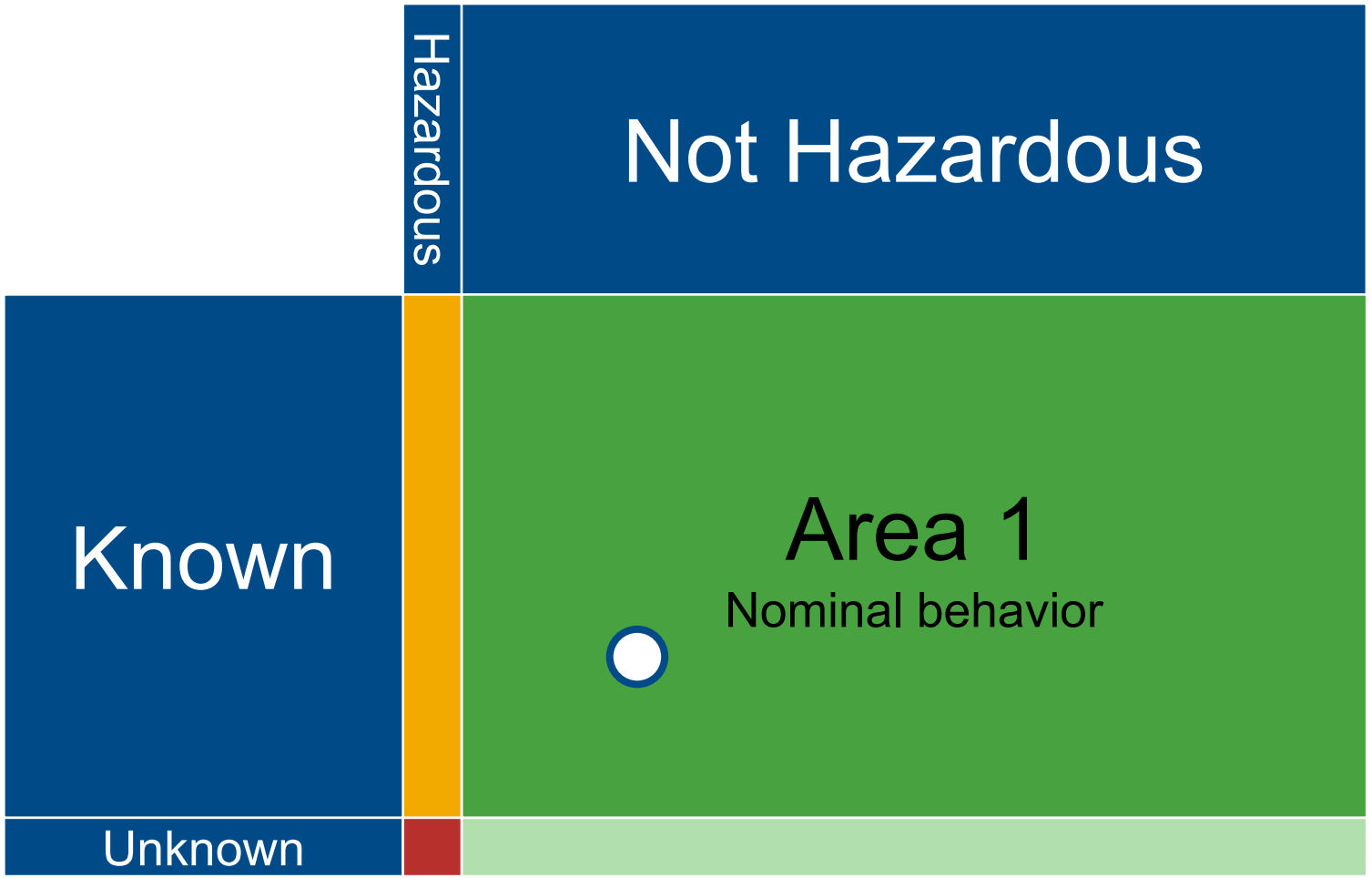

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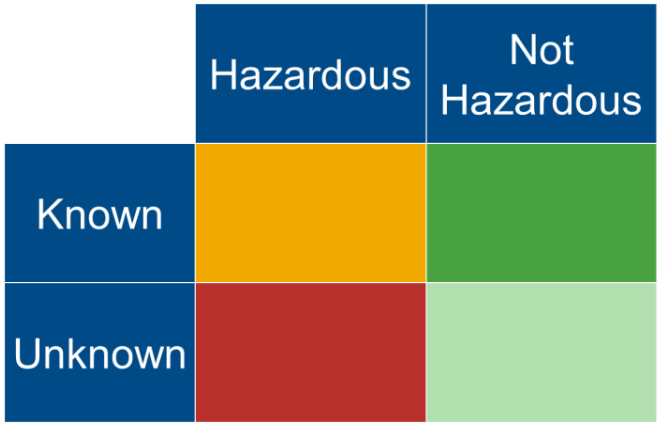
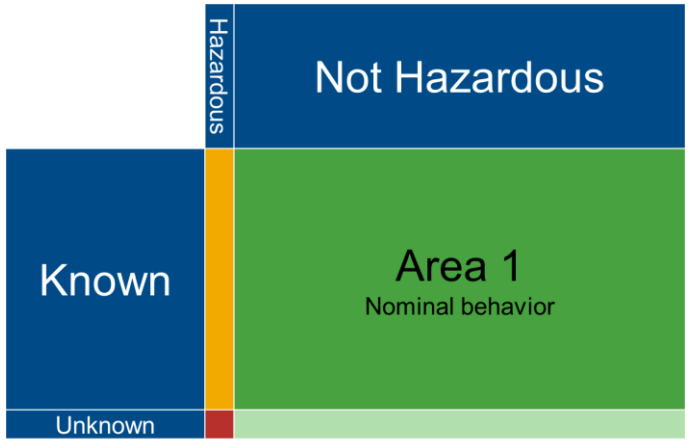


Know the unsafe

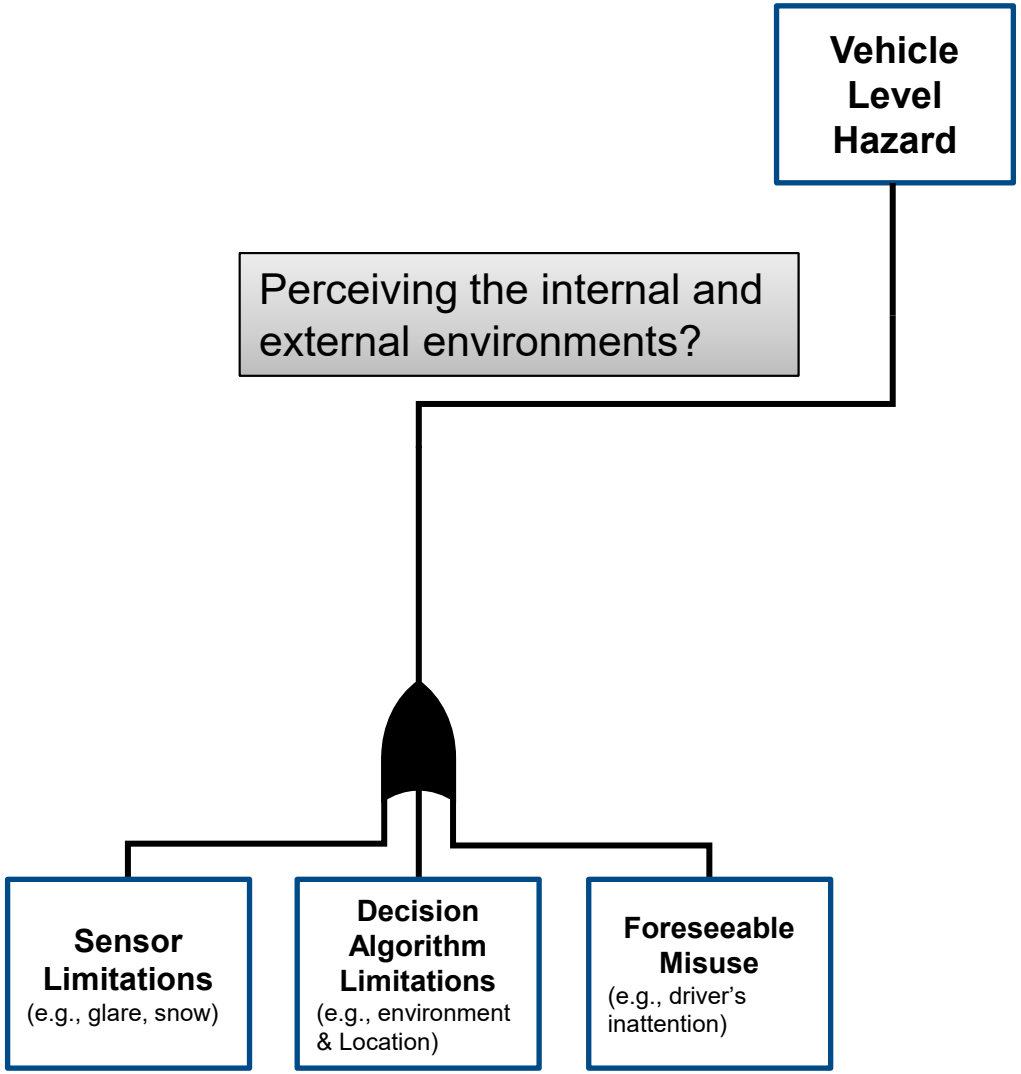
Make the unsafe safe



Accumulate evidence to reach the acceptance criteria

P(fatality) < 10^{-x} /h
P(injury) < 10^{-y} /h

Which scenarios to test?



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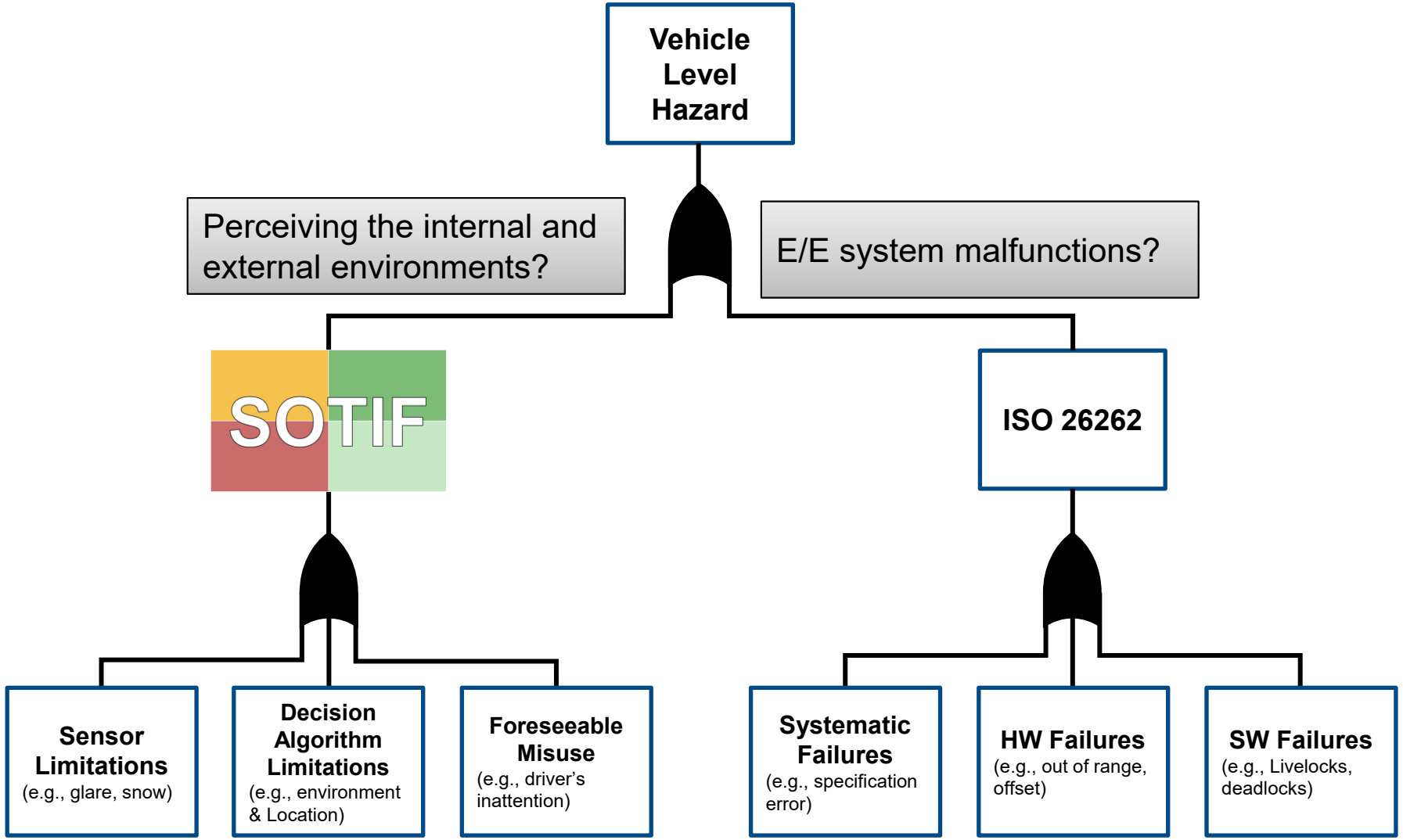
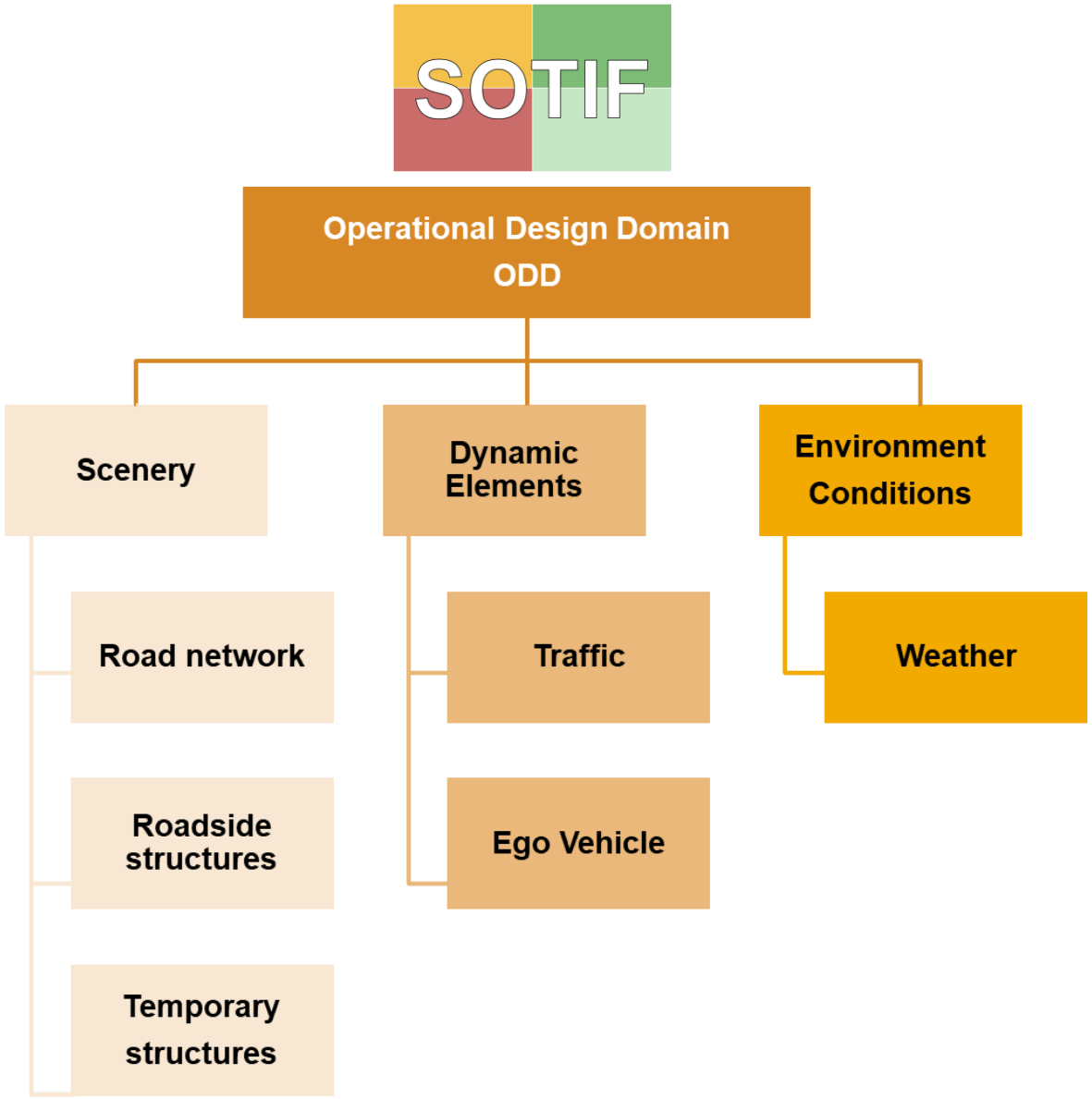


Structuring the Environment

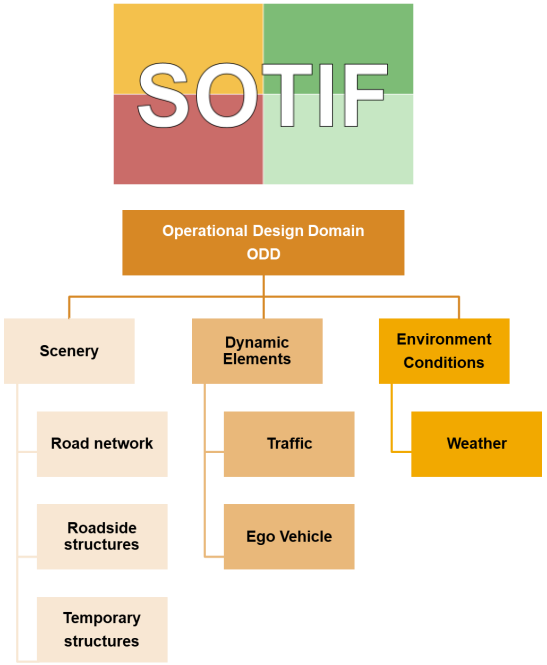


SAE J3016 defines ODD as

Operating conditions under which a given driving automation system … is specifically designed to function, including…

Scenario Derivation

Functional Scenarios → **Logical Scenarios** → **Concrete Scenarios**



1) Safety Argumentation

- Safety Of The Intended Function (*SOTIF*)
- Scenario Coverage

2) Modelling & Simulation

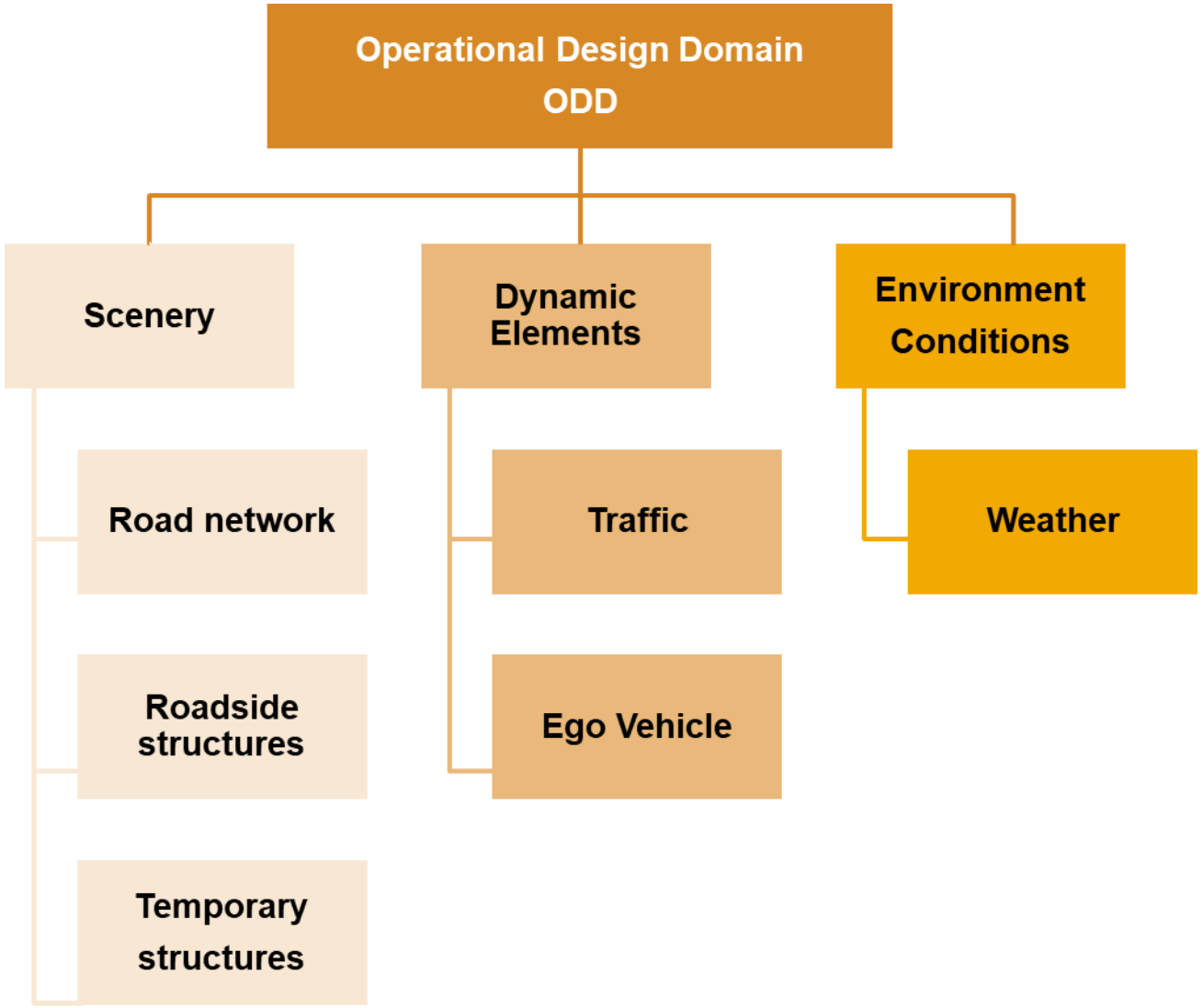
- **Environment (scenes & scenarios)**
- System under test (AD/ADAS)

15] km/h

Test Cases

Number of scenarios

Creating scenes follows a similar workflow as Scenario Derivation



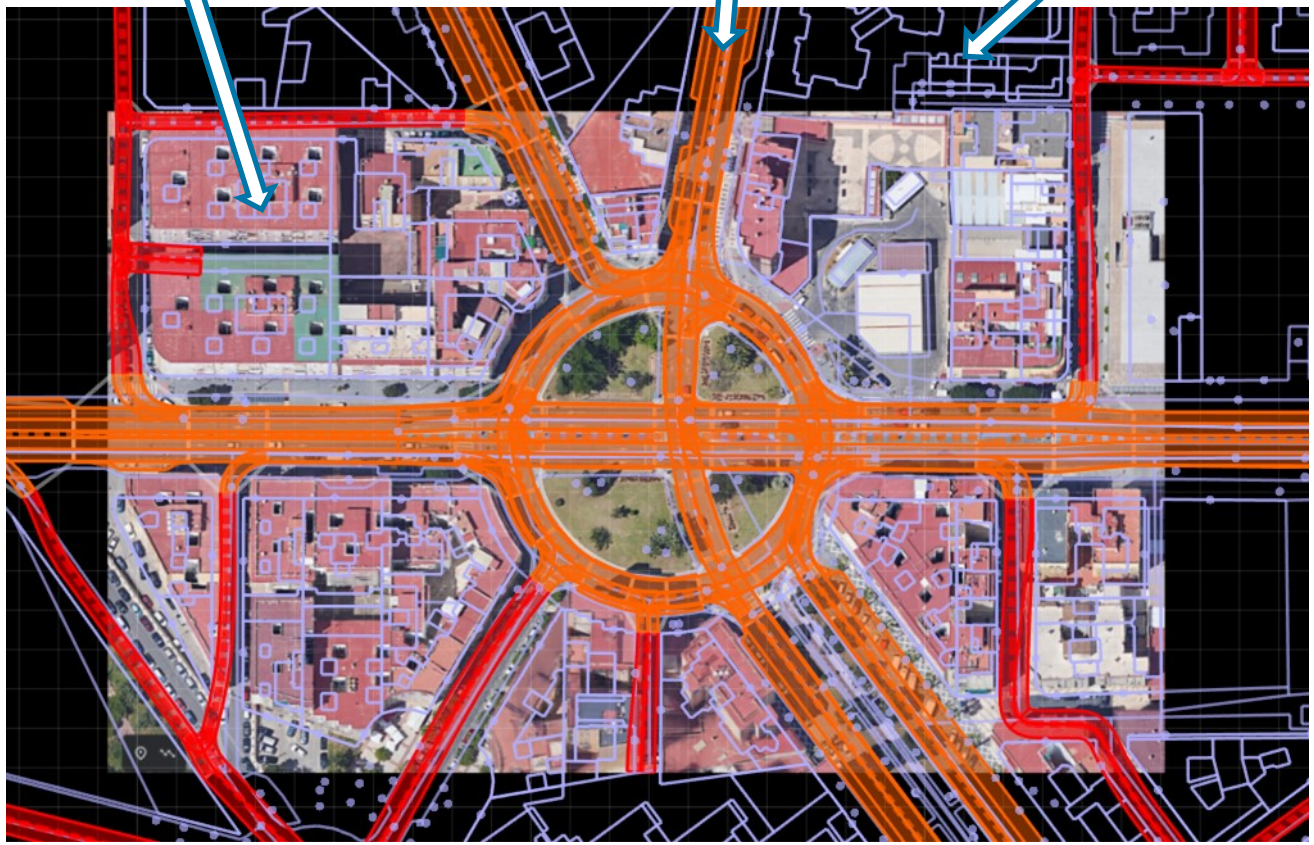
The industry uses different sources of information for *road networks*

- **Scenery**
  - **Road network**
  - **Roadside structures**
  - **Temporary structures**

Orthoimagery

HD Maps

Vector Data (e.g. OpenStreetMap)



Aerial images support manual modelling of *road networks*, as well as *Roadside Structures*

- **Scenery**
  - **Road network**
  - **Roadside structures**
  - **Temporary structure**

Orthoimagery

HD maps allows industry to automate the creation of virtual versions of real *road networks*

- **Scenery**
- **Road network**
- **Roadside structures**
- **Temporary structure**

High-Definition Maps

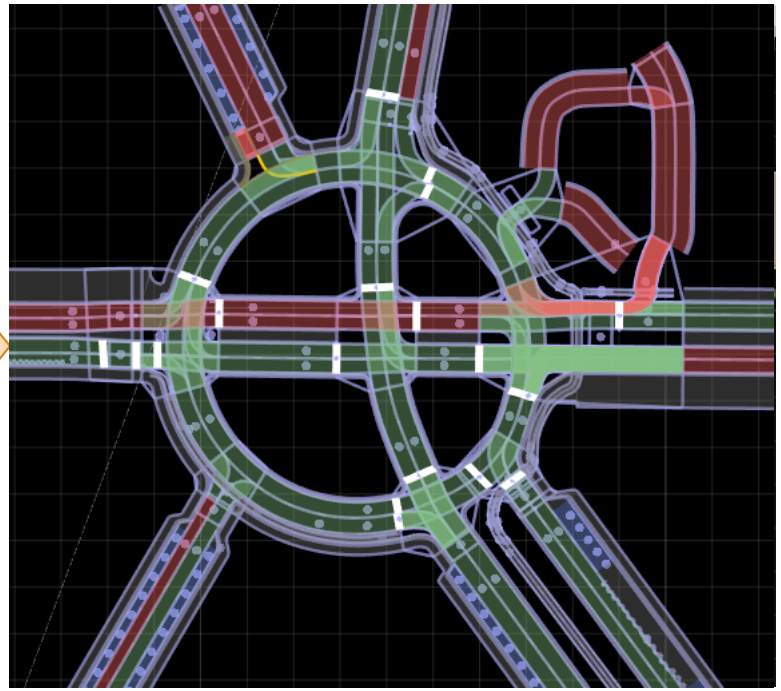
A challenge, in industry, is the number of formats for the scenes.

The ASAM OpenDRIVE provides a common base for describing road networks

Multiple Simulators
- CARLA
- Unreal Engine®
- Unity®
- LGSVL
- VIRES Virtual Test Drive

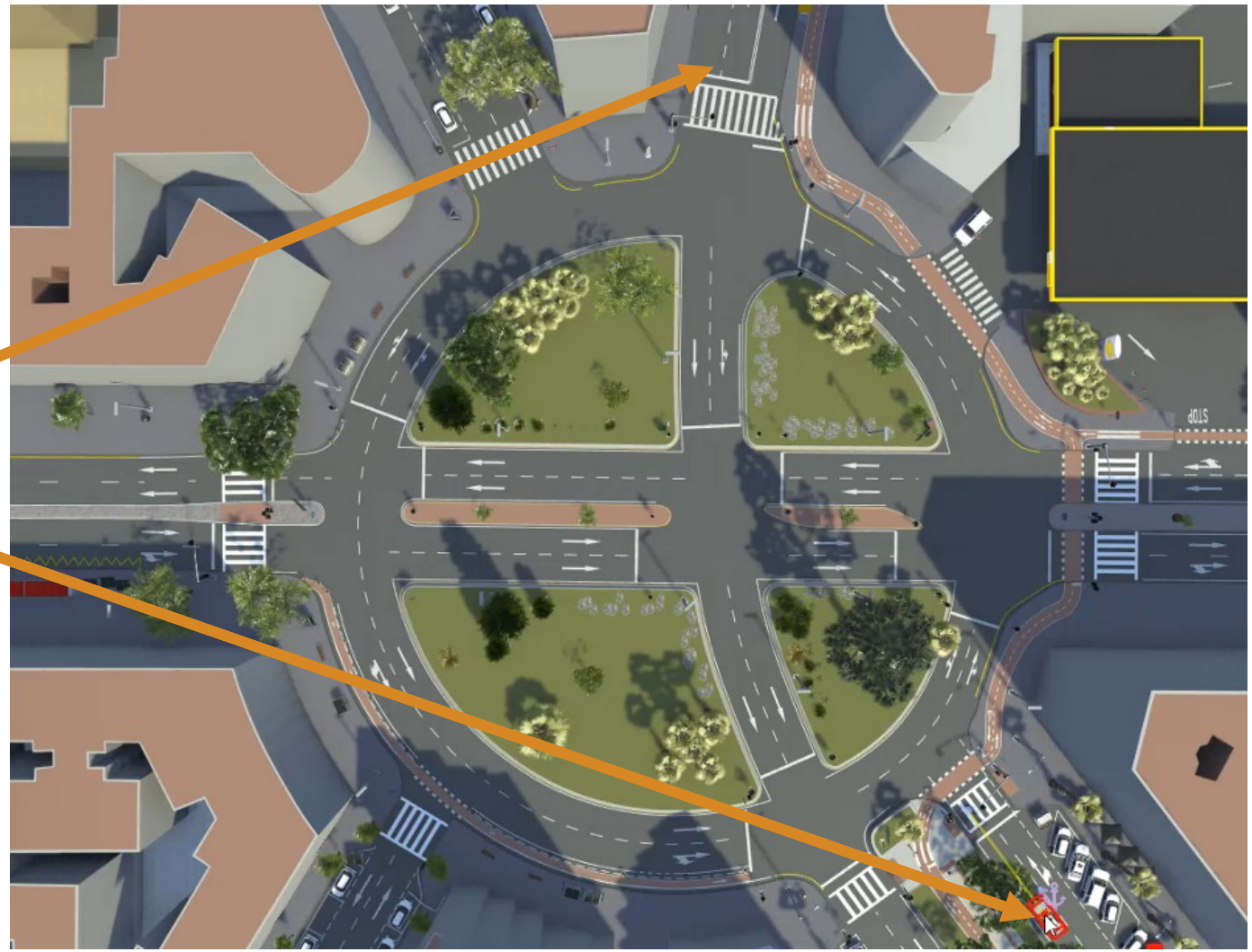
OpenDRIVE

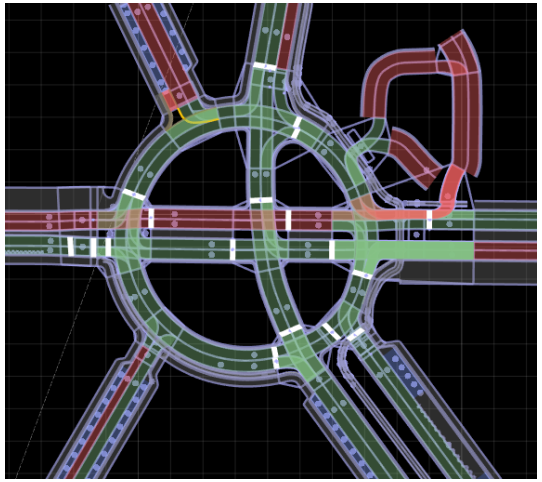
- Cognata
- Baidu Apollo
- Tesis Dynaware
- TaSS PreScan
- NVIDIA DRIVE Sim through Universal Scene Description (USD)



Modelling the Dynamic Elements

- **Dynamic Elements**
  - **Traffic**
  - **Ego Vehicle**





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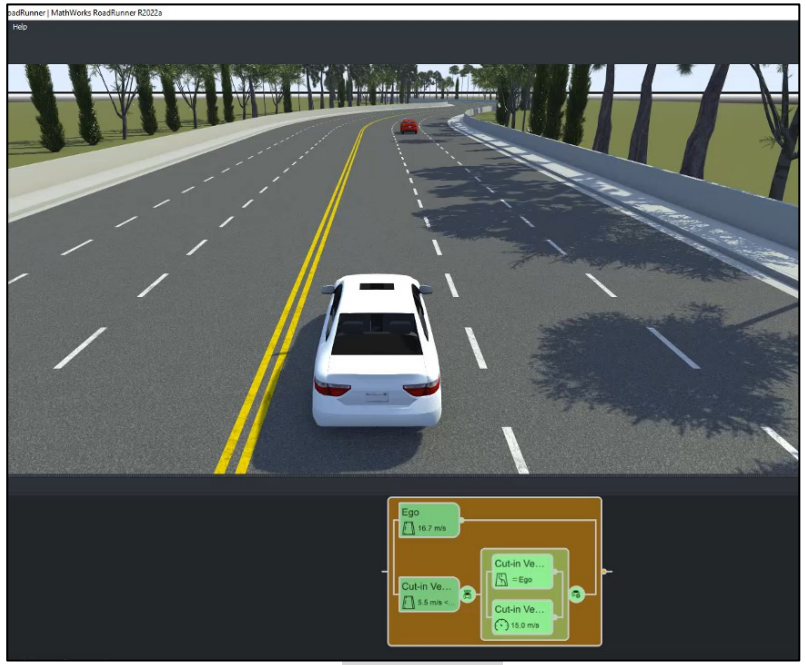

OpenSCENARIO

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</Condition>
</ConditionGroup>
</StartTrigger>
</Event>
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<LongitudinalAction>
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</SpeedAction>
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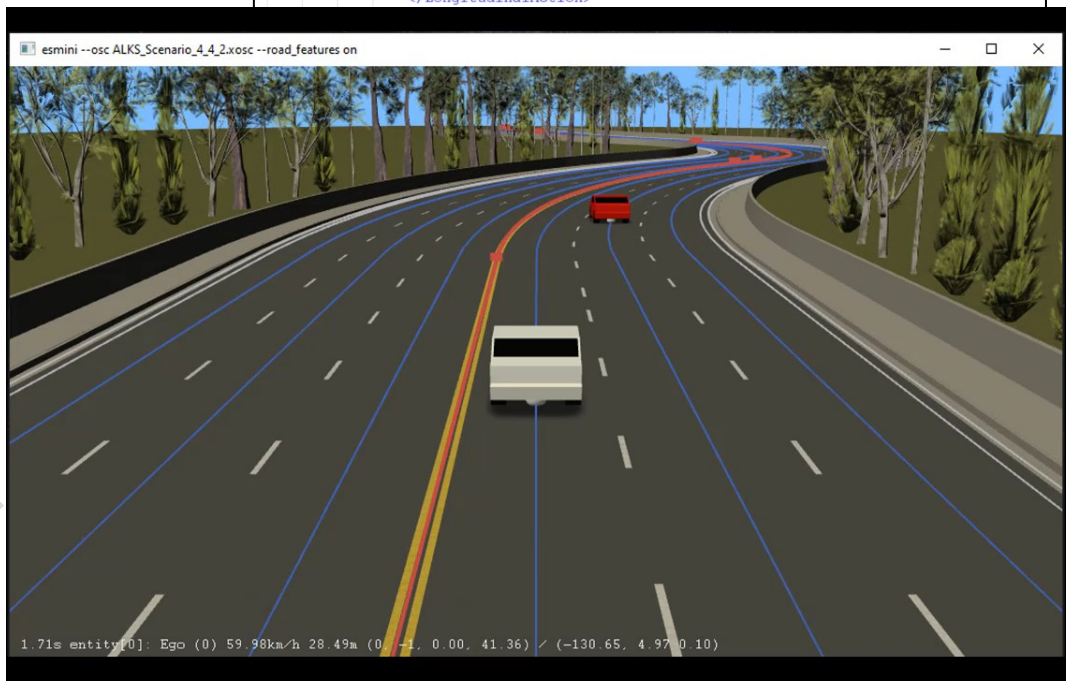
```



https://github.com/esmini/esmini

Modelling the Environment conditions

Environment Conditions

- **Weather**

Sun Altitude =90, Sun Azimuth =180 (Noon)

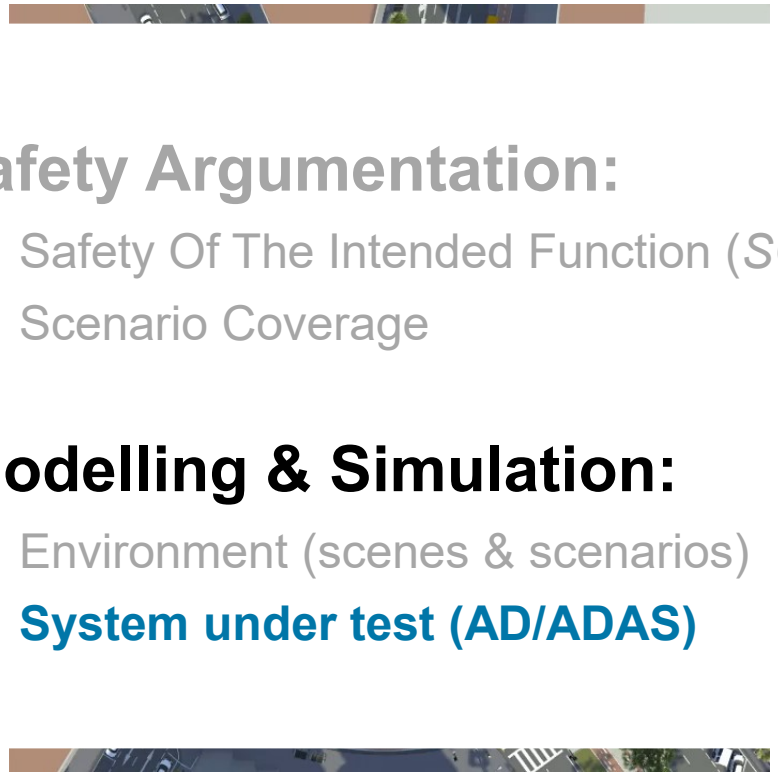
Sun Altitude =-90, Sun Azimuth =180 (Midnight)

Sun Altitude =0, Sun Azimuth =180 (SunRise)

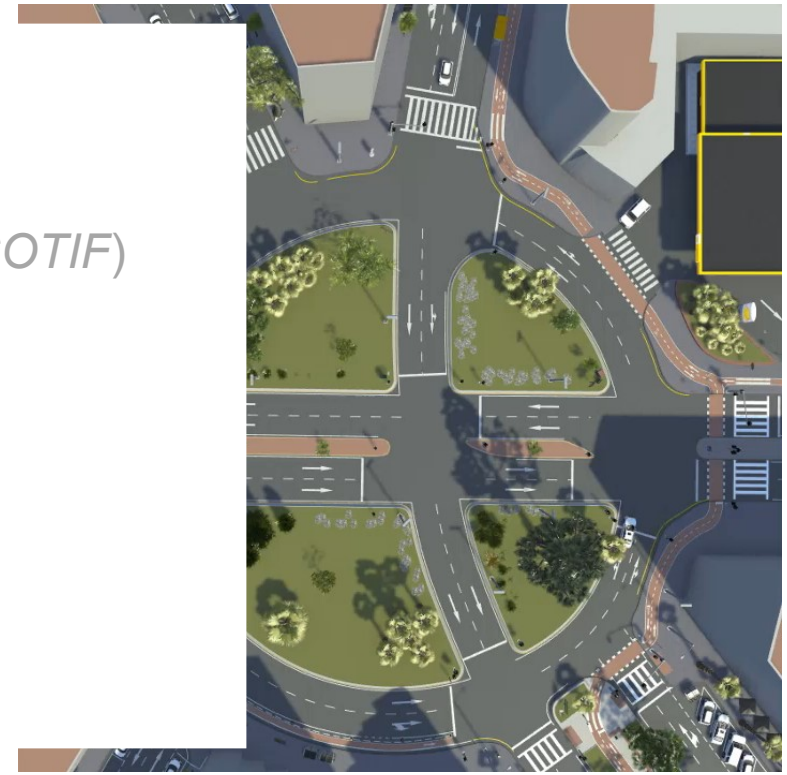
Modelling large amounts of concrete scenarios through programmatical parametrization

Speed of the **Ego Vehicle:**

6 m/s



8 m/s



10 m/s

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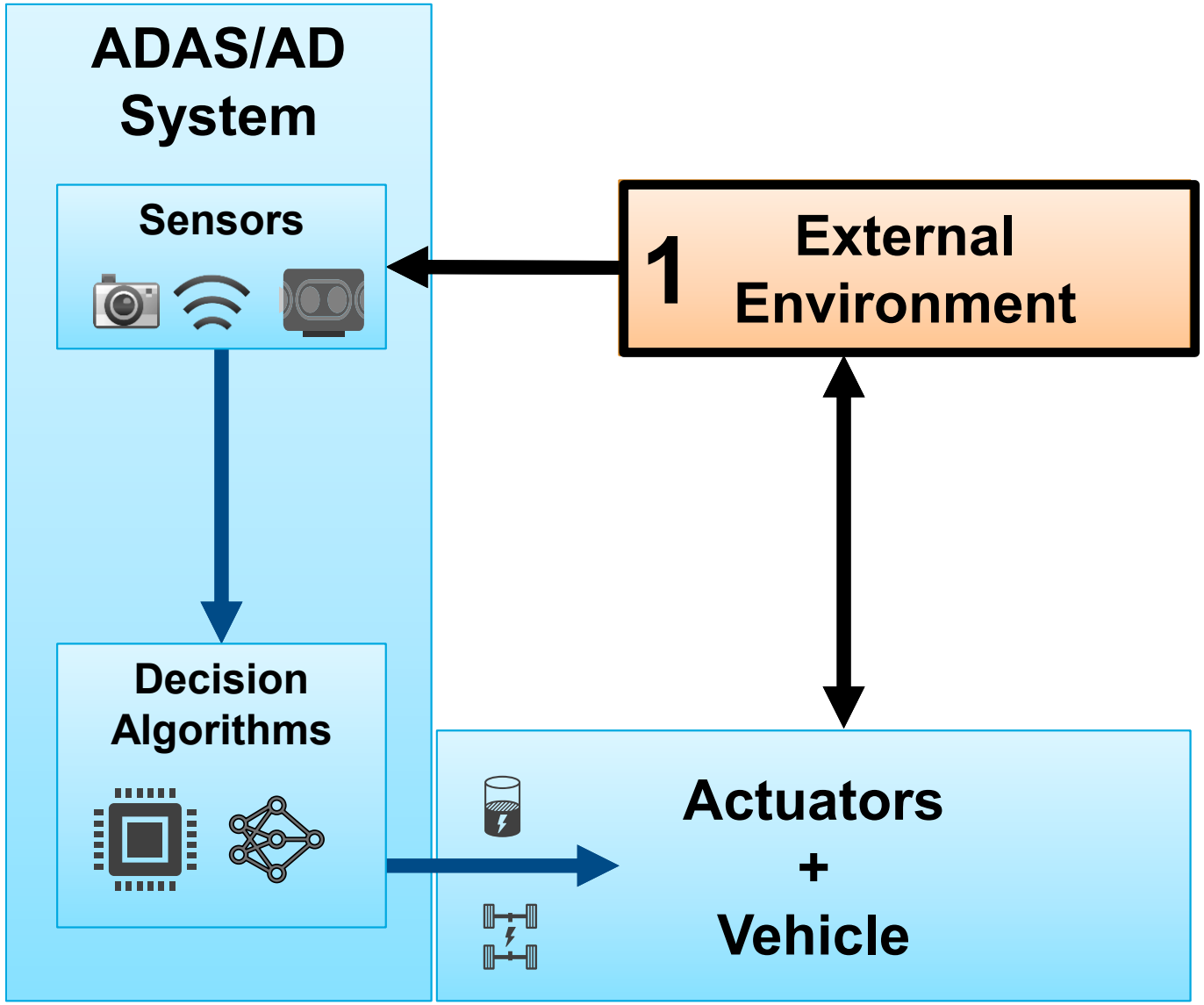
2) Modelling & Simulation:

- Environment (scenes & scenarios)
- **System under test (AD/ADAS)**

Conceptual Framework for Verification and Validation of ADAS/AD



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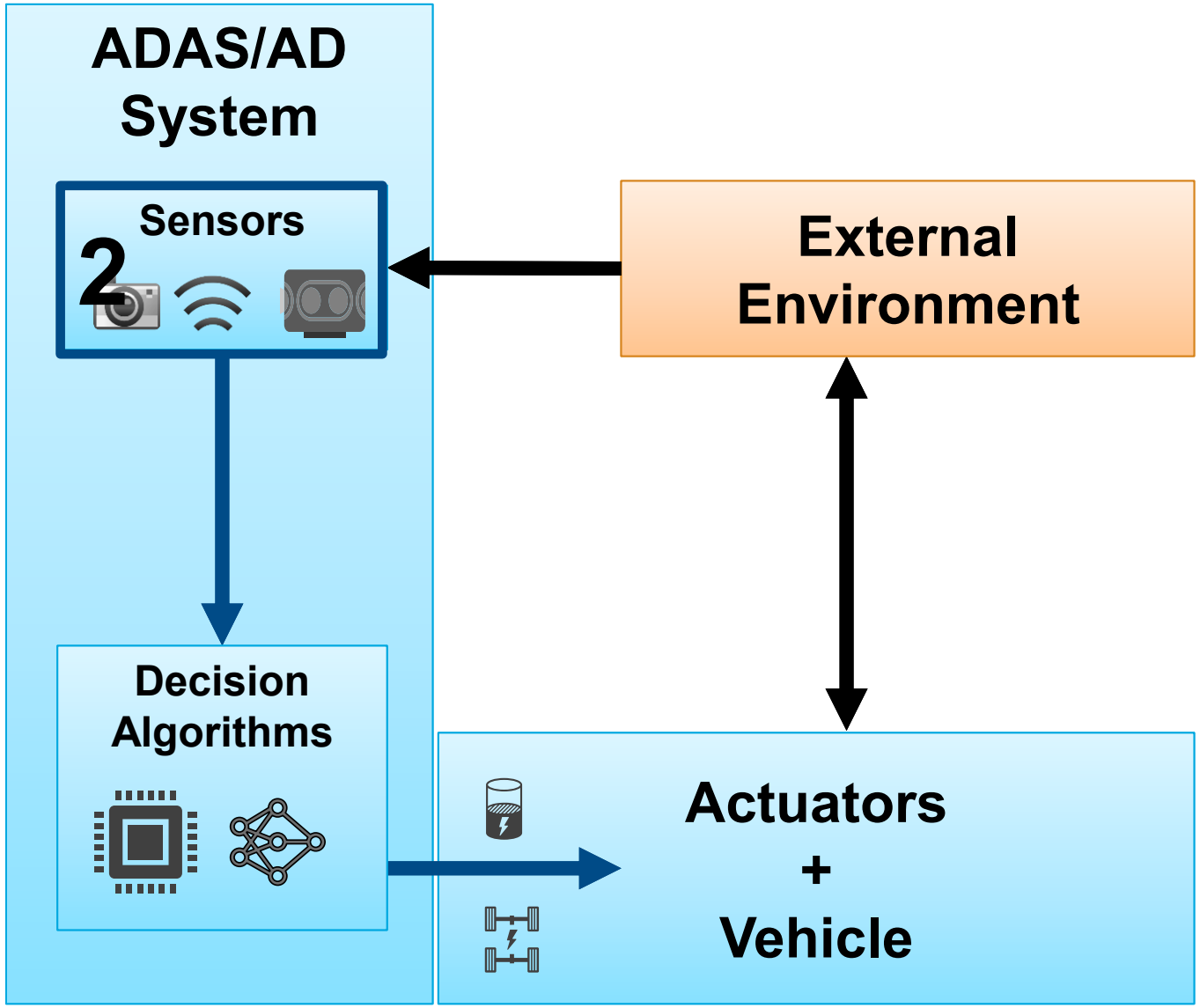

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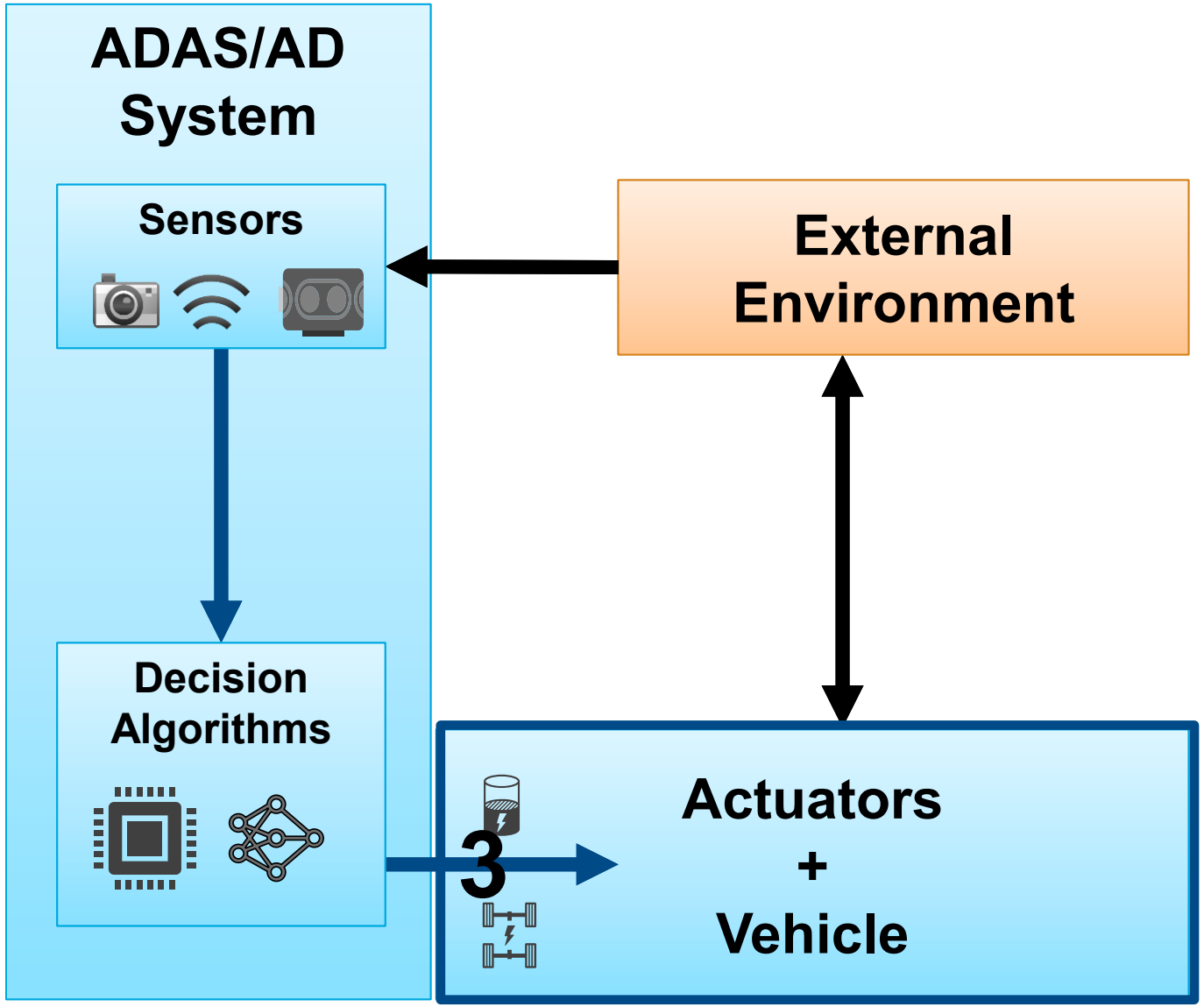

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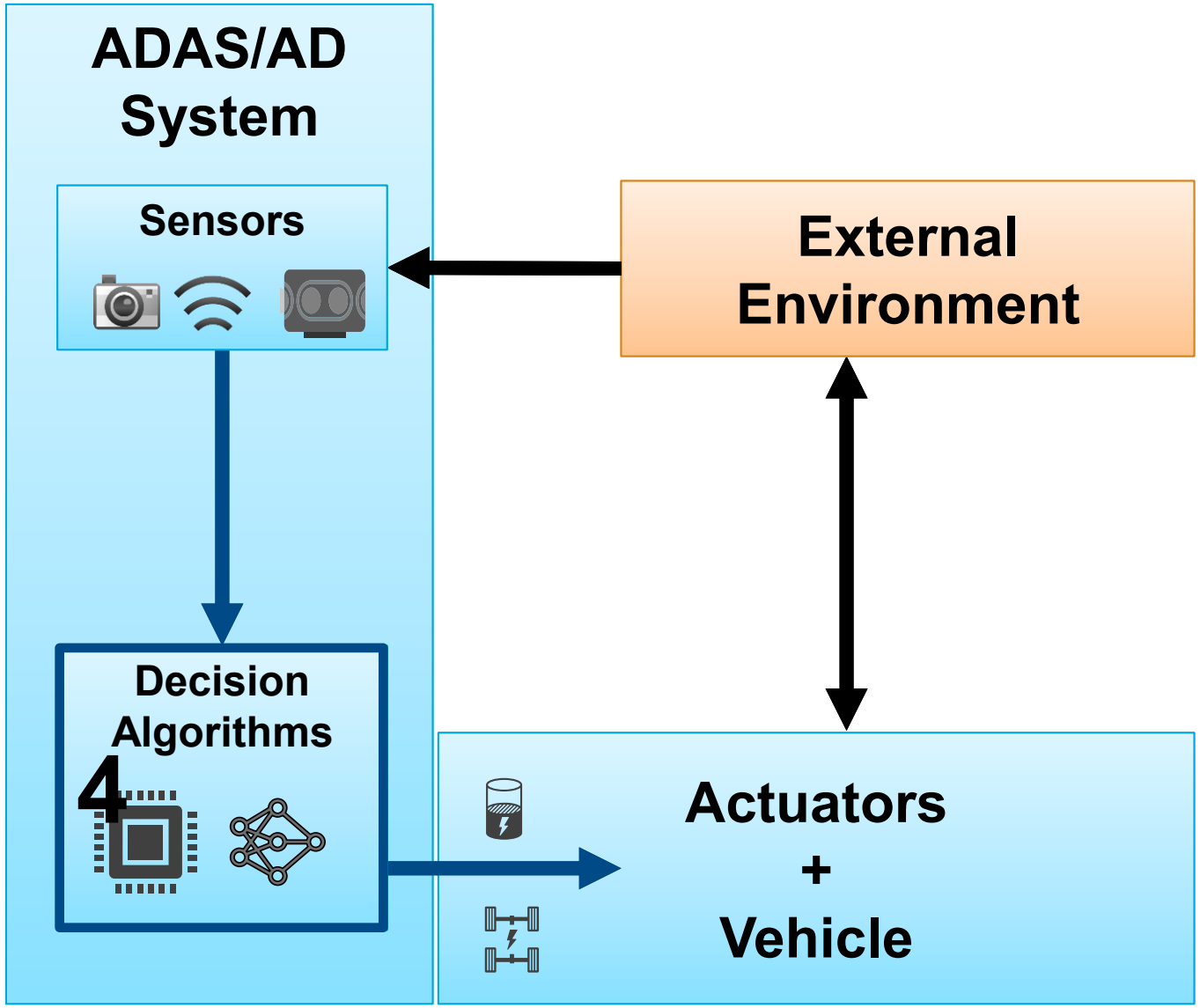

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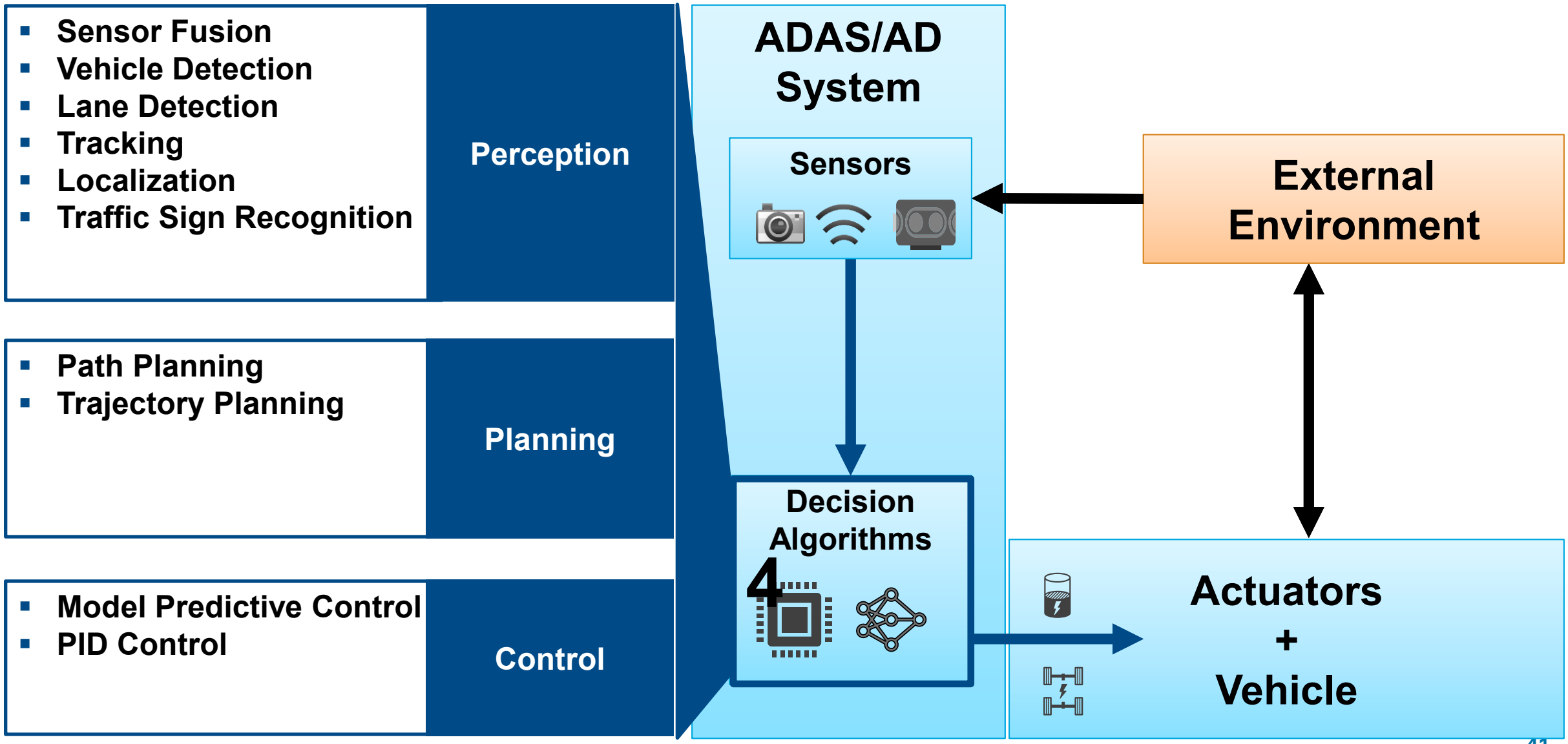
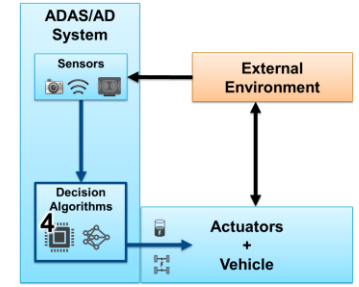
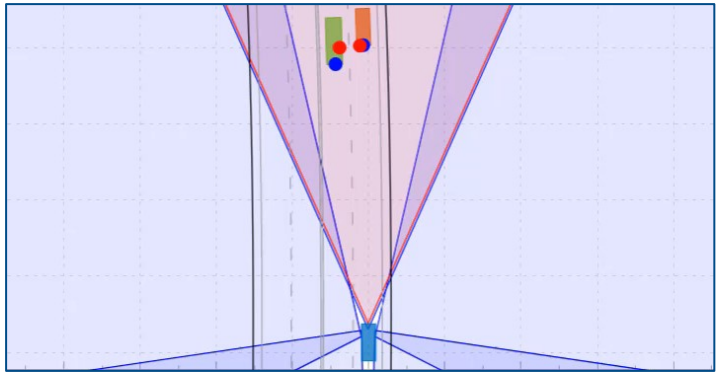


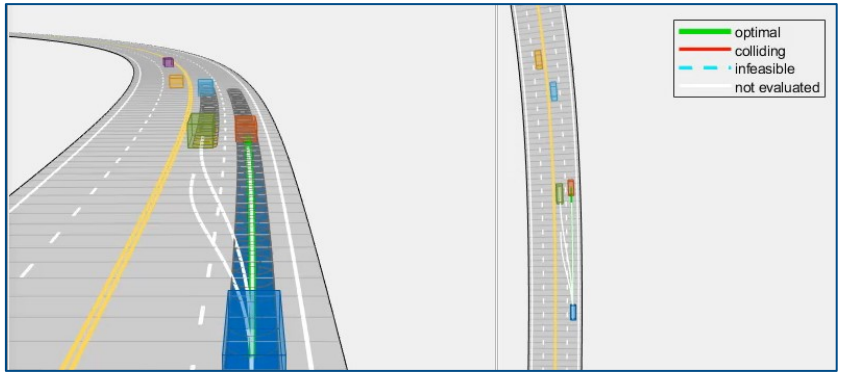
The maturity of your development/simulation



Perception



Tracking and Fusion



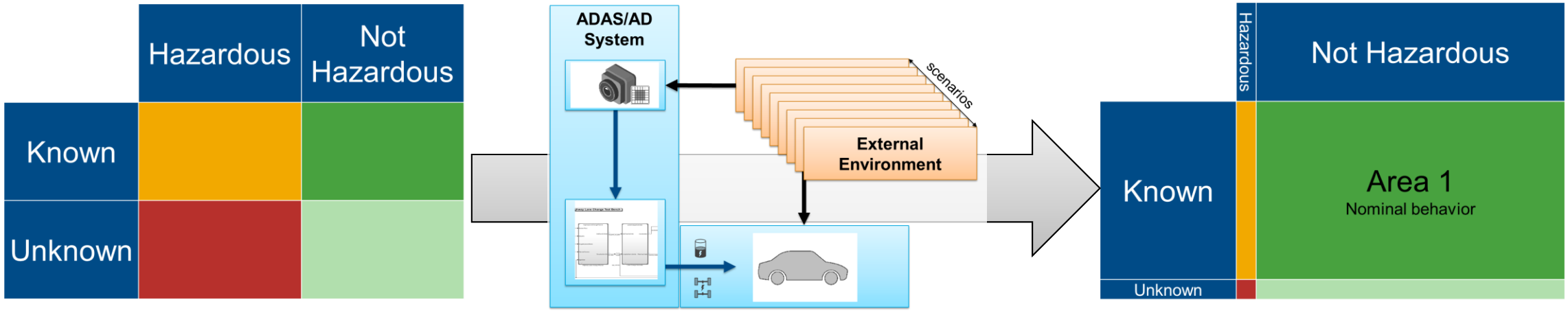
Planning

	MIL	SIL	PIL	HIL	DIL
Decision Algorithms	Start Simple	Model		Hardware	
Sensor					
Driver					
Vehicle					
External Environment					

Virtual to Physical

Concluding Remarks

How is the industry addressing the safety of ADAS/AD?



- **Argumentation framework** to ensure SOTIF
- **Identification of critical scenarios through analysis**
- Development of V&V strategy based on **virtual testing**
- **Identification of critical scenarios from real driving data**
- Standardized **interfaces** between tools in simulation toolchain