



Simulation and Testing for Automated Driving

Driving Simulation Conference 2020, 10th September 2020, Antibes

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Mercedes-Benz
The best or nothing.





Sustainable Modern Luxury

Focus on our core-values: [ease](#), [respect](#), [trust](#) and [love](#).

*“We want to combine the strengths of the **Mercedes-Benz brand**, such as long-standing **tradition** and **high innovative strength**, with mobility that is more **sustainable** and **intuitive**. This is anchored in our corporate strategy and we act responsibly. All the products and services we offer are not only intelligent, but also emotional.”*



Britta Seeger, CES Las Vegas,
2020

Member of the Board of Management, Daimler AG



Digital Transformation

Digitization and Services are key to a successful customer relationship.

Launch in 2020:

new

mercedes-me app: more features,
more customer-centric.

Projection to 2025:

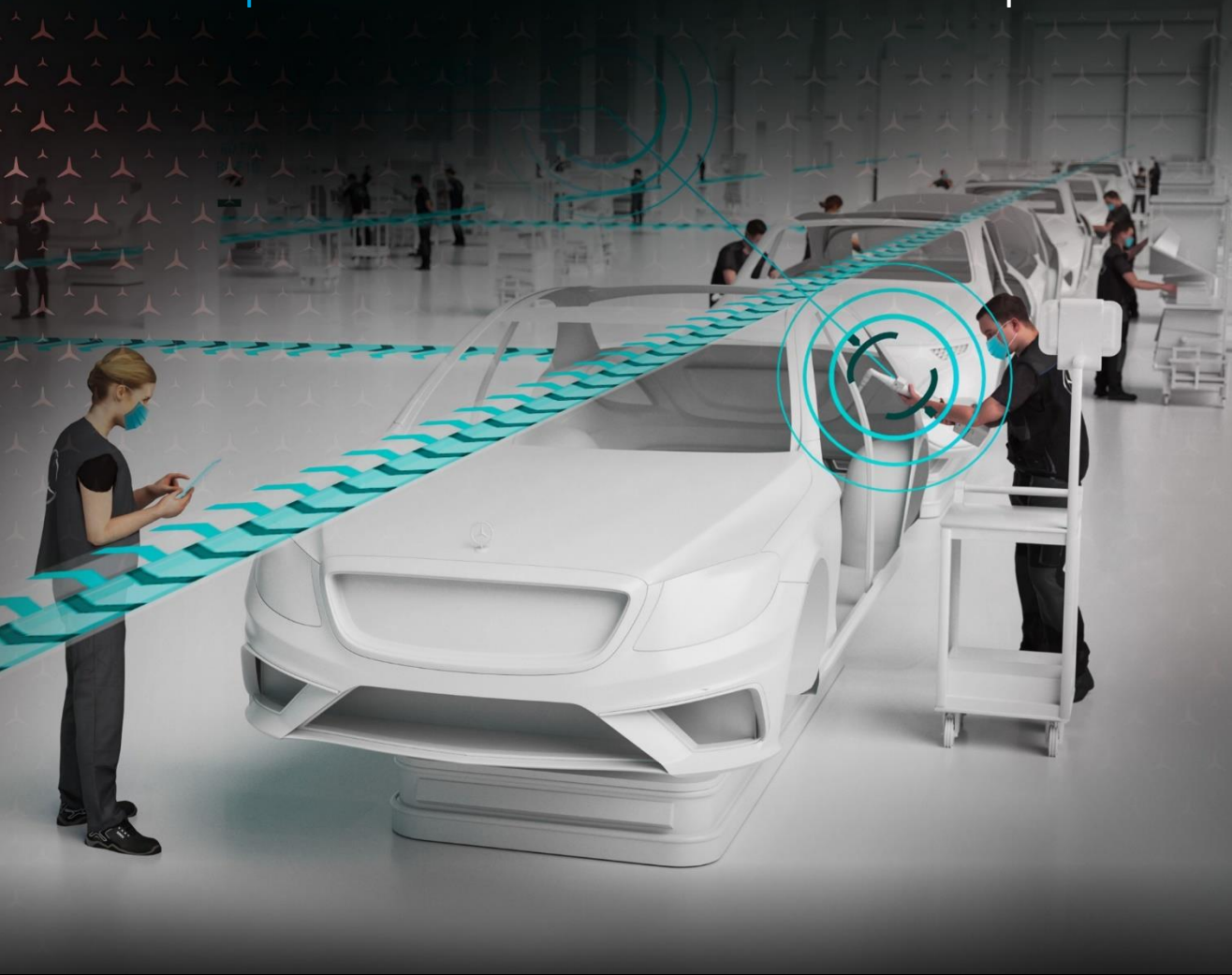
25%

of global passenger sales will
be performed online.



Our latest beacon of Digitization: Factory 56

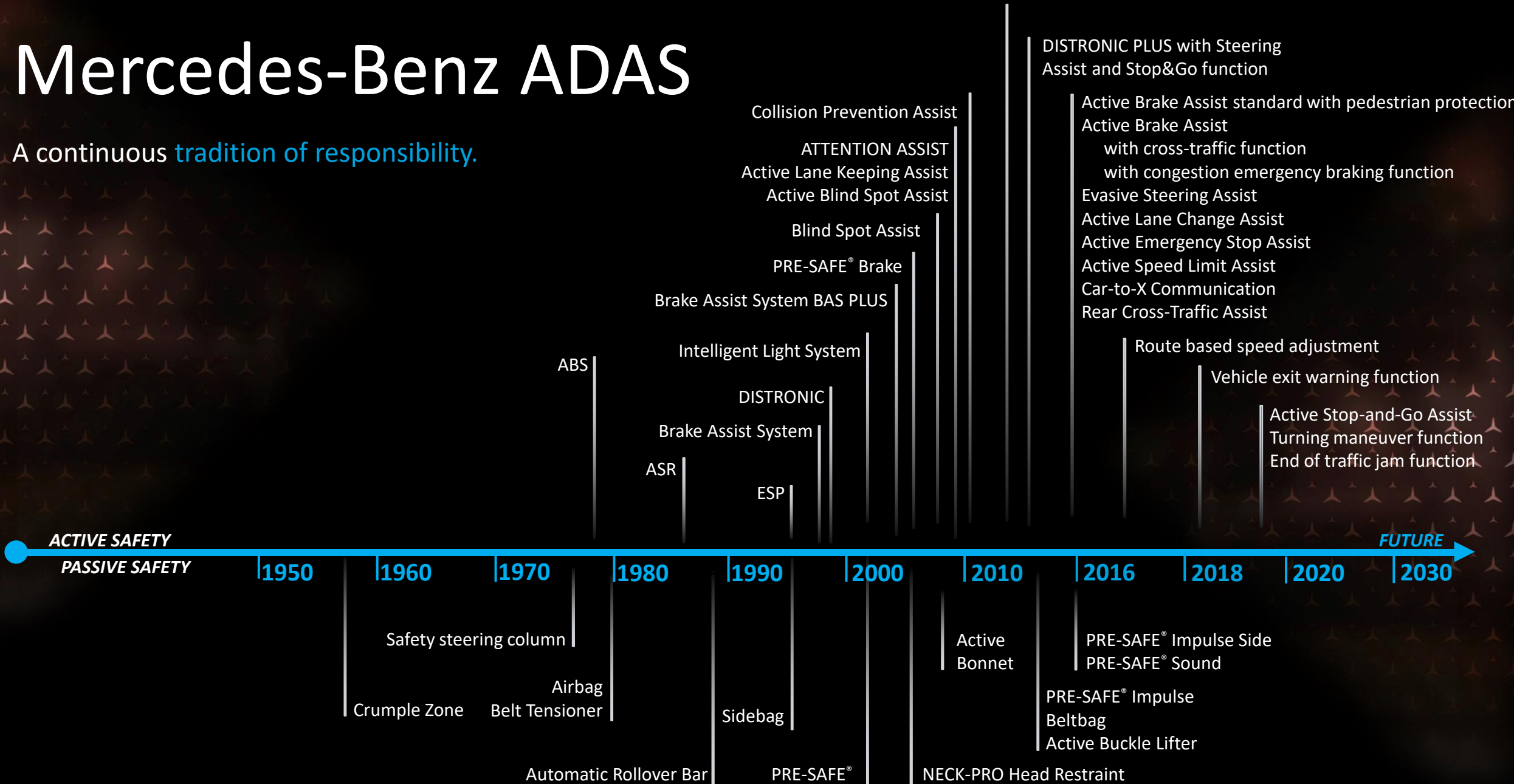
The birthplace of the new S-class embodies our requirements for future production sites.



- „digital, flexible, green“.
- the world's first 5G mobile network for automobile production.
- "TecLines" allows high-efficiency assembly for large-scale production and increases flexibility.
- The assembly hall is completely paperless.
- *Mercedes me app*:
"Digital Anticipation", customers can gain exclusive insights into the production of their vehicles.

Mercedes-Benz ADAS

A continuous tradition of responsibility.



ADAS Validation

V-Model

1.
Challenges of
Simulation at
Automated
Driving


Agenda

4.
What's
next?

NVIDIA

What drives us

Event based system

Framework DriveSim

2.
Simulation

3.
Testing

Real-life Safety

Field Validation

Immendingen

ADAS Validation

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Validation of an automated driving system is challenging

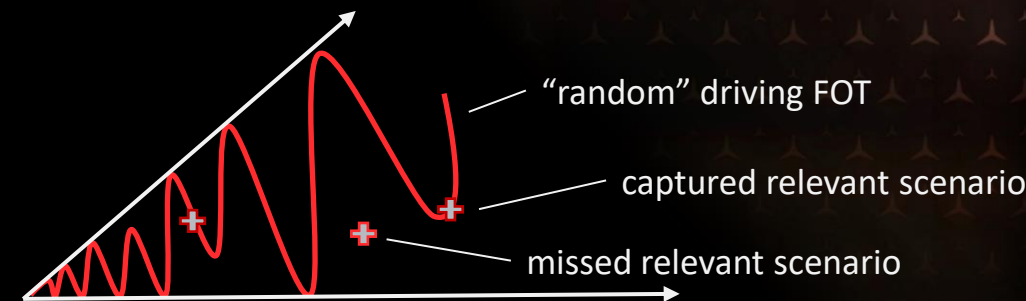
Assessment and validation of *passive safety* based on a practicable number of *crash tests* under well defined worst case conditions is well established and widely accepted.



In contrast *active safety* assessment and validation of L3 is characterized by

- a *huge* number of relevant scenarios and environmental conditions
- high complexity of systems and variability of driver behaviour

To validate a safety performance higher than the average human driver by pure Field Operational Testing FOT (only by means of statistics), a mileage of approx. **10^8 to 10^9 miles¹** is necessary.

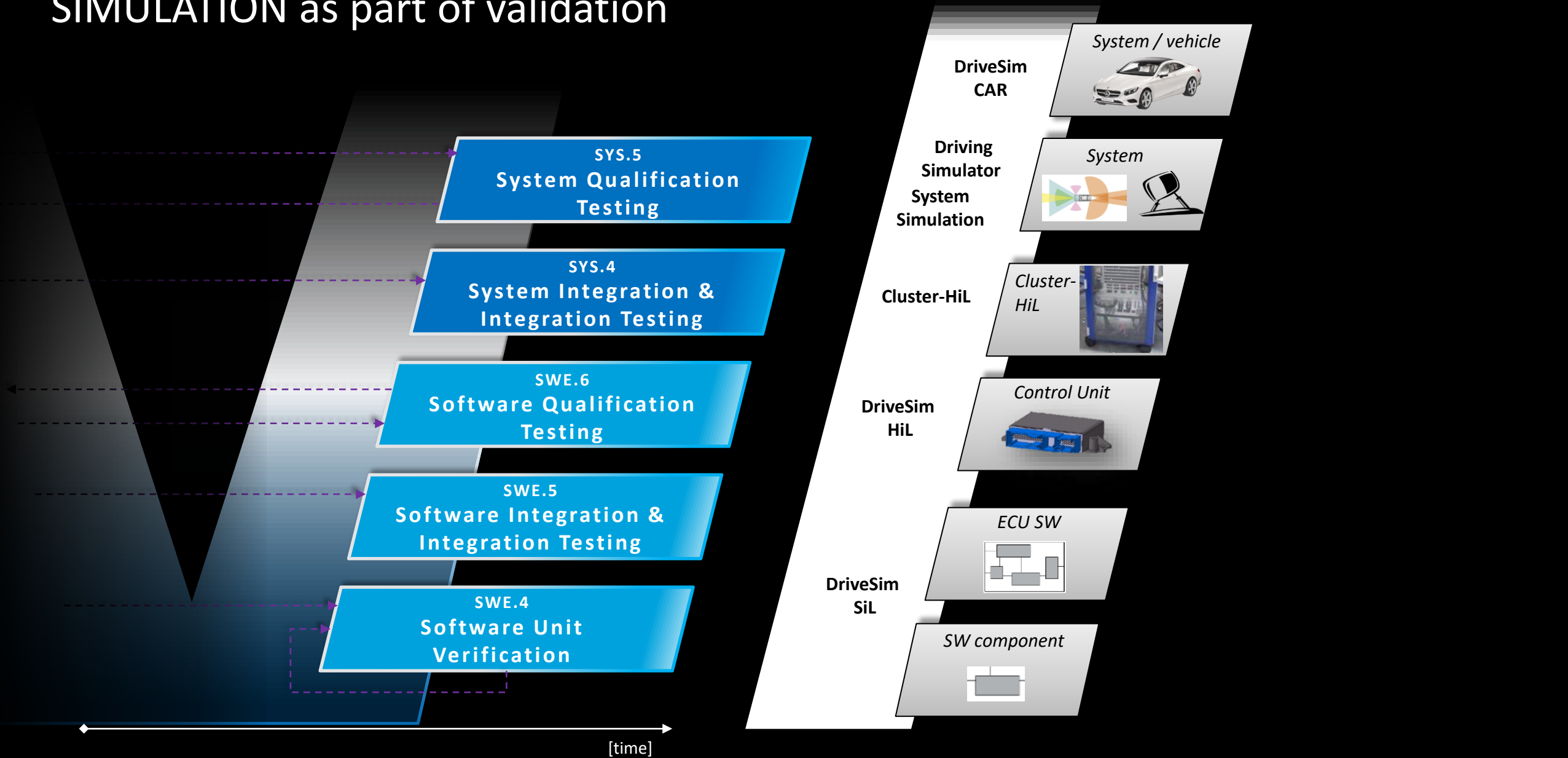


Fundamental problem of L3+ BLACK-BOX validation

... to approve an automated driving system a „clever“ validation and test strategy is necessary to hit the target

- high complexity
- variability of driver behaviour
- a huge number of relevant scenarios and environmental conditions
- repeatability
- time & money reasons: find problems as early as possible
-

SIMULATION as part of validation



V-Modell according to ASPICE, 2015

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Simulation at
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Agenda

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3.
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Real-life Safety

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Immendingen

SYSTEM SIMULATION as a key element to validate and verify the new level of automated driving system

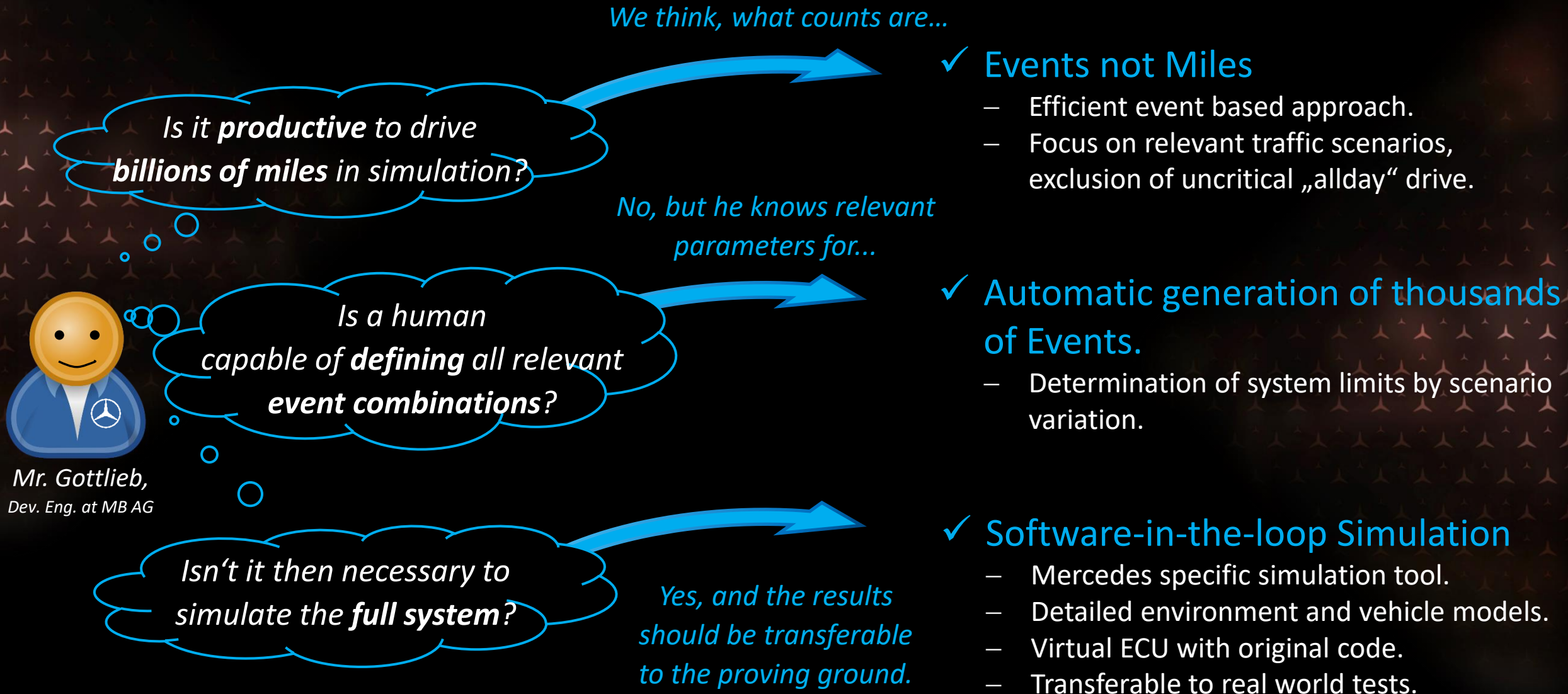
Event based system simulation*

- large number of functions, complexity and scenarios
- save environment
- time frame
- variety of traffic scenarios and their probability of occurrence enables a risk assessment for the respective scenario/use case.

Without this intelligent simulation concept we wouldn't have a chance to approve our next level of automated driving.

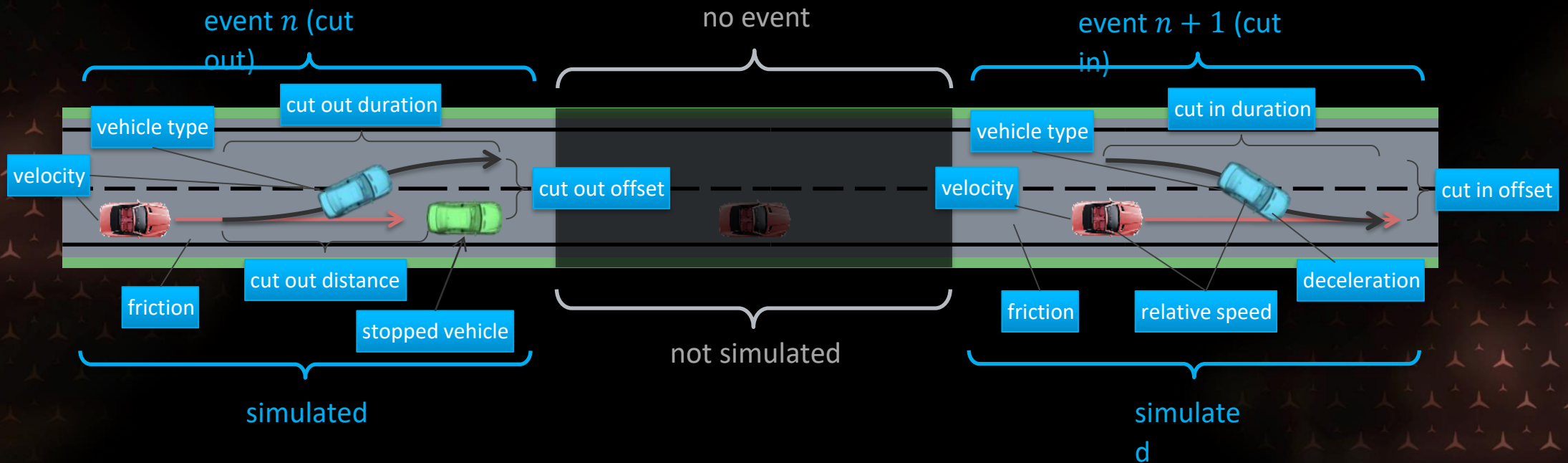
* "M. Rasch, P. T. Ubben, T. Most, V. Bayer, R. Niemeier (2019), *Safety Assessment and Uncertainty Quantification of Automated Driver Assistance Systems using Stochastic Analysis Methods*, NAFEMS World Congress 2019, Canada"

Simulation Approach for AD Level 3 @ Mercedes



Mr. Gottlieb,
Dev. Eng. at MB AG

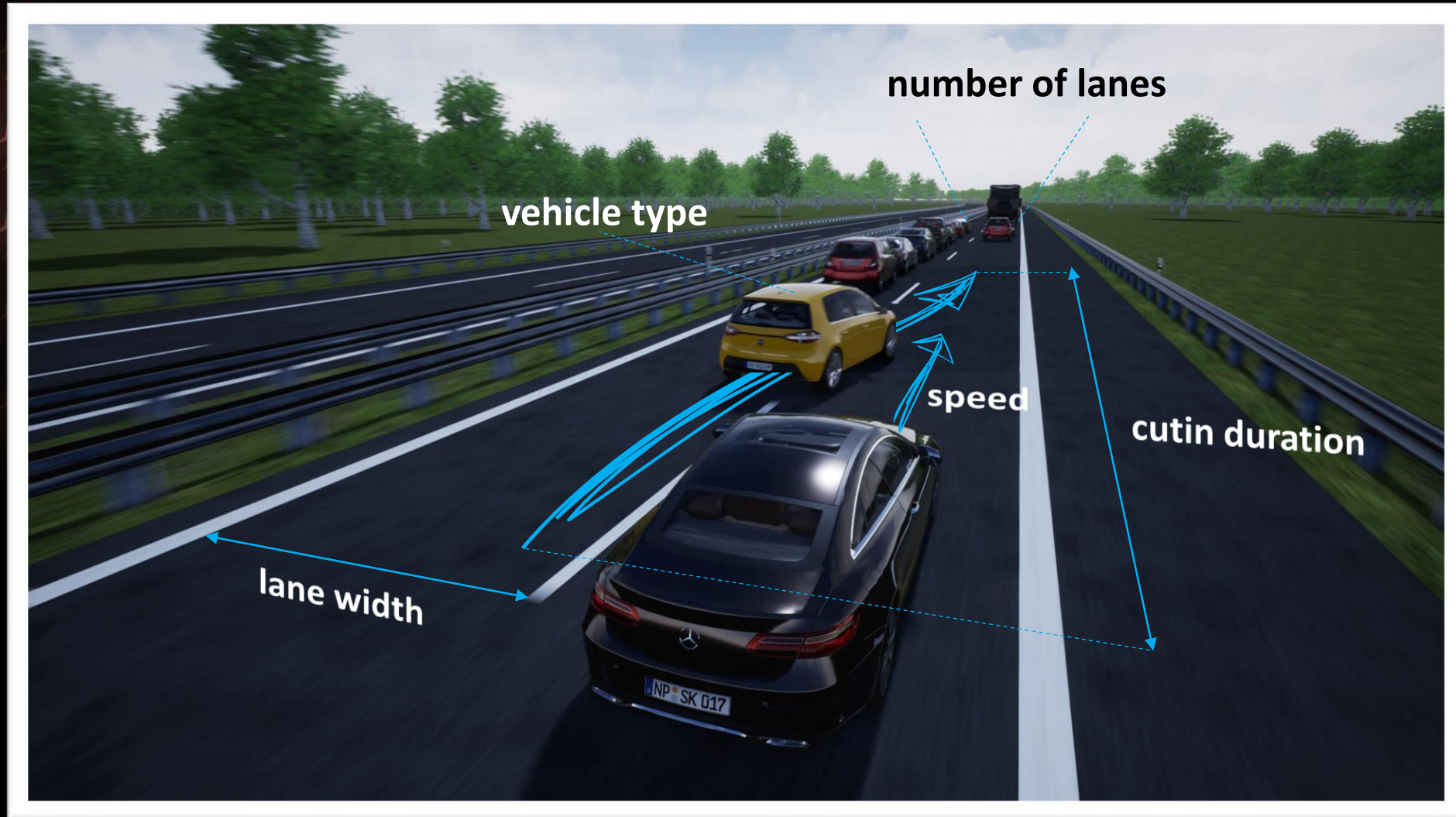
Event based Approach* - Scenario Parameterization



- Focus on the relevant scenarios
- Simulate and vary logical scenarios like the overall group of cutout scenarios
- Each simulated event is a concrete scenario, e.g., a cutout scenario at specific speed, vehicle type, road conditions etc.

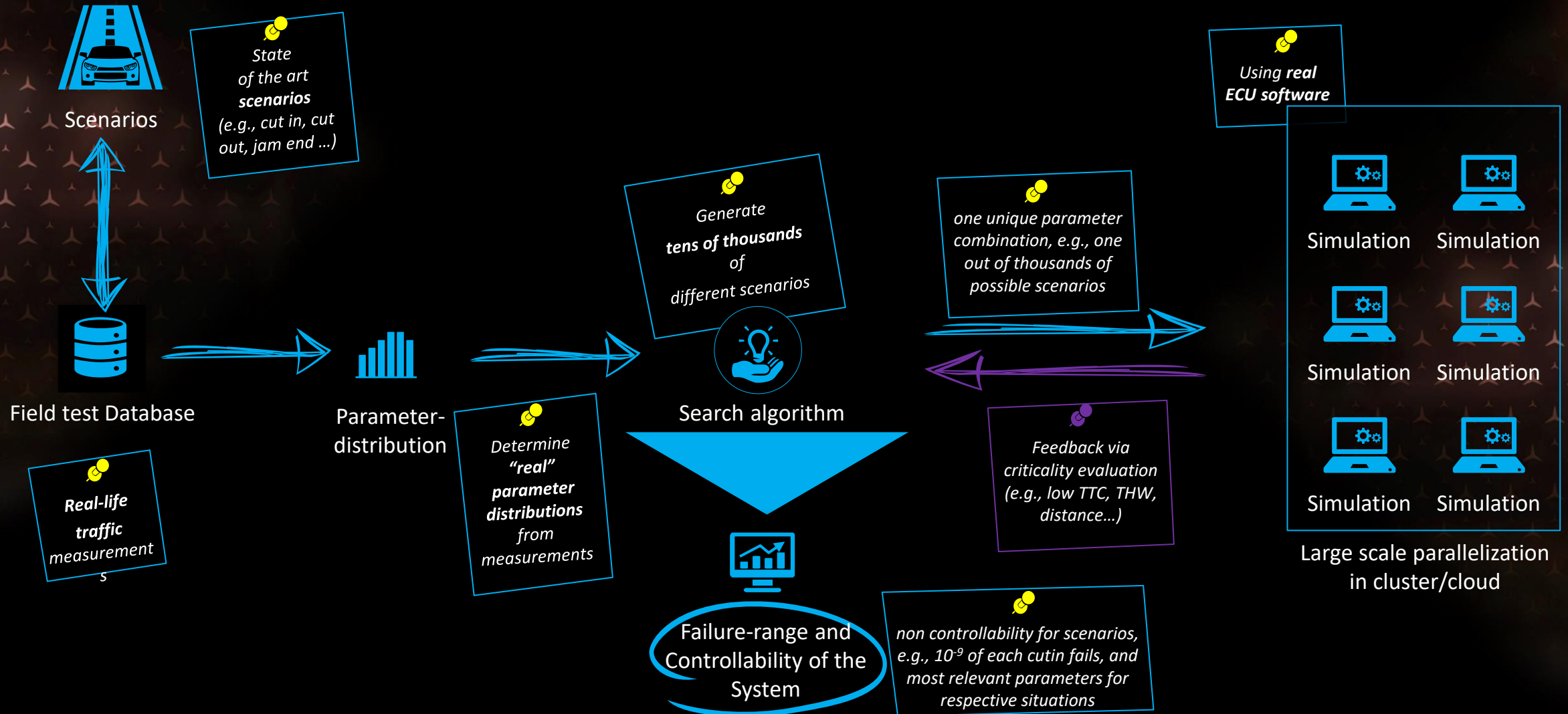
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Examples for Scenario Parameters



Workflow Reliability Analysis –

Goal: Find most probable critical scenarios



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V-Model

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Automated
Driving

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Agenda

4.
What's
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What drives us

Event based system

Framework DriveSim

2.
Simulation

3.
Testing

Real-life Safety

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Immendingen

Simulation Framework: DriveSim – consistency is crucial

THIRTEEN years ago, the need for a closed-loop simulation framework arose:


DriveSim@Mercedes

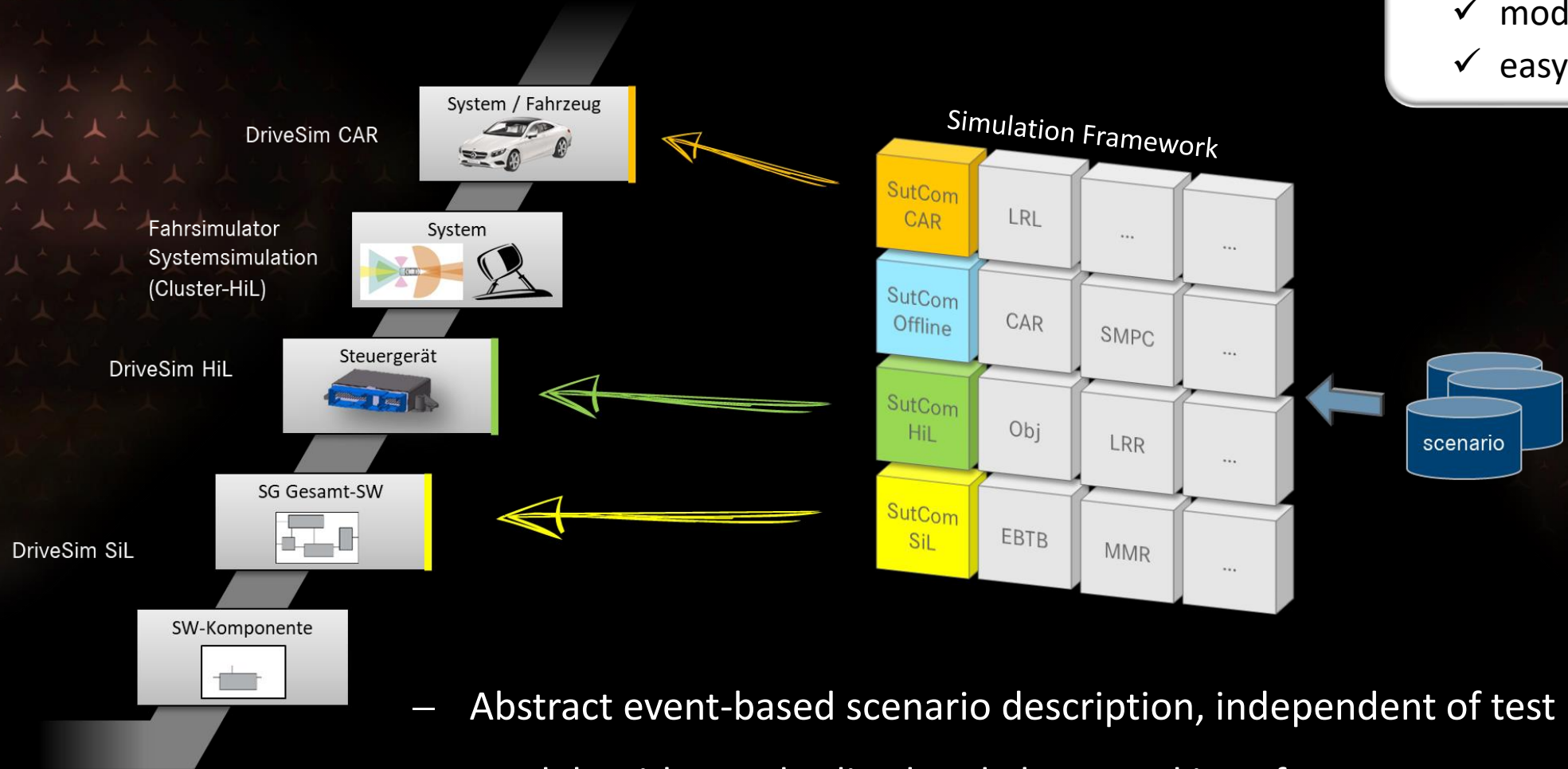
- modular, easy handling
- flexibility to connect external SW-models (e.g. of suppliers)
- a tool for a quick review of code changes
- over 75 HiLs

AND we developed a **programming language** to create test cases and scenarios.

Portability - Tests created in SiL can also be run on HiL.

DriveSim: Consistency and Reusability

- ✓ flexible
 - ✓ modular
 - ✓ easy
- 



- Abstract event-based scenario description, independent of test platform and signals
- Models with standardized and abstracted interface

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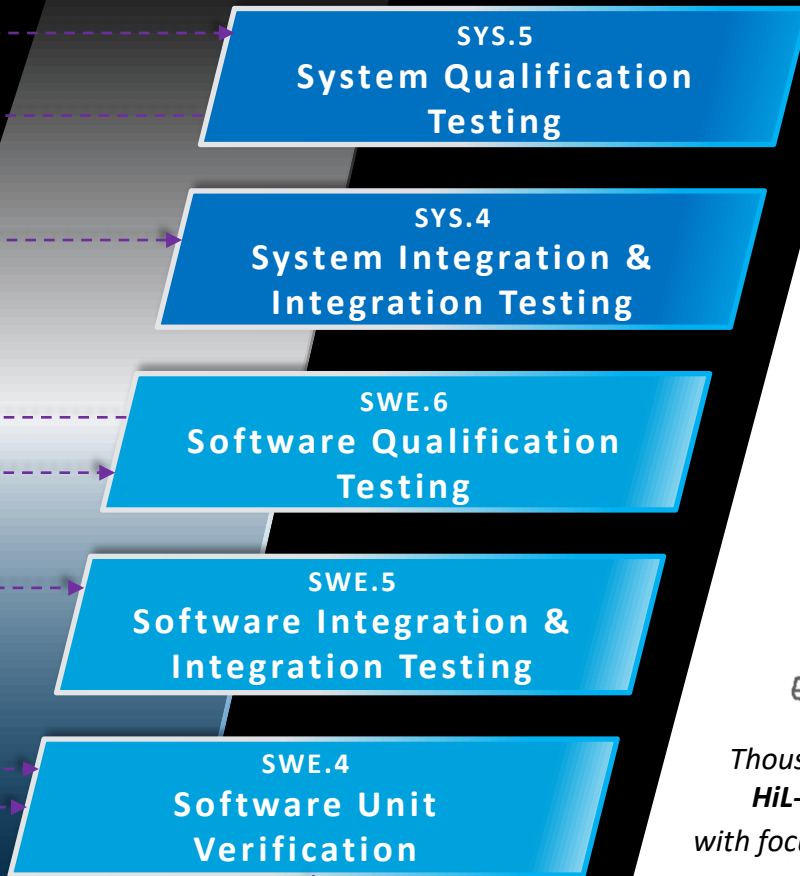
3.
Testing

Real-life Safety

Field Validation

Immendingen

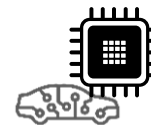
TESTING as part of validation



Functional Testing



Thousands of *on-road* Testing kilometres with focus on ADAS worldwide.
(EU, USA, CN, KOR)



Thousands of *HiL-Tests* with focus on E/E.

Integration & Stability



Daily Night Runs – global testing network enables 24hrs testing a day.



Communication and startup tests,
...

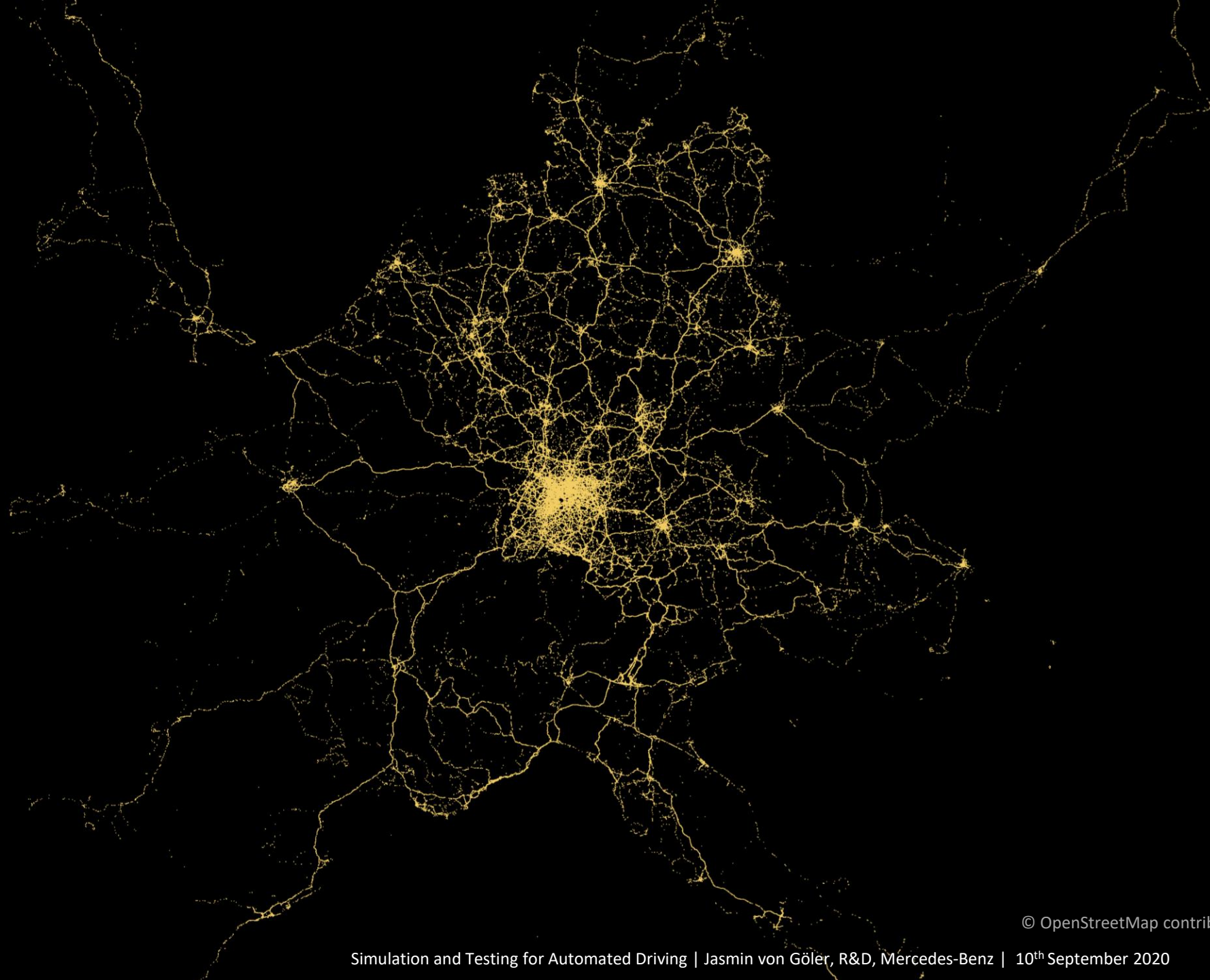
Field Validation



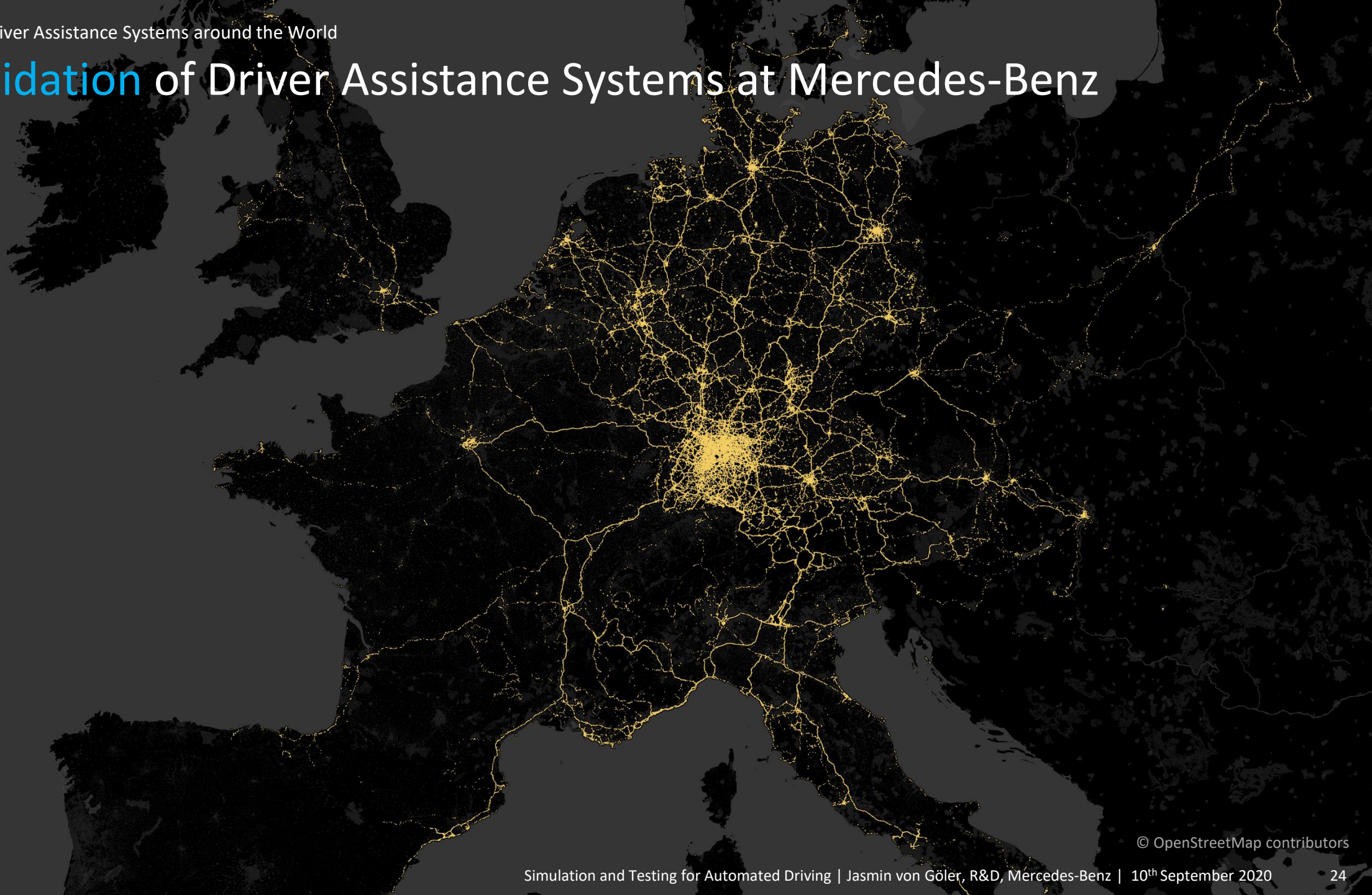
ADAS-Fleet Endurance runs with focus on market demands



Ensurance of *intended functionality* within **all variants**.



Field Validation of Driver Assistance Systems at Mercedes-Benz



Field Validation of Driver Assistance Systems at Mercedes-Benz

Validation of **205** Releases in **43** Projects

> **11.500.000** km driven in Europe, USA, China

> **195** Test Vehicles

> **6200** Test Drives in **9** Years

> **1.600.000** Measurements

> **500.000** Events, **270.000** analyzed in Detail

Real life safety - proving grounds, test facilities & field validation



Real life scenarios:



are tested with Global Soft
Crash Targets.



Testing and Technology Centre Immendingen

Worldwide vehicle testing consolidated in one place



30 different test routes and tracks
on an area of 520 hectares.

Asphalt and rough tracks for offroad testing



68 kilometers total length of test routes.

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Framework DriveSim

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Simulation

3.
Testing

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Mercedes-Benz and NVIDIA develop the next upgradable generation of automated driving and safety functions



Mercedes-Benz and NVIDIA develop the next upgradable generation of automated driving and safety functions

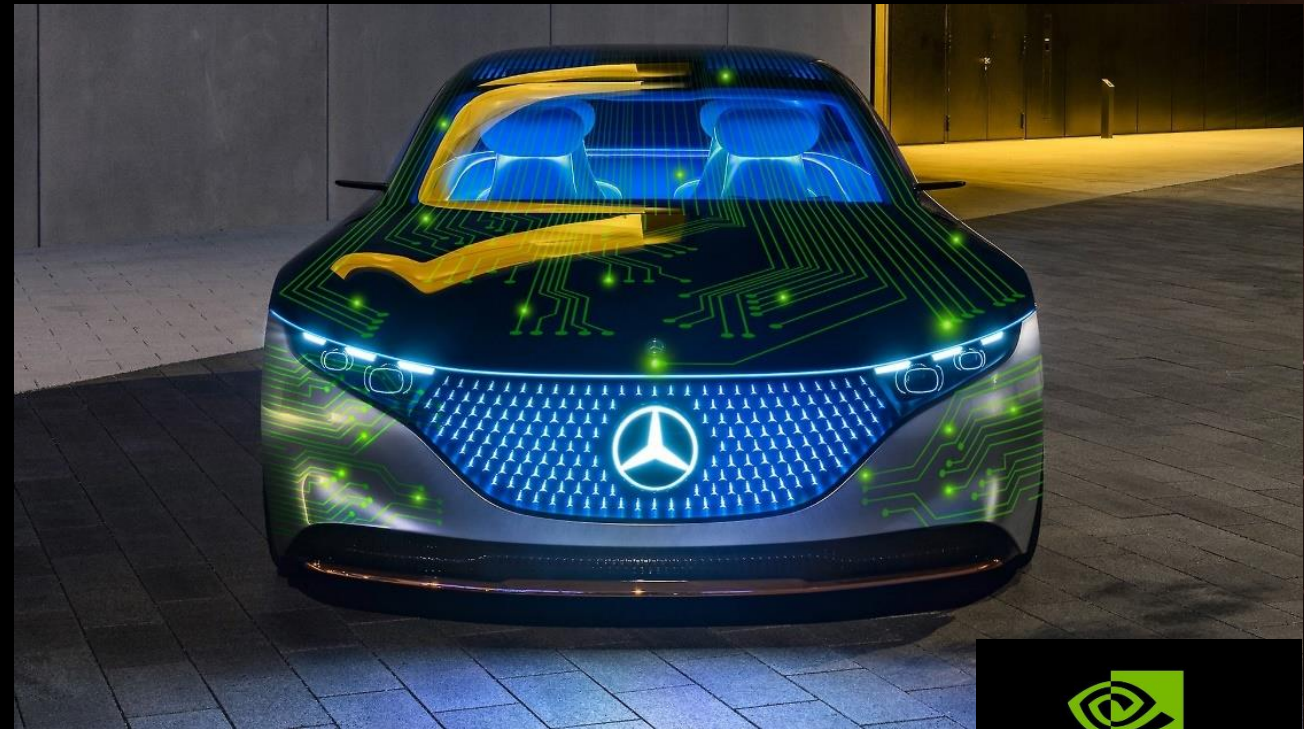
- automated driving along regular routes from one address to a specific destination with the corresponding legal framework in place (Level 2 and 3)
- automated parking functions (up to Level 4)
- based on artificial intelligence
- over-the-air upgrades
- subscription services throughout the life cycle

NVIDIA DRIVE™ is a continually expandable computing platform - the “brain” of autonomous vehicles

Virtual reality autonomous vehicle validation platform

TEST AND VALIDATE BILLIONS OF MILES IN THE DATACENTER

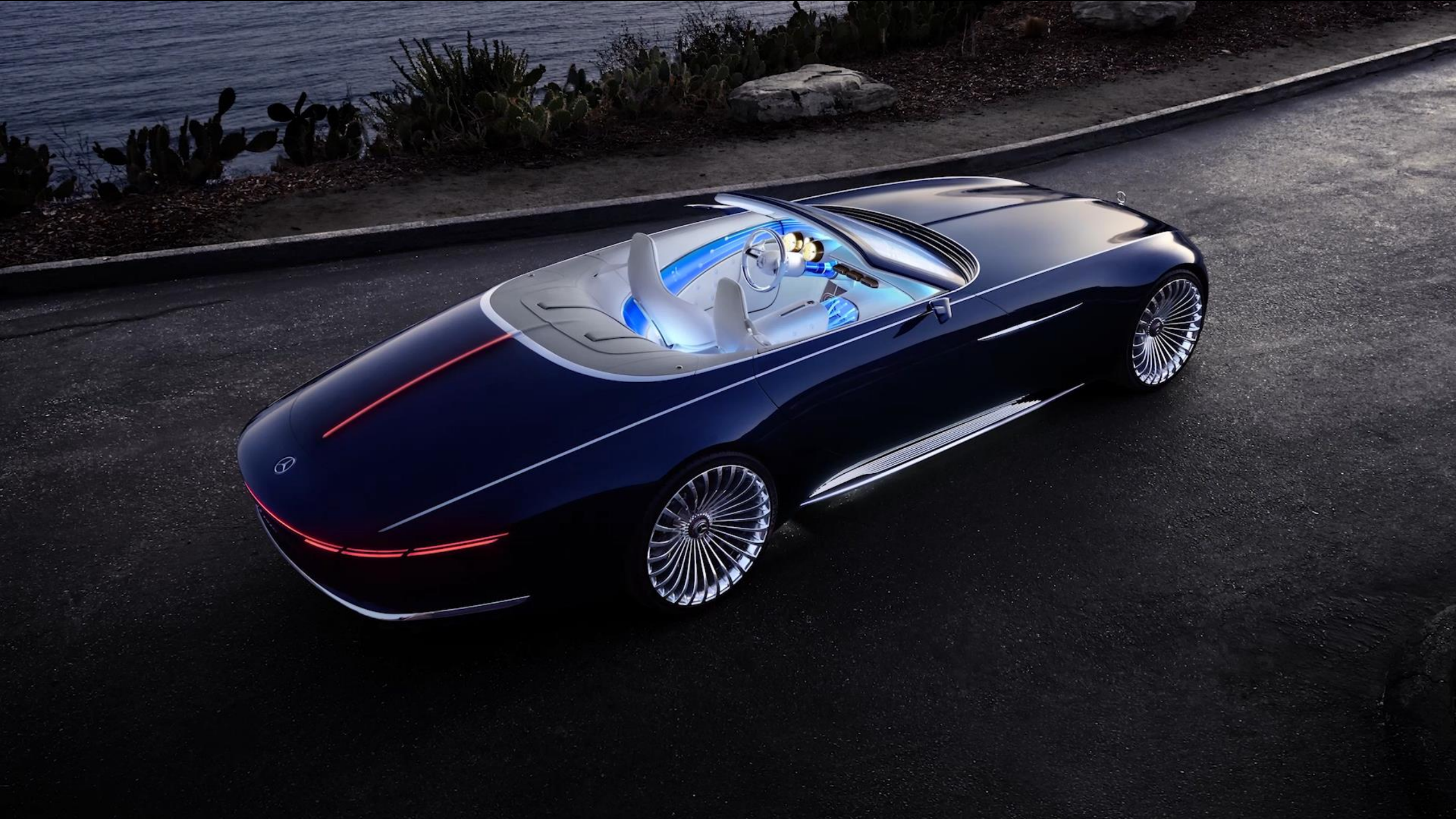
- Software in the Loop tests running as continuous integration and continuous development pipelines in data center to check thousands of scenarios.
- Hardware in the loop tests are also possible with “Drive Constellation” in data center
- Scenario creation with OpenSCENARIO and OpenDRIVE ASAM Standards



You want to know, what drives us ?

It's passion for the product...





Thank you very much for your attention !

What are the **key take-aways** from my presentation ?

Transformation Process

*Sustainable modern luxury
CASE: connected, autonomous, share, electric
Digital Transformation*

Challenges for AD Simulation

*focus on relevant scenarios
consistency is crucial.*

Glimpse at the future

*We will continue our path to accident-free driving
jointly with the best partners – for the best
solutions at the market.*

