Data Driven Development for Autonomous Vehicles

Tomáš Fridrich; fridrich@humusoft.cz

www.humusoft.cz, www.dspace.com, www.understand.ai

dSPACE

Autonomous Driving – typical approach

Data driven development

Record real world data

Data base with real world data

Real world and simulation must be brought together

Train/validate DNNs

Data base with simulation scenarios

AD software

Perception & Fusion

Preprocess

Fuse

Detect/track

Localize

Driving Function

Understand

Plan

Predict

Control

Cloud

SIL

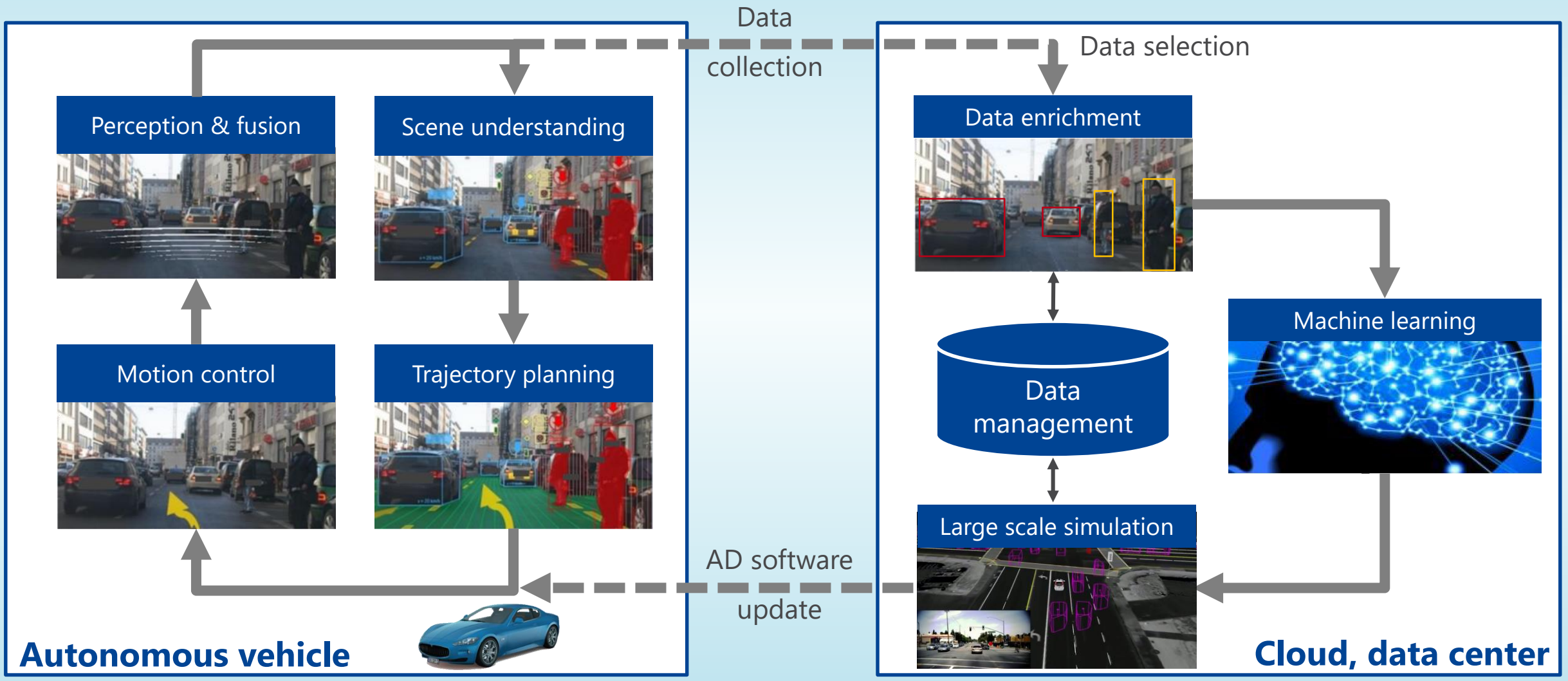
HIL

Update AD software

Perform large scale simulations

dSPACE

Data driven development



dSPACE

Data driven development

Data collection

Perception & fusion

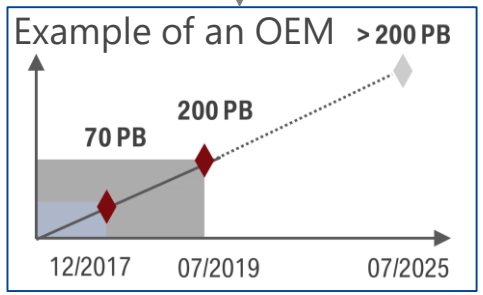
Scene understanding

Motion control

Trajectory planning

Autonomous vehicle

AD software update



Scale, quality and diversity of data is the new IP!

Cloud, Data center

dSPACE

Managing so much data is extremely expensive

- Real driving tests are costly (equipment, people, time …)

AUTONOMOUS VEHICLE SENSORS		
Sensor type	**Quantity**	**Data generated per sensor**
Radar	4-6	0.1-15 Mbit/s
LIDAR	1-5	20-100 Mbit/s
Camera	6-12	500-3500 Mbit/s
Ultrasonic	5-16	<0.01 Mbit/s
Vehicle motion, GNSS, IMU	-	<0.1 Mbit/s

Total bandwith can reach up to **40 Gbit/s (~19TB/h)**

Source: Stephan Heinrich, Flash Memory Summer 2017 Santa Clara, CA

- 100 000 km / 40 km/h avg speed / 19 TB/h = **~ 50 PB**

- According Nvidia volume of data required to teach AI differ between **200 – 600 PB**
  Source: https://developer.nvidia.com/blog/training-self-driving-vehicles-challenge-scale/

dSPACE

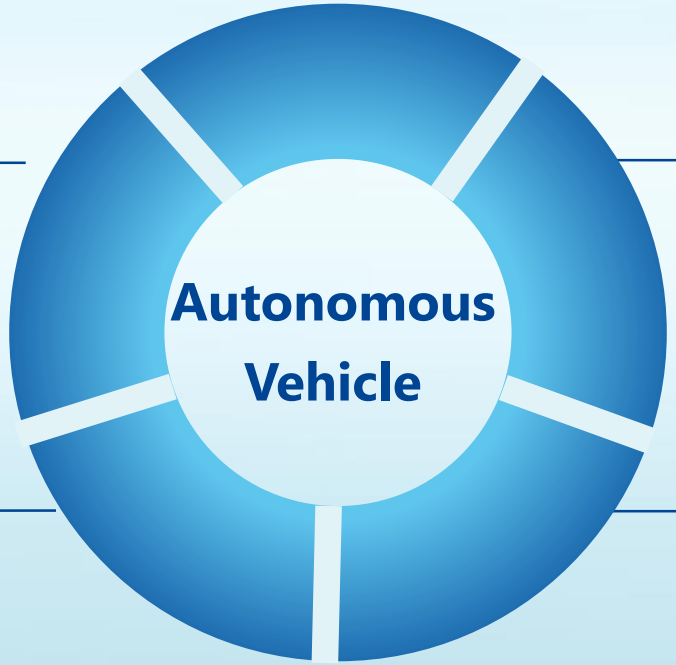
Challenges with autonomous driving

Environment sensors

- New technologies
- 360° view, all weather conditions

Data processing

- High performance computing
- Data management



Vehicle networks

- Increasing bandwidth
- Service-oriented communication

Artificial Intelligence (AI)

- Deep Neural Networks (DNNs)
- Data driven development

Validation and homologation

- From real world to simulation
- New testing methodologies and operational safety

ISO 26262 Road Vehicles - Fuctional Safety

SOTIF

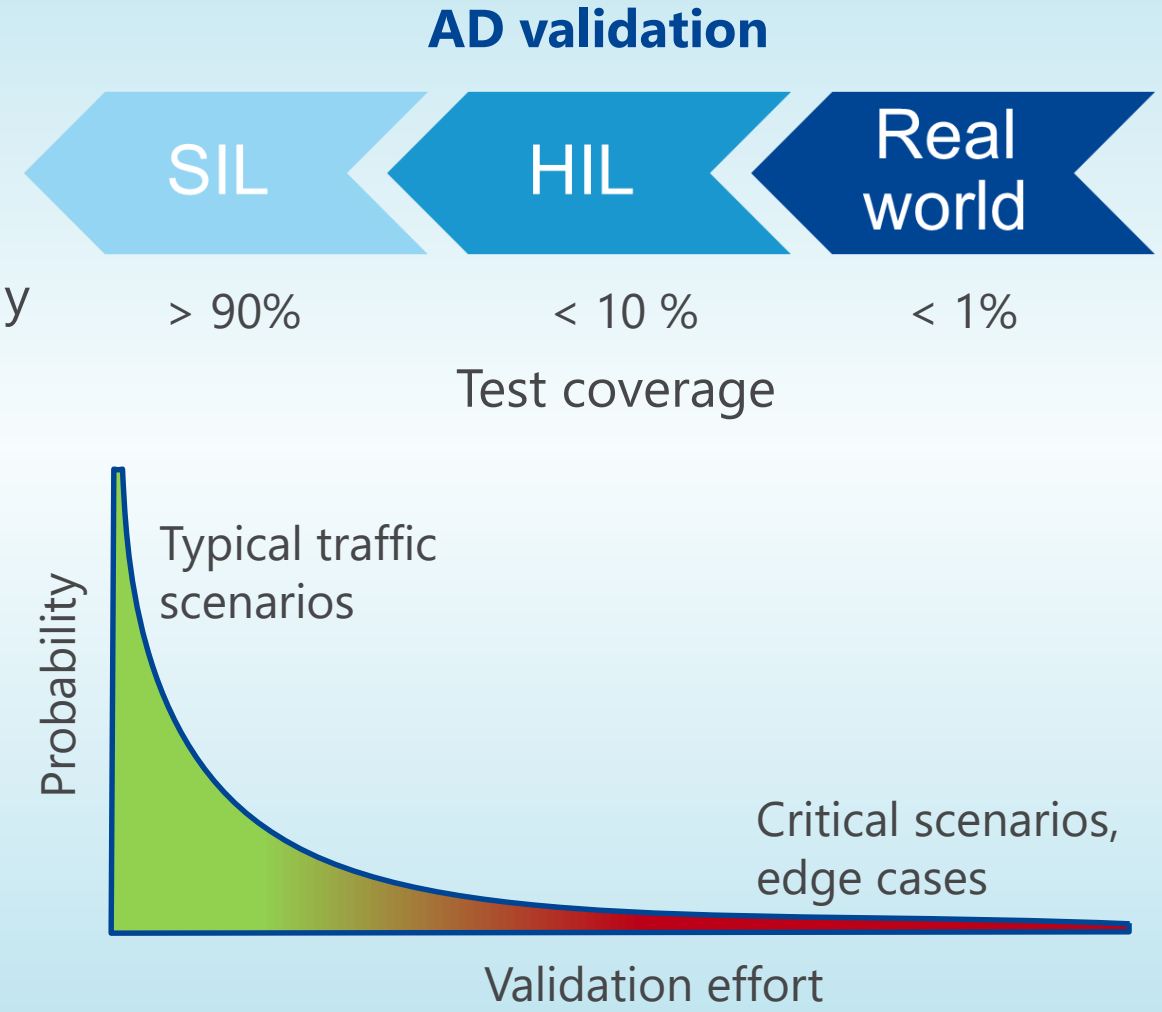
UNECE

NHTSA NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

dSPACE

Autonomous Validation – The problem …

- Realism of complexity in simulation
- Creating thousands of simulation scenarios efficiently
- Critical traffic scenarios and edge cases
- Key: Effective Scenario-based Testing



dSPACE

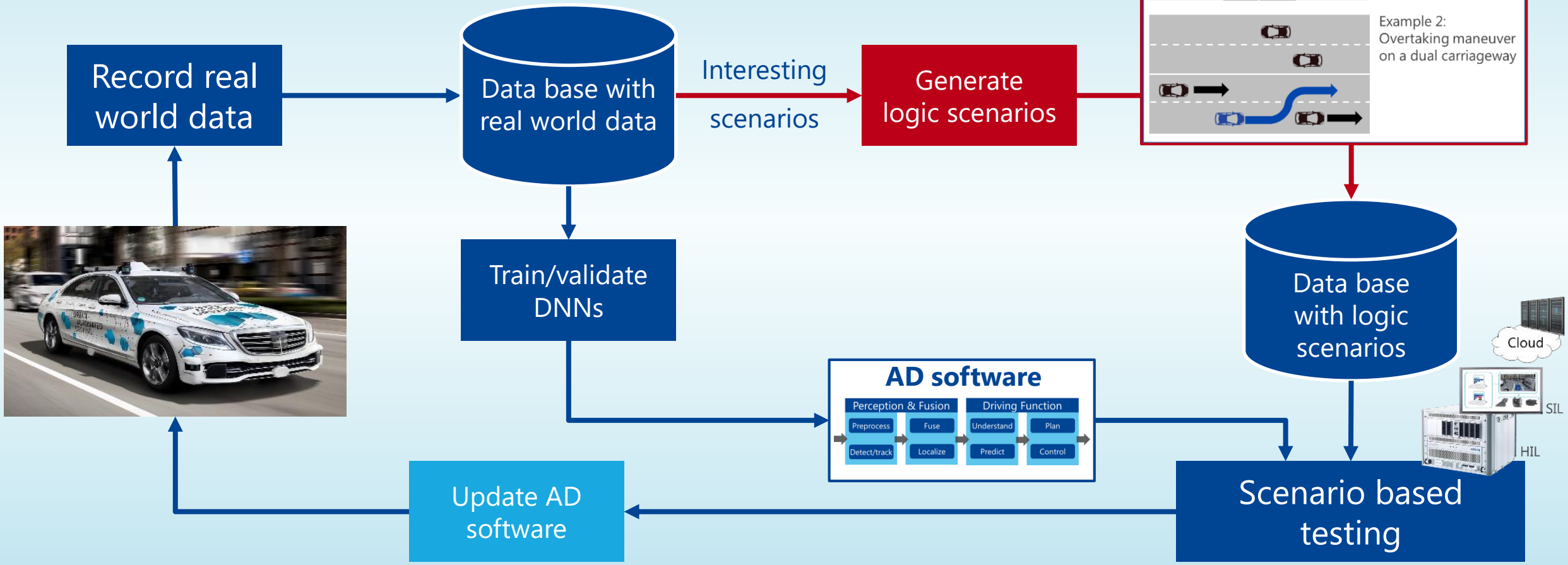
Autonomous Driving – The solution …

Bringing the complexity of the real-world into AV simulation

SPACE

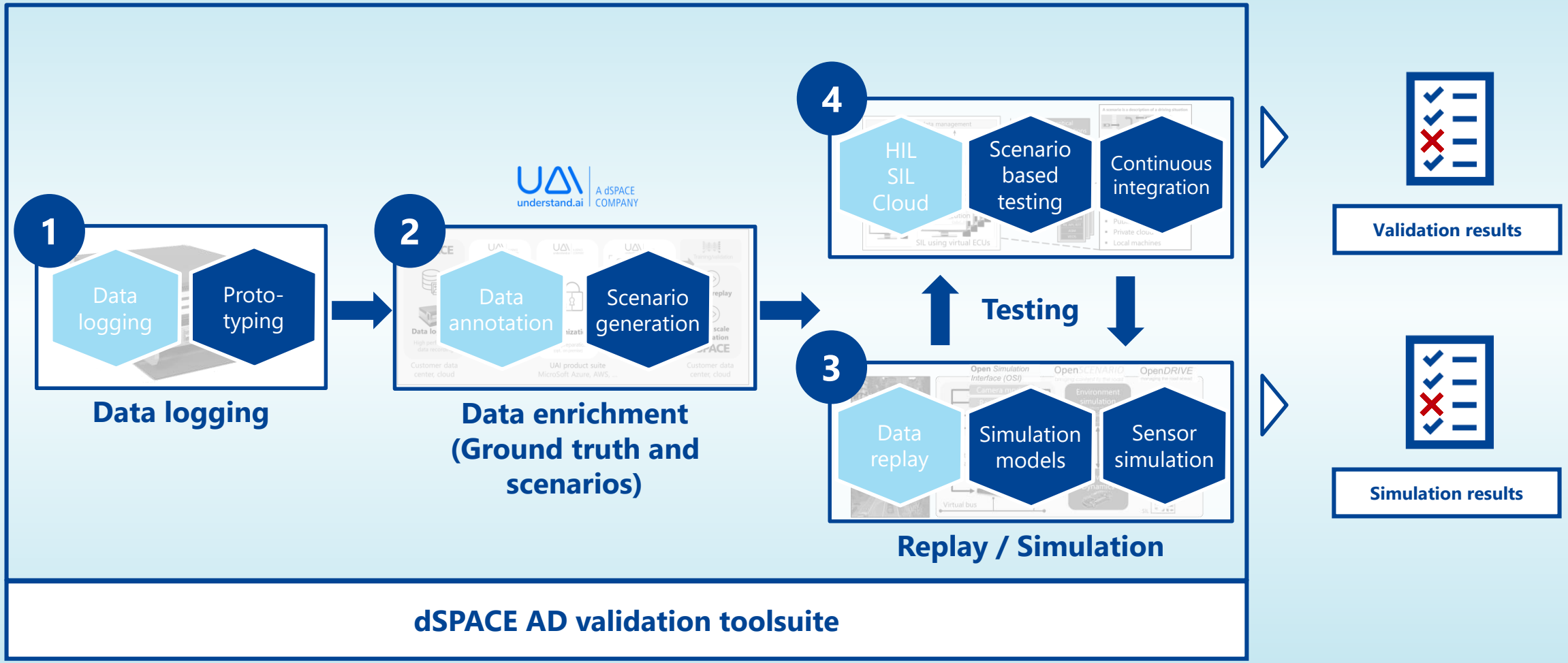
Autonomous Driving – The solution …

Generate simulation scenarios from real world data



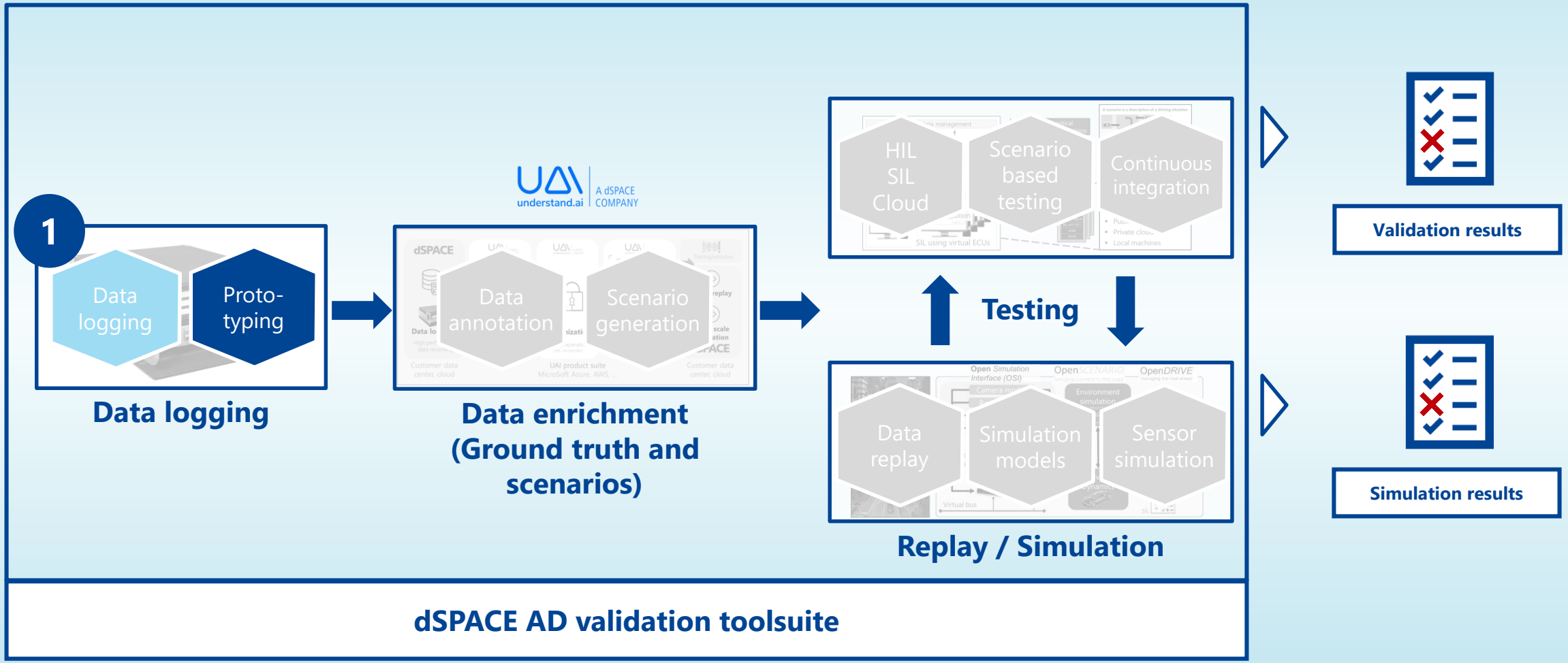
dSPACE

Integrated AD validation toolsuite for data-driven development



dSPACE

Integrated AD validation toolsuite for data-driven development



dSPACE

Data logging - AUTERA

Flexible Configuration with 6 General Purpose Slots

For BUS-/Network-Card, GPU and Data Logging Extension

>50 Gbit/s bandwith

Up to 32TB data Storage (64 TB planned)

High END GPU/FPGA support

Unique performance of data logging and data replay in terms of **bandwidth** and **synchronization**

Easy-to-scale if you need more bandwidth or sensor interfaces

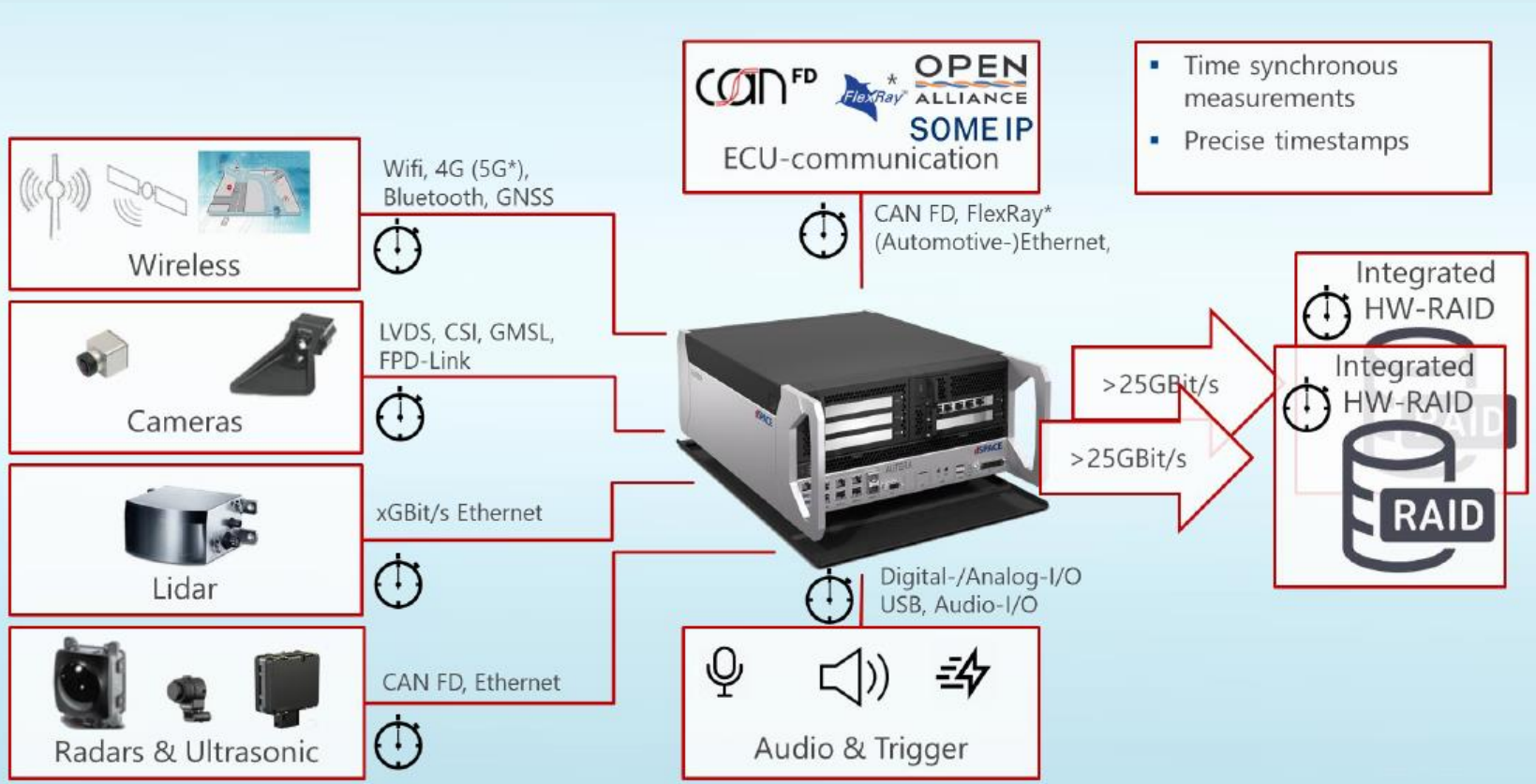
Maximum flexibility to adapt to different sensor interfaces, buses and Networks

Easy-to-use and **fast** data upload with AUTERA upload station

Prepared for **online data selection** with **AI algorithms** and **GPU power** to log “only the interesting scenarios”

dSPACE

Data logging - AUTERA



Open Linux base System
50 Gbps+ sustained data throughput

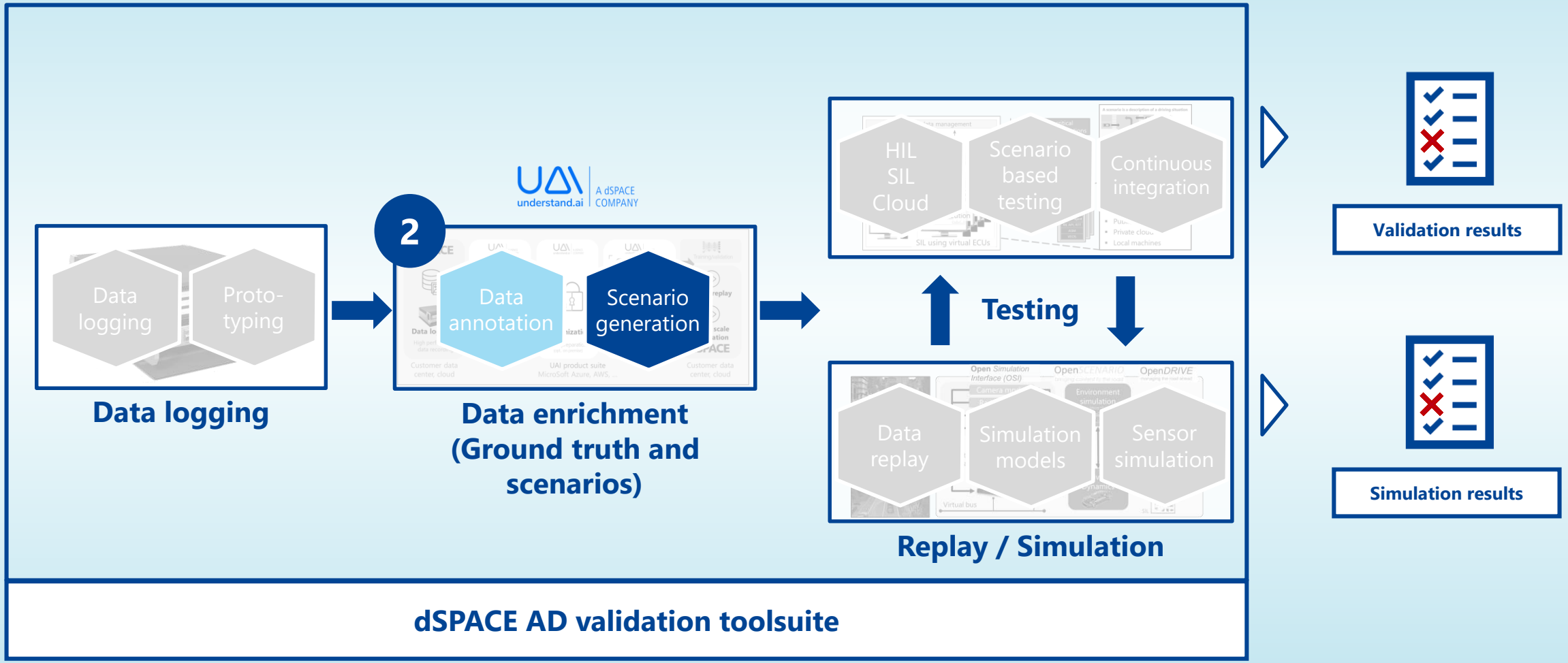
Fast adaptation to new sensor types and Other communication interfaces

Precise time synchronization and time Stamping between all bus, network and Sensor interfaces

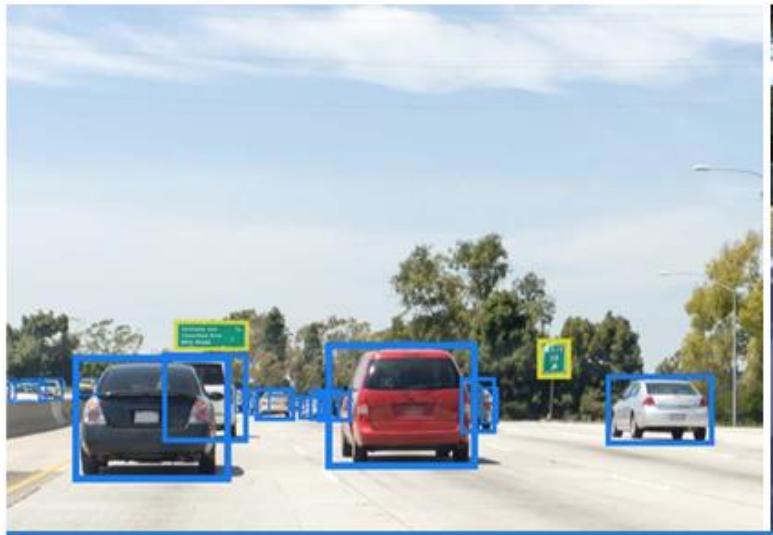
Import of communication description For buses to reduce **amount of logged Bus data**

dSPACE

Integrated AD validation toolsuite for data-driven development

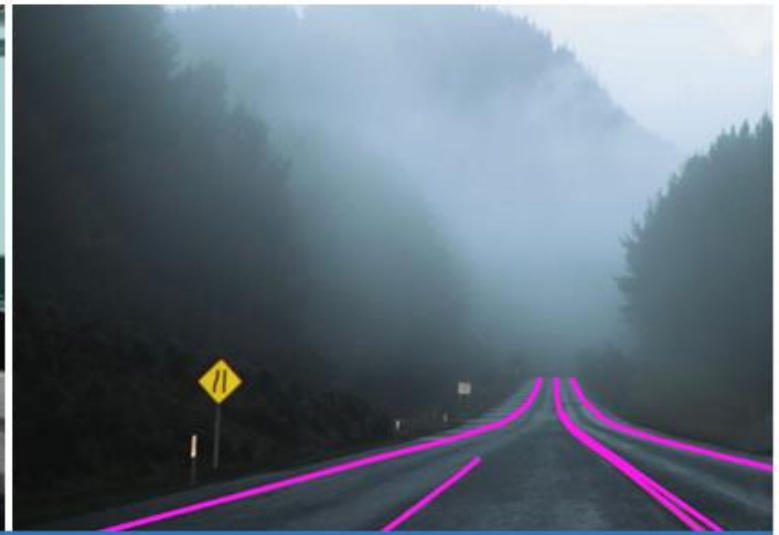


dSPACE



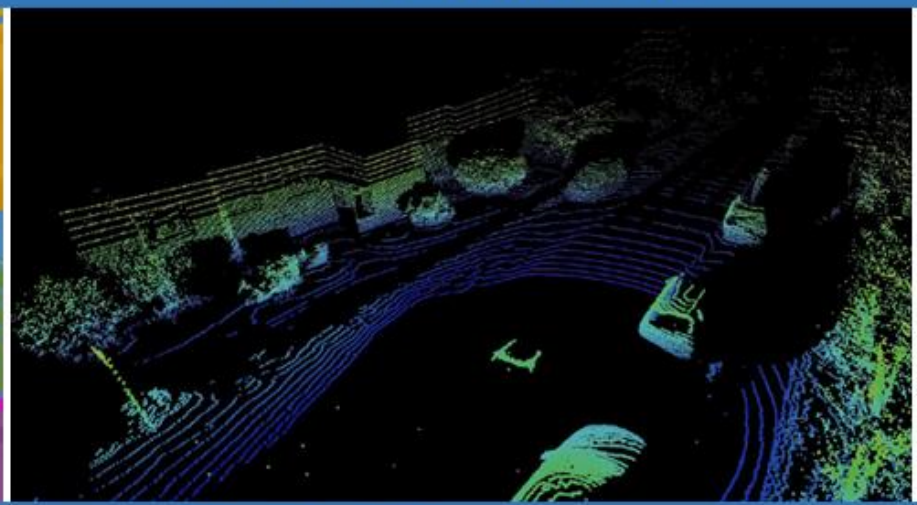
2-D Bounding Box Annotation

3-D Cuboid Annotation

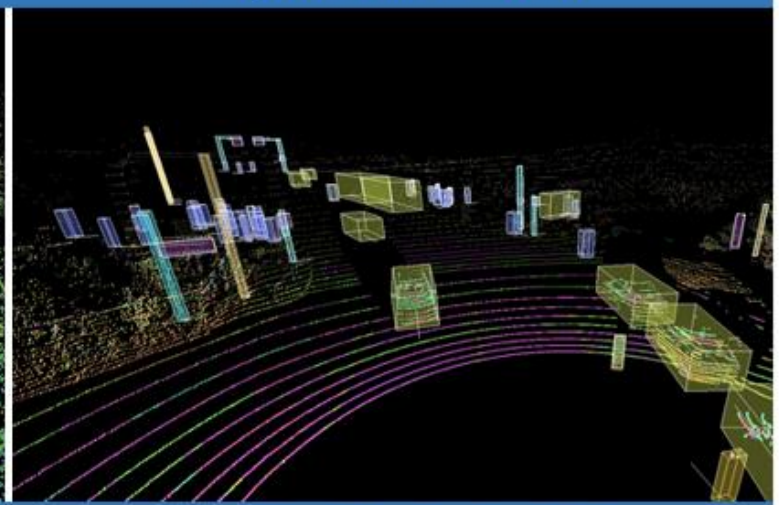


Polyline Annotation

Semantic Segmentation



3-D Lidar/Radar Segmentation

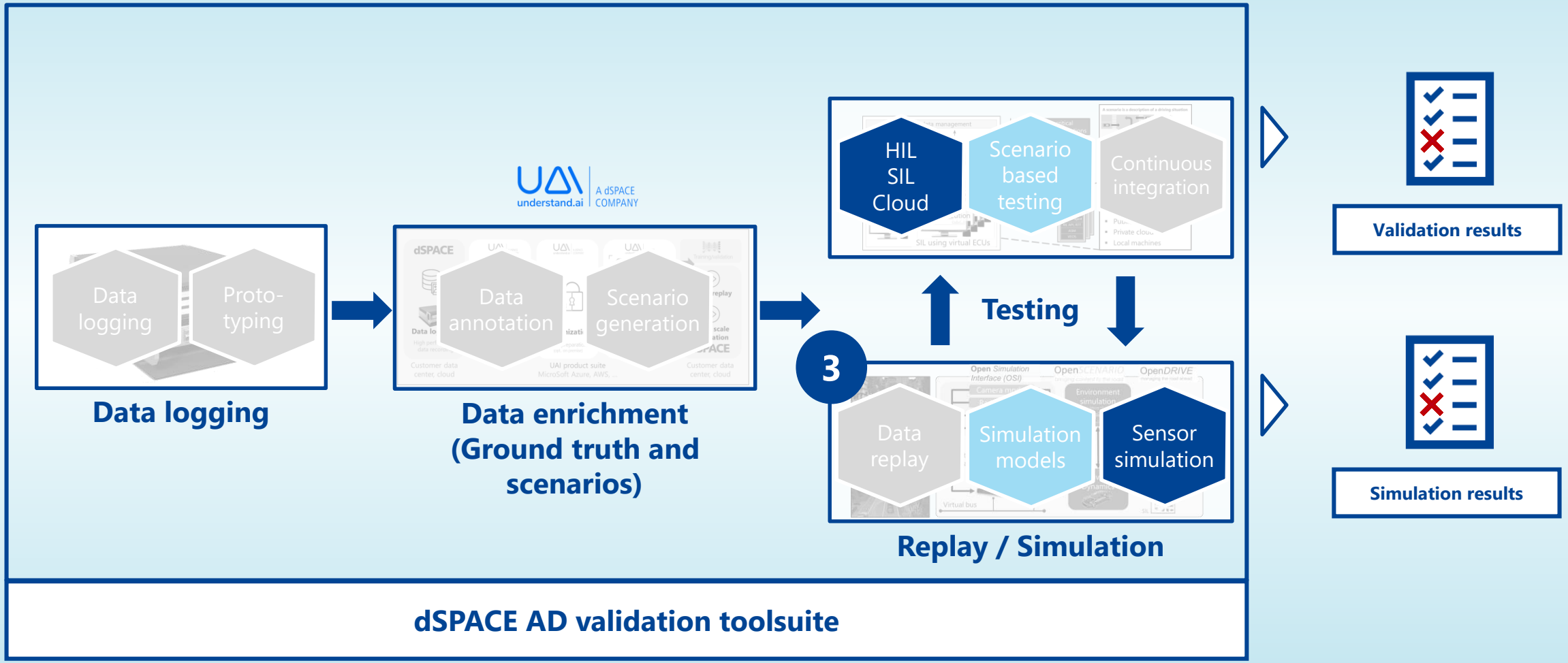


3-D Lidar/Radar Cuboids

Some Examples

dSPACE

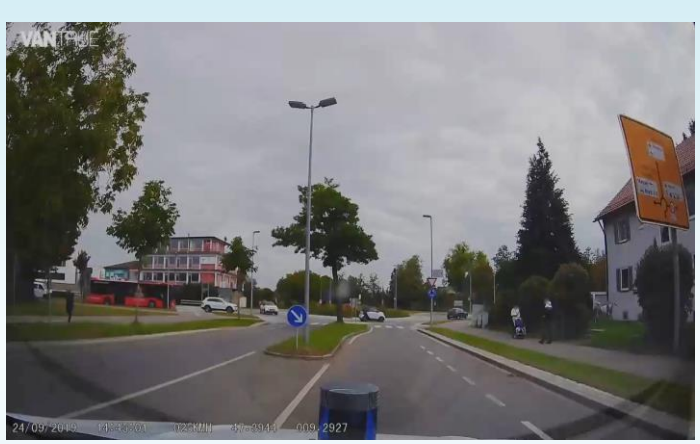
Integrated AD validation toolsuite for data-driven development

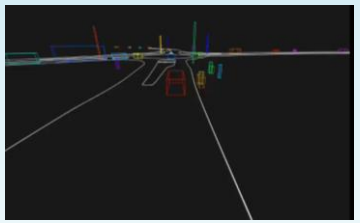


dSPACE

Scenario Generation service by dSPACE and understand.ai

Generating scenarios from real world measurements





Measurement data

Scenario Generation

Simulation

Service generating scenario for validating ADAS/AD

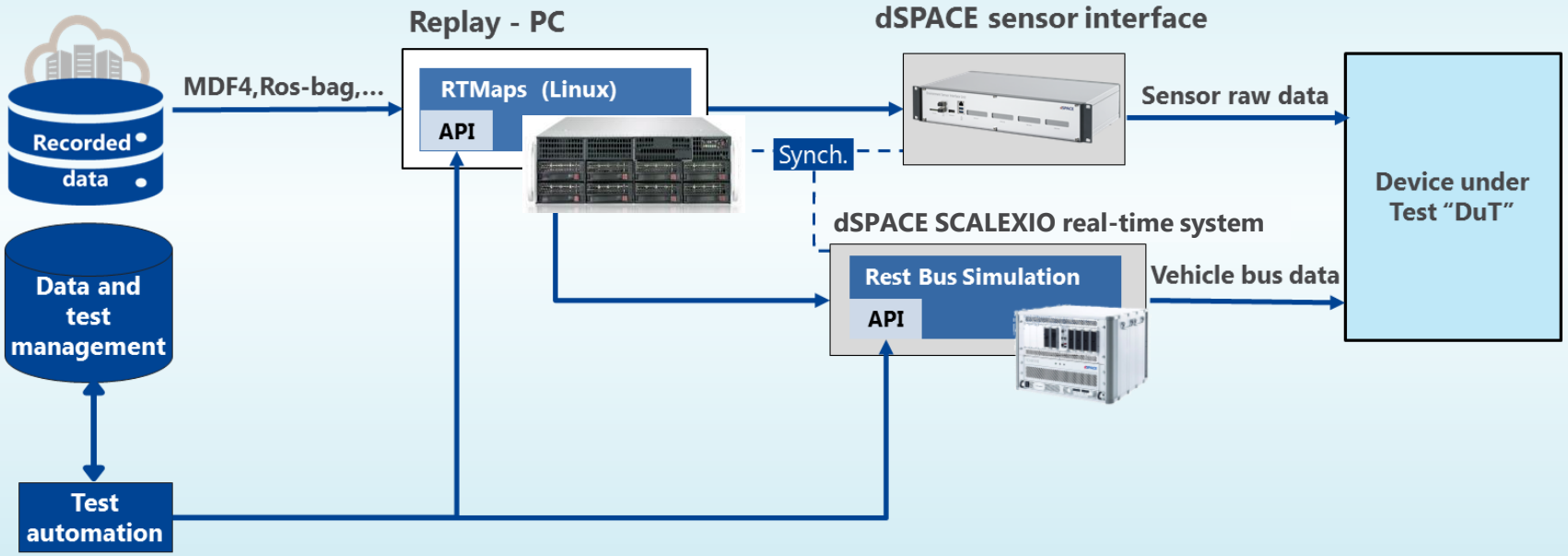
Logical Scenario

Replay Scenario

dSPACE

Data replay HW/HIL solution

Sensor fusion and environment perception tests



Key takeaways

Minimal jitter due to usage of SCALEXIO real-time system

Closed loop **environment simulation up to the initial state of the recording**

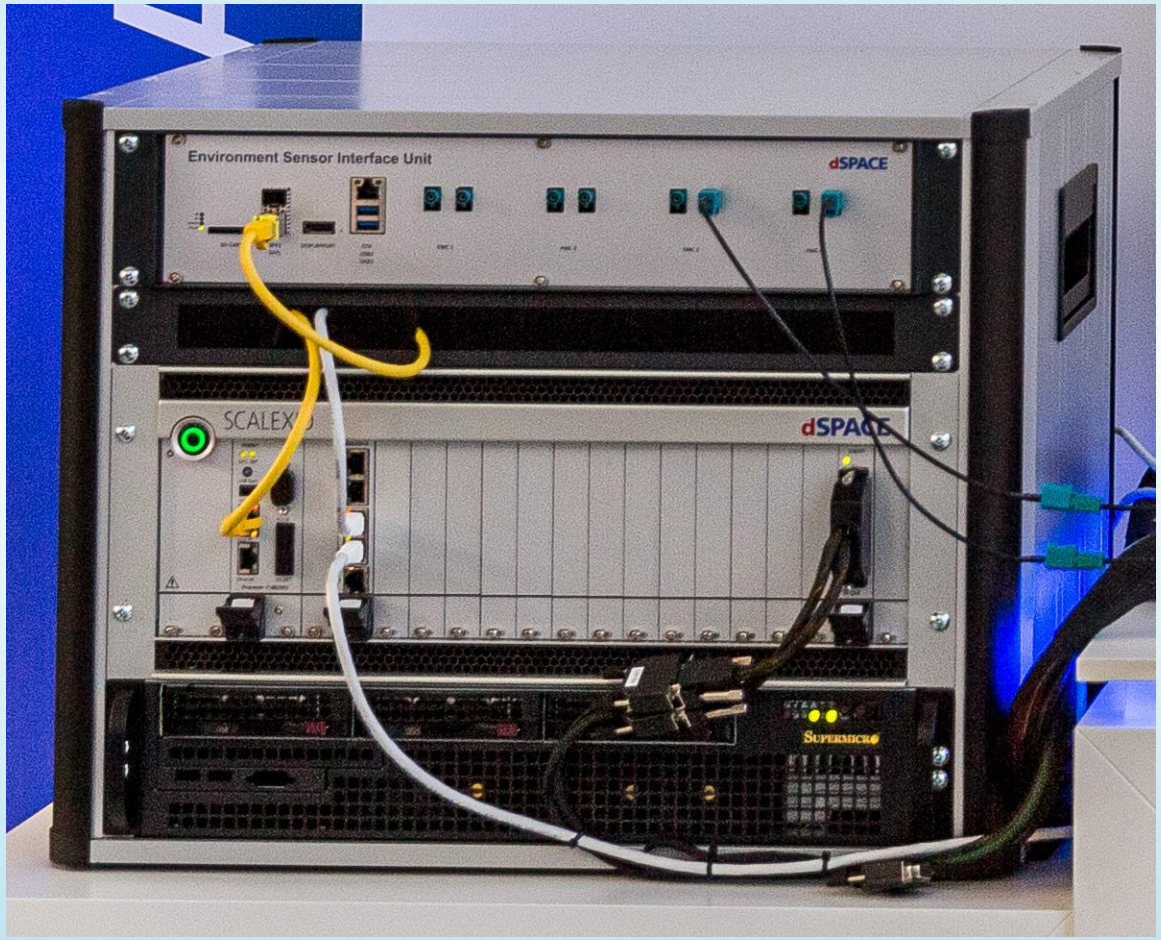
Extensive bus and sensor support with **bus monitoring and manipulation** features

Suitable for **electrical failure testing**

Multi-role system; a single system for data replay and closed-loop simulation.

dSPACE

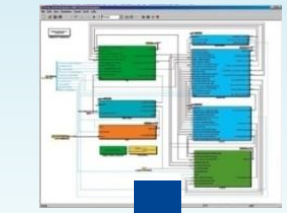
HW data replay demo: Setup

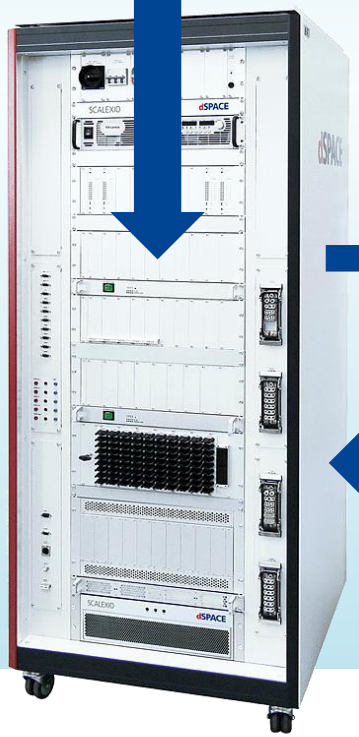


dSPACE

Use Case: Test functions for AD by means of HIL simulation

Automotive Simulation Models (ASM)
for vehicle, sensor and traffic simulation



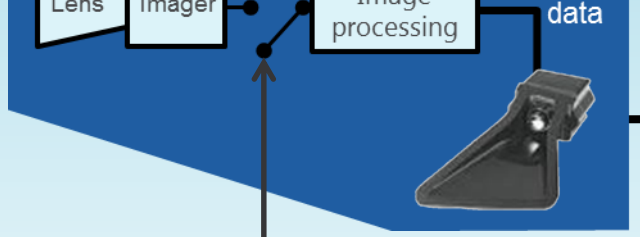


Sensor Simulation PC
with GPU

GigE

HDMI

Environment Sensor
Interface Unit



...

High-performance
processing unit

Rest bus simulation

Vehicle network

Hardware-in-the-Loop (HIL)
simulator

© Copyright 2020, dSPACE GmbH

dSPACE

dSPACE