



Interoperable simulation – a UK case study



STATE OF THE ART TECHNICAL TESTING ASSETS TO MEET ALL YOUR REQUIREMENTS

 Conventional Powertrain	 Future Powertrain	 Safety	 Comfort & Quality	 Reliability & Durability	 Connected Mobility
 Engine test cells	 2E, 3E & 4E powertrain rigs	 EuroNCAP & passive safety labs	 EMC chambers	 Powertrain test systems	 Simulation
 Light & heavy-duty chassis dynos	 12 battery pack test chambers	 ADAS & active safety labs	 NVH chambers	 Heavy duty structures lab	 5G CAV Village
 PEMS laboratories	 E-machine / EDU systems & test labs	 Indoor & outdoor winter tyre testing	 NVH brake dyno	 Shock and vibration test rigs	 TEQMO test centre / 5G

WORLD CLASS PROVING GROUNDS TO MEET ALL YOUR VEHICLE TESTING REQUIREMENTS

Linass-Monthéry PG



- >23km of test tracks
 - High Speed Oval
 - Dynamic platforms
 - Acoustic track
- TEQMO test center
 - 12km hi-tech tracks
 - 5G CAV specialisms
 - ADAS expertise

Millbrook PG



- 70km of test tracks
 - High Speed Oval
 - Alpine Handling
 - 4x4 Off Road
 - Mile straight
 - Special Surfaces
- 5G CAV Test Bed

Mellatracks & Airport PG



- 100km outdoor tracks
 - Snow & Ice handling
 - Split friction tracks
 - Split friction slopes
- Indoor Circuits x6
 - Snow & Ice (x4)
 - Wet & Dry Asphalt (x2)

Mortefontaine PG



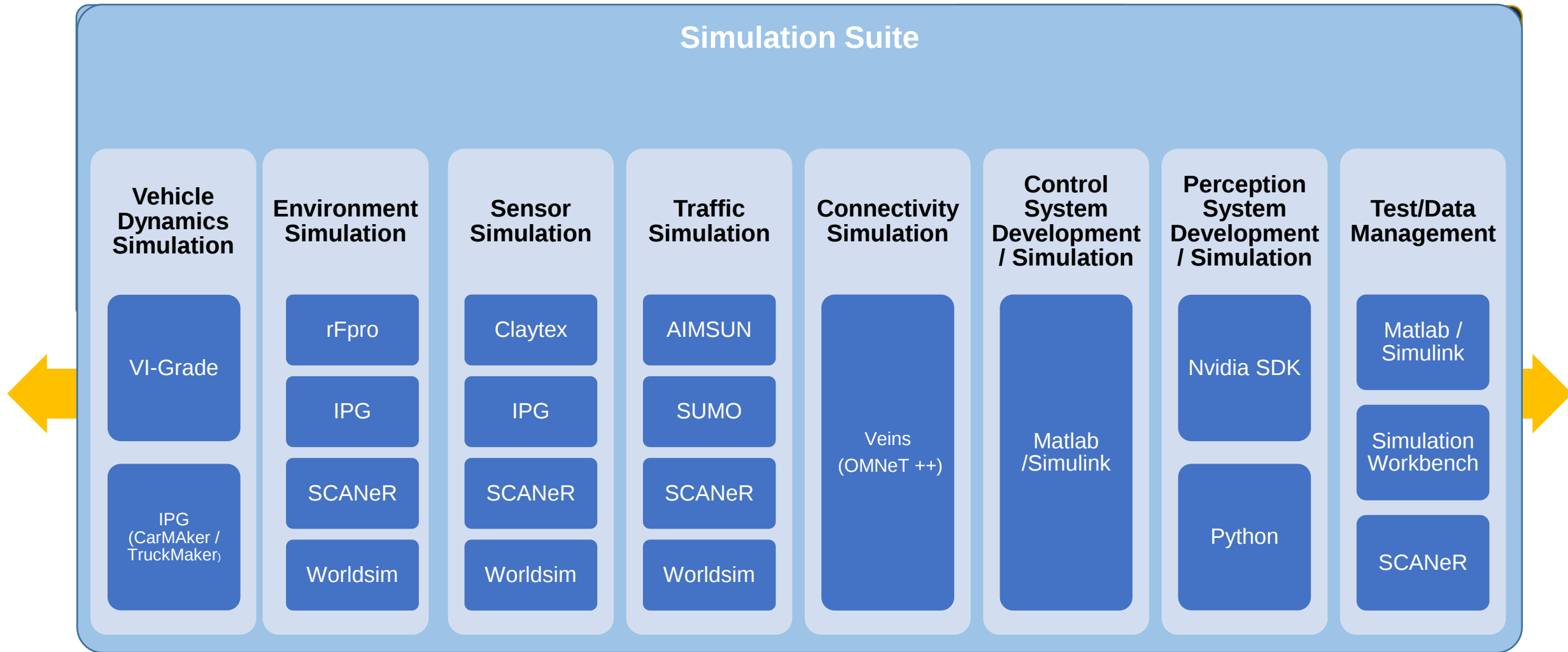
- >19km of test tracks
 - High Speed Oval
 - Urban & Off Road
 - Special Surfaces
 - Dynamic platforms
 - Acoustic tunnel

Oued Zem PG



- Hot climate testing
 - High Speed Track
 - 4km Coast Down
 - Low grip wet braking
 - Dynamic platforms
 - Special surfaces
- Opening Q4 2021

SENSORS IN THE LOOP AND SENSOR MODELS





ViL FACILITATED BY PRIVATE NETWORK

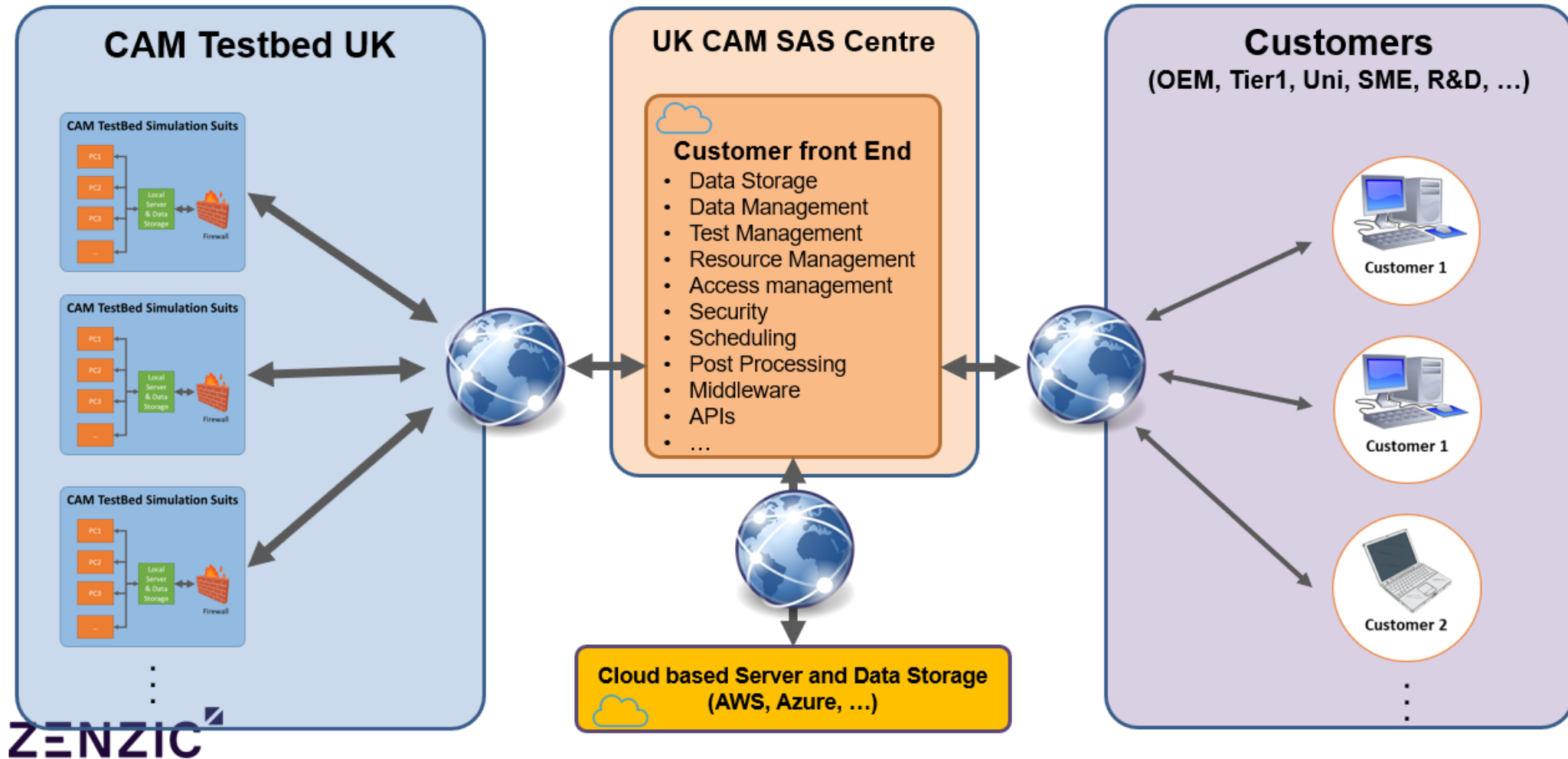


- **Establish** a common and flexible integration framework.
- **Demonstrate** the state-of-the-art technical solutions for integrated capabilities across the UK simulation ecosystem.
- **Align** with customer needs and their development processes.
- **Showcase** how existing simulation capabilities can be made interoperable
- **Operate** beyond the capacity of any single CAM Testbed UK facility.

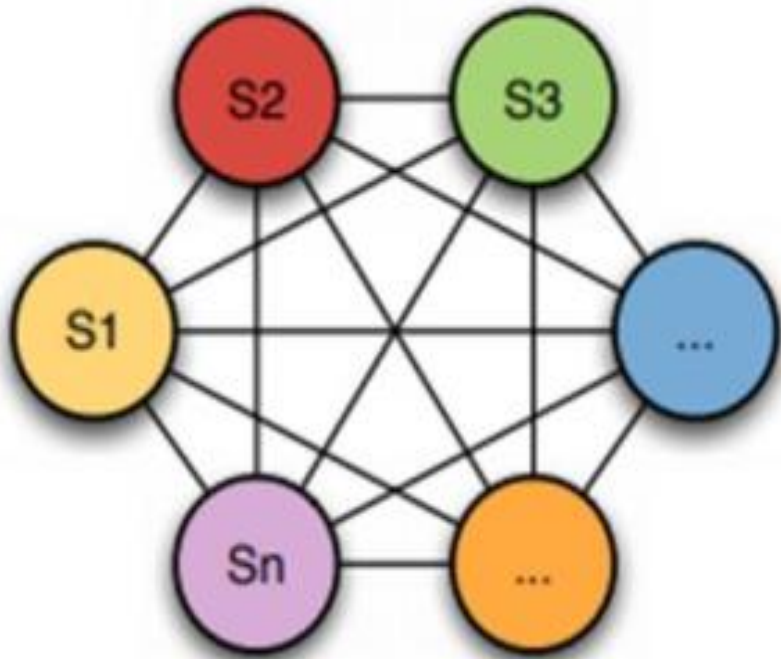


CAM Testbed UK can offer new and valuable propositions for research, development and testing of CAM

INITIAL IDEA



POINT TO POINT OR DATA CENTRIC?



PARTNER ROLES



- UTAC, **driving simulator** (DiL): **Compact simulator from VI-Grade** integrated with the IPG vehicle dynamics simulation through Concurrent Simulation workbench.
- UTAC, **test track**: real time data fed into the simulation environment using 4G/5G connectivity. Integration across the network performed by DDS data bridge
- Applus IDIADA, **Vehicle-to-Everything** (V2X) HiL rig, communication hardware and software.
- University of Leeds, **PiL simulator** (HIKER): real pedestrians into the simulation. HIKER: (Highly Immersive Kinematic Experimental Research), the world's largest high-resolution cave based pedestrian simulator.



A HORIBA COMPANY



UNIVERSITY OF LEEDS



THE UNIVERSITY OF WARWICK



UK Smart Mobility
Living Lab
@ Greenwich



SELF-DRIVING REVOLUTION

PARTNER ROLES

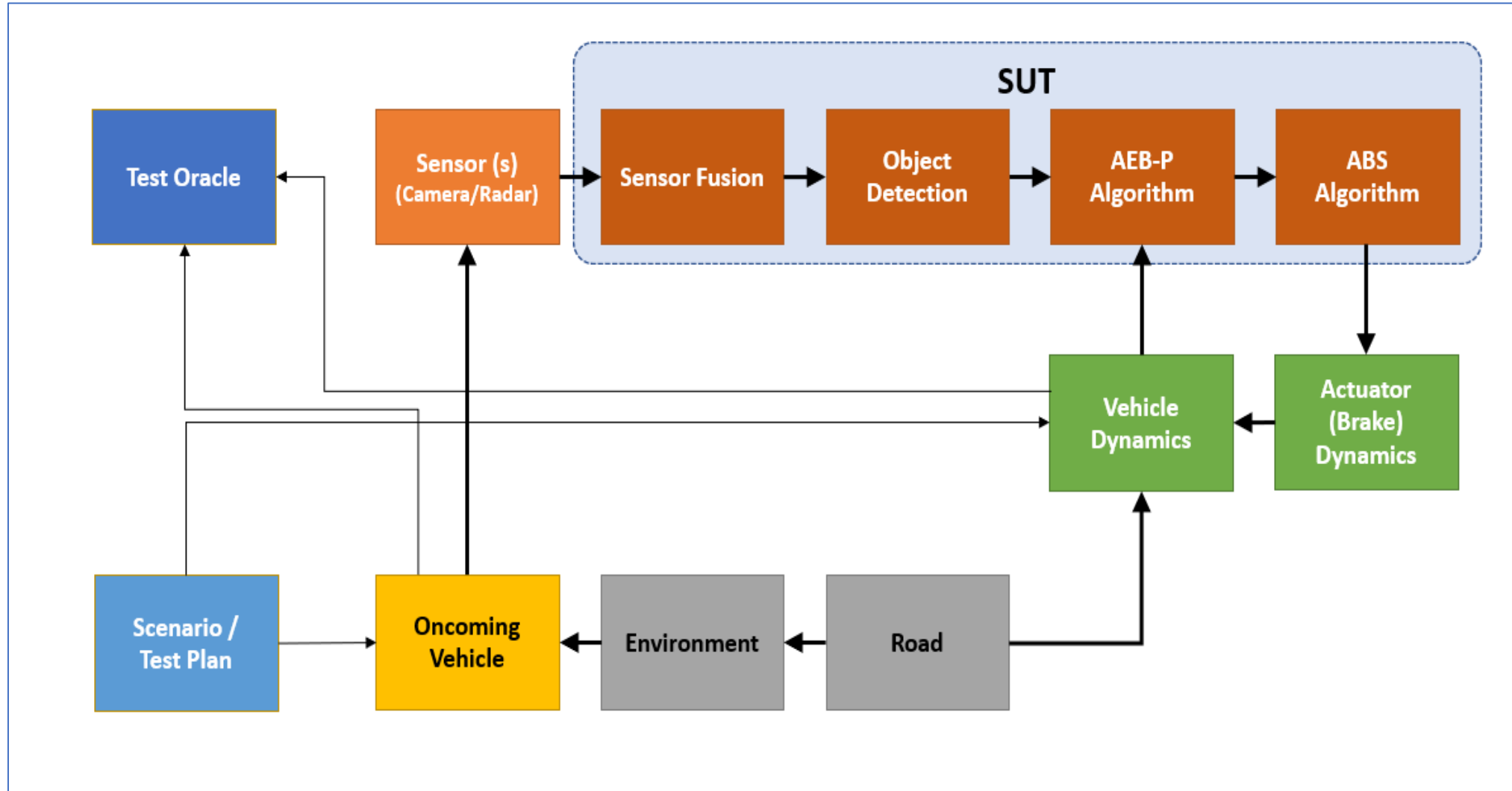
- Ford / IPG, **ViL simulator**: enables ADAS and Automated Driving System (ADS) development and validation in multiple complex or dangerous scenarios.
 - XPack4 HiL system
 - ADAS ECU, ABS ECU. Camera Box, Castle Box: opposed arrays of parking sensors,
- SMLL, **scenario generation**: novel methodology to generate scenarios from real road scenes
- HORIBA MIRA, **test oracle**: assess the outcome of the simulation execution and study the behaviour
- WMG, **V&V pipeline**: end-to-end, scenario-based V&V pipeline to form a closed-loop simulation setup.



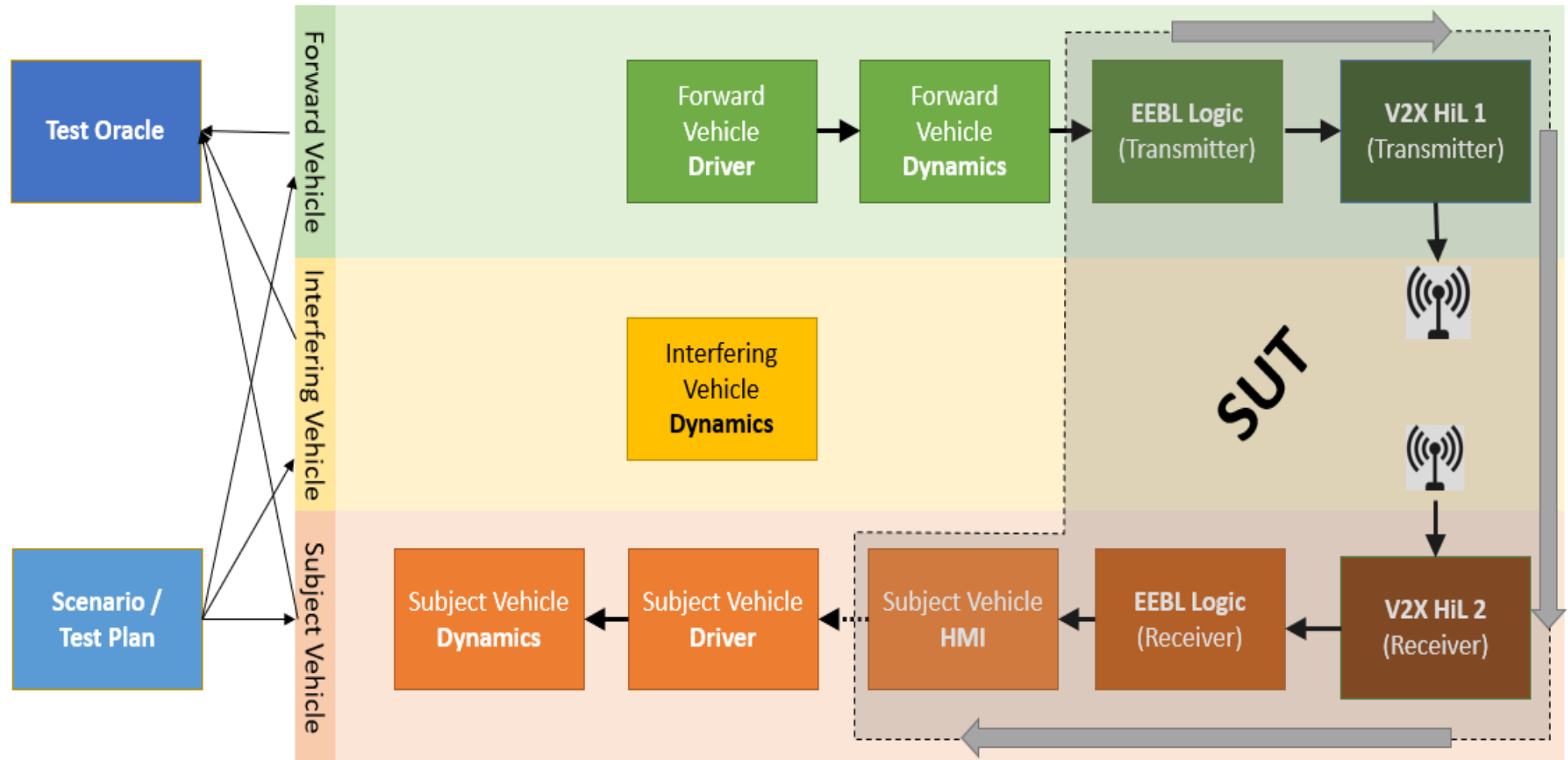
A HORIBA COMPANY



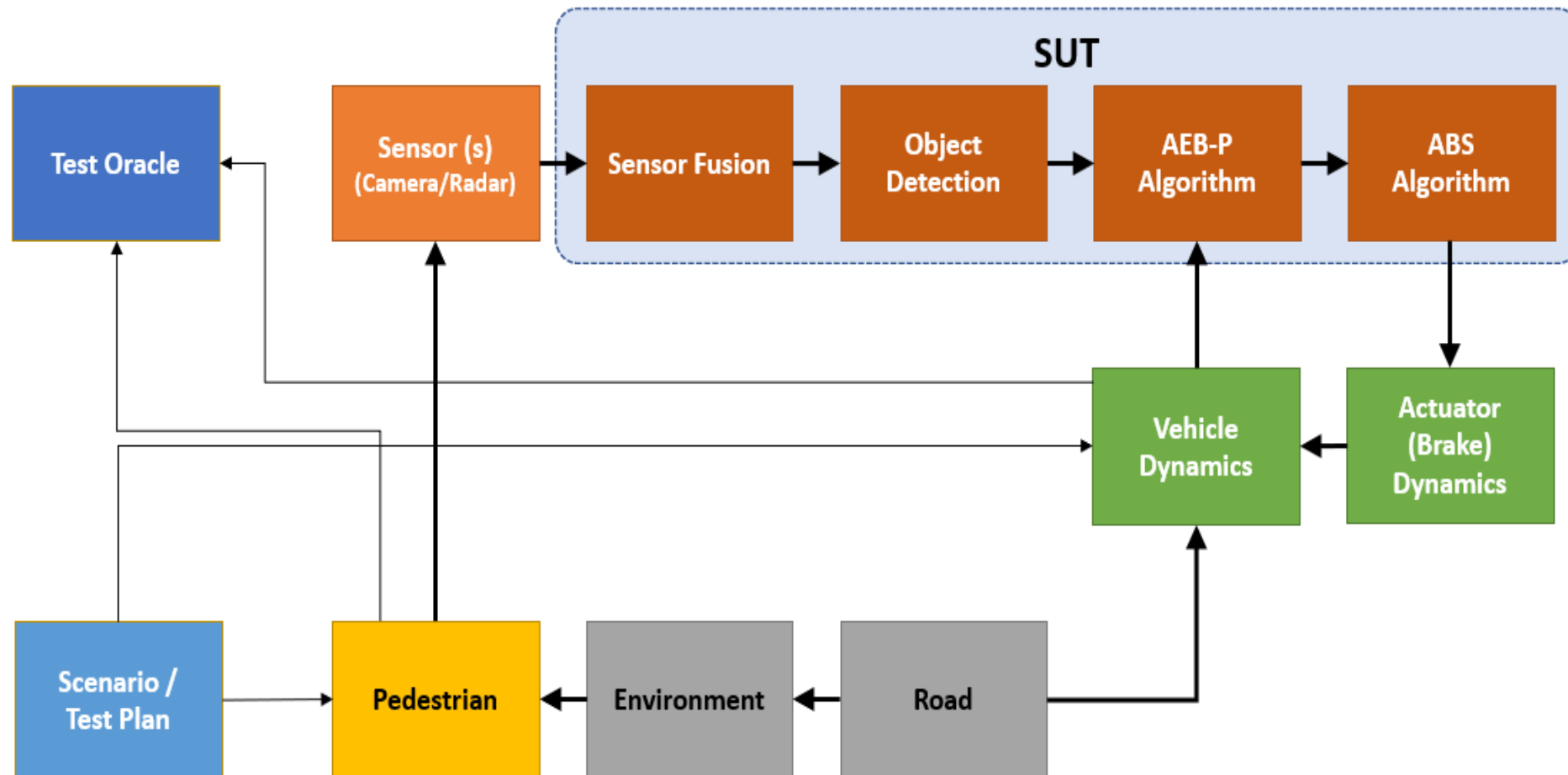
AEB – O SYSTEM OF SYSTEMS



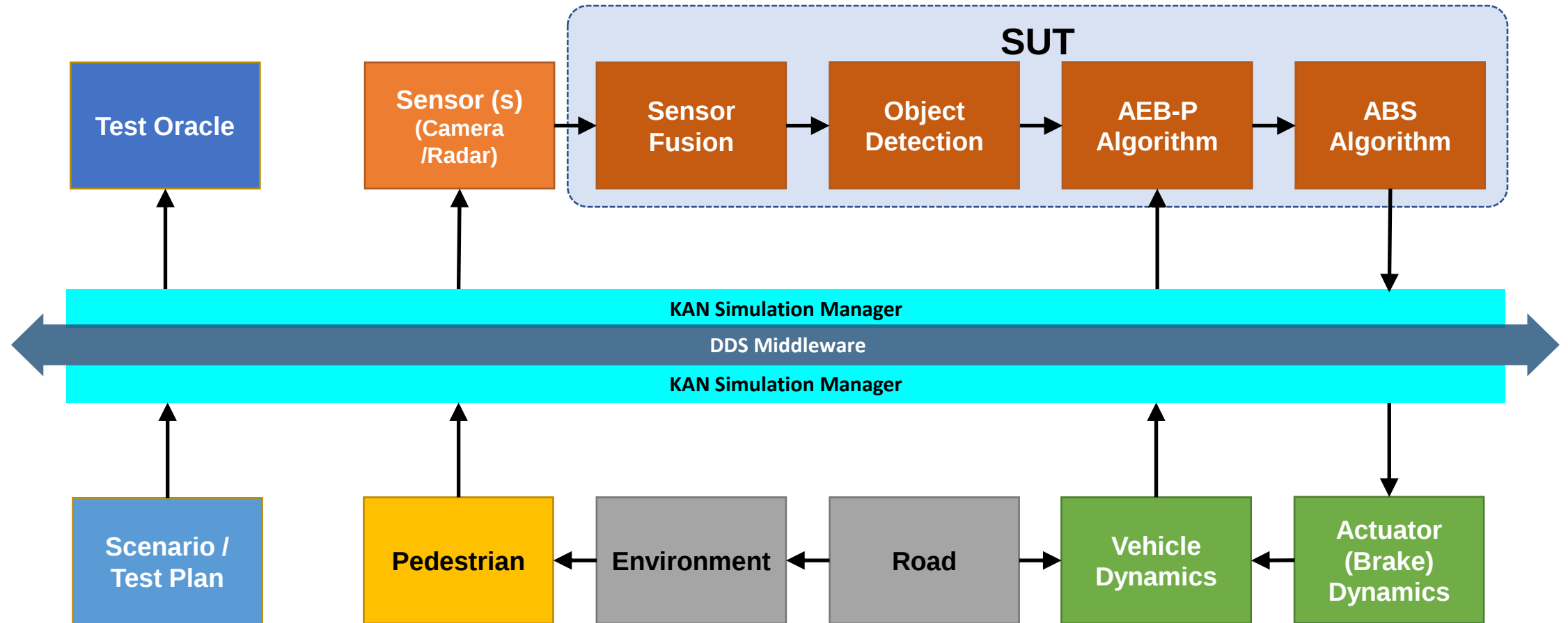
EEBL SYSTEM OF SYSTEMS



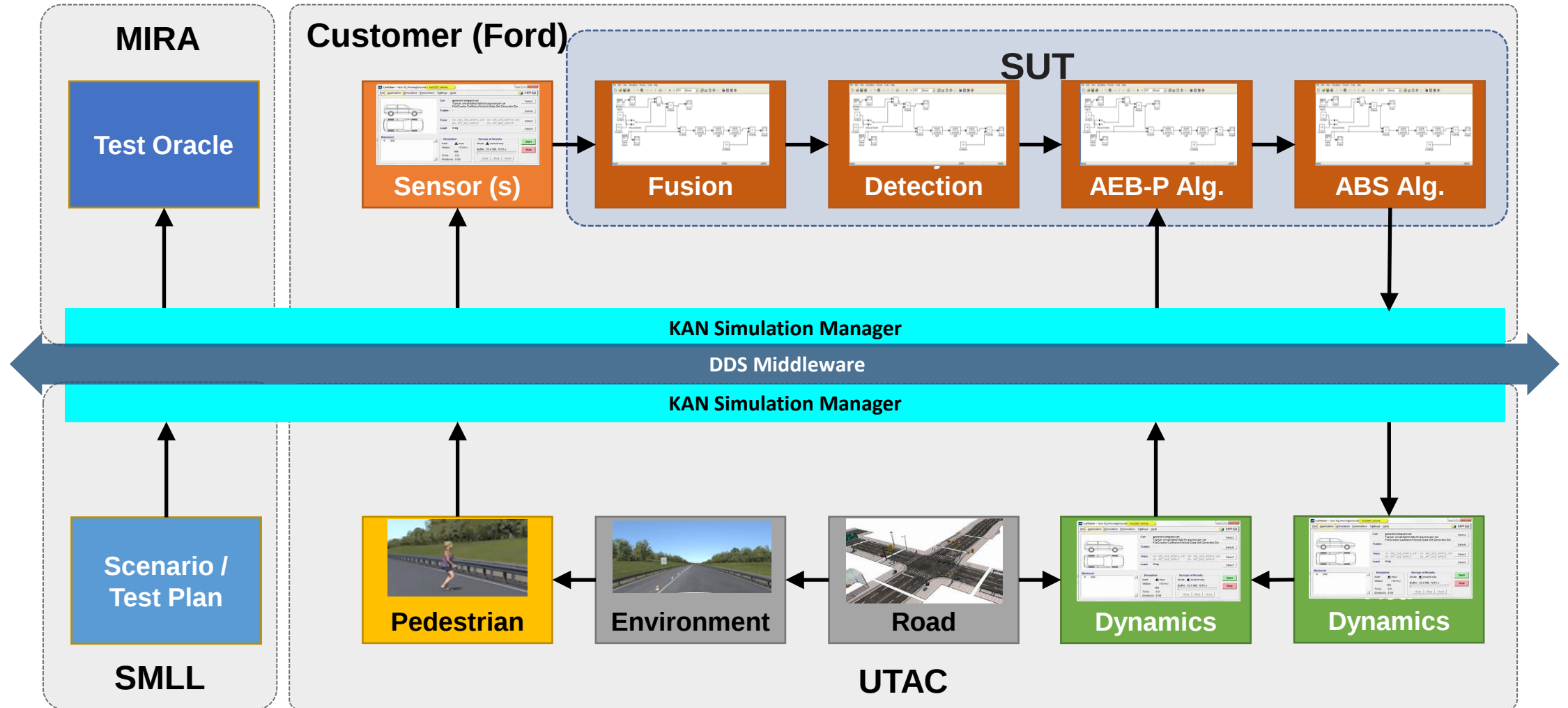
AEB - P SYSTEM OF SYSTEMS



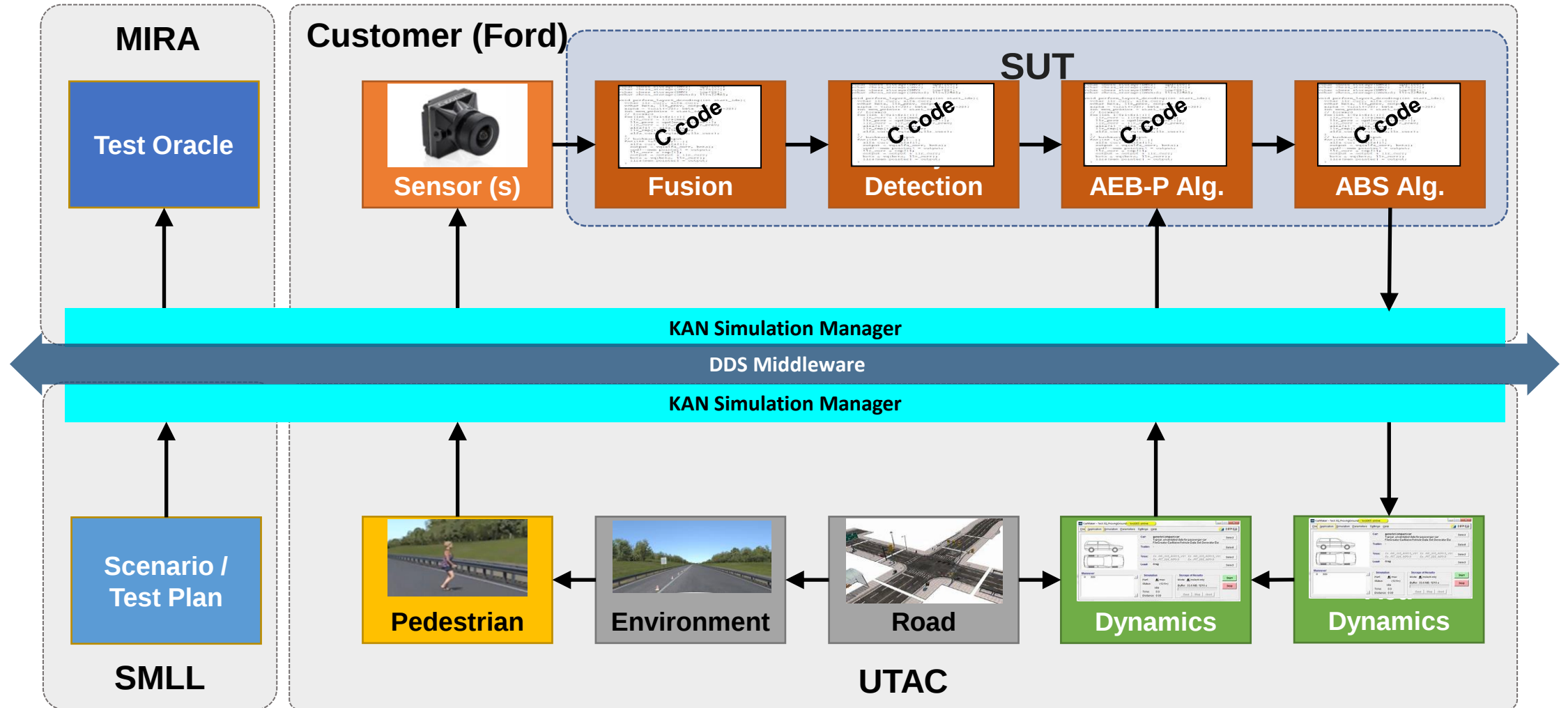
AEB - SYSTEM UNDER TEST INTEROPERABLE DISTRIBUTED SIMULATION SETUP



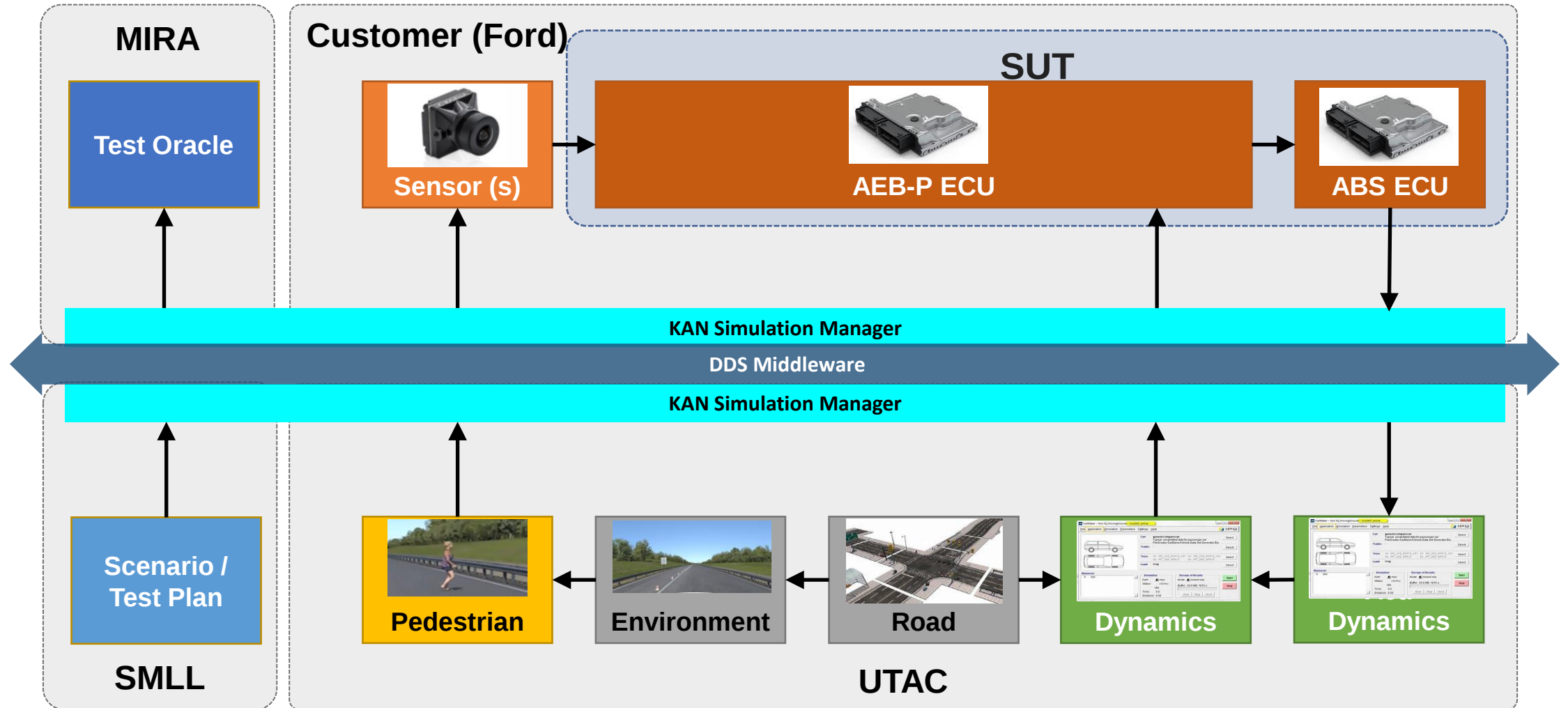
AEB - MiL TEST



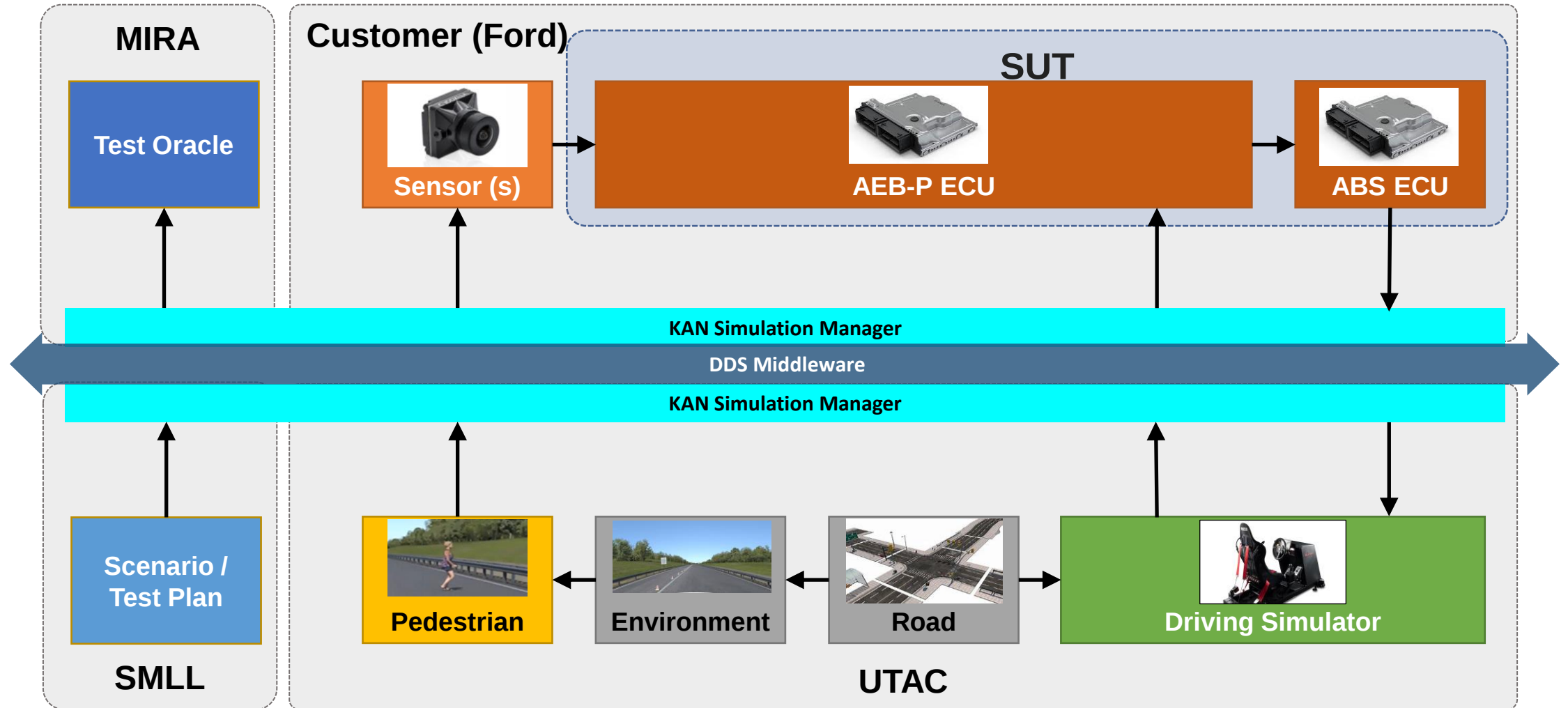
AEB - SiL TEST



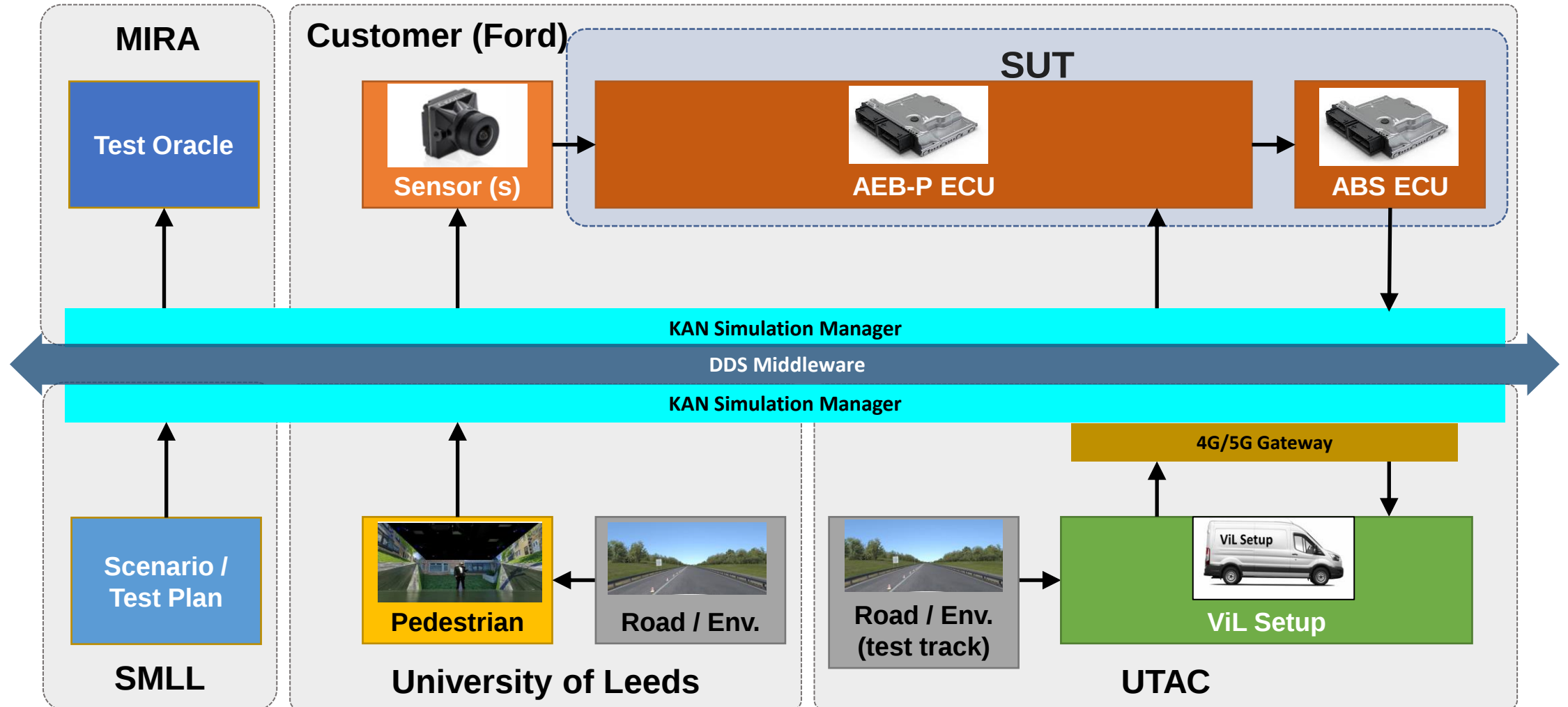
AEB - HiL TEST



AEB - DiL TEST



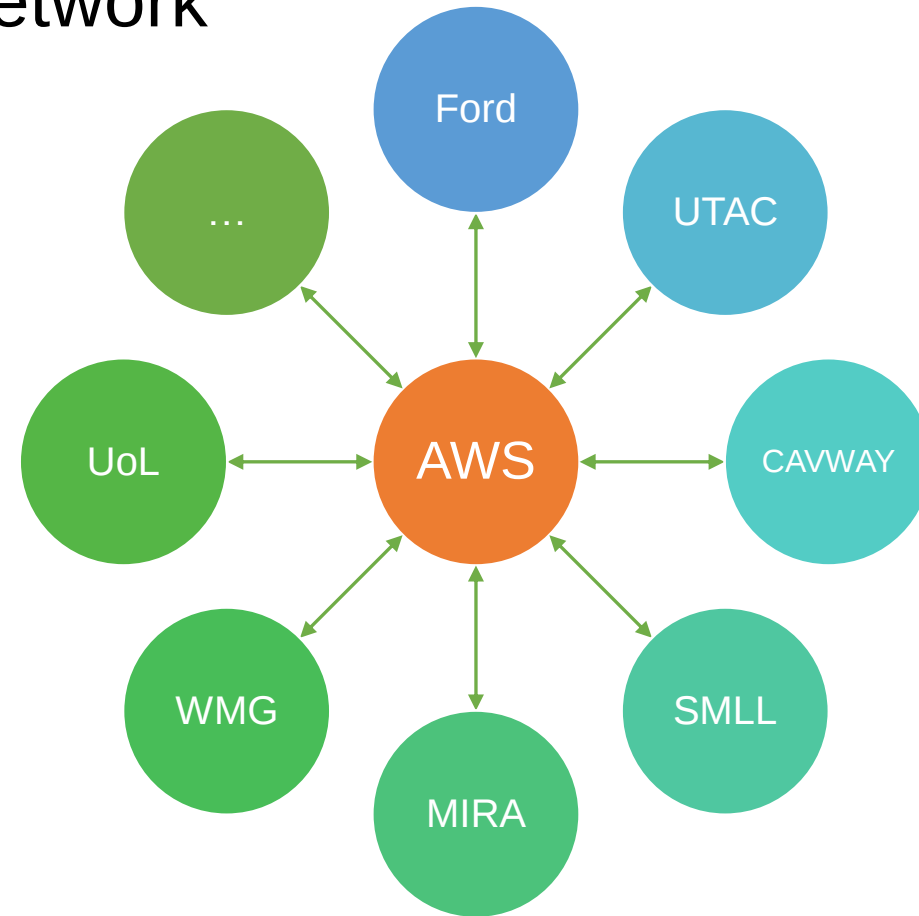
AEB - ViL TEST



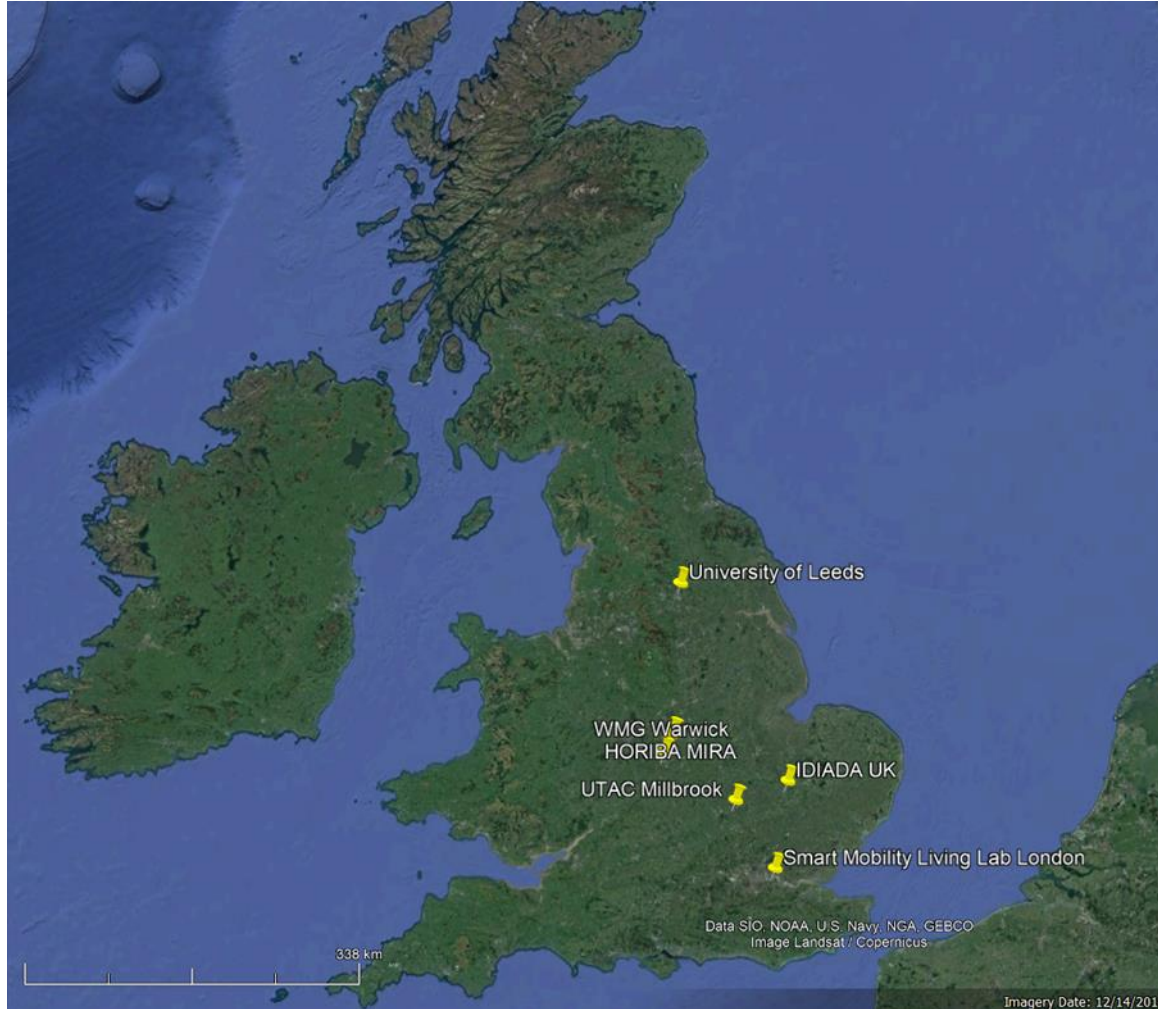
Independent from any Partner Network

KEY FACTORS:

- Connectivity
- Data Storage / Management
- Security
- Access level Management
- Additional Processing capacity



CONNECTING IT ALL TOGETHER



Testbed	Integrated simulation capabilities	Type
UTAC	VI-Grade static driving simulator (DiL)	Bespoke
	UTAC's full-scale driving Simulator	Bespoke
	Vehicle telemetry (ViL) via private 4G/5G network	Bespoke
	rFpro	COTS
	IPG Carmaker	COTS
	SUMO	Open Source
	Aimsun	COTS
	PTV VISSIM	COTS
University of Leeds	HIKER	Bespoke
Applus/IDIADA	V2X IDAPT	Bespoke
	VISSIM	COTS
SMLL	SCOOT (Via VISSIM)	COTS
	Scenario generation (OpenSCENARIO)	Open Source
HORIBA MIRA	Test oracle	Bespoke
WMG	V&V (Closed-loop simulation)	Bespoke
	Safety Pool	Bespoke

BUT, BUT, BUT.... LATENCY!

Overall latency in any distributed simulation system: three main sources

- **Individual simulation tools,**
 - More powerful hardware processors, parallel processing, faster peripheral and I/O connections, optimised software codes.
- **Network** between simulation systems, to form a distributed co-simulation system,
 - LAN, networking could be as low as a few microseconds, high-speed switching
 - More advanced (high bandwidth, low latency) connectivity solutions such as MPLS, or AWS Direct Connect.
- **Middleware, APIs** and simulation manager software, to form and manage a distributed simulation architecture.
 - Inter-Process Communication (IPC) latencies of ROS2 middleware - ms / few hundred microseconds
 - Reduced to a few microseconds using RTI's Connex DDS software, up to 96% improvement

Implementation	Data Size in Bytes						
	64	256	1k	4k	16k	60k	1M
ROS 2 & RMW(X)	438	436	434	452	432	491	964
ROS 2 & RMW(Y)	275	277	279	282	306	322	632
ROS 2 & RMW(Z)	231	235	238	231	248	264	506

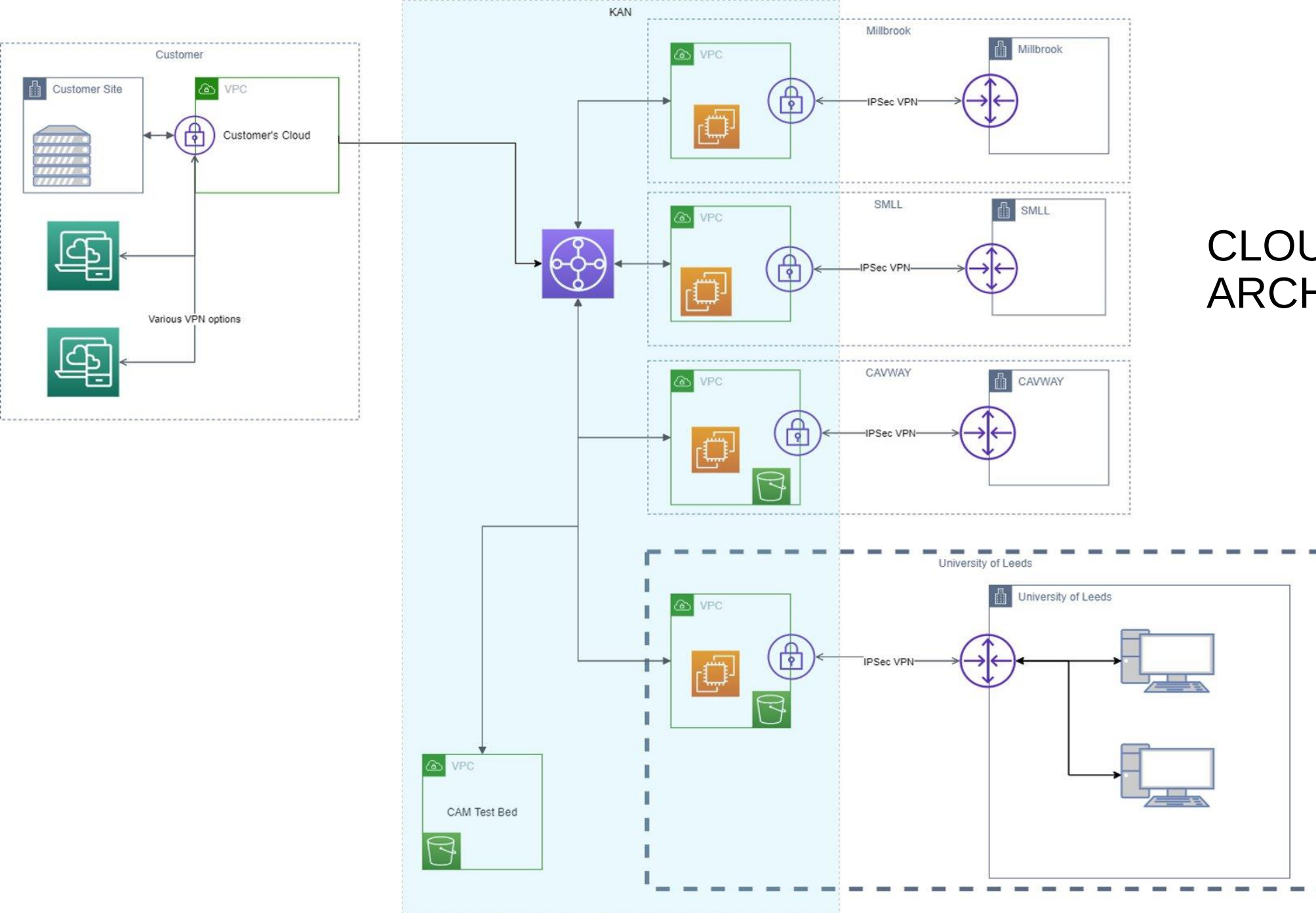
One-way latency in microseconds

Implementation	Data Size in Bytes						
	64	256	1k	4k	16k	60k	1M
ROS 2 & RMW(Z)	231	235	238	231	248	264	506
Connex DDS	9	9	9	10	11	19	339
Latency Reduction	96%	96%	96%	96%	96%	93%	33%

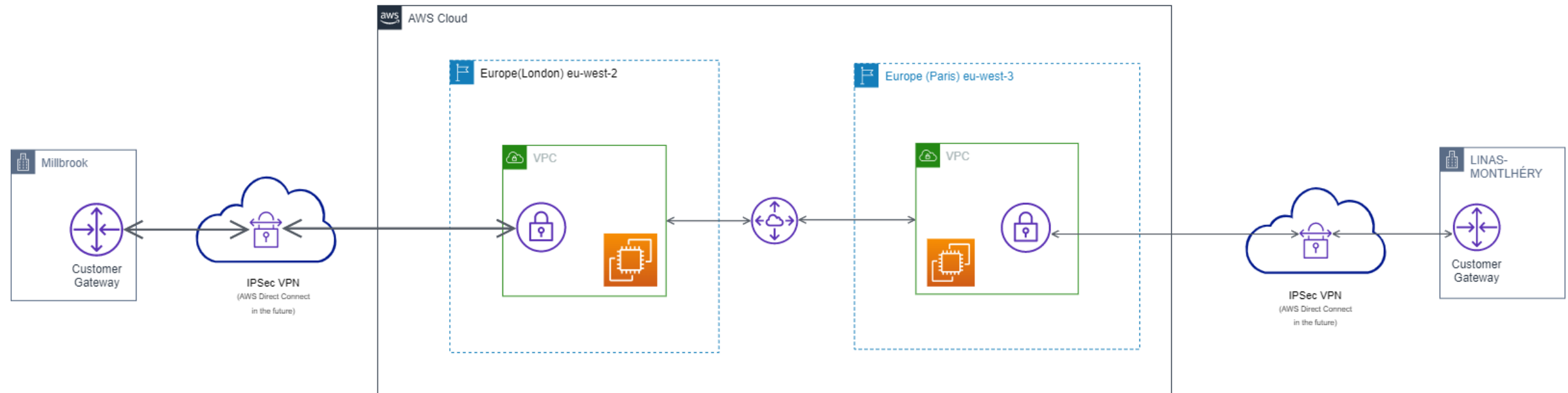
One-way latency in microseconds

Source:(Puthuff, 2021):The Indy Autonomous Challenge: Achieving Extreme Performance with ROS 2 (rti.com)

CLOUD BASED ARCHITECTURE

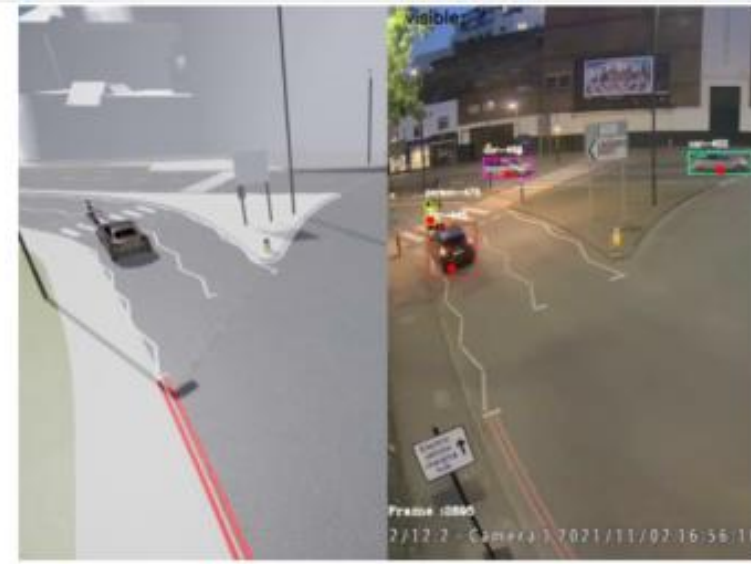


SIMPLE CONNECTIONS - EXAMPLE



THE OUTCOME – SCENARIO CAPTURE

- Vehicle movements & classification were used. Pedestrian in the scene along with a vehicle, with a hard deceleration of $>5\text{m/s}^2$



THE OUTCOME – HIKER LAB

- 9 x 4 m walking space
- Walls are plate glass with rear projection from an array of 4k projectors
- The scene responds to the participants head position and gaze.



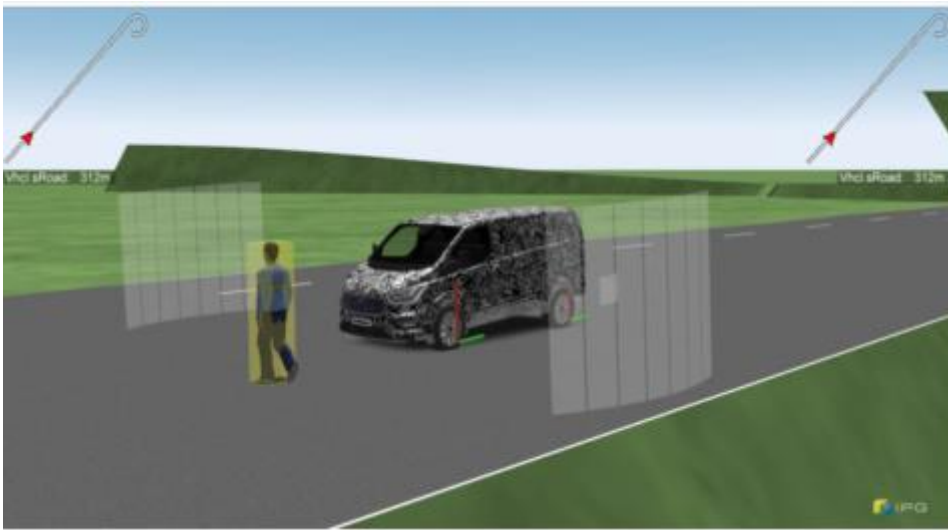
- Participants can see their own body and interact with the scene as well as with tracked objects, use their own mobile phones or any other tool.

- Motion capture used to fix position of pedestrian
- Transmit position in real time to UTAC

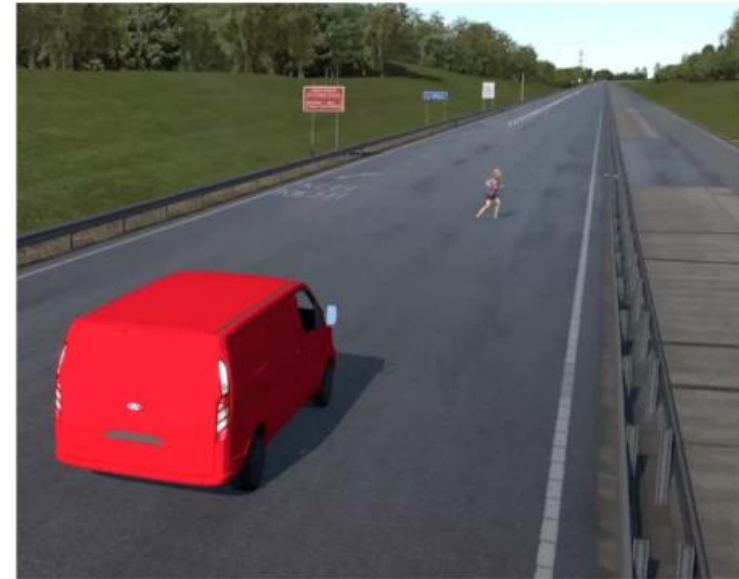


THE OUTCOME - TEST ENVIRONMENT

- Integration of vehicle and AEB model to other components such as rFPro; a higher degree of photorealism.



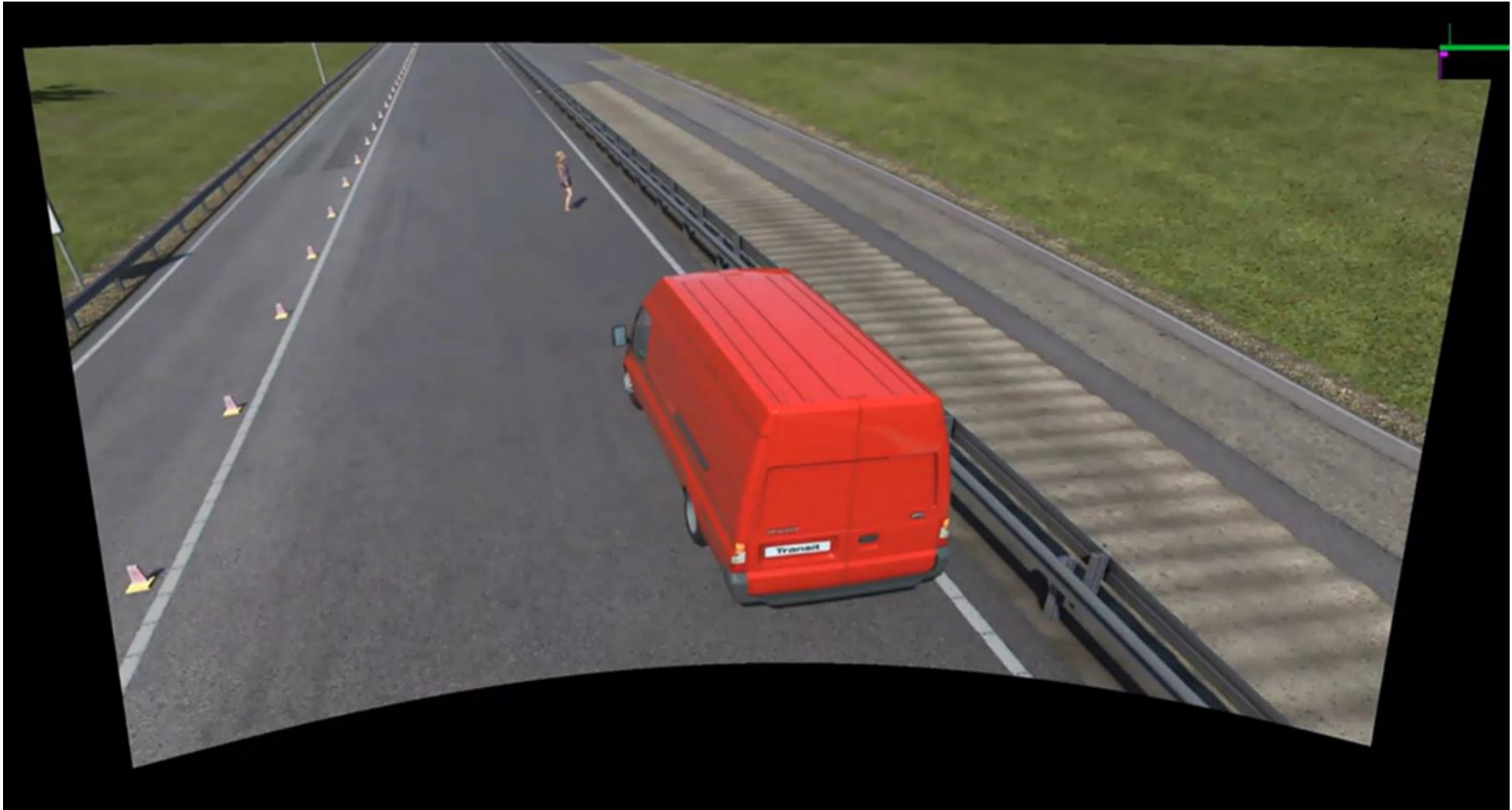
IPG



rFPro

If the sensor models, in Carmaker, are made universal such as via ASAM Open Simulation Interface (OSI), any external sensor plugin which uses such standards can be easily integrated into the model.

EARLY DAYS.....

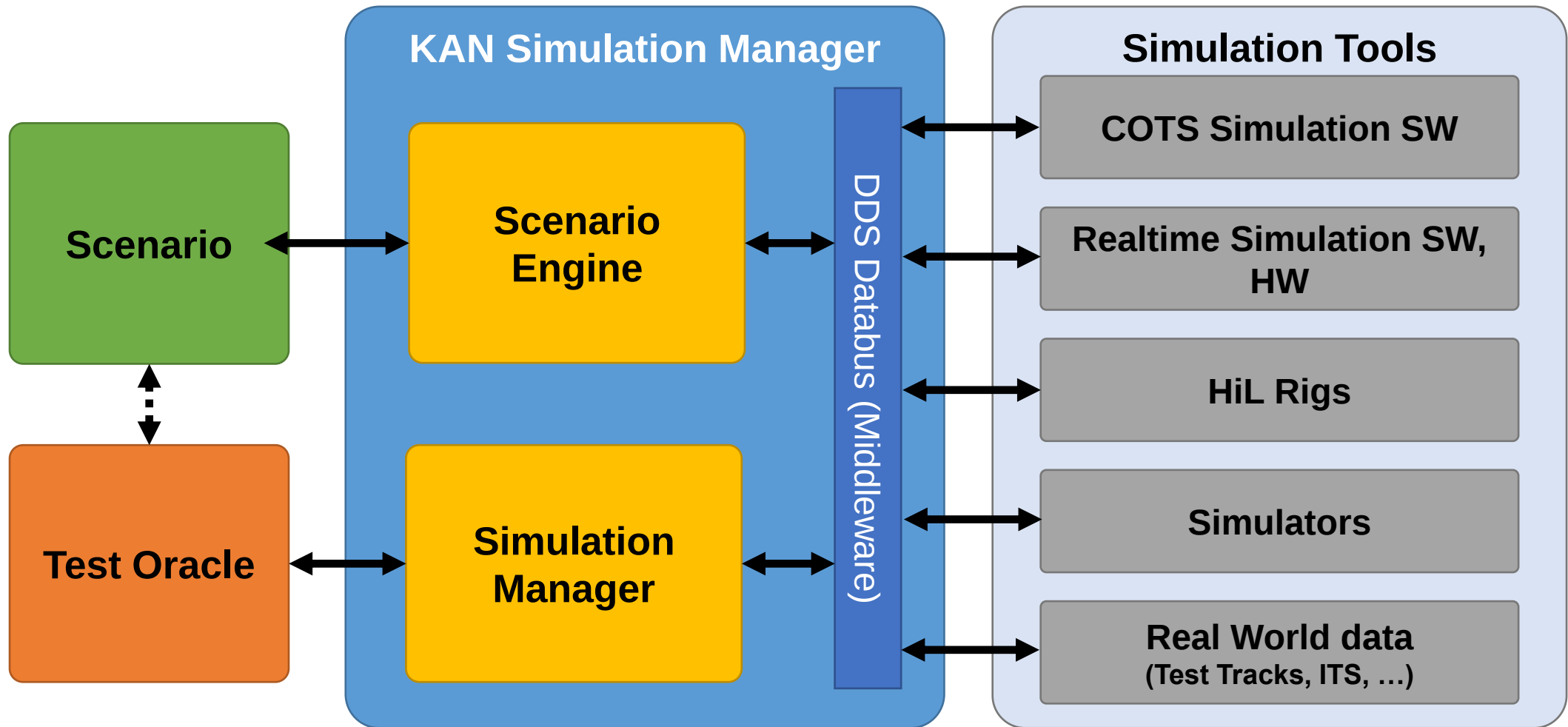


THE RIGHT WAY ROUND!





AN END-TO-END SIMULATION TOOLCHAIN



Simulation SW

1. rFPro
2. IPG
3. VI-CRT
4. VISSIM
5. Aimsun
6. SUMO
7. CARLA
8. SCANeR
9. SimWB
10. NI LabVIEW
11. Matlab/Simulink
12. ROS 1, ROS 2
13. ...

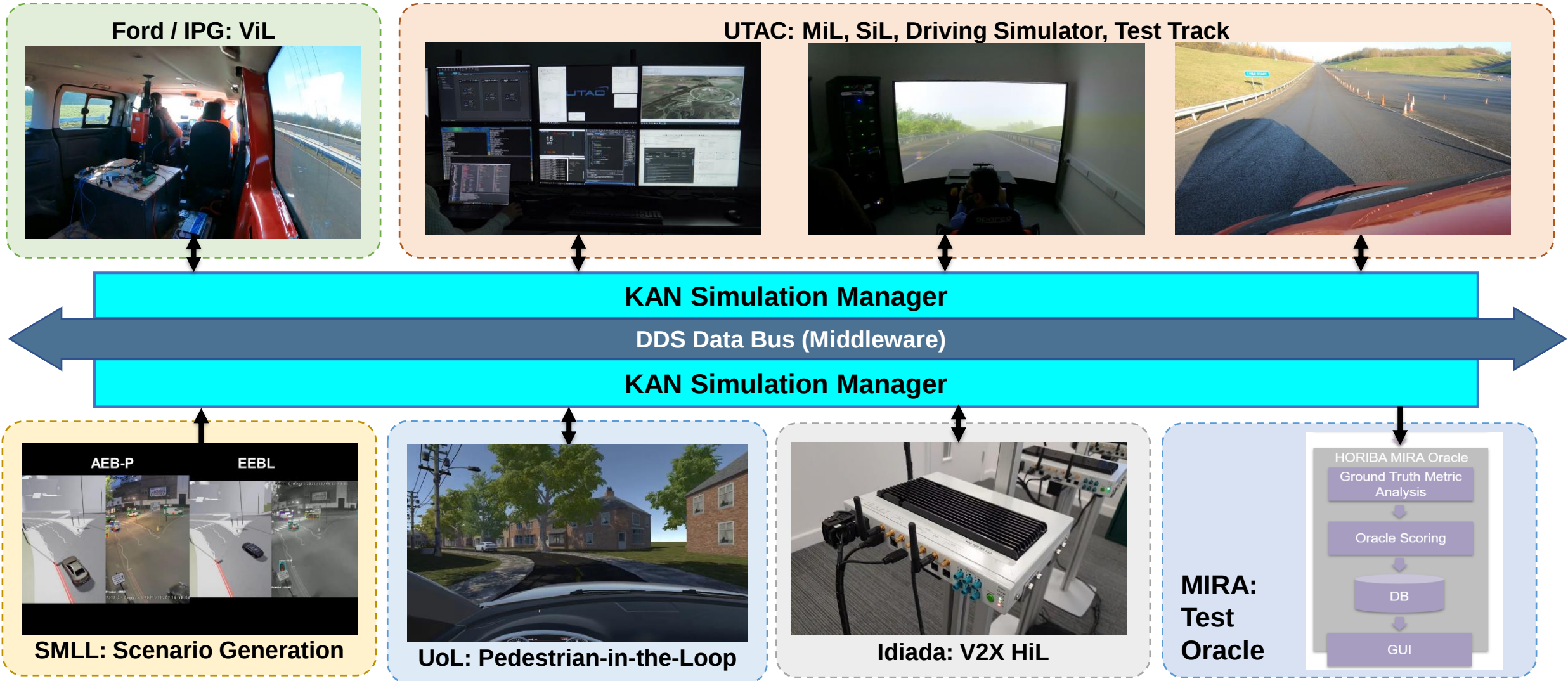
Simulation Rigs

1. UTAC Driving Simulator
2. UTAC Vehicle Simulator
3. UTAC Powertrain Rig PR1
4. UoL Pedestrian Simulator [HIKER]
5. Idiada V2X HiL
6. UTAC Millbrook Test Track
7.

Simulation V&V

1. OpenScenario input
2. MIRA Test Oracle
3. WMG V&V flow
4. Safety Pool Integration
5.

AN INTEGRATED SIMULATION ENVIRONMENT





www.utac.com