METI Ministry of Economy, Trade and Industry

MLIT Ministry of Land, Infrastructure, Transport and Tourism

ADS Safety Assurance Initiative in Japan

Prof. Hideo Inoue, Kanagawa Institute of Technology

DIVP

SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles

AD-URBAN

Agenda

From FY23, commissioned by METI ,3 Projects (Sakura/DIVP/AD-URBAN) are working together to consider ADS-Safety assurance framework

Organization

METI Ministry of Economy, Trade and Industry

MLIT Ministry of Land, Infrastructure, Transport and Tourism

jama Japan Automobile Manufacturers Association

Mobility Digital Transformation (DX) Strategy committee

Safety assessment strategy WG

ADS Safety Evaluation Subcommittee — Requirement → Safety assessment strategy WG

advisor → ADS-safety assurance project

JAMA Guideline

ADS-safety assurance project — Leader : Prof . Inoue

Strategy layer
- Team0
  - Gathering of needs and use case through collaboration with each ADS-regional project, etc.
  - International collaboration

Cross function layer
- Team1: Traffic Scenario～ sensor weakness scenario～ concrete scenario dataset/model
- Team2: 2-stage metrics & modelling, total CI construction from metrics driven approach

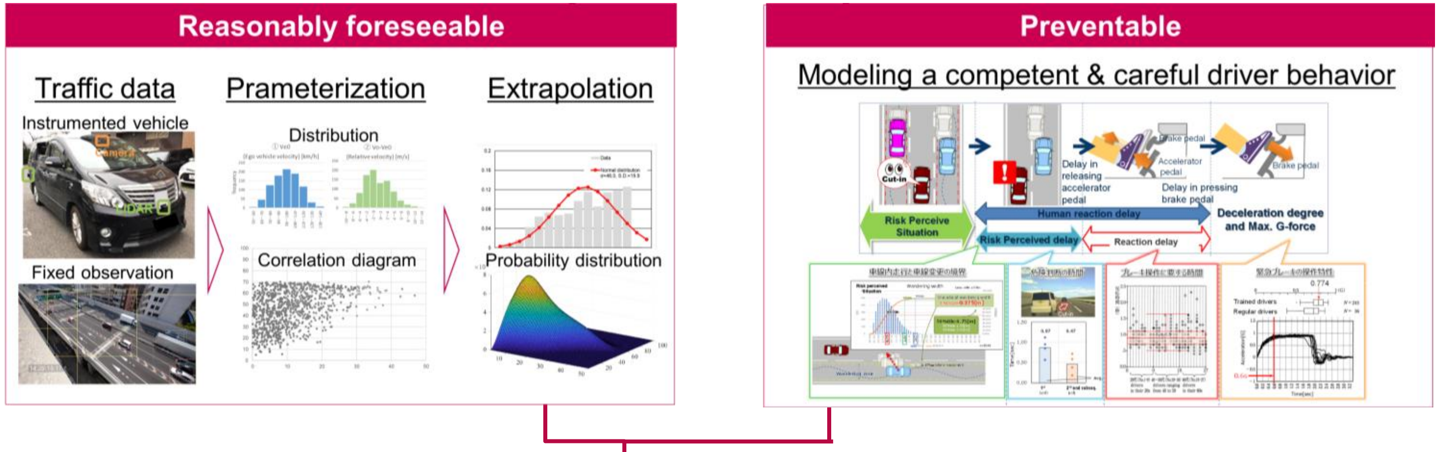
Basic technology layer
- SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles: Scenario
- DIVP: Virtual validation
- AD-URBAN: ADS-system recognition

Sponsored by METI Ministry of Economy, Trade and Industry

Achievement of SAKURA project

Quantify foreseeable and preventable

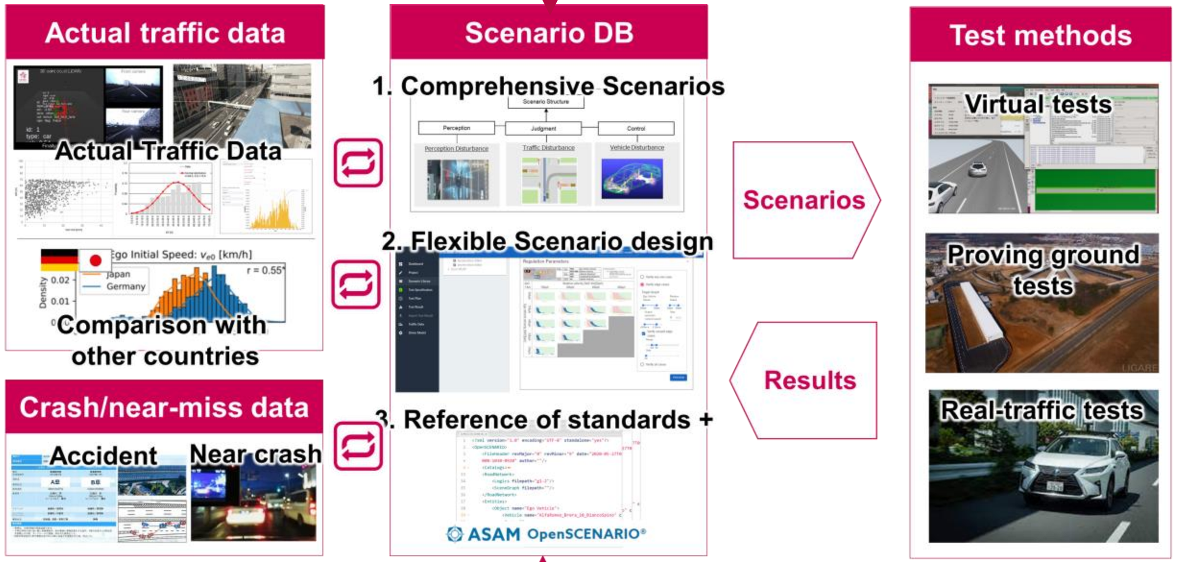
- Measurement of traffic data
  - Validate functional scenarios
  - Estimate parameter distribution
- Modelling C&C driver behavior
  - Preventable boundary



Integrate with test methods

- Provide relevant exposure
- Near crash/Accident scenarios
- Output concrete scenarios

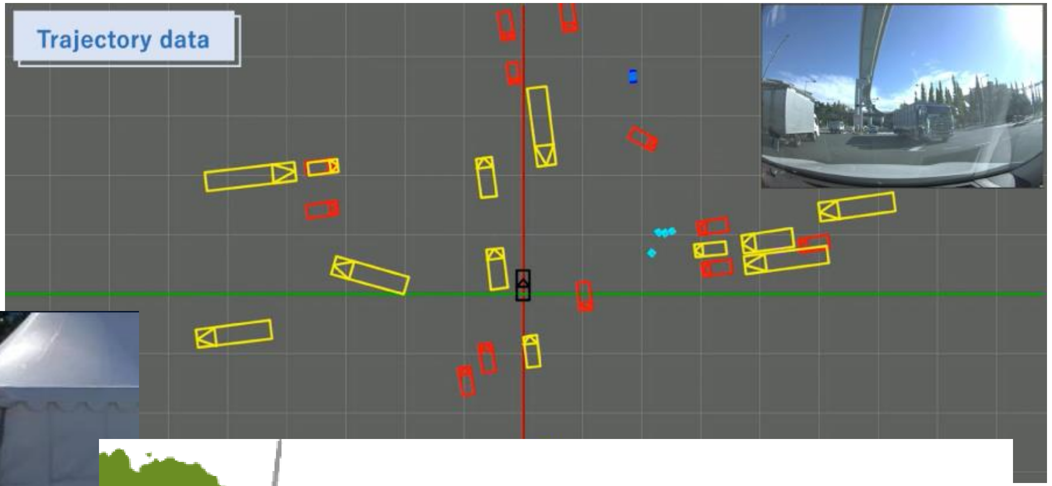
SAKURA project
(Safety Assurance Kudos for Reliable Autonomous Vehicles)
https://www.sakura-prj.go.jp/project_info/



The AD-URBAN project has deep experience in the development of AD. Through SIP-adus, AD-URBAN has deep experience in FOT as well as in research on high recognition technology.

AD-URBAN Project form Prof. Suganuma

- Automated driving system R&D
- Field Operational Test (FOT)
- Perception, Recognition, Fusion algorithm R&D



Field Operational Test (FOT)
in ODAIBA through SIP-adus

Recognition algorithm

The trinitarian J-team integrates traffic scenarios, sensing weakness scenarios and establishes a validation framework for ADS-safety assurance by connecting Scenario, Validation, and Metrics.

Total validation framework for ADS-safety assurance

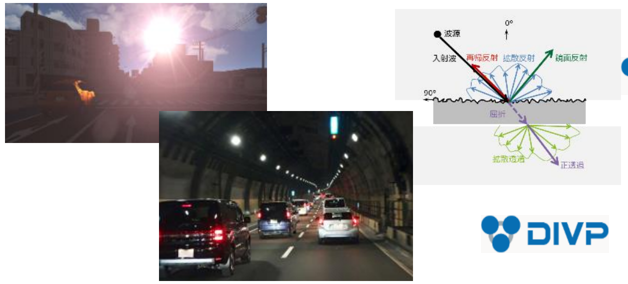
Scenario

System layer

- **Geometric movement scenario** based on road accident data analysis

Sensor layer

- **Sensing weakness** scenario based on expert knowledge



- Tool chain

Coupling tool (SDMG)

Validation

Sensor model with **real/sim consistency**

Camera

RADAR

LiDAR

SUT* AD-control

AD-URBAN

Simulation

HILS / VILS

PG / Public road

Metrics

- **Safety Risk margin** based on geometric positioning simulation

Preventable ?

- **Perception performance** based on Highly Consistent & Measurable Outputs

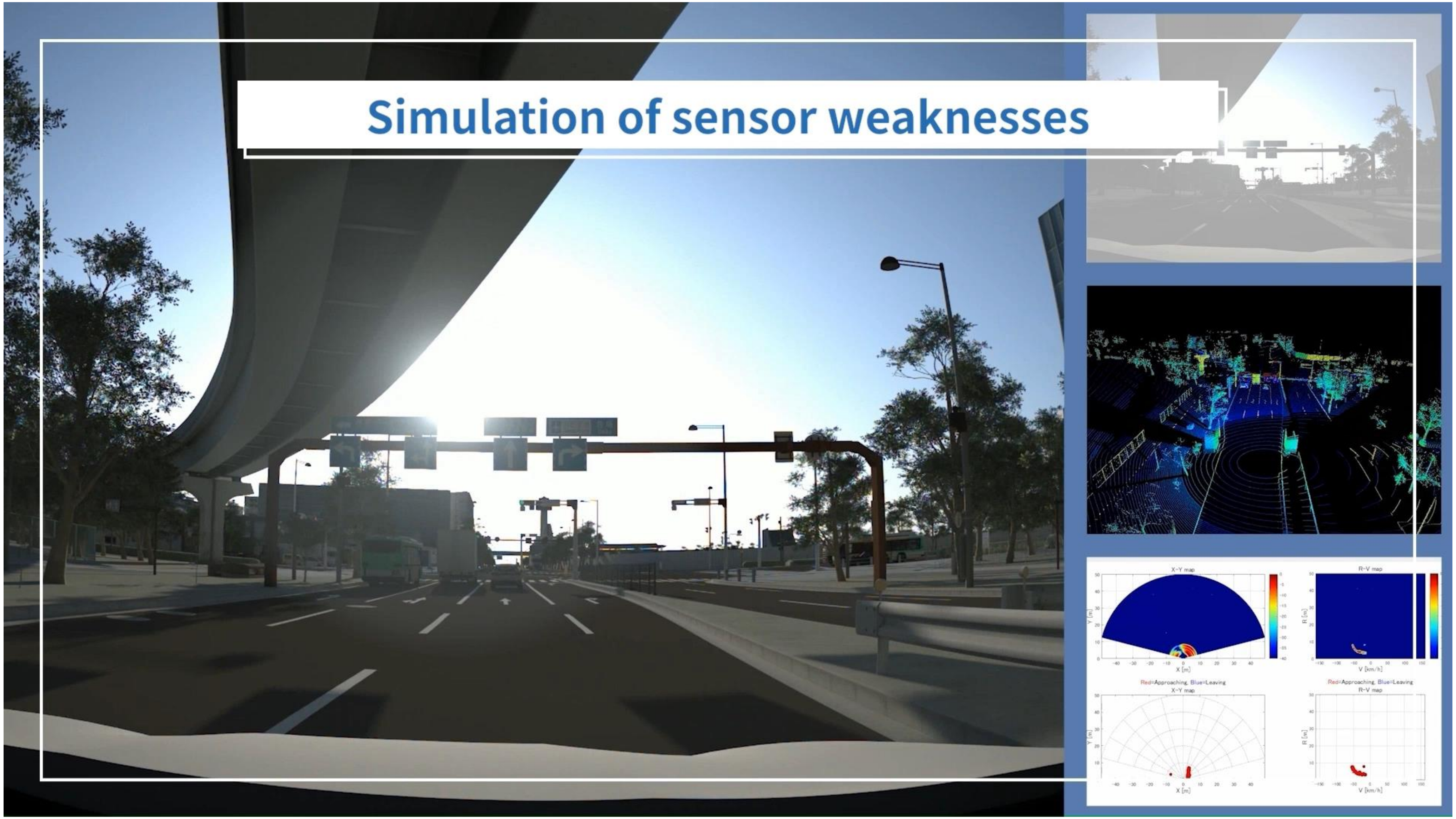
Perceptible ?

SDMG: Space Designed Model Generator

SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles | AD-URBAN | DIVP

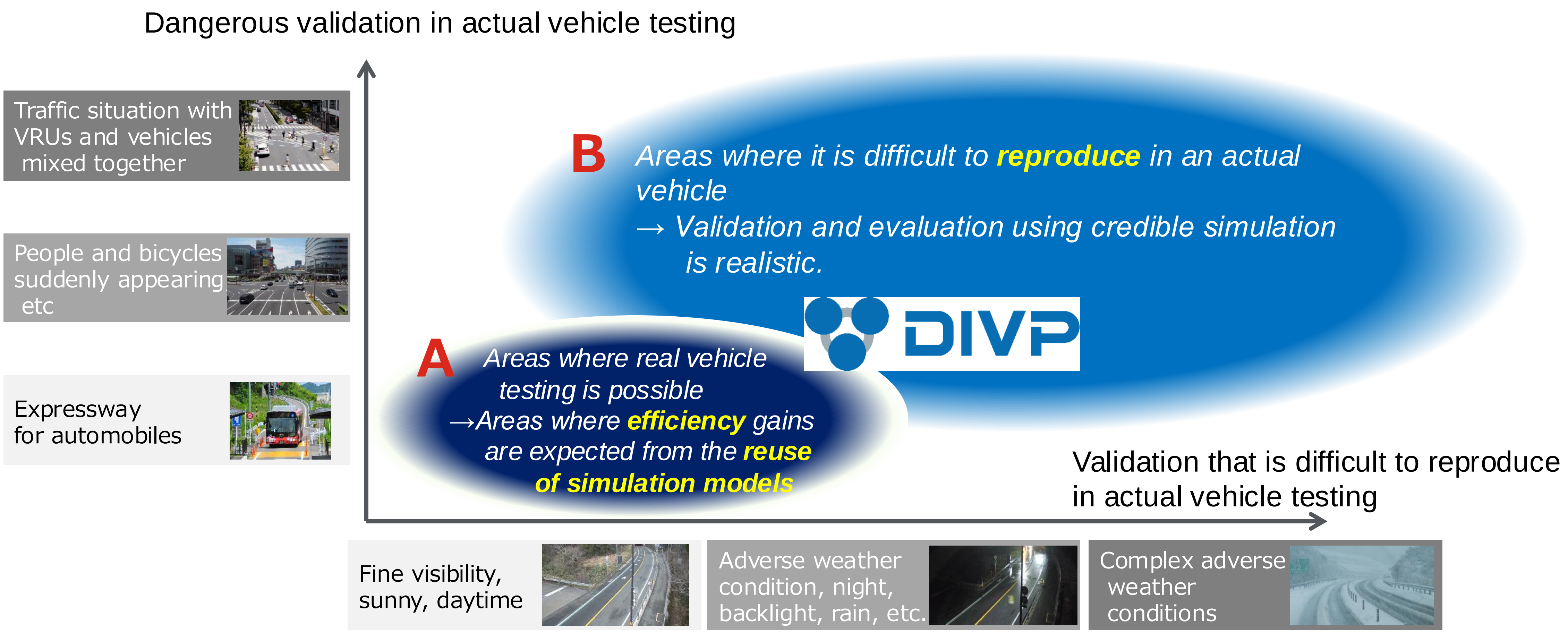
Agenda

DIVP outline;
SIP-adus FOT demonstration to virtual space and evaluation in sensor weakness scenario



Risk assessment in ODD of ADS cannot avoid dealing with hazardous events caused by the recognition performance of sensors, and validation by virtual and reproducible simulation is necessary.

Areas of effective use of simulation



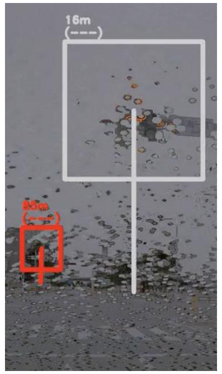
Traffic signal recognition in rainy weather; verification of recognition limit performance is possible with virtual space simulation

Contribution to safety assessment for ADS-system evaluation using virtual space model

Difficult to catch signal recognition limit conditions in public road due to lack of control over rainfall condition levels

Public road tests	Normal weather	Rainy weather (a few mm/h)
Recognition rate	0.982	0.984

DIVP® simulation allows for intense rainfall settings → Signal recognition limit verification is possible



DIVP® simulation	Normal weather	Intense rainy weather
Recognition rate	0.989	0.868

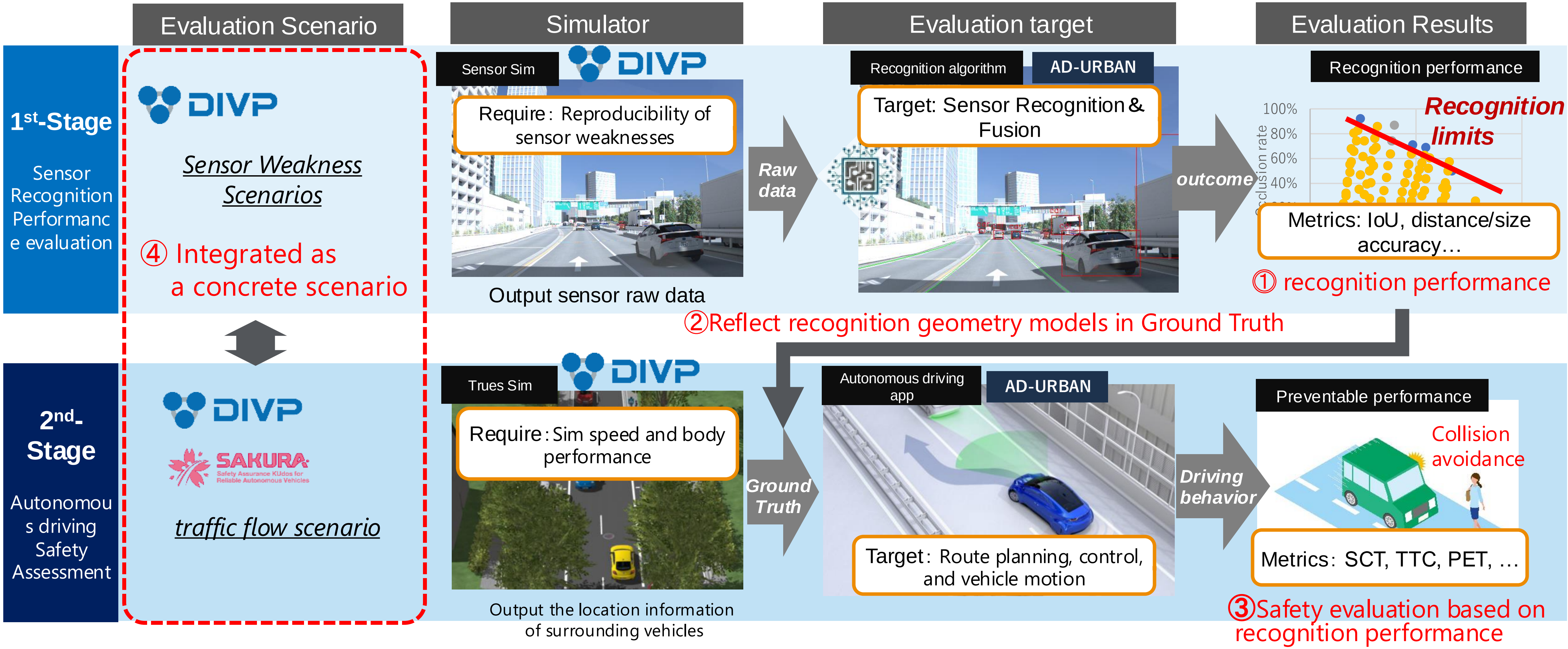
Evaluation by extrapolation is possible

The overall recognition rate deteriorated with increasing rainfall in DIVP® simulation.

- Undetected due to shielding by raindrops
- Misrecognition due to color change, etc.

2-Stage evaluation framework by DIVP, AD-URBAN and SAKURA collaboration.

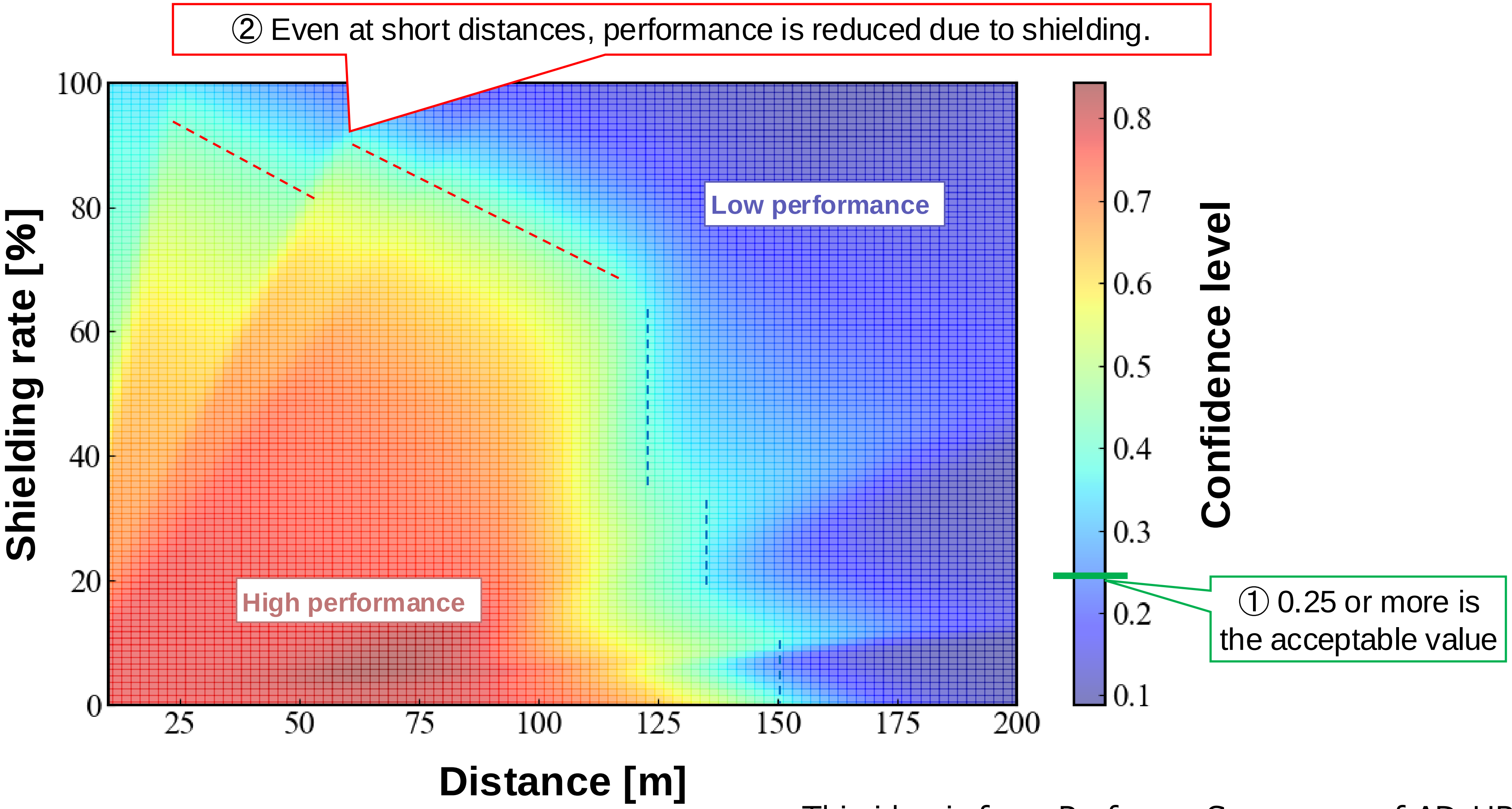
Establishment of evaluation framework and metrics



SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles AD-URBAN DIVP

By calculating the recognition (& limit) performance for each generated scenario by DIVP-1st stage, the load on the input data for the true value simulation (2nd stage) is reduced.

Recognition performance model (LiDAR)



＊This idea is from Professor Suganuma of AD-URBAN.

By connecting the 1st-stage to the 2nd-stage using the integrated scenario obtained from the FOT use case, it is possible to evaluate the ADS avoidance behavior based on recognition performance.

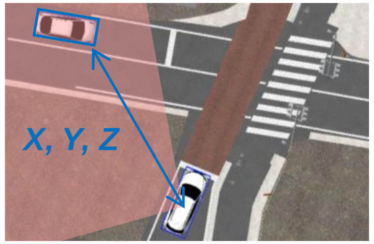
2nd-stage : Assessment of ADS avoidance behavior

Legend
- : Ego-ADS.
- : Undetected-V.
- : Detected-V
- : shielding buildings
- : Blind spot

Integrated scenario from FOT use case

Relative distance and direction of target object

Intersection with no traffic lights



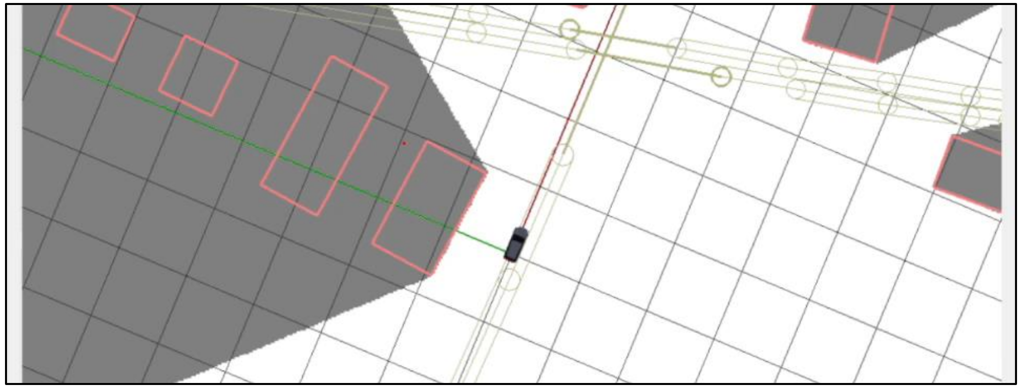
Target object shielding rate

Target vehicle color

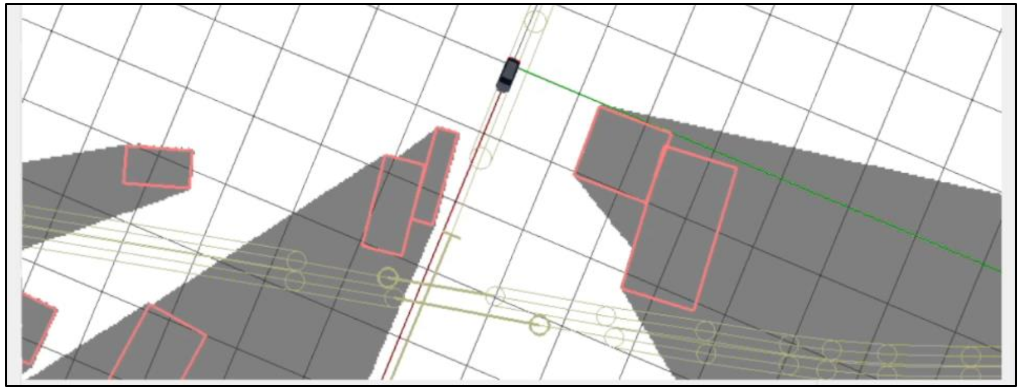
Date, time, weather

Though 1st-stage recognition performance

ADS avoidance behavior based on recognition performance



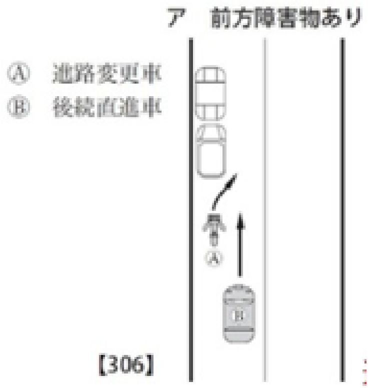
A. Passing through the intersection, avoiding crossing vehicles



B. The ADS got stuck because it couldn't recognize the crossing vehicle due to the lack of contrast between the building and the shadow.

SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles AD-URBAN DIVP

Reproduction of simulation examples of accidents at intersections with good visibility that could not be recognized due to backlighting, fatal bicycle accidents, etc. → Possible to study how to respond to such accidents.



Dynamic accident reproduction by DIVP simulation

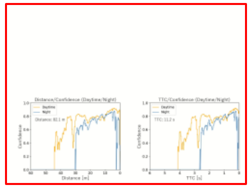
intersection accident reproduction with good sunny weather, but with backlit

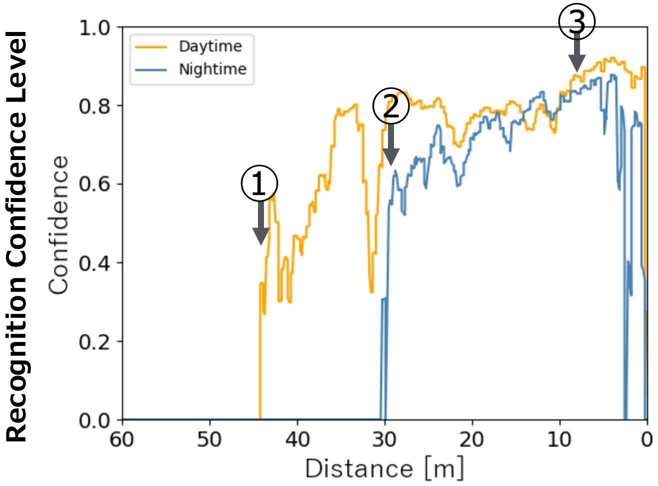
Reproduction of a fatal bicycle accident at night

DIVP simulator can reproduce accidents in dynamic digital space from static accident information
→ Allows evaluation of geometry risk avoidance performance as TTC from the sensor's recognized position

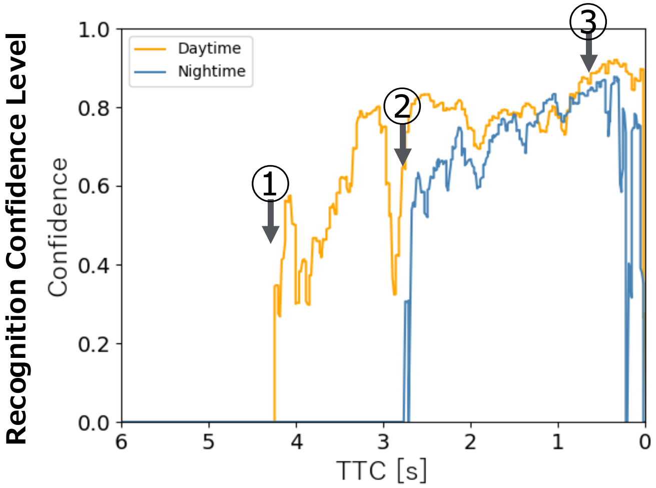
Dynamic accident reconstruction from fatal accident information

Relative distance from pedestrian to ego-vehicle





Time to Collision from pedestrian to ego-vehicle

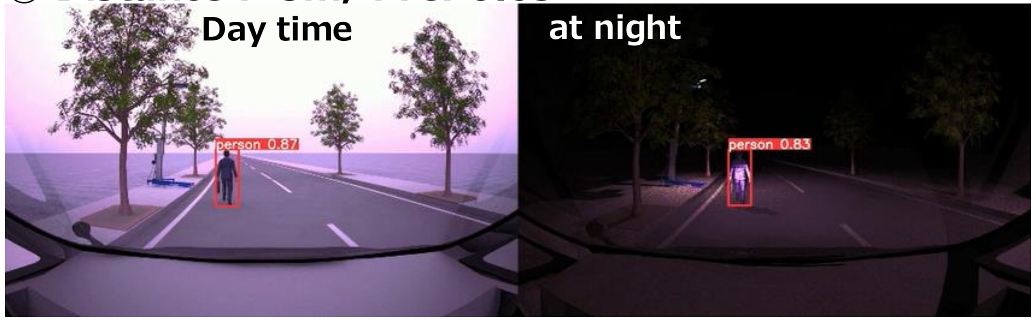


TTC; Time to Collision

① Distance: 44m, TTC: 4.1s

② Distance : 30m, TTC: 2.6s

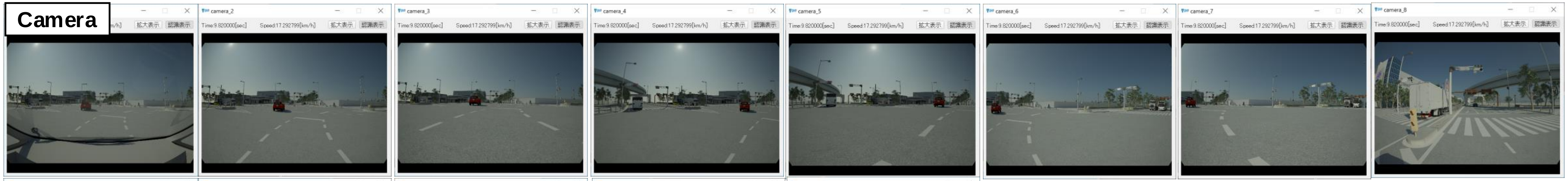
③ Distance : 8m, TTC: 0.6s

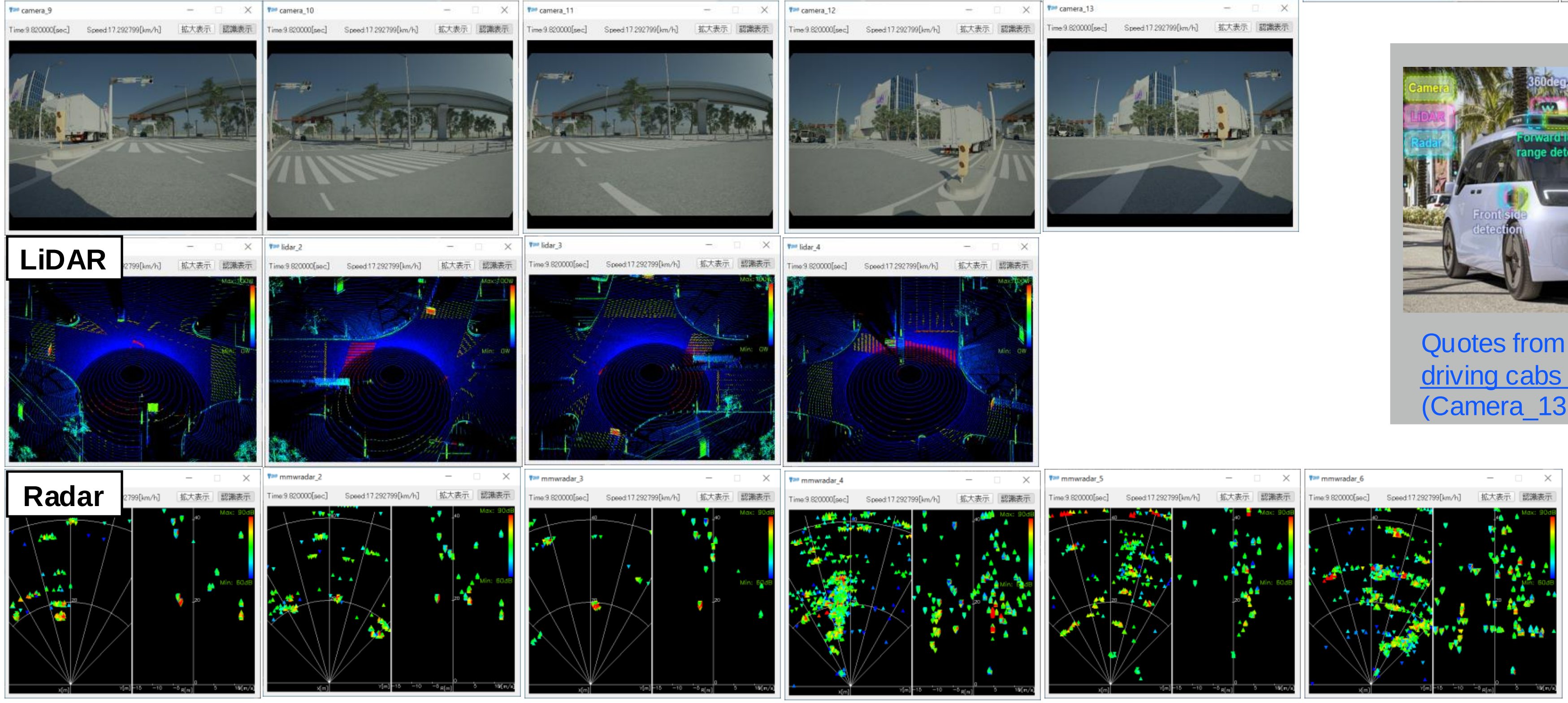


SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles AD-URBAN DIVP

The new DIVP platform enables high-capacity, high-speed multi-sensor calculations in the cloud. Local GPU multi-layer parallel computing environment is also supported.

Development of new DIVP platform; 13 cameras, 4 LiDAR, 6 radar, total of 23 sensors can run simultaneously





Quotes from the Waymo, sixth generation of self-driving cabs with advanced sensors- Impress Watch (Camera_13, LiDAR_4, Radar_6)

Agenda

1. Outline of ADS safety assurance initiative in Japan

2. DIVP (Driving Intelligence Validation Platform) for ADS safety assurance

3. Virtual FOT applications collaborated with the ADS-FOT projects

4. Summary

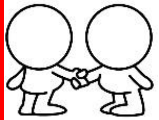
In Japan, the Safety assurance project supports the development of the RttL4 project with virtual simulations. Examples of the implementation of Theme 4 are presented here.

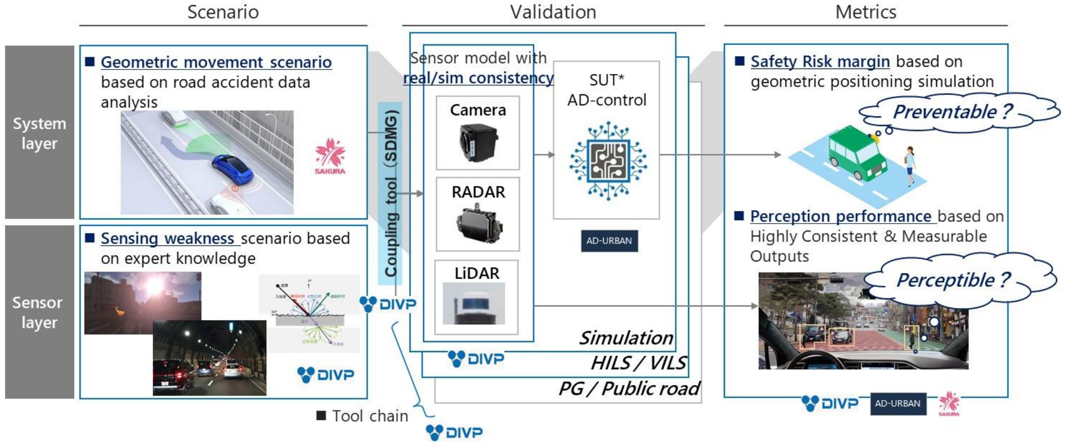
Real & Virtual ADS-FOT through collaboration between the RttL4 and ADS-safety assurance project

MLIT Ministry of Land, Infrastructure, Transport and Tourism

METI Ministry of Economy, Trade and Industry

RoAD to the L4 FOT project (Real)





SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles | AD-URBAN | DIVP

Simulation project (Virtual)

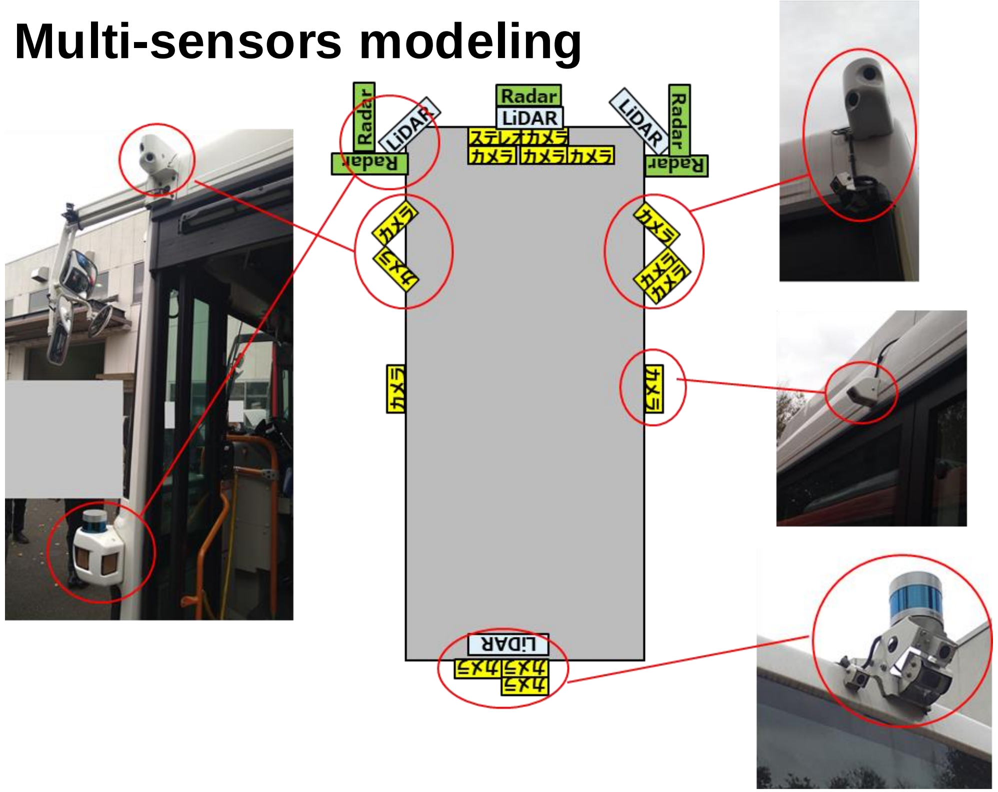
SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles | AD-URBAN | DIVP

DIVP is utilized in the development of object recognition algorithms through AI learning

Create bus and multi-sensor models by DIVP simulation

Bus shape model

Multi-sensors modeling

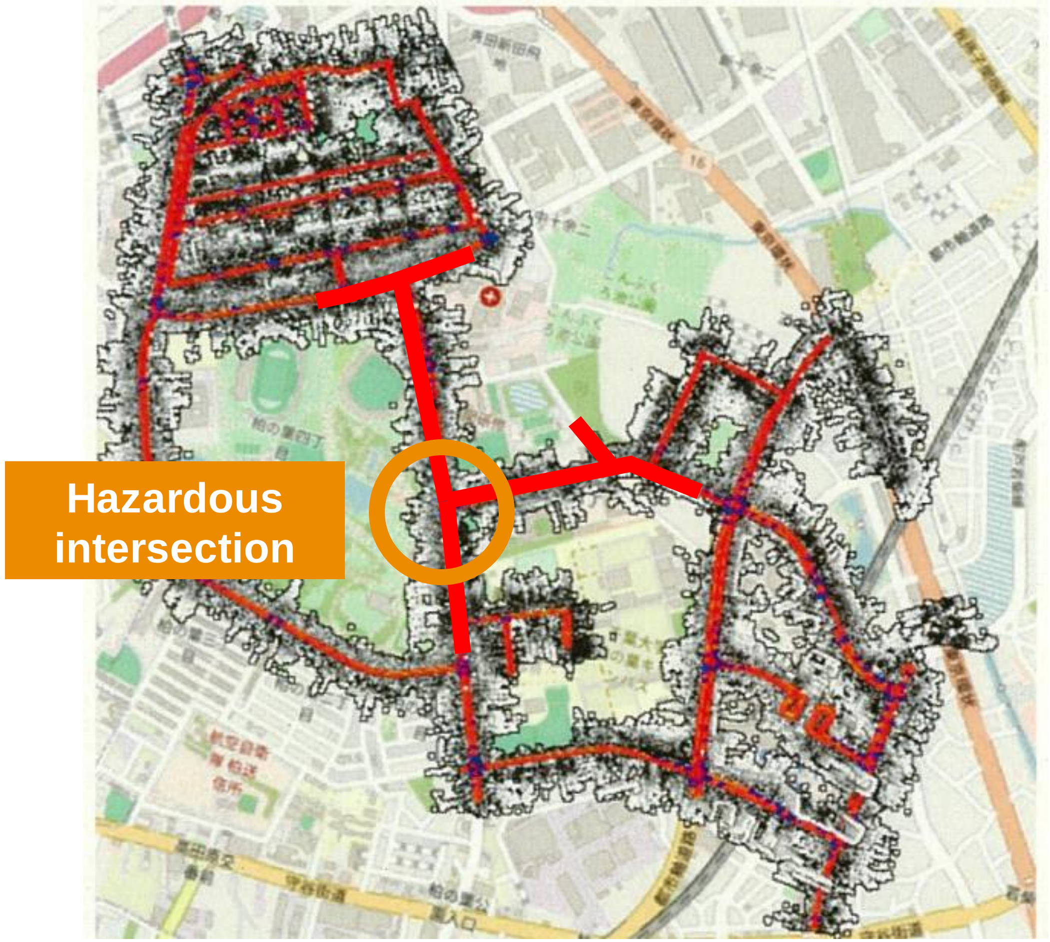


- Camera;9 （Fisheye; 4 → Rear side detection)
- LiDAR;4
  (Distance measurement by fusion of LiDAR and camera)

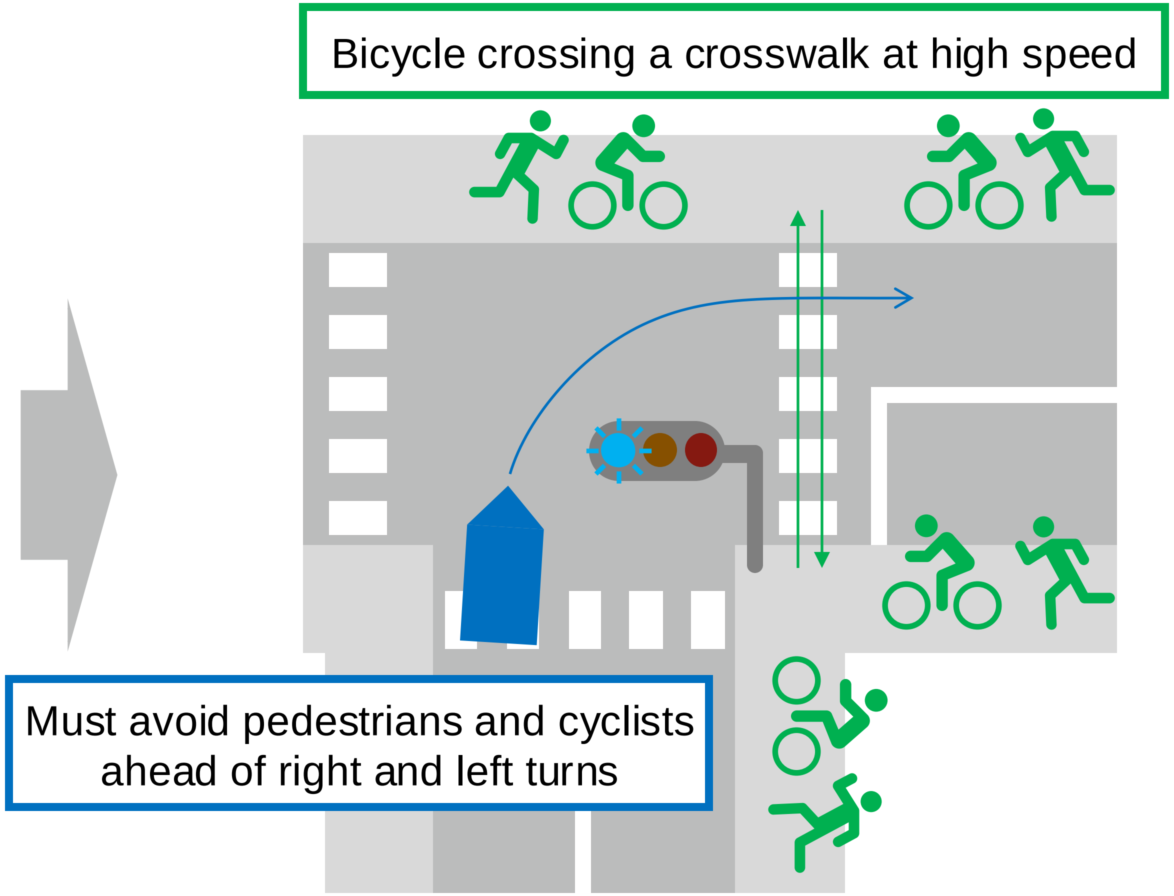
The ADS developer and we collaborated on a virtual simulation to determine how to avoid the hazards identified in the ODD risk assessment.

ODD risk assessment identifies hazardous use cases

Creating 3D spatial models from MMS measurement



Generate concrete scenario models based on hazardous use cases

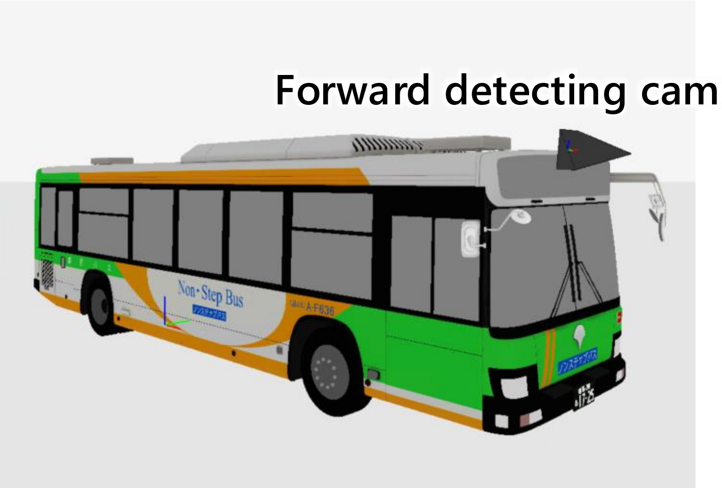


The camera cannot recognize a bicycle that runs across the street from a street tree and crosses a pedestrian crossing until it is very close to the bus.

Hazardous use case (1) : Turn right and left at T-intersection

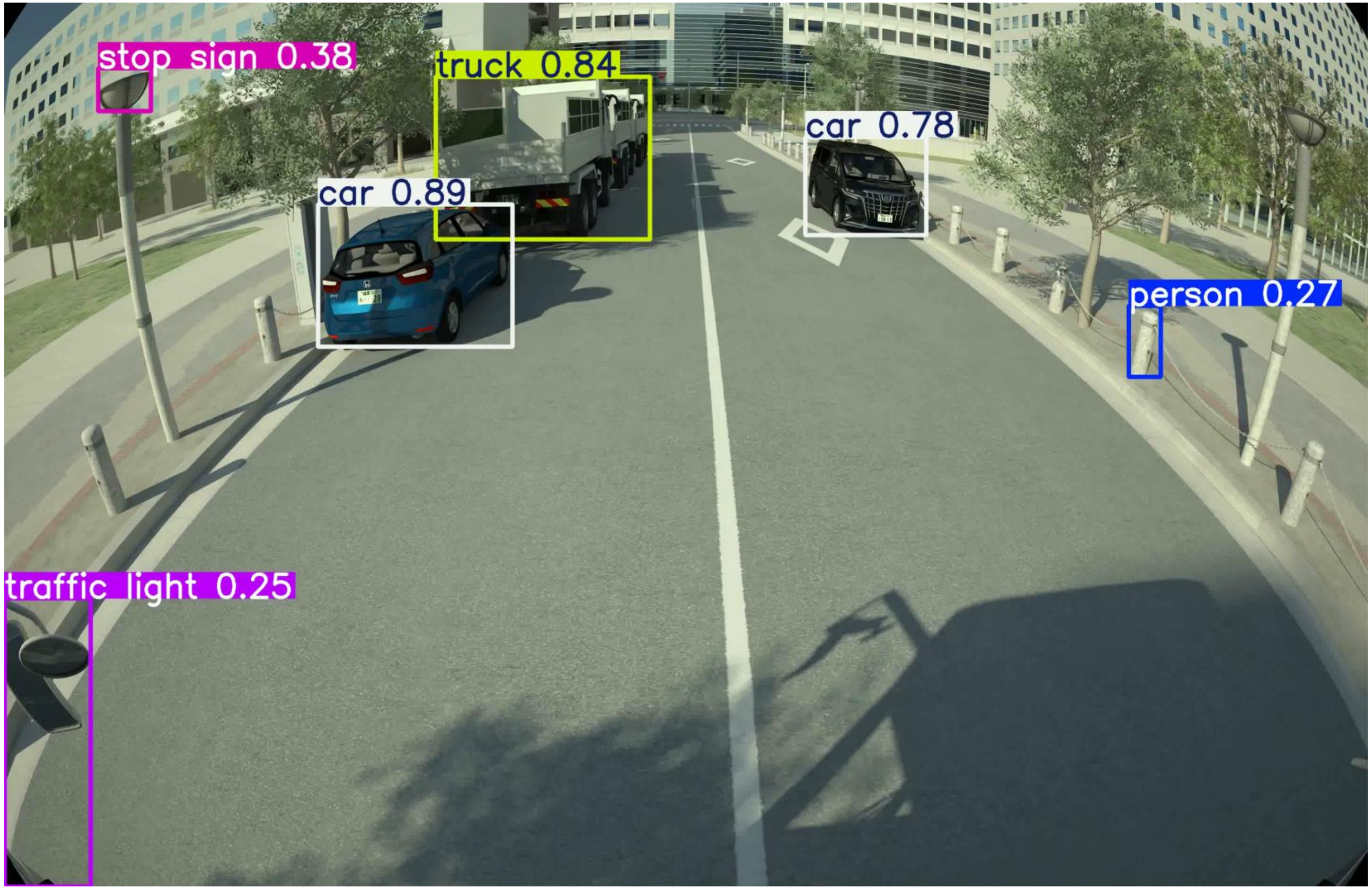
Using “Yolo v8” as a recognition algorism

Camera mounting position



A camera view mounted high on the bus is effective and allows early recognition of children flying out. However, there are cases where children and roadside poles are misidentified.

Hazardous use case (2) : Pedestrians and children dart out of parked trucks and passenger cars



Using "Yolo v8" as a recognition algorism

SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles AD-URBAN DIVP

The DIVP project supports the development of the RttL4 Theme 3 ADS-FOT, trucks logistics. The collaboration is presented here.

Real & Virtual ADS-FOT through collaboration between the RttL4 and ADS-safety assurance project

MLIT Ministry of Land, Infrastructure, Transport and Tourism

METI Ministry of Economy, Trade and Industry

Team1:Eiheiji-cho(L4)

- 鉄道廃線跡地の自転車歩行者専用道路を自動運転車両の走路として通行許可承認取得
- 木々の深い山間の走路のため、電磁誘導線を用いた小型電動カートを活用
- 1人の遠隔監視・操作者が３台を運行可能なレベル３の自動運行装置の認可を日本初で取得し、2021年3月から無人自動運転移動サービスとして事業運行中

Team2:Hitachi BRT

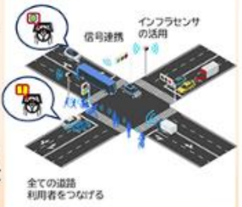
- 鉄道跡地をバス専用道路空間として整備
- 一般車両や自転車などが混在しない
- 時間帯顧客別にダイヤを構成。朝夕は駅への通勤・通学利用が多く、日中はスーパーなどを沿線住民が利用

Team3:Truck logistics in NewTomei highway (L3/L4)

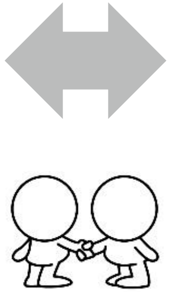
- 日本の大都市間（東京～名古屋）を接続する高速道路
- 従来の東名高速道路に並行し、現在、6車線化（片道3車線）の整備が進む
- 路車間通信（V2I）実証実験も予定

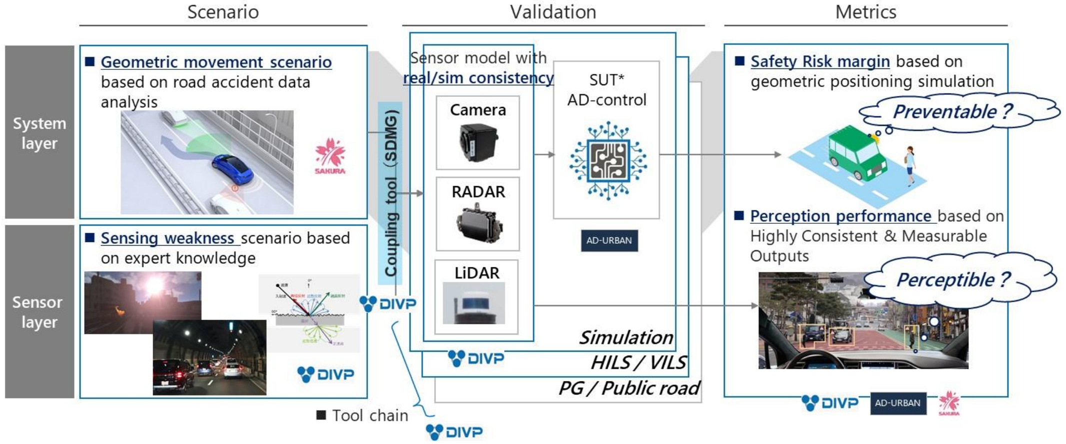
Team4:Kashiwanoha Bus (L4+V2X)

- 東京大学、がん研究センターなど拠点施設が存在する再開発エリア
- 「柏の葉スマートシティコンソーシアム」として、地域の移動需要を多様なデータ（プロー ブデータなど）から把握・予測し、MaaS展開を見据えた情報基盤を構築



RoAD to the L4 FOT project (Real)





SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles   AD-URBAN   DIVP

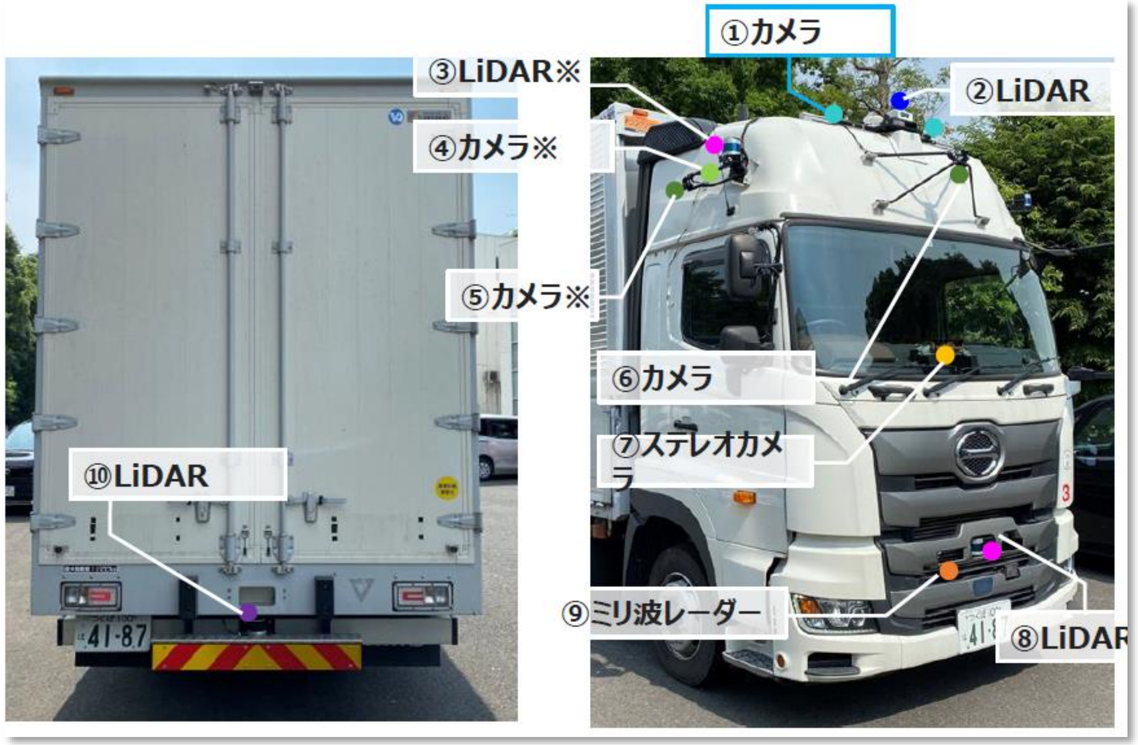
Simulation project (Virtual)

RoAD to the L4   DIVP

Near miss data including hazardous factors are extracted from measured data of highways from the truck's point of view. Hazardous events peculiar to truck driving are typified and data are accumulated.

Collaboration with Road to the L4, Team3: ADS-truck logistics in highway project

ADS-FOT Truck



Examples of hazardous events encountered in past highway demonstrations

Matchmaking at merging

reversing vehicle

Nighttime, shoulder stop Large vehicles

Motorcycle passing through

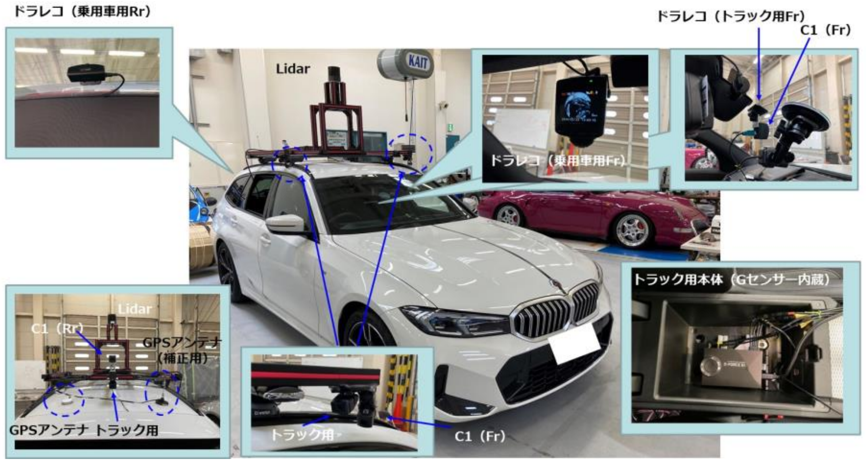
Source : 先進モビリティ(株)提供資料より

RoAD to the L4 DIVP

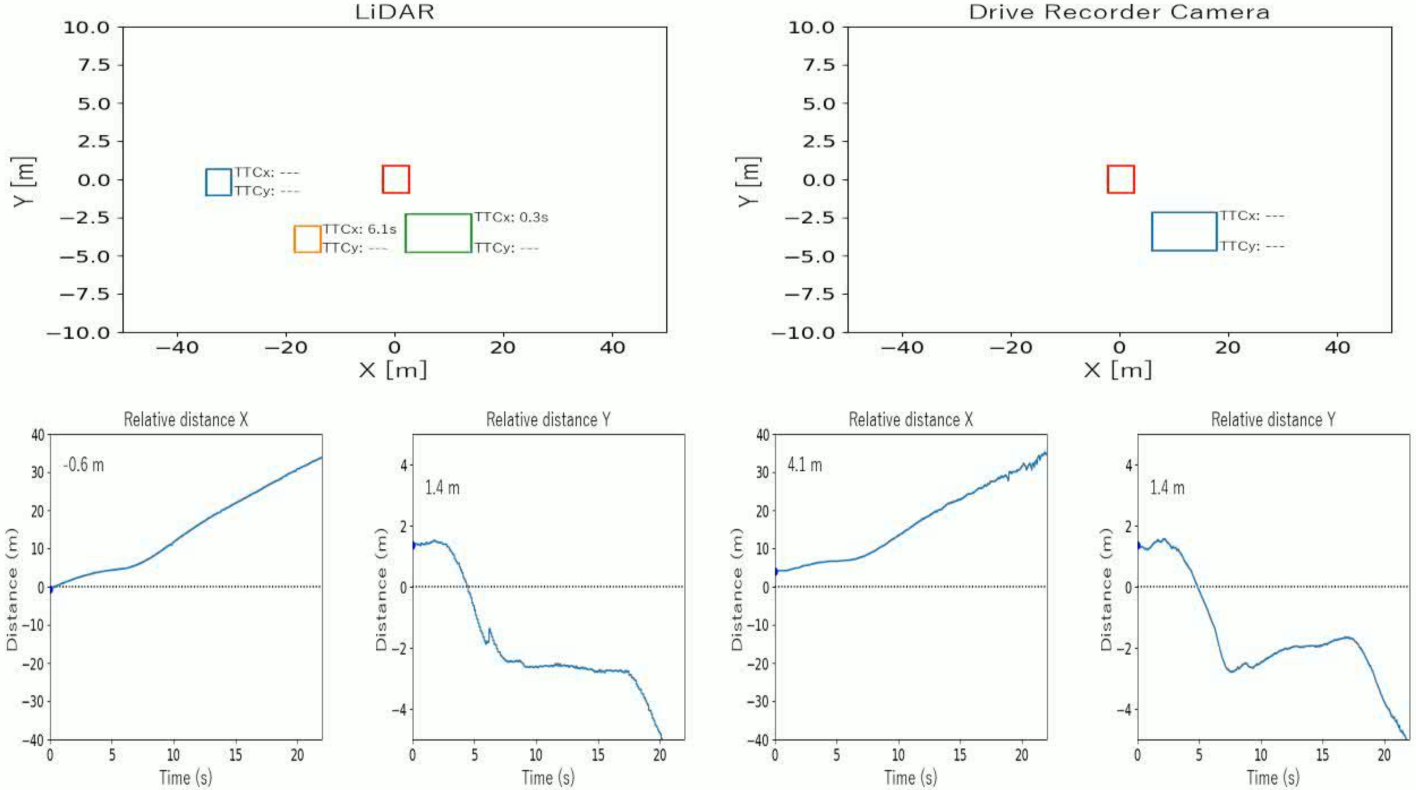
Extraction of driving behavior of surrounding vehicles from drive recorder camera images.

It was verified that camera image recognition can measure the movement of vehicles in the vicinity as well as LiDAR up to 50m in the vicinity.

Deployment of simple measurement with drive recorders on general trucks



KAIT Measuring Vehicle



Calculate the frequency of occurrence of near-miss levels (incident H, M, L) using the “Safety Cushion Time : SCT” metrics.

Simulation generates traffic flow assuming a merging point

例：第2東名清水IC（※NEXCO中日本H30・R2）
本線：51,200台（一日平均）
合流：17,930台（一日平均）
→　交通流　本線：2,133台/hr，合流：747台/hr

Using
PTV Vissim

Calculate the frequency of occurrence of near-miss levels (incident H, M, L) using the "Safety Cushion Time : SCT" metrics.

Risk assessment using "Safety Cushion Time : SCT" metrics

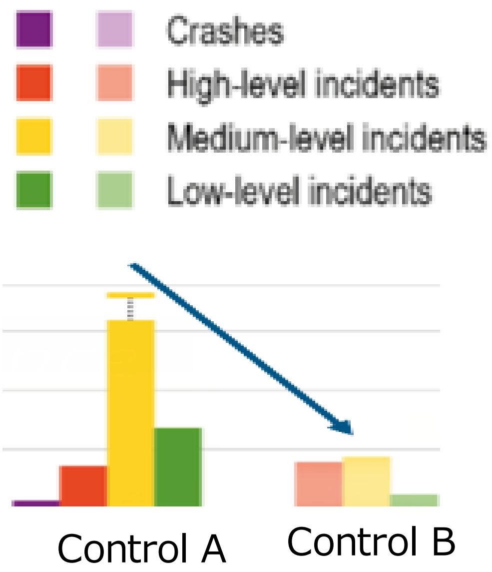
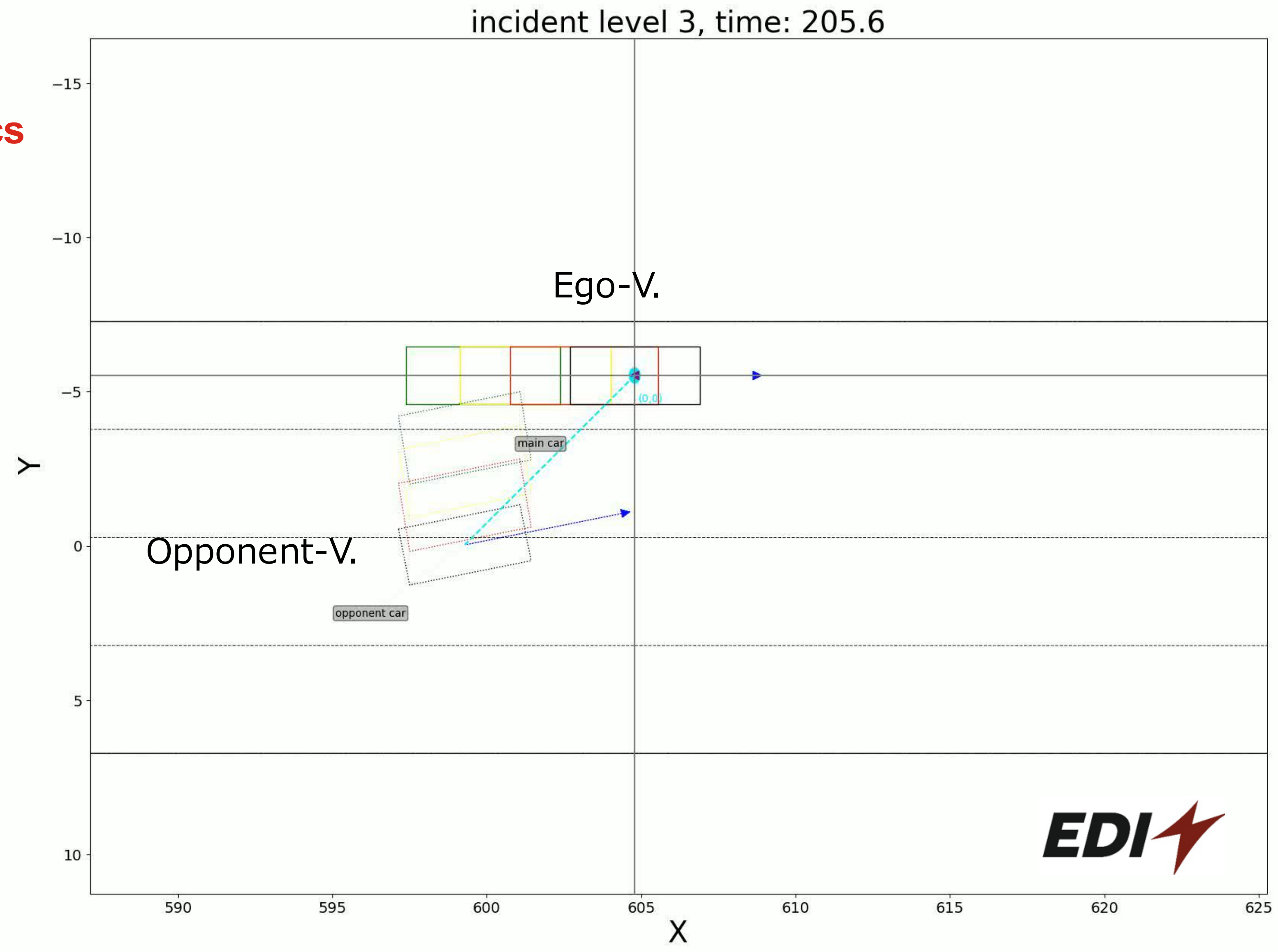


Image diagram; Frequency of Crashes/Incidents(High/Medium/Low)



Scenario data set from geometry risk assessments is extended to include perception risk requirements such as weather conditions. → Reflected in ODD, ADS

DIVP use extended to perceptible risk scenarios such as weather and poor visibility conditions

Agenda

1. Outline of ADS safety assurance initiative in Japan

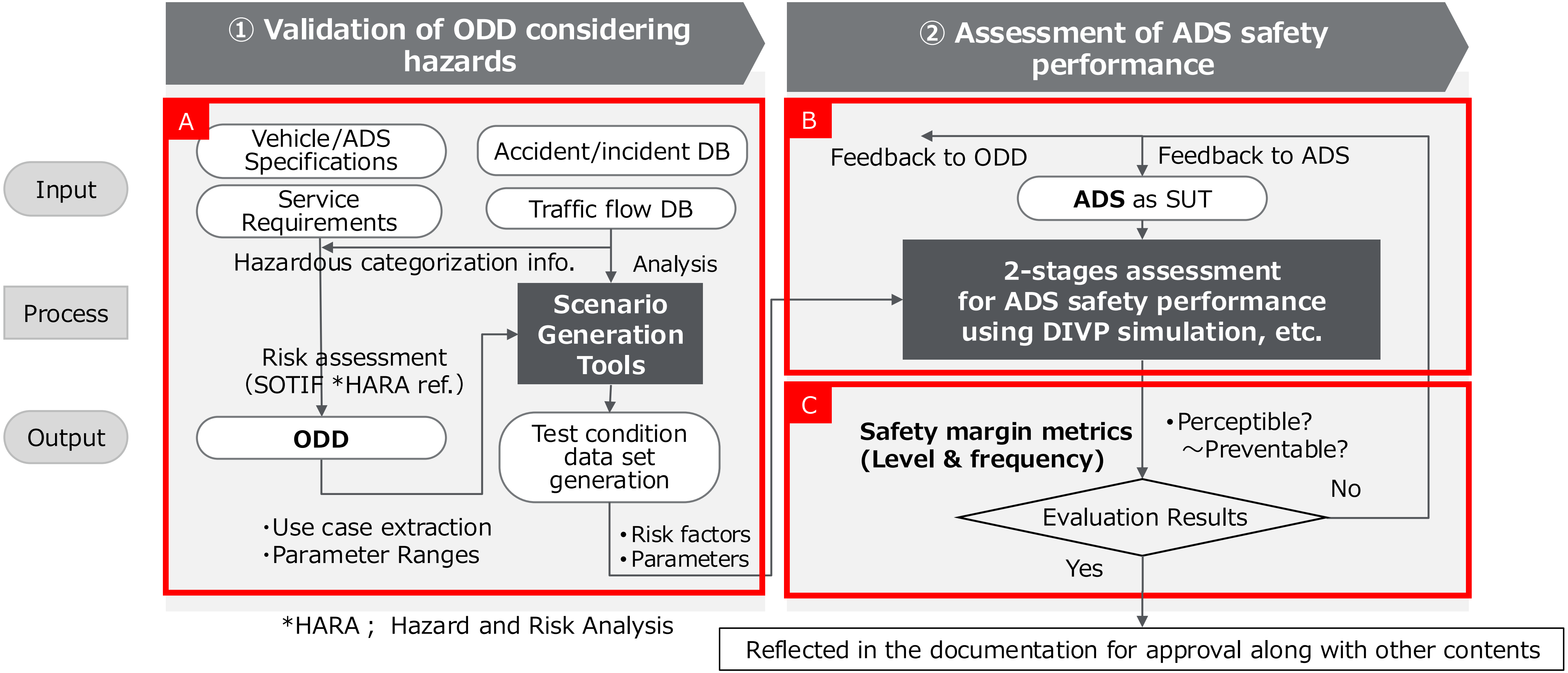
2. DIVP (Driving Intelligence Validation Platform) for ADS safety assurance

3. Virtual FOT applications collaborated with the ADS-FOT projects

4. Summary

We have developed a safety assessment framework using simulation, which will be reflected in the development of the ADS(L4) regional project. we will verify the practicality of the framework in cooperation with each FOT.

Safety Assessment Framework draft for ADS regional FOT in Japan



*HARA； Hazard and Risk Analysis

*reference to ISO34502 and ISO21448

SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles | AD-URBAN | DIVP

	national project	ministry in charge	Executing Agency	Main Research Areas			Applicable FOT		remarks
				A. ODD/ Scenario	B. Validation PF	C. Metrics	Highway	Urban	
①	ADS-safety assurance project	METI 自動車課	DIVP SAKURA AD-URBAN	(A4) Gen.AI ○ (A3)Scenario generation tool chain（SDMG） VRU behavior model	(B1)DIVP approval ○ (R&D) (B2)SUT requirement	(C1) metrics validation & implementation (C2)Safety & traffic compatibility ○ (B2)Risk metrics (safety cushion time)	－	**柏の葉FOT** RttL4 **Team4 collabo.** (A1)Pipeline validation	■ モビリティDX連絡会安全性評価戦略WGへ報告
②	SBIR; Small and Medium Enterprise Innovation Promotion	MLIT 自動車局	TierⅣ DIVP （KAIT/BIP./ﾃﾞﾛｲﾄ）	○ (A1) Pipeline	(Application)	○	－	**塩尻FOT**	■ TierⅣ_塩尻DBとデータ連携／TierⅣSim.～DIVP Sim.の結合 ■ 塩尻FOTの安全性評
	project	自動車課	DIVP （BIP. /KAIT/ﾃﾞﾛｲﾄ）	(A2) data accumulation & Hazard Event Categorization		(C1) Risk metrics (safety cushion time)	**沼津～浜松** (A1) Pipeline validation in highway		■ トラック業者でのヒヤリハットデータ収集
④	Digital National Comprehensive Maintenance Plan (data structure)	digital agency METI情経課	DMP NTT DATA DIVP （BIP./KAIT) （TierⅣ連携）	○ (A2) data accumulation	(Application)	○	新東名 沼津～浜松	－	■ 高速道でのバーチャル安全性評価の実施 ■ データ連携基盤の構築
⑤	L4 Legal requirement formulation study	MLIT 自動車局	デロイト (東工大/筑波大/KAIT/MPC)	○ (A2) Hazard Event Categorization	(Application)	(C1) Logic Validation of metrics (Formulaization)) ○	－	(○)	■ リスクアセス，ODD＆L4認可の基盤要件の明確化

In FY2024, each national project is assigned R&D themes for issues in areas A, B, and C, and validation is conducted through ADS-FOT.

SAKURA Safety Assurance KUdos for Reliable Autonomous Vehicles　AD-URBAN　DIVP

DIVP

SAKURA
Safety Assurance KUdos for Reliable Autonomous Vehicles

AD-URBAN

METI
Ministry of Economy, Trade and Industry

MLIT
Ministry of Land, Infrastructure, Transport and Tourism

Thank you for your kind attention!

Tokyo Odaiba → Virtual Community Ground

END