



Driving Intelligence Validation Platform for Automated Driving Safety Assurance

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Weather Forecast



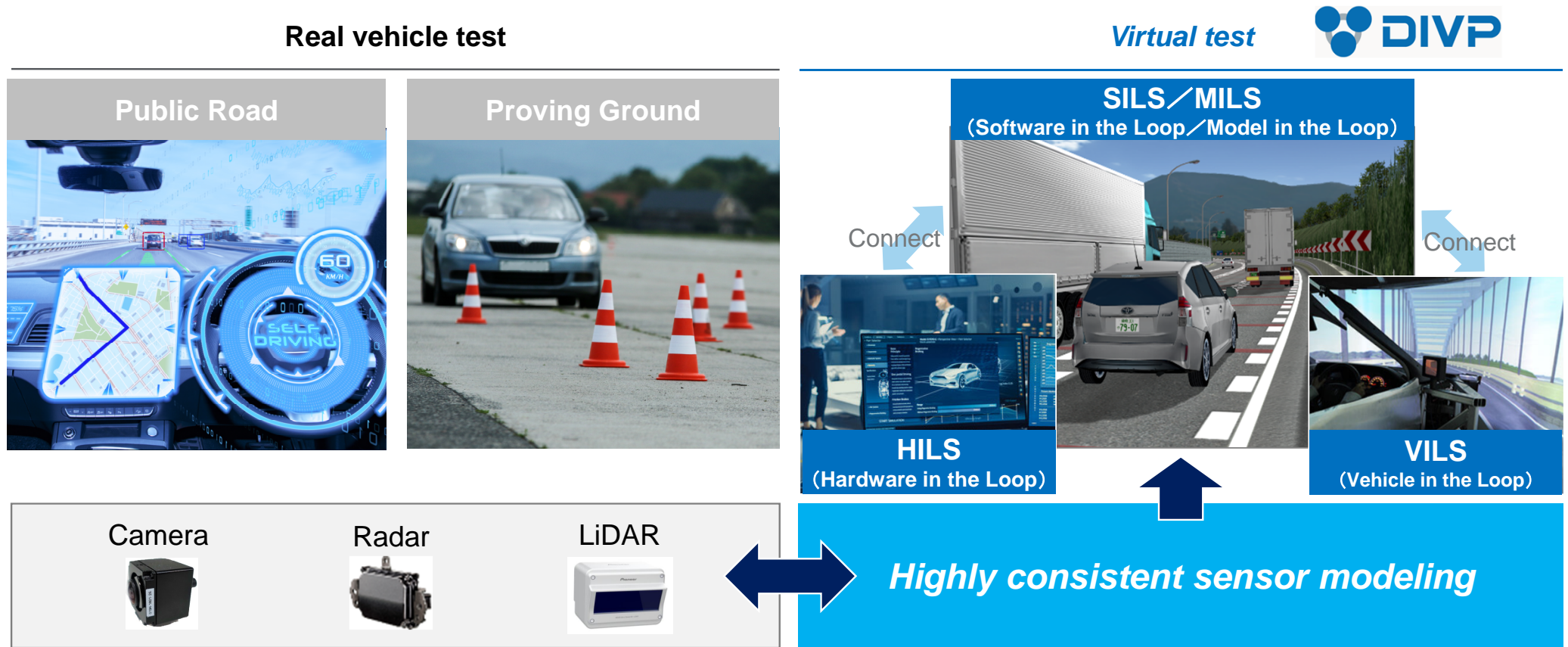
AD safety Assurance*



For Validation & Verification Methodology

Highly Consistent Sensor Modeling is a key enabler of virtual validation for AD/ADAS safety assurance, HCSM indicates environmental, spatial(ray tracing), and sensor models

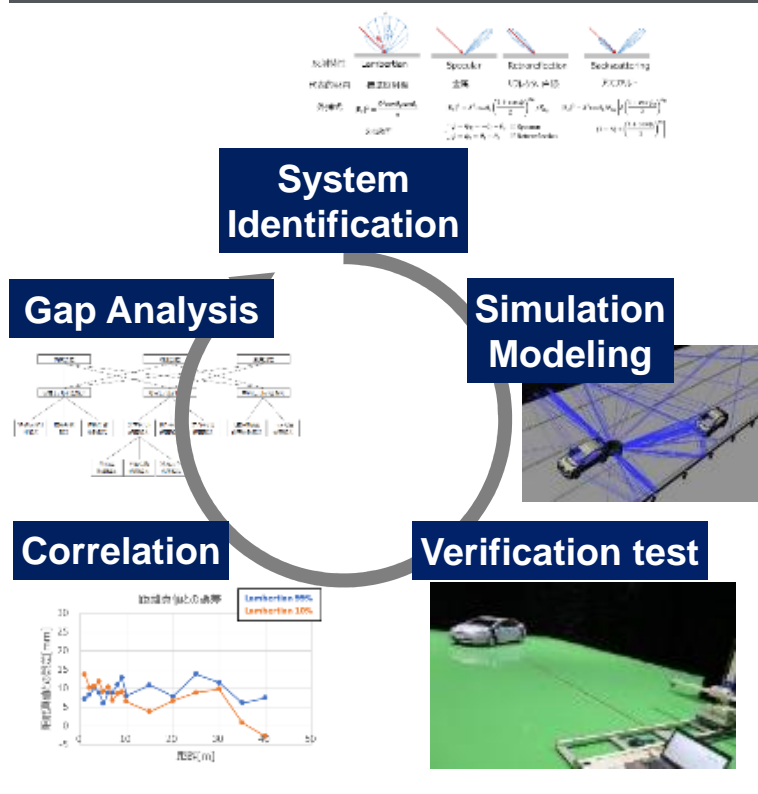
Motivation : Highly Consistent Sensor Modeling (HCSM)



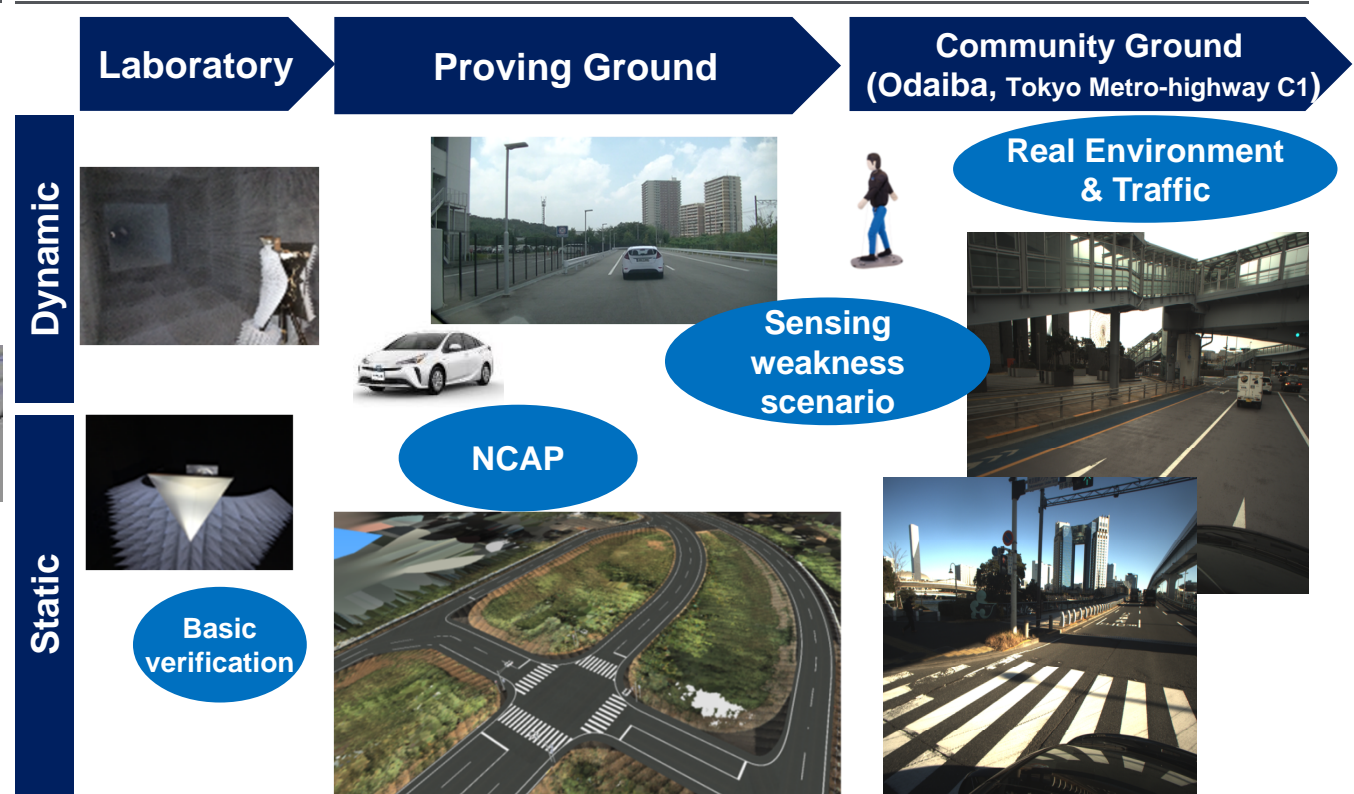
Measuring based modeling framework, DIVP[®] has developed Assessment scenario packages as Virtual-PG^{*1} & sensing weakness scenario packages in Odaiba as Virtual-CG^{*2}

Measuring based Modeling framework

Measurement based approach



Virtual space enhancement roadmap



*1 PG : Proving ground, *2 CG : Community ground
 Source : DENSO Corporation, SOKEN, INC, MITSUBISHI PRECISION CO.,LTD.
 DIVP[®] Consortium

Achievement

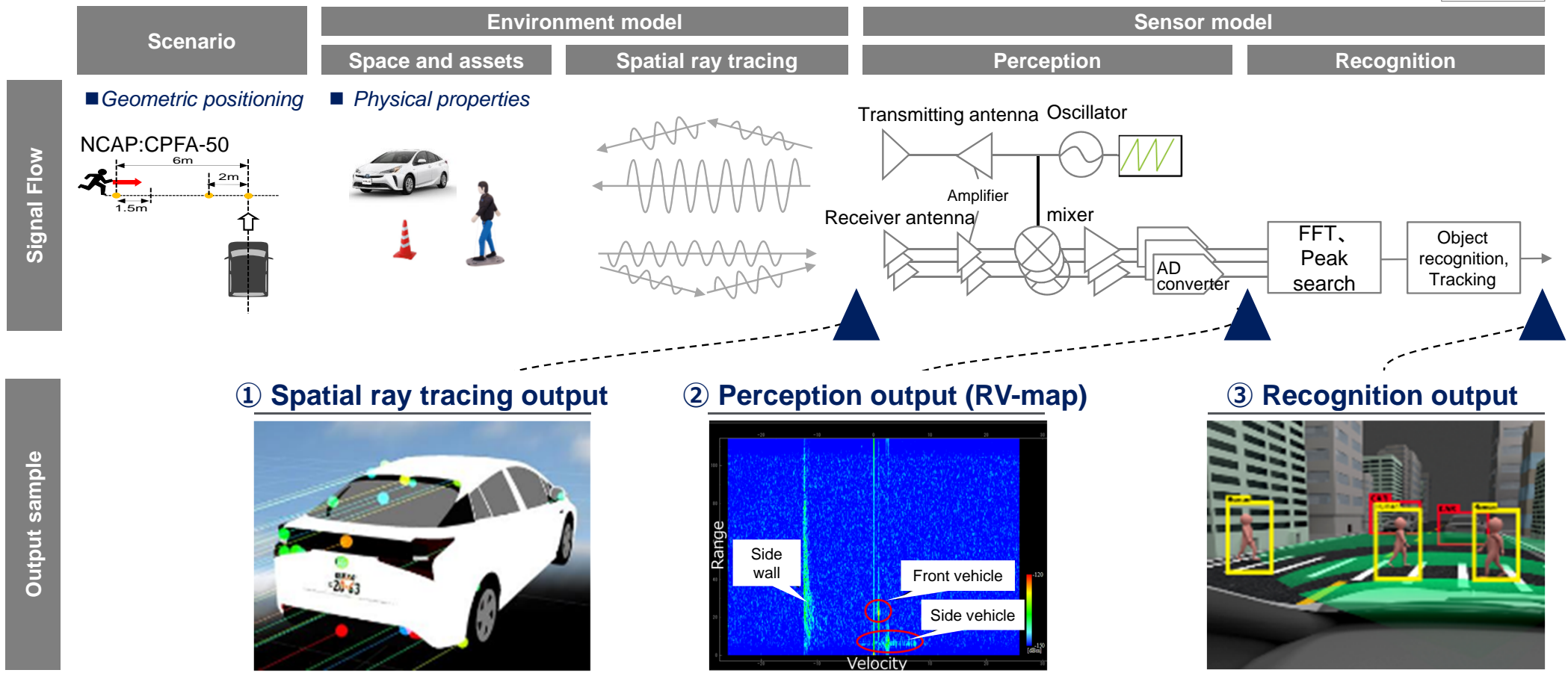
- Highly consistent sensor modeling

DIVP[®] models the sensing principle in detail and achieves highly consistency by verifying each individual module In-put / Out-put

■ Highly consistent sensor modeling

Sensor modeling (Radar)

Legend ▲ : I/F



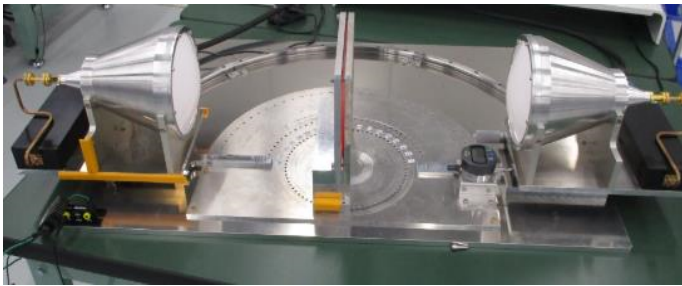
Precisely duplicated environmental and spatial models for sensor validation contributed by consistency verification using sensor perception and recognition outputs

■ Highly consistent sensor modeling

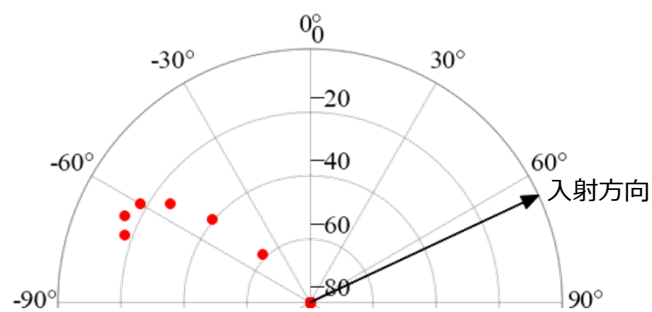
Radar output verification sample

Characteristic measurement

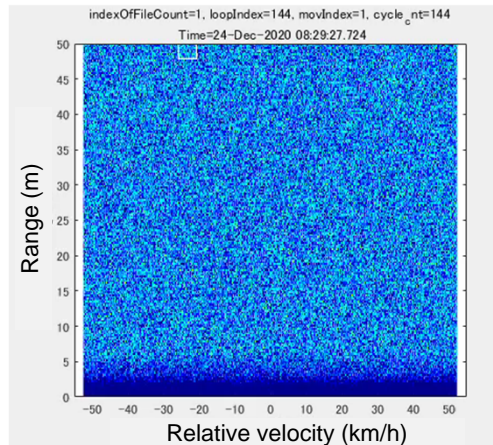
■ Surface characteristics measurement



■ Reflective properties

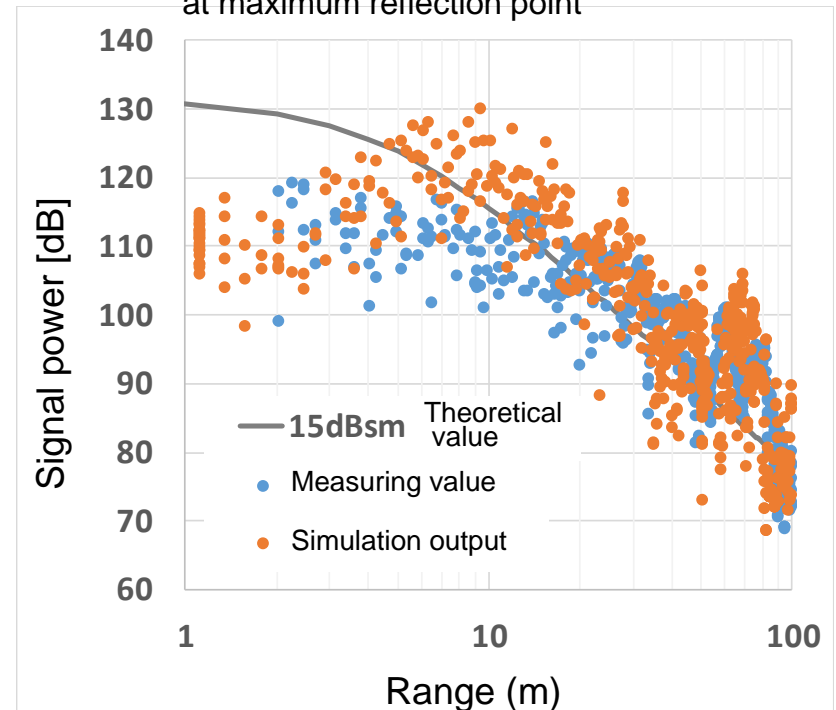


Real / Virtual simulation



Real/Virtual consistency verification

■ Example of signal strength comparison at maximum reflection point



Verified 20% deviation as Camera output Real to Virtual is similar to the actual Camera tolerances, means DIVP[®] is capable for sensor validation

■ Highly consistent sensor modeling

Camera Consistency verification result*

Real test result



SIM result (Clear sky)



Similar Brightness level

* 8bit in 24bit

Source : Sony Semiconductor Solutions Corporation, SOKEN, INC
DIVP[®] Consortium

DIVP[®] virtual space simulation for scenario packages

- Modelling for assessment scenario packages
- Modelling for Sensing weakness scenario packages
- Responding to user needs and expanding connectivity

Assessment scenario packages as Virtual-PG has realized some of Euro-NCAP protocols, and 80% of current Eur-NCAP protocol will be constructed in FY2021 as expansion plan

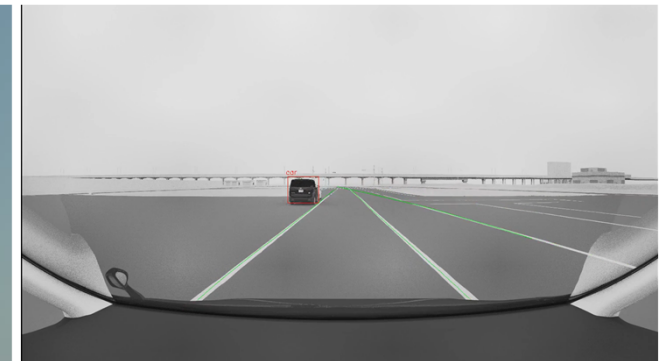
■ Modelling for assessment scenario packages

Euro-NCAP ; Pedestrian darting out scenario

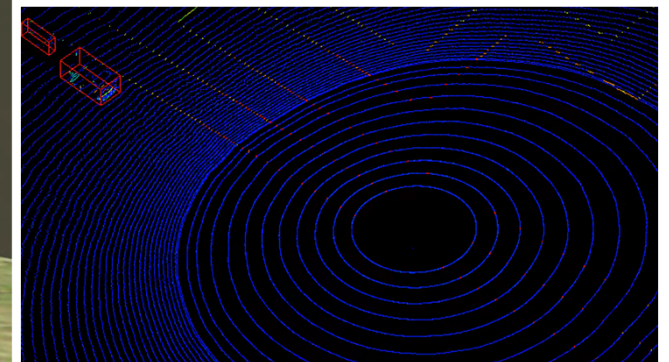
Pedestrian darting out scenario sim.



Camera sim.



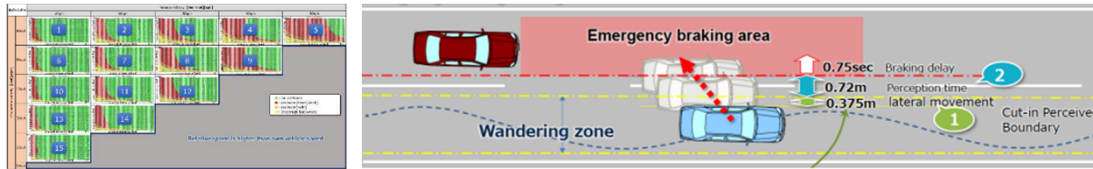
LiDAR sim.



ALKS cut-in scenario is capable for Camera, Radar & LiDAR assessment test

■ Modelling for assessment scenario packages

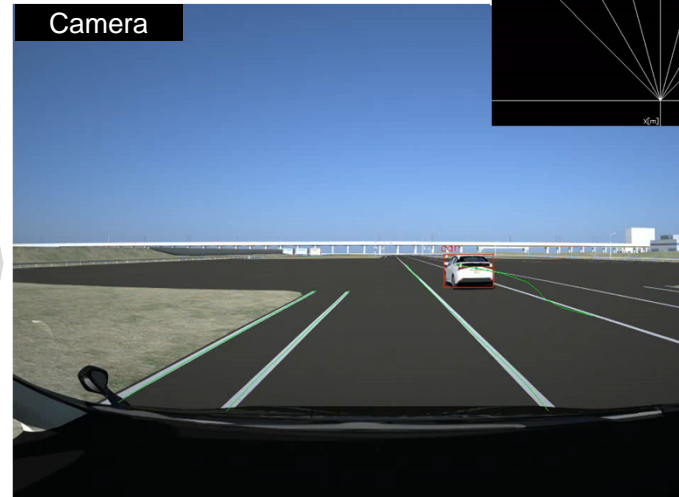
ALKS Cut-in Scenario Simulation



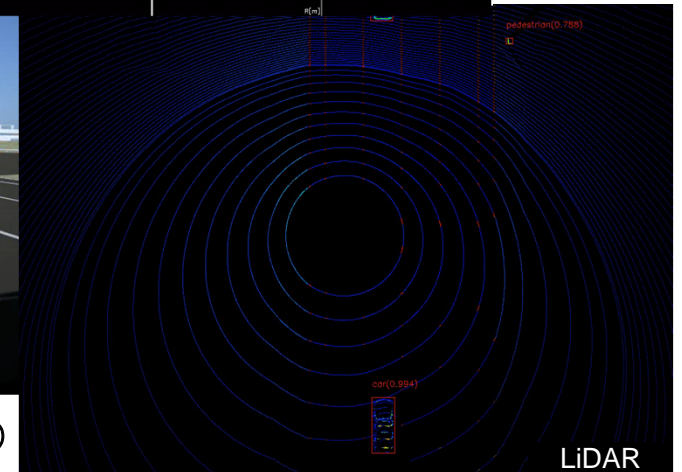
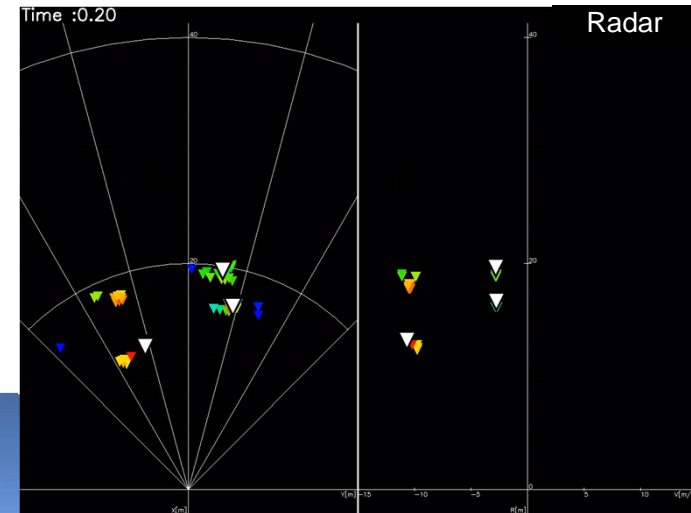
Concrete scenario (JARI/JAMA)



Scenario Simulation (Geometry)



Sensor simulations (Physical Property)

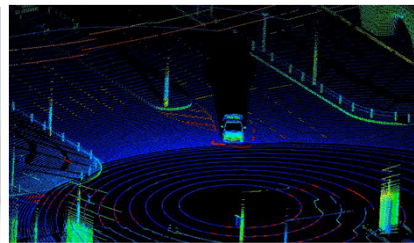


DIVP[®] simulation demonstration of AD virtual validation with sensing weakness scenario package on Odaiba & C1 expressway, is planned thru FOT in the Tokyo Waterfront Area

■ Modelling for Sensing weakness scenario packages

Scenario packages

Sensing Weakness Scenario Packages on Odaiba, C1



Various sensing weakness scenes

Hard-to-detect objects	Passing between adjacent vehicles	Black Leather Jacket	Black vehicle
	 Radar	 Camera LIDAR	 Camera LIDAR
	Upward structure	Low reflective road objects	Highly reflective road objects
Environment that affects reflection and propagation	 Camera LIDAR	 Radar	 Radar
	Backlighting, background light	Reflections on pronto glass	Rain condition
	 Camera LIDAR	 Camera	 Camera
	Blurred white lines	Thermal barrier painted road surface	Wall multi-path
	 Camera	 LIDAR	 Radar

Source : NEDO-HP <https://www.nedo.go.jp/english/news/ZZCD_100017.html>

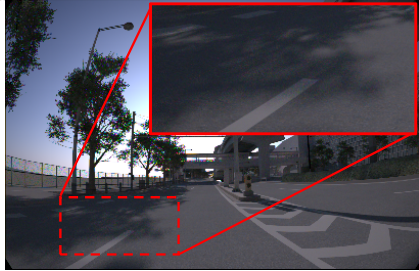





DIVP[®] Consortium

Approximately 20 sensing weaknesses scenario models in Odaiba and C1 express highway will be provided for user AD verification experience

■ Modelling for Sensing weakness scenario packages

Examples of sensing weakness scenarios (camera)

To be supplied: About 20 patterns (including variations)

Layer	White line misrecognition due to shadows of street trees	Reproducing the light distribution of traffic lights	Low floor carrier. Unrecognizable
Sample			<ul style="list-style-type: none"> ■ Wrong recognition of distance when recognized from behind 
L1:Road form	Near Odaiba Aomi Station (looking west) 	Odaiba Aume block 1 intersection 	North side of Tokyo International Exchange 
L2:Object/Transportation	White line, street trees	Traffic lights (red/blue/yellow/arrow/pedestrian)	straight road
L3:Temporary changes	-	-	-
L4:Moving objects	-	-	Low-floor carrier leading the front of vehicle
L5:Environmental conditions	Daytime	Daytime/Night	-

Duplicated tunnel model of Metropolitan expressway C1 enables evaluation of Radar multipath condition which is major concern of Radar robustness

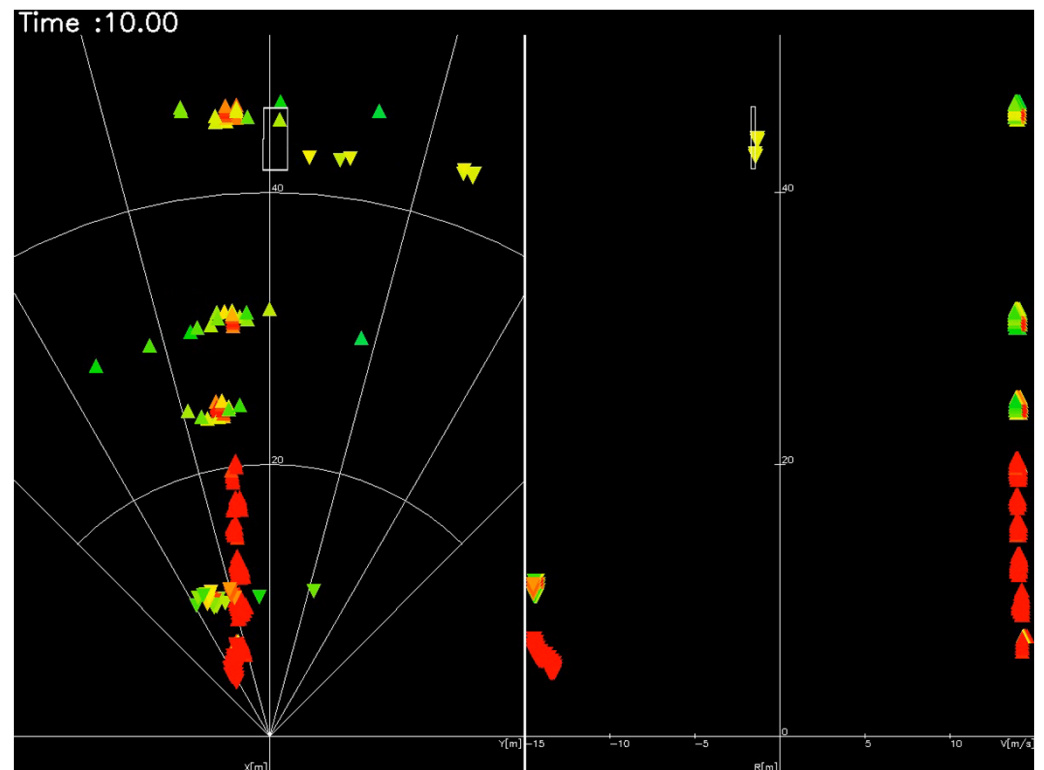
■ Modelling for Sensing weakness scenario packages

Metropolitan Expressway C1 Tunnel Simulation

Camera model view



Radar model view



Duplicated the effect of shade caused by sunlight, showing that camera recognition is particularly difficult when the white line is rubbed.

■ Modelling for Sensing weakness scenario packages
















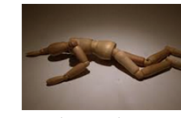


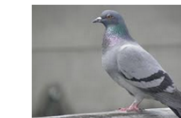
Odaiba, shadow effect from sunlight (blurred white lines)



In addition, DIVP[®] is promoting the expansion of a wide range of asset models to support various simulation validation needs

■ Modelling for Sensing weakness scenario packages

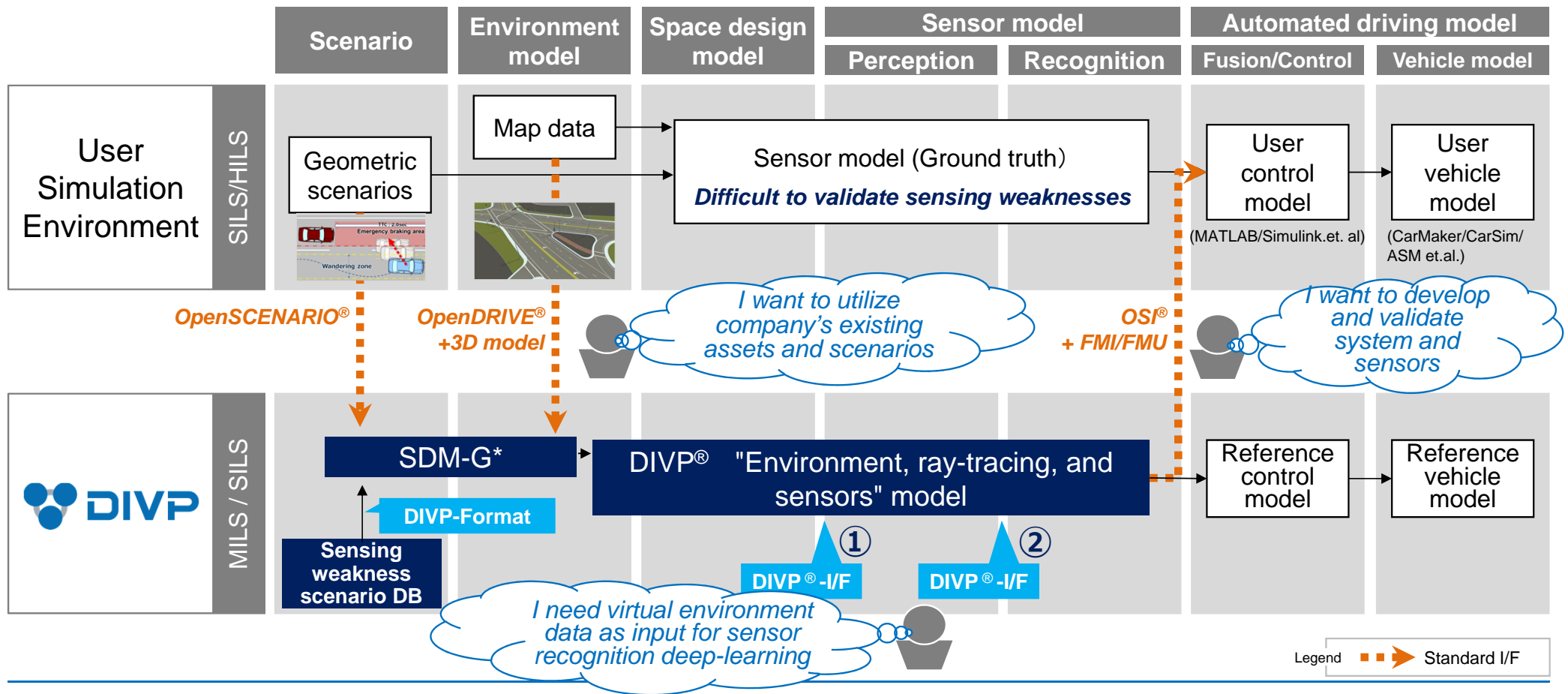
Examples of assets that are being prepared

Vehicle			Bike	Motorized bicycle	Bicycle	Pedestrian	...			
Large/Medium-sized vehicles	Large / small special car	Special vehicle	Large / normal two-wheeled vehicle	Type 1 / Type 2 motorized bicycle	Bicycle	Pedestrian	...			
									...	
hankyubus.co.jp	trafficnews.jp	amazon.com	gazoo.com	morita119.jp	kurashi-no.jp	yamaha-motor.co.jp	yamaha-motor.co.jp			
Bus	Tank truck	Road roller	Snowplow	Fire engine	Large motorcycle	Scooter	Children's bicycle	Adult * 12	Umbrella	
Truck	6t truck	Bulldozer	Military vehicle	Patrol car	Sidecar	Bike	Adult bicycle	Children * 5	Bag	
Semi-trailer	Truck-mounted crane	Agricultural tractor	Tram	Garbage truck	Big scooter	Specified motorcycle (tricycle)	Bicycle with children	Wheelchair	Black school bag	
Car carrier	Low floor trailer	Forklift	Segway	...			Road bike	Stroller		
Minibus	Logs flying from a light tiger	Excavator loader	Ambulance					With pets		
		Dump truck								
Construction equipment			Road obstacle			Other			...	
Signboard	Road security supplies	Illumination	Traffic guidance	Parked vehicle	Falling object	Other	Large animals	Small animals	Flying objects	...
										...
nogyo-shizai.com	search.rakuten.co.jp	item.rakuten.co.jp	sigotojob.biz		askul.co.jp	restlessmood.com		earthgale.ram.ne.jp	seikatsu110.jp	
Construction sign	Safety cone	Security light	Guide	Small car	Cardboard	Lying down	Boar	Cat	Bird	...
Tiger fence	Cushion drum	Beacon	Guidance robot	Large car	Board	Animal carcass	Deer	Raccoon dog	Soccer ball	...
	Barricade	Work light	Guidance display	Truck	Stepladder	Manhole	Large dog	Small dog	Drone	...
	Road pole			Accident car / Breakdown car	Utility pole	Flare light			Plastic bag	
	Cats eye				Fallen tree					

Responding to user needs, DIVP[®] is studying to ensure connectivity to various simulation environments to meet wider range of user needs for virtual simulation

■ Responding to user needs and expanding connectivity

Simulation types strategy(Co-Sim, connection)



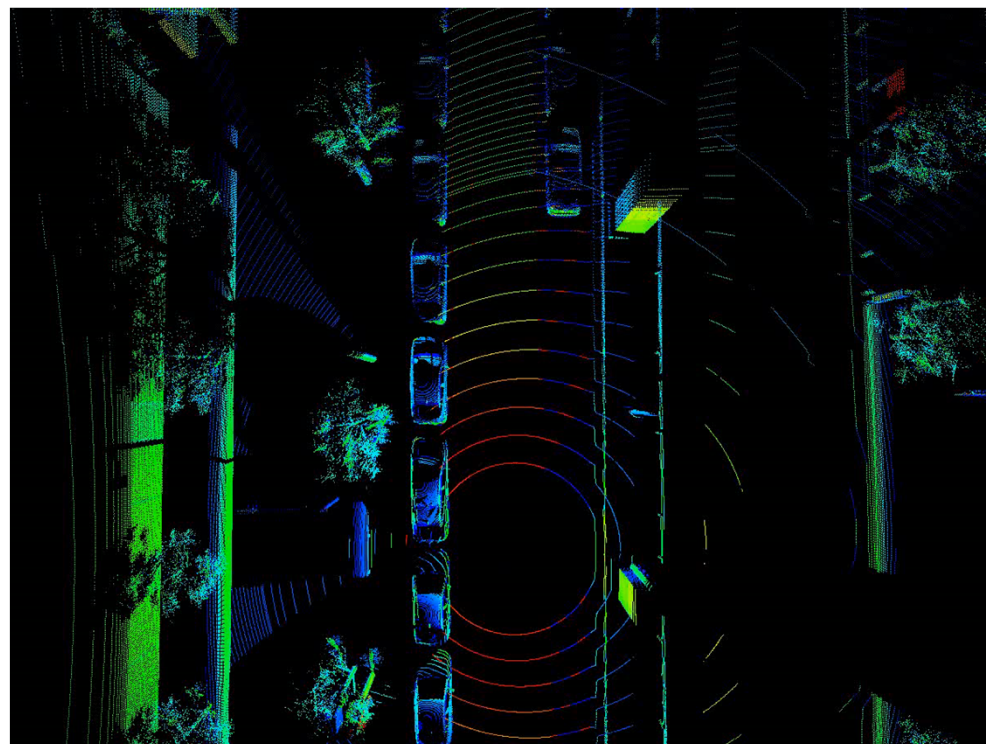
* SDM-G : Space Design Model Generator
DIVP[®] Consortium

DIVP® can duplicate adverse conditions that are difficult to set up in reality

■ Responding to user needs and expanding connectivity

Case Study at AD-URBAN (Kanazawa University project.)

Localizing Algorithm Robustness Verification using DIVP®



DIVP® duplicate number of parked vehicles scene which enable to validate the robustness of the localizing algorithm under severe conditions in virtually

※LIDAR Sim includes peripheral structures

Source : Case Study at AD-URBAN (Kanazawa University project)

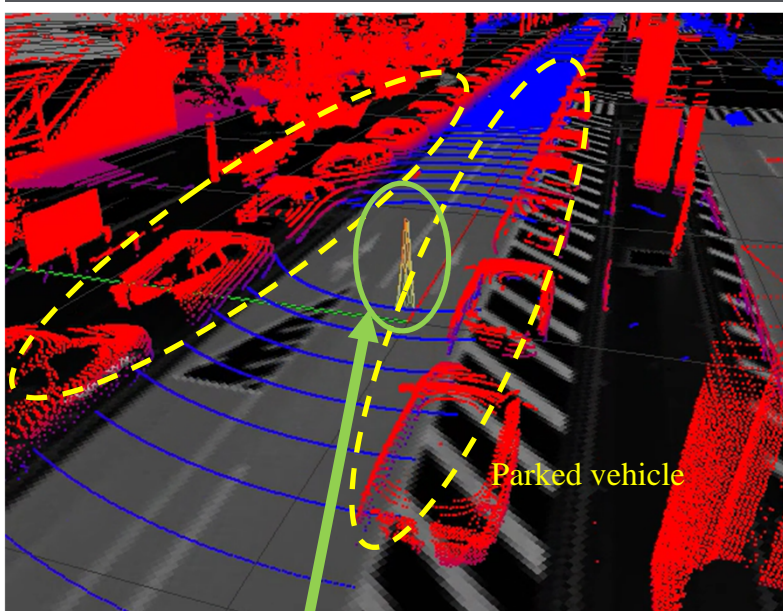
DIVP® Consortium

DIVP[®] is capable for algorithm robustness validation even in severe but difficult to real test conduction scene

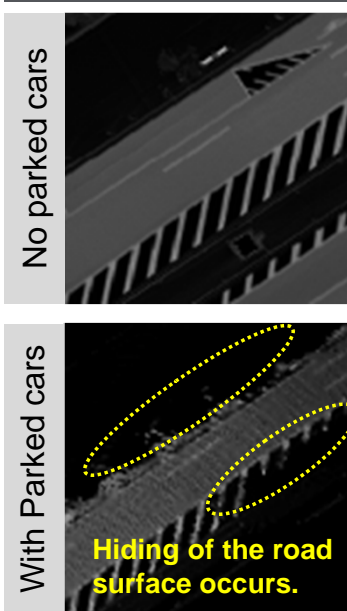
- Responding to user needs and expanding connectivity
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Localizing Algorithm Robustness Verification using DIVP[®]

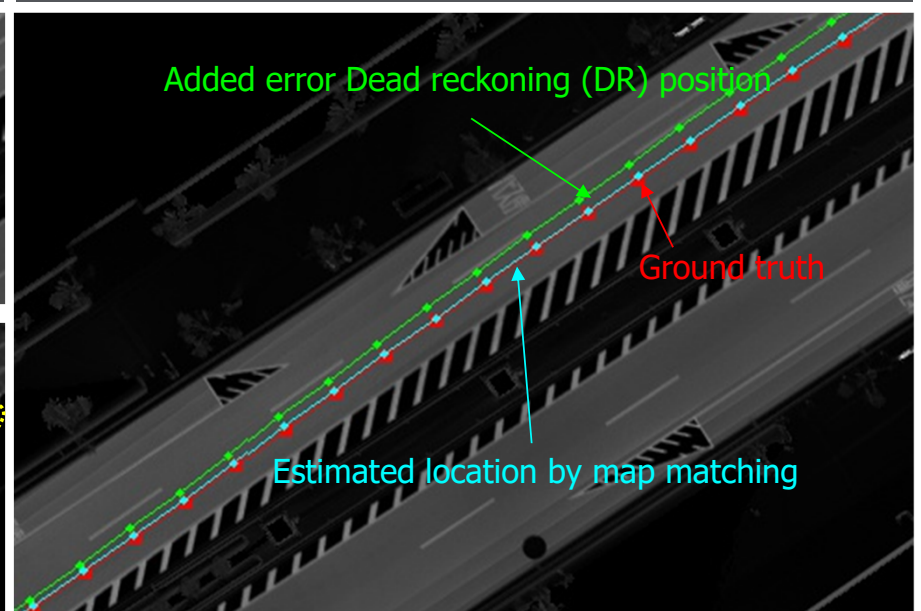
LiDAR output



Parked car affects



Effect on localizing accuracy



Estimated location
(posterior probability density distribution)

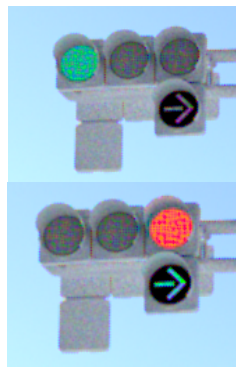
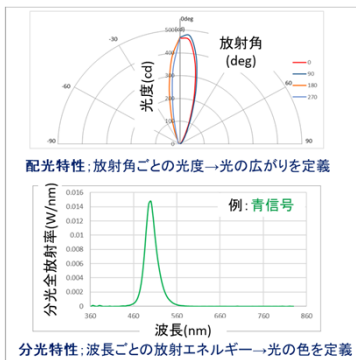
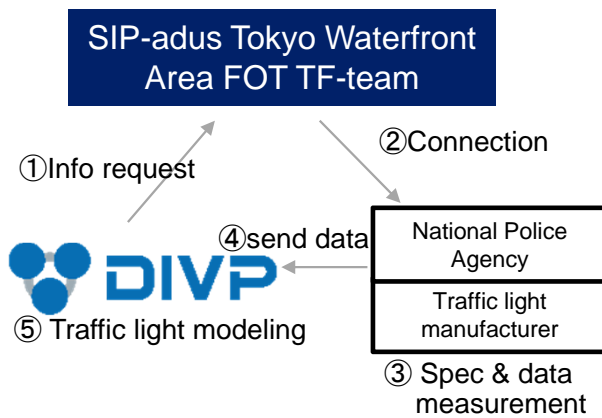
DIVP[®] is continuous constructing various environmental models such as rain and DR errors

Construction of highly consistent Odaiba Virtual-CG based on signal modeling supported by SIP-adus unique information distribution

■ Construction of Odaiba Virtual-CG

Odaiba Virtual-CG based on SIP's unique information gathering

Information flow for traffic signal modeling



DIVP[®] contribute to Simulation based AD-safety assurance with international collaboration

Summary; Contribution for AD-Safety assurance





END



Tokyo Odaiba → Virtual Community Ground

