ASAM OpenX

A study to assess whether the driving ability of autonomous vehicles in Real road traffic can be tested in virtual environments





Association for Standardization of Automation and Measuring Systems



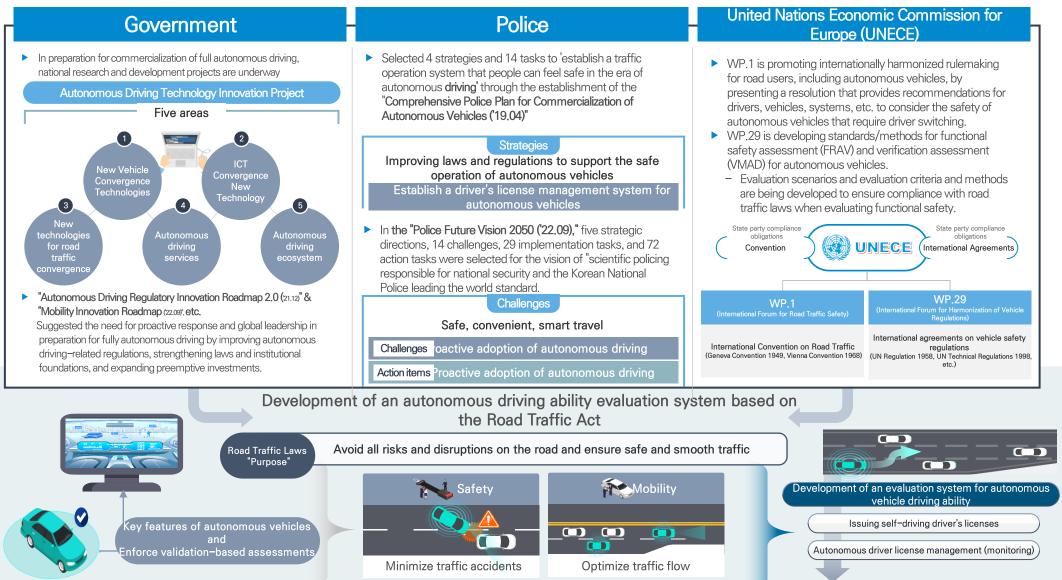
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Korea ROAD Traffic Authority Traffic Science Institute Tae Kyung, Kim Researcher



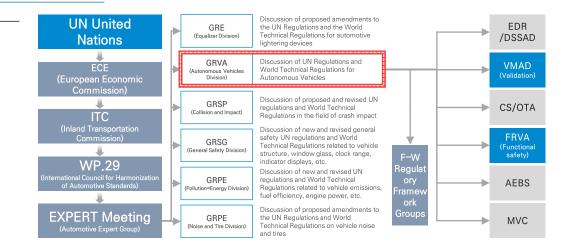




Foreign Policy for Autonomous Driving Evaluation

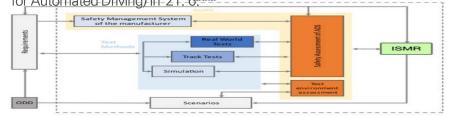
- WP.1 (Global Forum for Road Traffic Safety)
 - The Global Forum on Road Traffic Safety, which governs the International Conventions on Road Traffic (1949, 1968) and the International Convention on Road Signs and Signals (1968).
- WP.29 (World Forum for Harmonization of Vehicle Regulations)
 - Organization for the Harmonization of International Standards for Motor Vehicles, which establishes and revises international standards for motor vehicles among contracting states under the 1958 Agreement (UN Regulation), 1997 Agreement (UN Rules), and 1998 Agreement (UN GTR).
 - WP.29 is organized into six Working Groups (GRs) and affiliated Expert Working Groups (IWGs)
 - Regarding autonomous vehicles, related issues are being discussed and developed through FRVA (functional safety) and VMAD (verification assessment) centered on the GRVA specialized subcommittee.
- Functional safety (FRVA)
 - Developing performance and function standards for autonomous driving, developing test scenarios to comply with different road traffic laws in each country, and developing requirements for autonomous vehicles and ODD environments according to scenarios.

Scenario Type	Functional Requirement (FRAV-23-05Rev.2)	FRAV Detailed Provisions	Traffic Rule (UK)	Traffic Rule (Germany)	000 Dynamic Bements	ORUs Initial State (Direction)	ORUs Initial State	ORUs Initial State (Lat)	ORUs behaviou (Property)
	The ADS shall be capable of performing the	. The capability of the ADS to perform the entire DDT	124. You must not exceed the maximum speed	§ 1 Bask Rules					
	entire Dynamic Driving Task (DDT) within the	should be determined in the context of the COO of the	limits for the road and for your vehicle	(1) Participation in road traffic requires constant					
	ODD of its feature(s).	ADS	(motorways 70mph)	caution and mutual consideration.					
		 As part of the DDT, the ADS should be able to: 	125. The speed limit is the absolute maximum	(2) Anyone who takes part in traffic must behave					
		o Operate at safe speeds.	and does not mean that it is safe to drive at that	in such a way that no one else is harmed,					
		o Maintain appropriate distances from [other road users]	speed irrespective of the conditions.	endangered or more than unavoidable under the					
		by controlling the longitudinal and lateral motion of the	126. Drive at a speed that will allow you to stop	circumstances, hindered or annoyed.					
int-Keeping		vehicle.	well within the distance you can see to be clear.	§ 4 Distance	Nore	N/A	N/A	N/A	N/A
		a Adapt its behaviour to the surrounding traffic conditions	Yeu should:	(1) As a rule, the distance to a vehicle in front					
		(e.g., by avoiding disruption to the flow of traffic).	- leave enough space between you and the	must be so great that it is possible to keep					
		a Adapt its behaviour in line with safety risks (e.g., by	vehicle in front so that you can pull up safely if it	behind it even if it suddenly brakes. Those who					
		giving all road users and passengers the highest priority).	suddenly slows down or stops - the safe rule is	drive ahead must not brake hard without a					
			never to get closer than the overall stopping	compelling reason.					
			distance (see Typical Stopping Distances below) -	(2) Anyone who drives a motor vehicle for which					



Validation Assessment (VMAD)

• Developing a verification method for functional standards derived from FRAV, and developing five evaluation/verification methods (virtual environment simulation evaluation, track (PG) evaluation, real road evaluation, audit/evaluation, in-service monitoring and report) along with evaluation scenarios through the presentation of NATM (New Assessment/Test Method for Automated Driving) in '21. 6:===





Process of Autonomous Vehicle(AV) safety driving ability evaluation

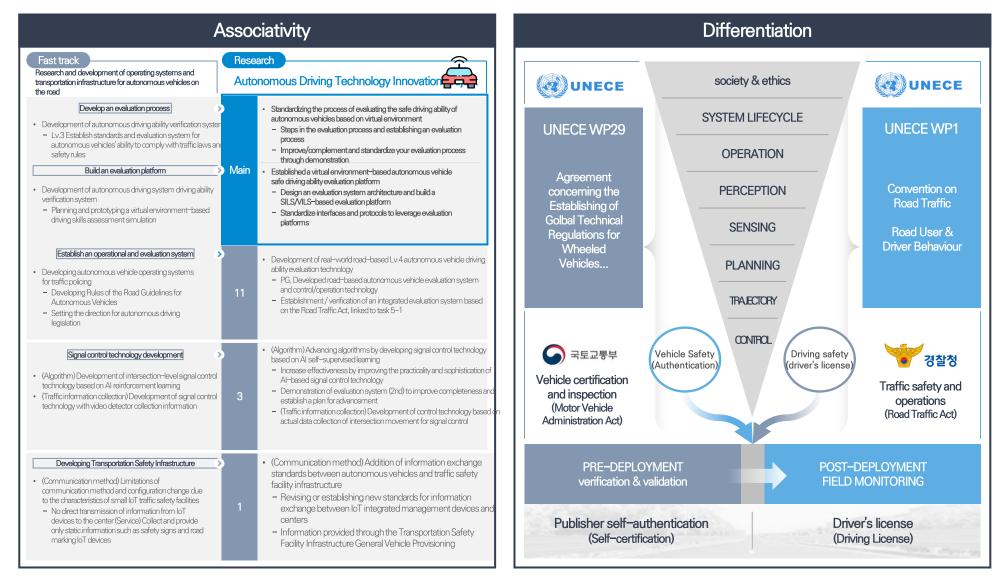




Annual research and development overview

Key res objectiv phase/	esby Step	Define evaluation model / o scenarios (single)	develop evaluation	Establishment of evaluation, demonstration	tion environment and system on/advancement
Dist	tinguish	2021 (Year 1)	2022 (Year 2)	2023 (Year 3)	2024 (Year 4)
Annualization Research Objectives		 Define an autonomous vehicle safety assessment model 	 Develop scenarios to evaluate autonomous vehicle safety 	 Build an evaluation environment and integrate your system 	 Evaluation of safe driving ability of autonomous vehicles Linking demonstration and real road evaluation
	Standardize evaluation process	 Develop an assessment process scope/framework 	 Model the evaluation process step by step 	 Establish an evaluation process 	 Complement and standardize your processes through demonstration
Research Perform	Develop evaluation scenarios	 Establish a direction for developing evaluation scenarios 	 Develop scenarios to evaluate autonomous vehicle safety 	 Develop and demonstrate complex scenarios 	 Demonstrate / supplement scenarios for evaluating autonomous vehicle safety driving capabilities
Sector	Build an evaluation platform	 Design system architecture and define interface specifications / functional scope 	 Design/build evaluation platforms and develop single scenario auto- generation systems 	 Assessment System Integration / Scenario Library Building 	 Deploying/Advancing Advanced-VILS
	Demonstration, refinement, and follow-on projects	 Define Driving Factor Assessment / Define Design and Guideline Direction 	 Developing a driver perspective autonomous vehicle evaluation methodology 	 Develop production usage guidelines 	 Establishment of evaluation system demonstration, advancement, and linkage to follow-up tasks





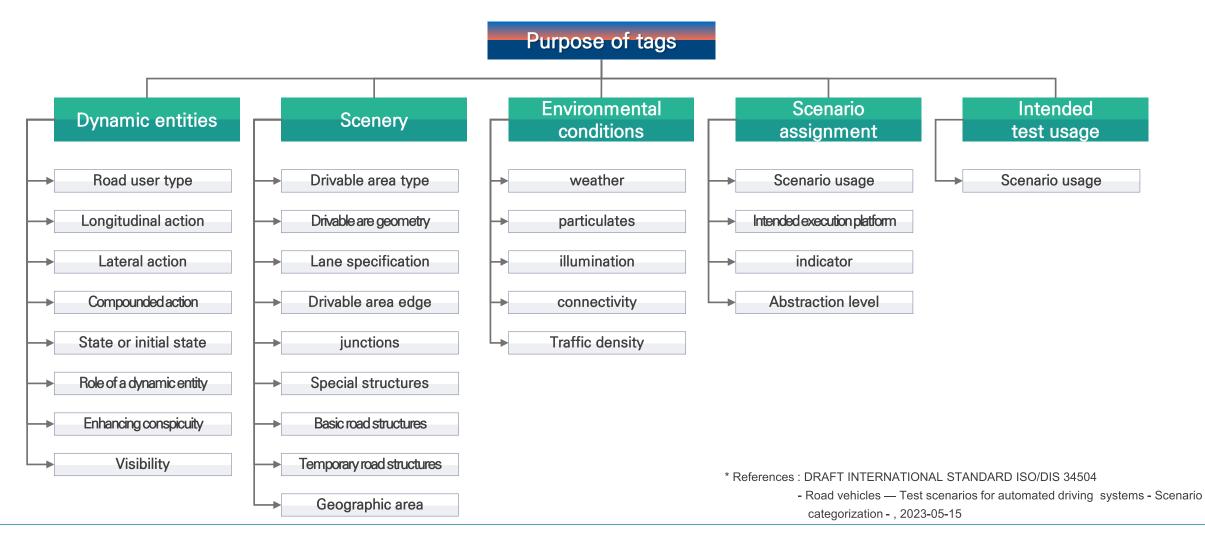


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Attributes and classification of scenarios in ISO 34504





International road traffic rules and Korean road traffic law

Category	TAAS Violation Category as per the Korean Road Traffic Law	Vienna Convention on Road Traffic
1	Speeding	Part 2 Article 13 Speed and distance between vehicles
2	Method of Intersection Traffic	Part 2 Article 16 Change of direction, Part 2 Article 18 Intersections and obligation to give way
3	Pedestrian Protection Obligations	Part 2 Article 21 Behavior of drivers towards pedestrians
4	Violation of the U-turn procedure	Part 2 Article 14 General requirements governing maneuvers
5	Violation of the Signal	Part 2 Article 5 Status of signs and signals
6	Non-Observance of Following Distance	Part 2 Article 13 Speed and distance between vehicles Part 2 Article 17 Slowing down
7	Failure to Comply with Safe Driving Obligations	Part 2 Article 7 General rules
8	Violation of the centerline	Part 2 Article 10 Position on the carriageway
9	Obstructing Straight and Right turn Traffic	Part 2 Article 18 Intersections and obligation to give way
10	Violation of the lane rules	Part 2 Article 10 Position on the carriageway Part 2 Article 11 Overtaking and movement of traffic in lines
11	Violation of Overtaking Rules	Part 2 Article 11 Overtaking and movement of traffic in lines
12	Breach of No-Overtaking Regulations	Part 2 Article 11 Overtaking and movement of traffic in lines
13	Violation of Stopping Procedure	Part 2 Article 12 Passing of oncoming traffic Part 2 Article 18 Intersections and obligation to give way
14	Violation of the Turn Procedure	Part 2 Article 16 Change of direction
15	Failure to yield right of way	Part 2 Article 18 Intersections and obligation to give way
16	Violate the obligation of giving way the path	Part 2 Article 12 Passing of oncoming traffic Part 2 Article 18 Intersections and obligation to give way

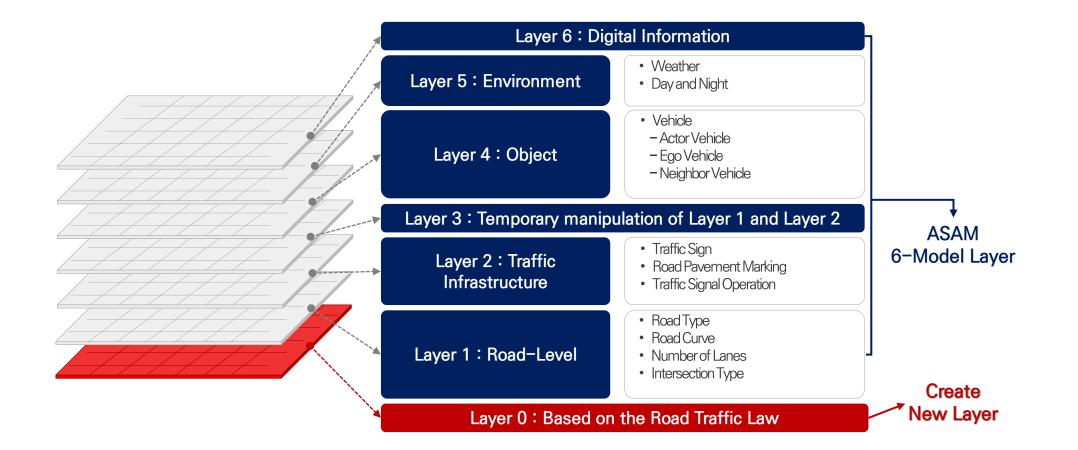


Road Traffic Law-based Evaluation Criteria

Category	Evaluation Criteria	Category	Evaluation Criteria
1	Signal	12	Obligation of Giving way the path
2	Obey Traffic Road Markings and Signs	13	Method of Overtaking
3	Prohibition of Traffic	14	Prohibition of the Overtaking
4	Prohibition of Centerline Violation	15	No Cutting in lines
	Prohibition of Straight Right turn progress	16	Method of Railroad crossing
5	Obstruction	17	Method of Intersection Traffic
6	Prohibition of Crossing	18	Method of Vehicle's Equalization and Signals
7	Pedestrian Protection Obligations		
8	Safe Driving Obligations	19	Method of Slowly down and Stopping
9	Prohibition of Stopping and Parking		Method of passing the shoulder
10	The Specified Speed	20	of a road
11	Observance of a Following Distance	21	Lane of a Road

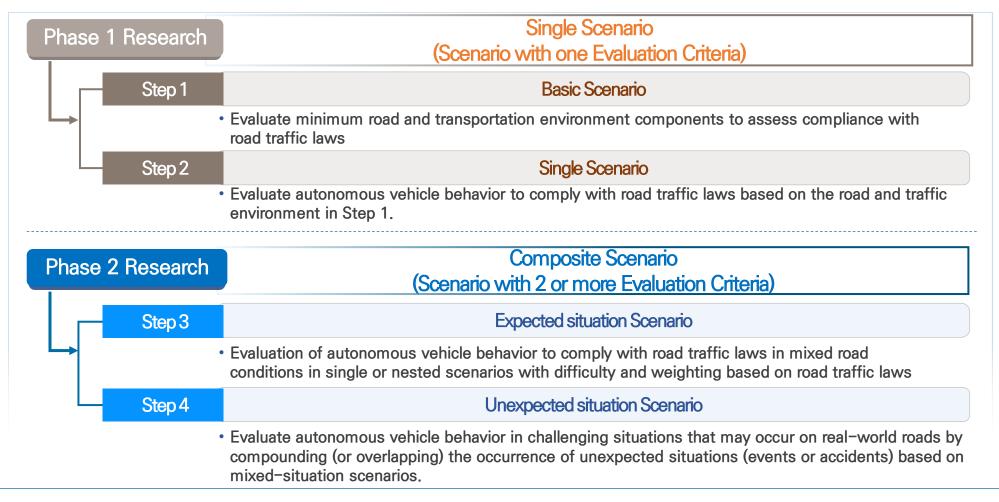


Creating Road Traffic Law based layers with ASAM openScenario



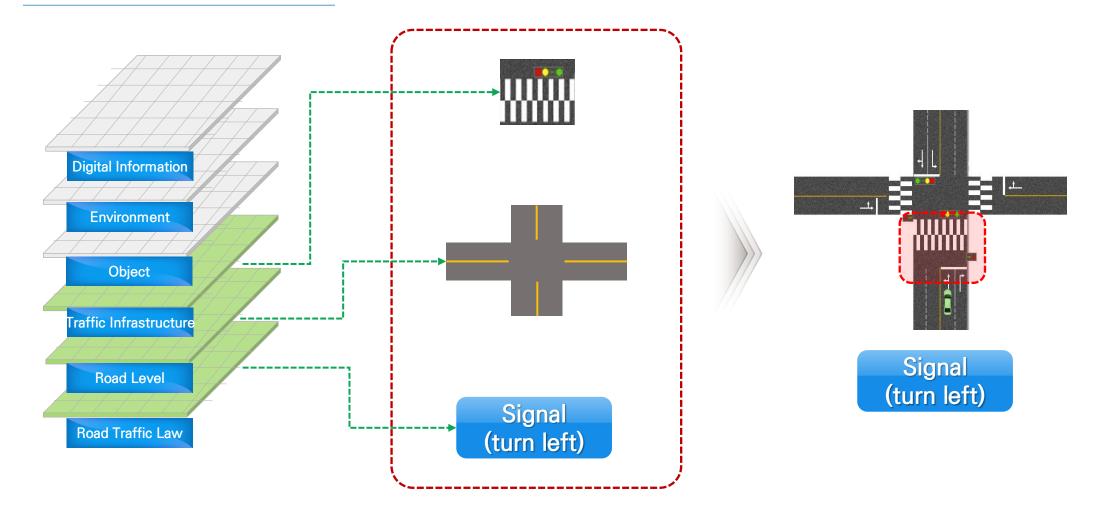


Road traffic law-based autonomous vehicle evaluation scenario development





Sample of Basic Scenario





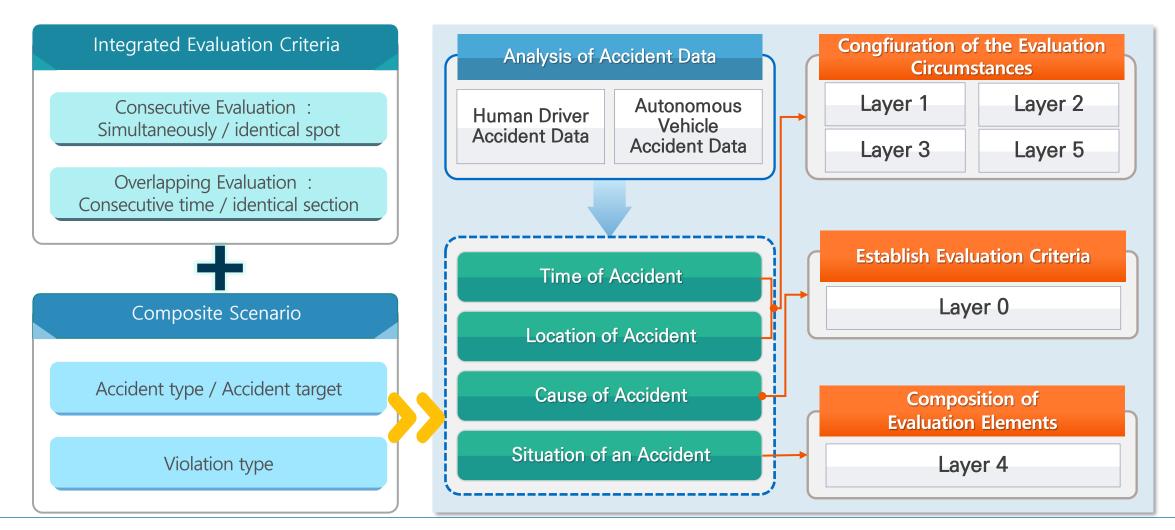
Sample of Single Scenario

Scenario No.	S-0005-01		0		
Layer 0 Code	LW-026(4)-000(0)-000(0)		1 Start 🗧		
Evaluation overview	 Evaluate whether autonomous vehicles con against impeding straight right turns by yie traveling west when turning left on a roadw three-way intersection 	lding to a straight vehicle	 2 평가 - 직진차량에 진로양보 후 좌회전 		
Evaluation Criteria	 Assessing Compliance with Obstructing a S 1. Comply with the prohibition of obstructing straigh 2. Violated the prohibition of obstructing straight right 	t right turns while driving : Pass	۱۱۱۱۱۱۱ بــــــــــــــــــــــــــــــ	اللہ اللہ اللہ اللہ اللہ اللہ اللہ اللہ	i

Scer	nario No.	S-0008-01			1 Start	l .	
Laye	er 0 Code	LW-048(1)-000(0)-000(0)		② 평가 - 보행신호 등화 :	후 좌회전 📮		
	aluation erview	 Evaluate whether an autonomous very the duty of care by driving when the the west side of the road is green we from the north side of an intersection light 	e pedestrian signal on /hen making a left turn	من من المعرف المعرف المعرف المعرف المعرف المعرف المعرف		● ↓ → → → → → → → → → → → → →	3 I D stination
	aluation riteria	 Assessing compliance with safe driven and the safe driven of the duty of safe and the duty of safe driven and the duty of safe driven	driving : Pass		F		

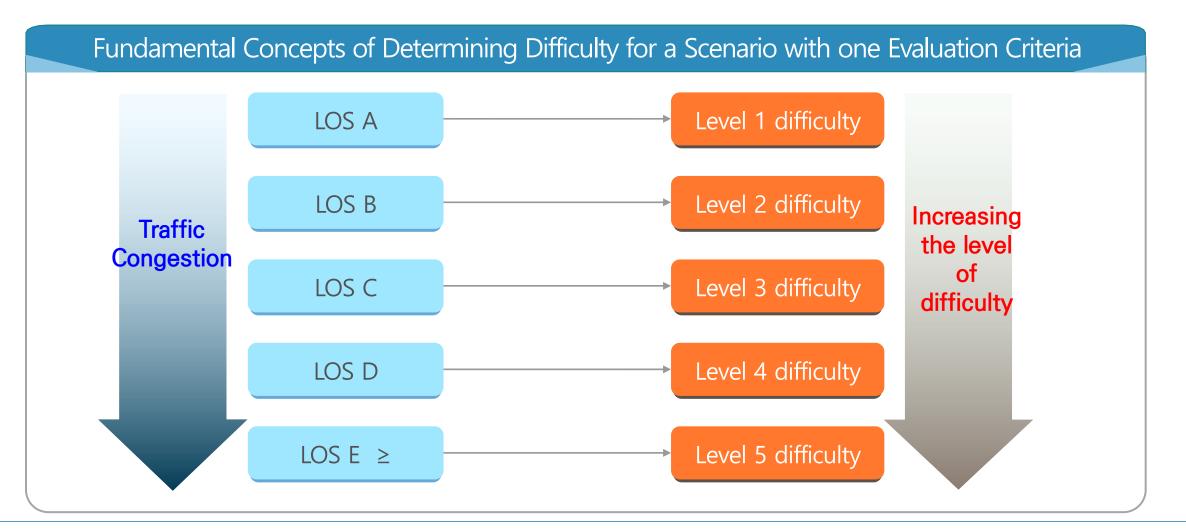


Composite Scenario overview



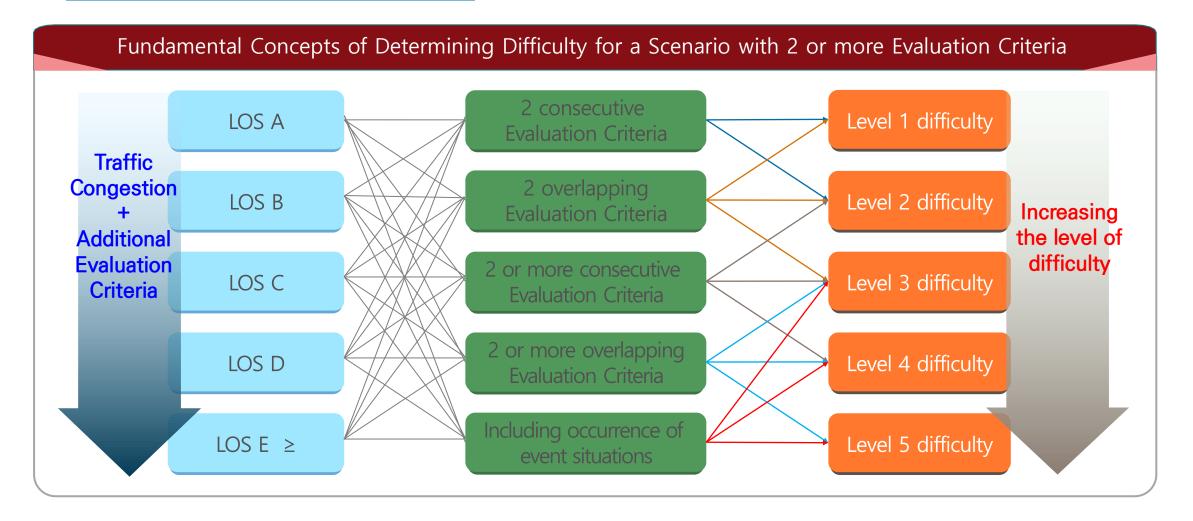


Concepts of Determining Difficulty





Concepts of Determining Difficulty



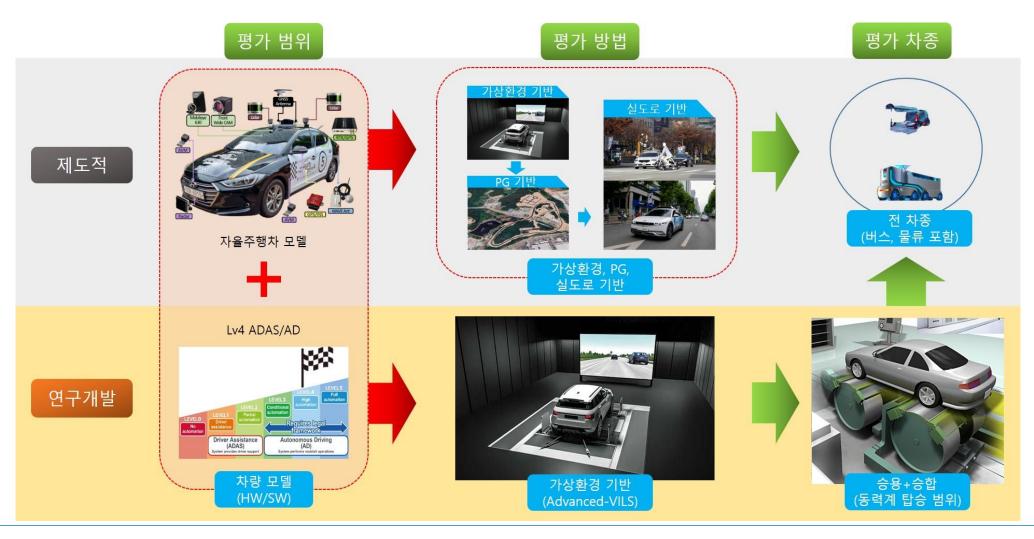


AV driving ability evaluation system using Virtual Environments

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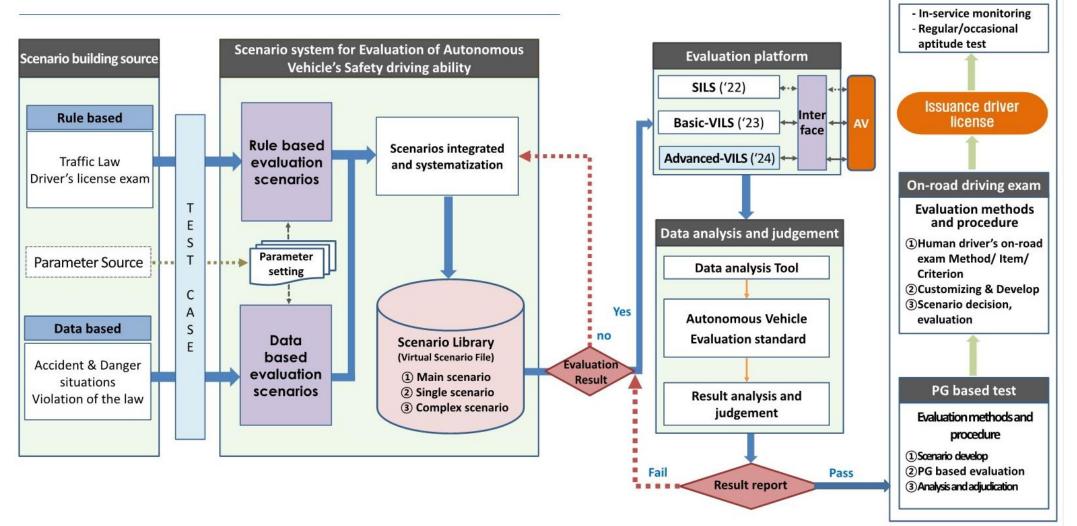
3. AV driving ability evaluation system using Virtual Environments What and how to evaluation





3. AV driving ability evaluation system using Virtual Environments

Frame work for AV evaluation Process

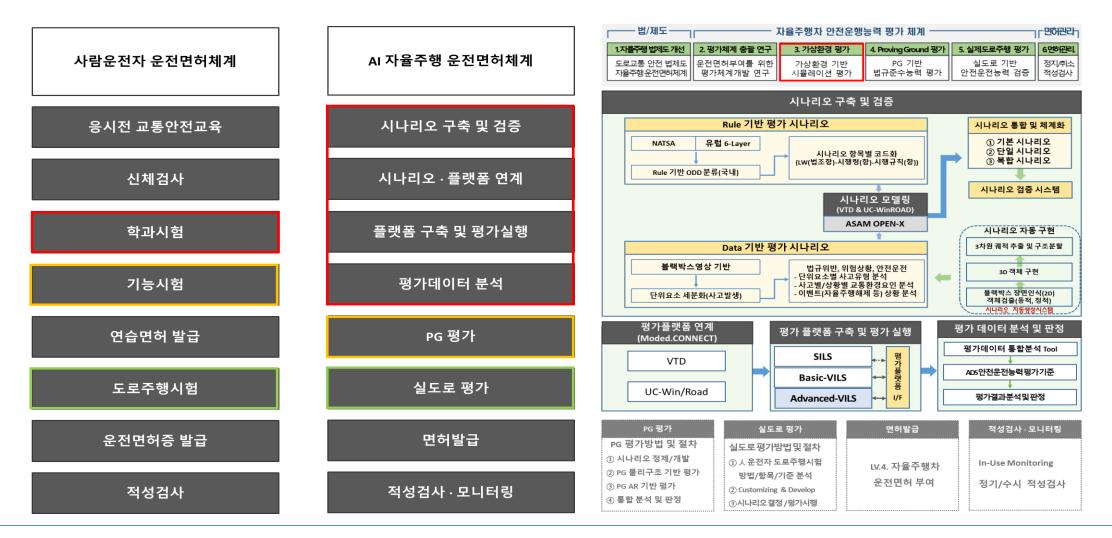




PG/On-road evaluation-

3. AV driving ability evaluation system using Virtual Environments

Current driver's license system and autonomous driving evaluation system





3. AV driving ability evaluation system using Virtual Environments

Process of autonomous driving evaluation management systems



[Preparation System]

- ✓ Establish an evaluation process
- classification)Institutionalization of evaluation method (law revision)
- ✓ Derive evaluation items and calculate weightsEstablishment of evaluation criteria

[Execution Management System]

- ✓ Establish detailed procedures and methods for assessing safe driving skills
- Build and test scenarios based on the Road Traffic Act according to the evaluation arade
- Analyze accident causes based on actual accident data Additional supplementation and verification of scenarios through additional supplementation of scenarios
- ✓ Plan to link PG and real road test after virtual environment evaluation

[Results Utilization and Improvement System]

- Analyzing Assessment Results Judgment
- ✓ Judgment through result data D/B (PASS/FAIL or grading)
- ✓ Complex scenario test
- ✓ Complementation through monitoring



Future research plans

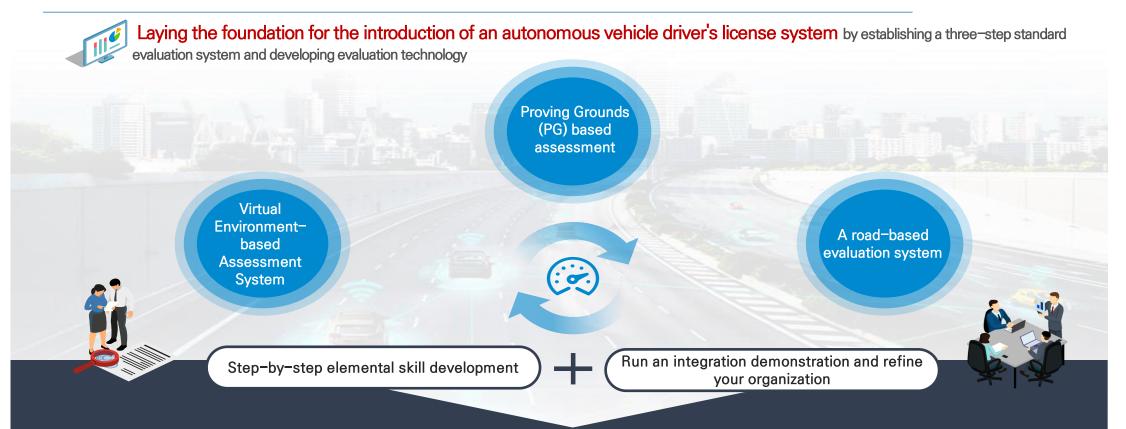
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4. Future research plans

Setting the direction for autonomous driving integration evaluations



To "establish a traffic operation system that people can feel safe in the era of autonomous driving"

Development of Lv.4 autonomous vehicle driving ability evaluation technology based on road traffic law



4. Future research plans

1. Develop a safe driving ability evaluation system and establish a plan to improve the legal system					
1.1 Develop a rating system	 Establish a roadmap for the development of a driving ability evaluation system based on the level of autonomous driving technology Developed a standard ODD for evaluating the driving ability of autonomous vehicles based on the Road Traffic Act 				
	Develop driving ability evaluation items, evaluation criteria, and evaluation methods (PG+practical road) Engineering judgment for abstract road traffic violations				
1.2 Developing a scenario	 Developing autonomous vehicle driving skill assessment scenarios for PG-based assessments Developing guidelines for evaluating autonomous vehicle driving skills for on-road evaluation Validate evaluation scenario appropriateness 				
1.3 How to improve the legal system	 Establishing a plan to introduce a driver's license for autonomous vehicles through revision of the Road Traffic Act Driving ability evaluation guidelines, standard business model for performance diffusion, etc. 				

2. Develop factor skills

- ☑ Develop PG operation/control technology for PG evaluation (infrastructure, dummy, MR, etc.)
- PG-based real-time evaluation, data collection/analysis, and operation monitoring technology development
- Utilization of existing driver's license test centers and presentation of PG standard physical structure, etc.
- ☑ Develop driving test route selection guidelines for on-road assessments
- $\ensuremath{\mathbb{Z}}$ Real-time evaluation data collection/analysis and operation monitoring technology based on real roads
- E Development of technology to reproduce the driving situation of autonomous vehicles to be evaluated, etc.
- Develop skills in integrated management system elements
 Evaluation data integration/management and standardization technology, evaluation scenario management technology, evaluation pro
 Sessionmanagementtechnology, selutionselarities and technology, evaluation scenario management technology, evaluation pro

3. Build an evaluation environment and system

2.1 Proofing Grounds (PG)

2.2 Real Roads

2.3 Integrated Management

System





