

ASAM OpenX

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



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Association for Standardization of
Automation and Measuring Systems

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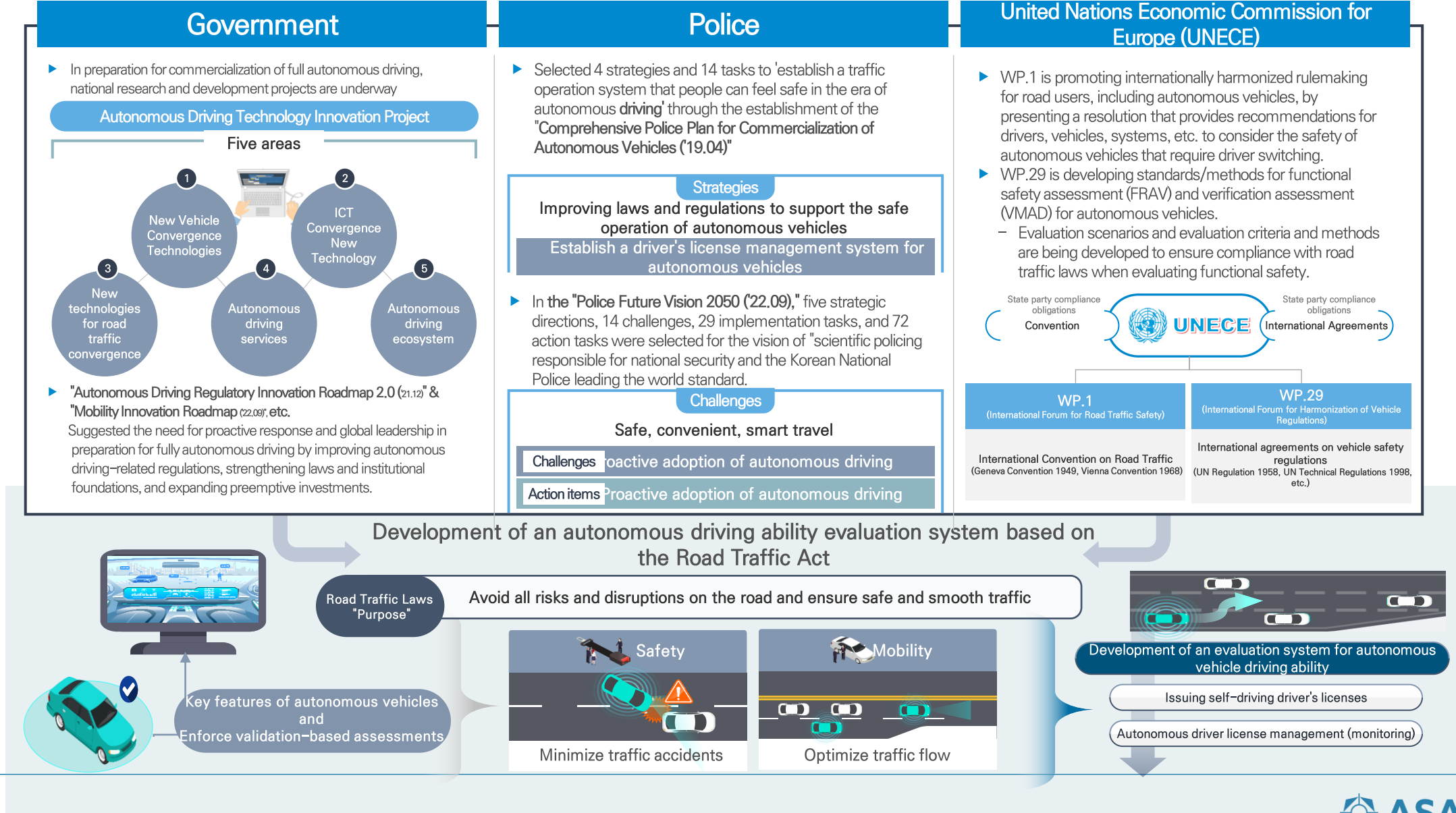
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Research overview

Korea ROAD Traffic Authority
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1. Research overview



1. Research overview

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)

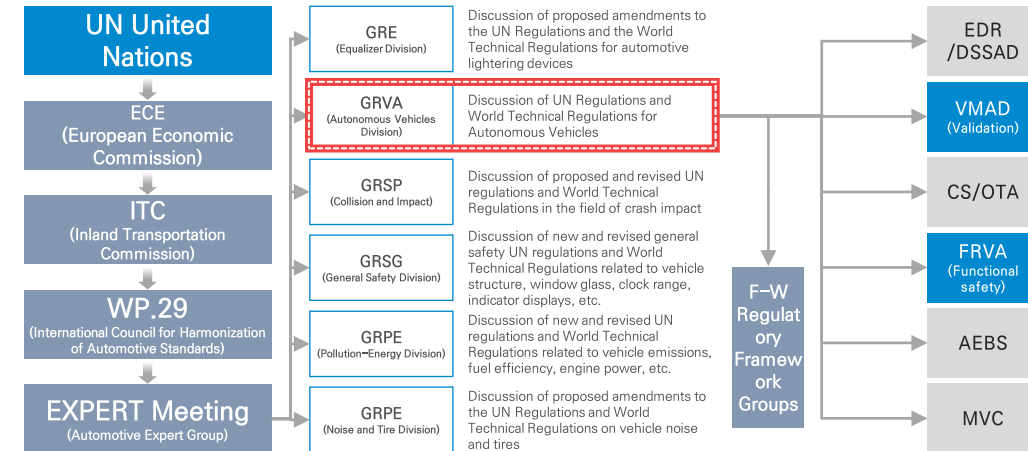
- Organization for the Harmonization of International Standards for Motor Vehicles, which establishes and revises international standards for motor vehicles among contracting states under the 1958 Agreement (UN Regulation), 1997 Agreement (UN Rules), and 1998 Agreement (UN GTR).
- WP.29 is organized 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.

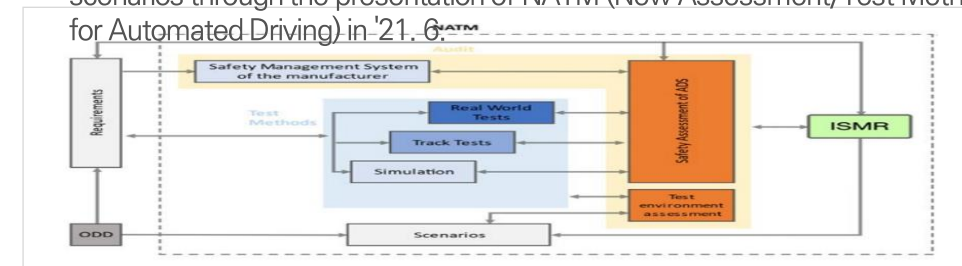
Core Behaviour competencies and Test Scenarios for Highway Use Case

Scenario Type	Functional Requirement (FRVA-21-01aen2)	FRVA Detailed Provisions	Traffic Rule (UK)	Traffic Rule (Germany)	ODD Dynamic Elements	ODDs Initial State (Direction)	ODDs Initial State (Range)	ODDs Initial State (Lat)	ODDs Initial State (Property)
lane-keeping	The ADS shall be capable of performing the entire Dynamic Driving Task (DDT) within the ODD of its features.	<ul style="list-style-type: none">• The capability of the ADS to perform the entire DDT should be determined in the context of the ODD of the ADS.• As part of the DDT, the ADS should be able to:<ul style="list-style-type: none">◦ Operate at safe speeds◦ Maintain appropriate distances from other road users by controlling the longitudinal and lateral motion of the vehicle.◦ Adapt its behaviour to the surrounding traffic conditions (e.g., by avoiding disruption to the flow of traffic)◦ Adapt its behaviour in line with safety rules (e.g., by going at road users and passengers the highest priority)	124. You must not exceed the maximum speed limits for the road and for your vehicle (maximum 70mph)	§ 17 Basic Rule (1) Participation in road traffic requires constant caution and mutual consideration. (2) Anyone who takes part in traffic must behave in such a way that no one else is harmed, endangered or more than unavoidable under the circumstances, hindered or annoyed.	None	N/A	N/A	N/A	N/A
		125. The speed limit is the absolute maximum and does not mean that it is safe to drive at that speed irrespective of the conditions.	§ 125. The speed limit is the absolute maximum and does not mean that it is safe to drive at that speed irrespective of the conditions.	§ 4 Distance (1) As a rule, the distance to a vehicle in front must be so great that it is possible to keep behind it even if it suddenly brakes. Those who drive ahead must not brake hard without a compelling reason.					
		126. Drive at a speed that will allow you to stop well within the distance you can see to be clear.	You should: <ul style="list-style-type: none">• leave enough space between you and the vehicle in front so that you can pull up safely if it suddenly slows down or stops – the safe rule is never to get closer than the overall stopping distance (see Typical Stopping Distances below) – (2) Anyone who drives a motor vehicle for which						



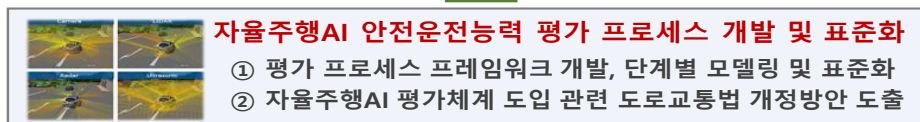
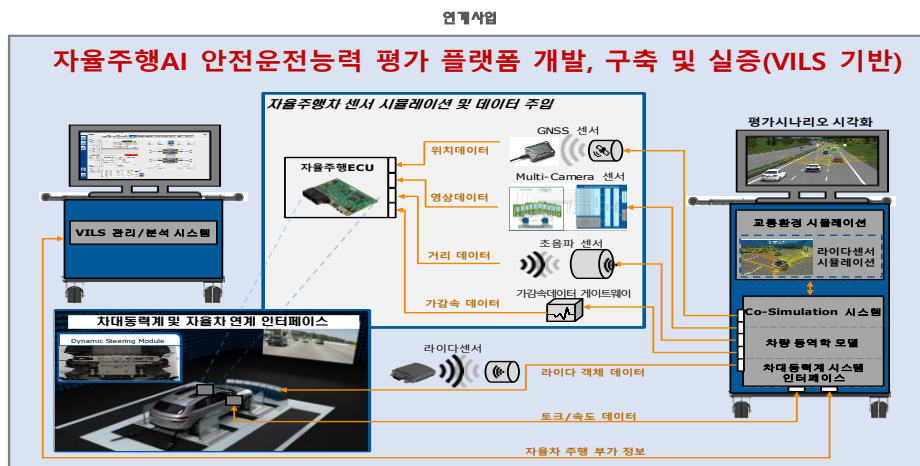
► Validation Assessment (VMAD)

- Developing a verification method for functional standards derived from FRVA, 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.

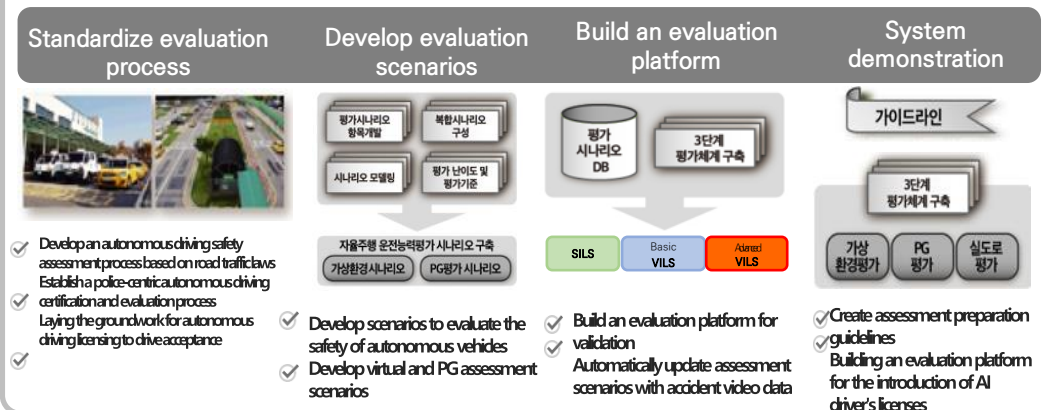


1. Research overview

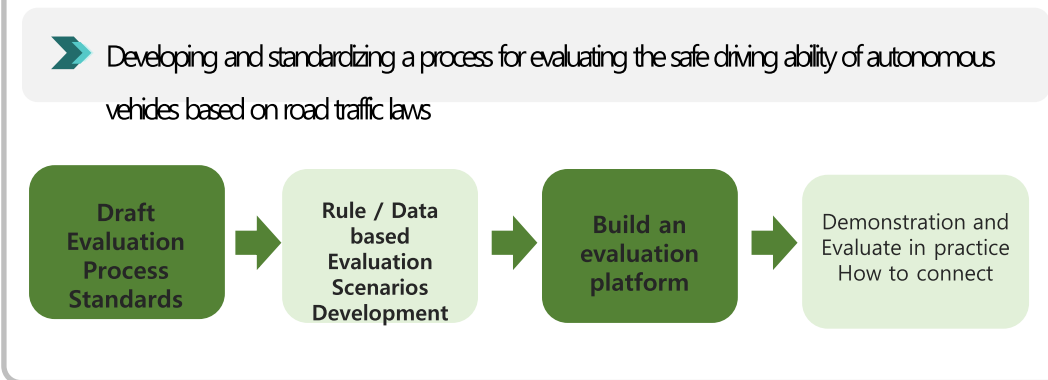
Process of Autonomous Vehicle(AV) safety driving ability evaluation



Development and standardization of a safe driving ability evaluation system for autonomous vehicles based on road traffic laws

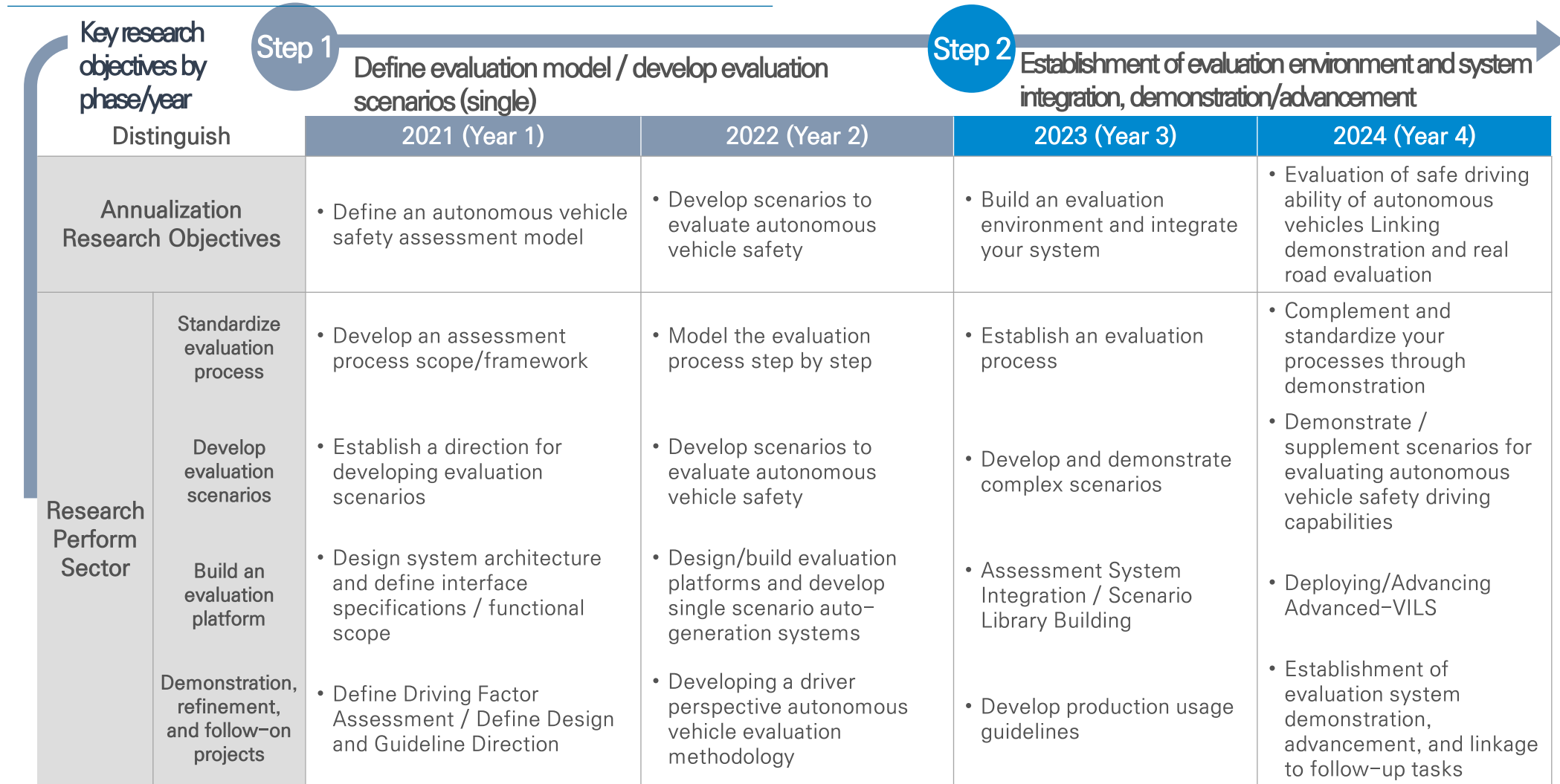


The end goal of the Research

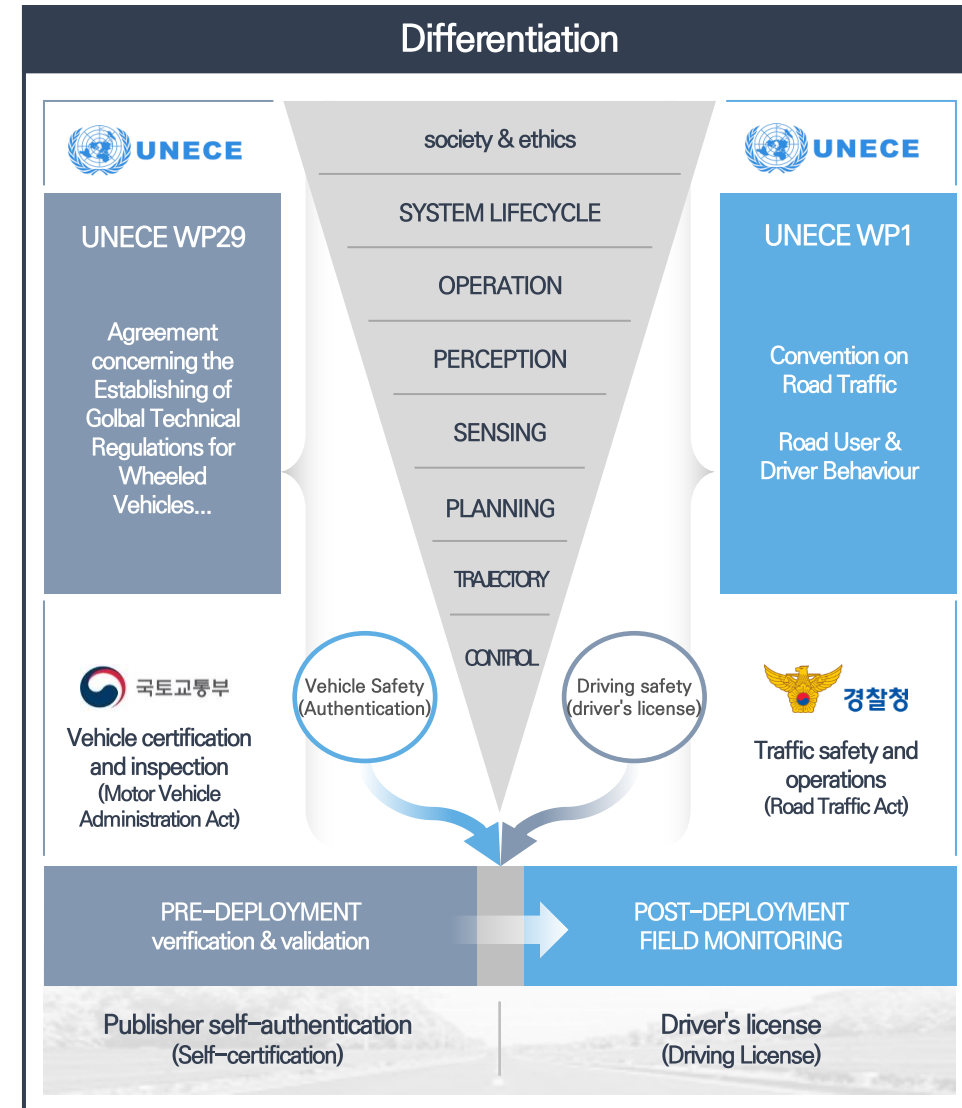
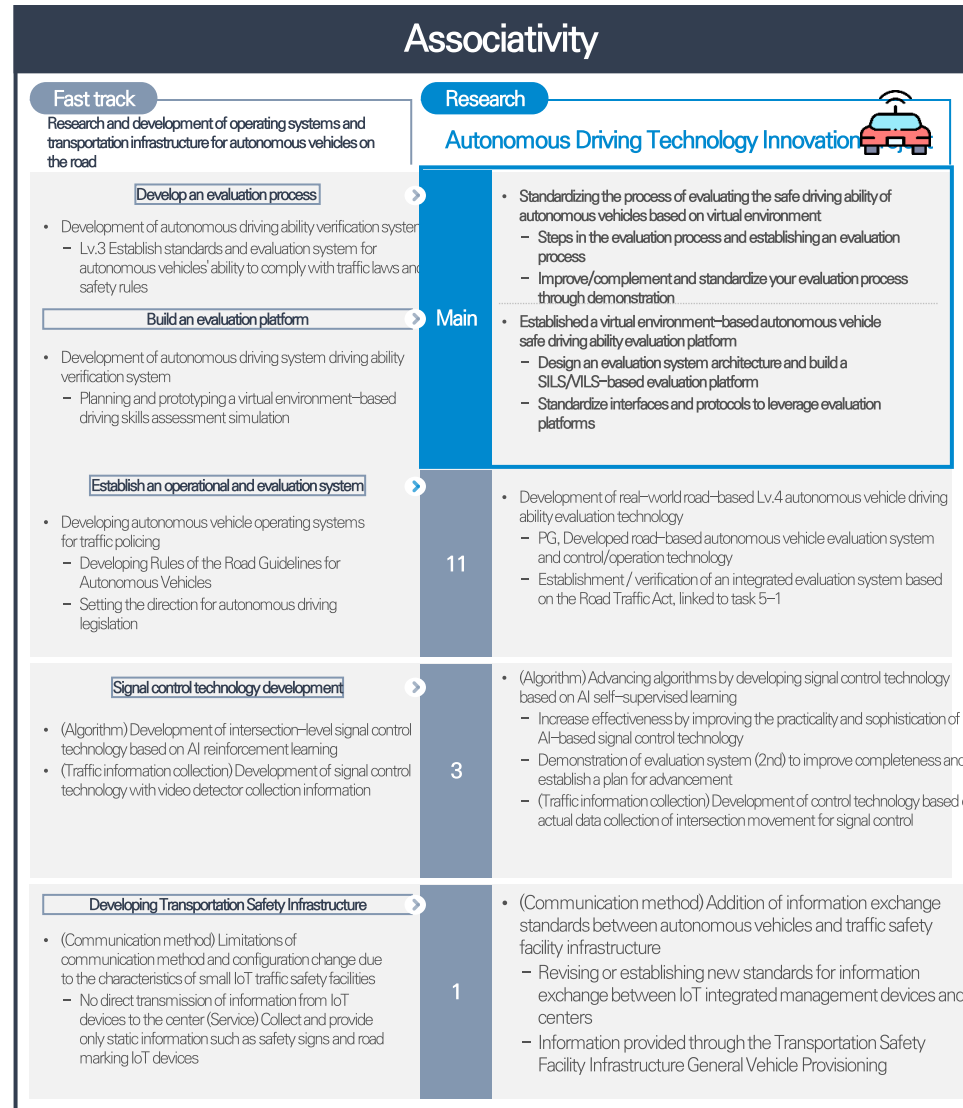


1. Research overview

Annual research and development overview



1. Research overview



Scenarios for evaluating AV driving ability based on Road Traffic Laws

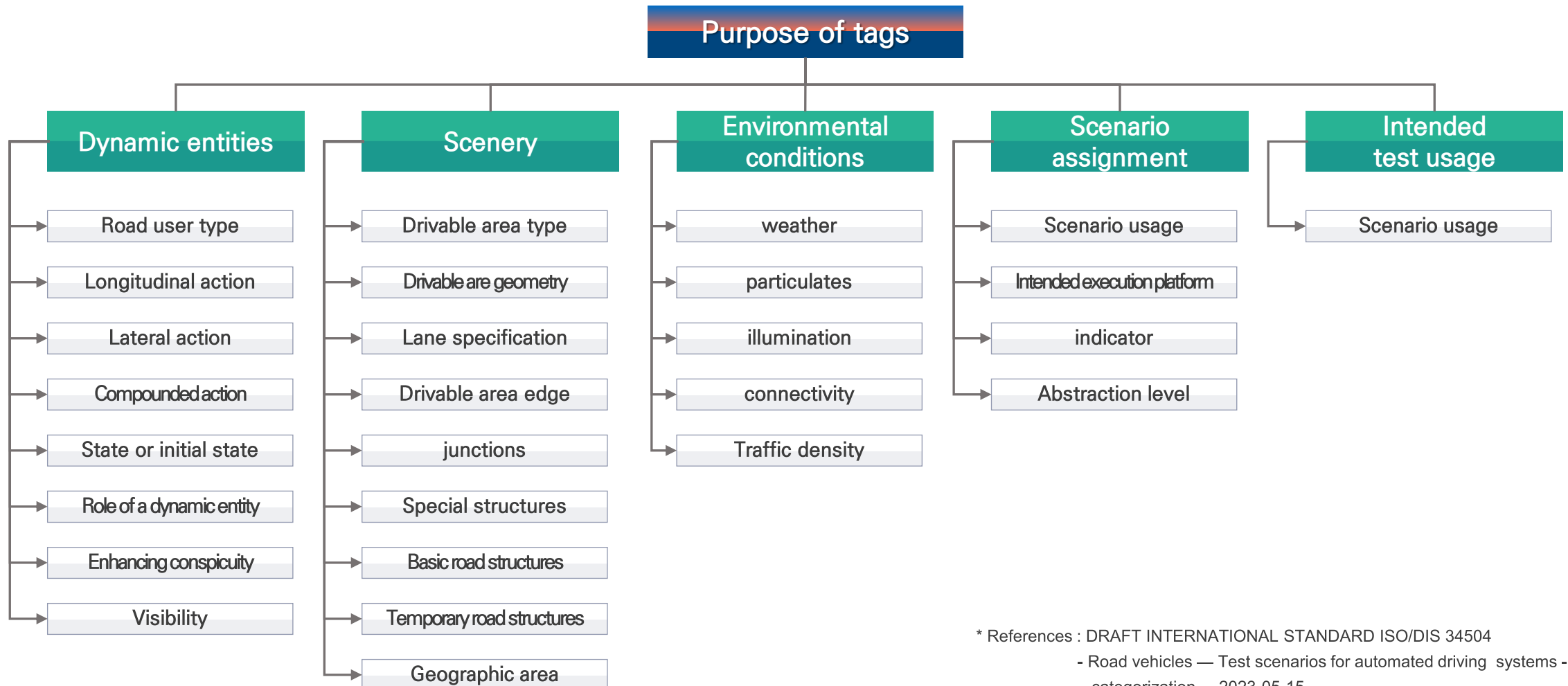
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2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Attributes and classification of scenarios in ISO 34504



* References : DRAFT INTERNATIONAL STANDARD ISO/DIS 34504
- Road vehicles — Test scenarios for automated driving systems - Scenario categorization - , 2023-05-15

2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

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

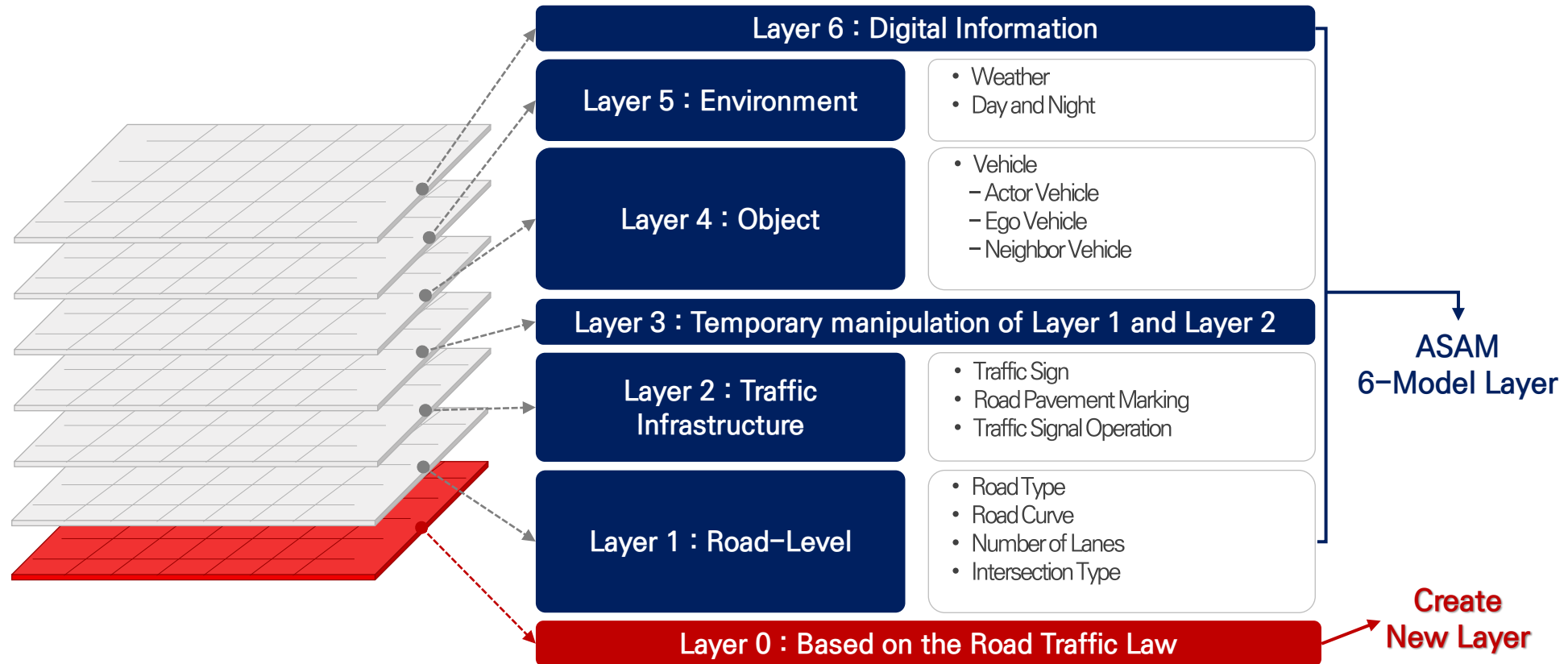
2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

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
5	Prohibition of Straight Right turn progress Obstruction	16	Method of Railroad crossing
6	Prohibition of Crossing	17	Method of Intersection Traffic
7	Pedestrian Protection Obligations	18	Method of Vehicle's Equalization and Signals
8	Safe Driving Obligations	19	Method of Slowly down and Stopping
9	Prohibition of Stopping and Parking	20	Method of passing the shoulder of a road
10	The Specified Speed		
11	Observance of a Following Distance	21	Lane of a Road

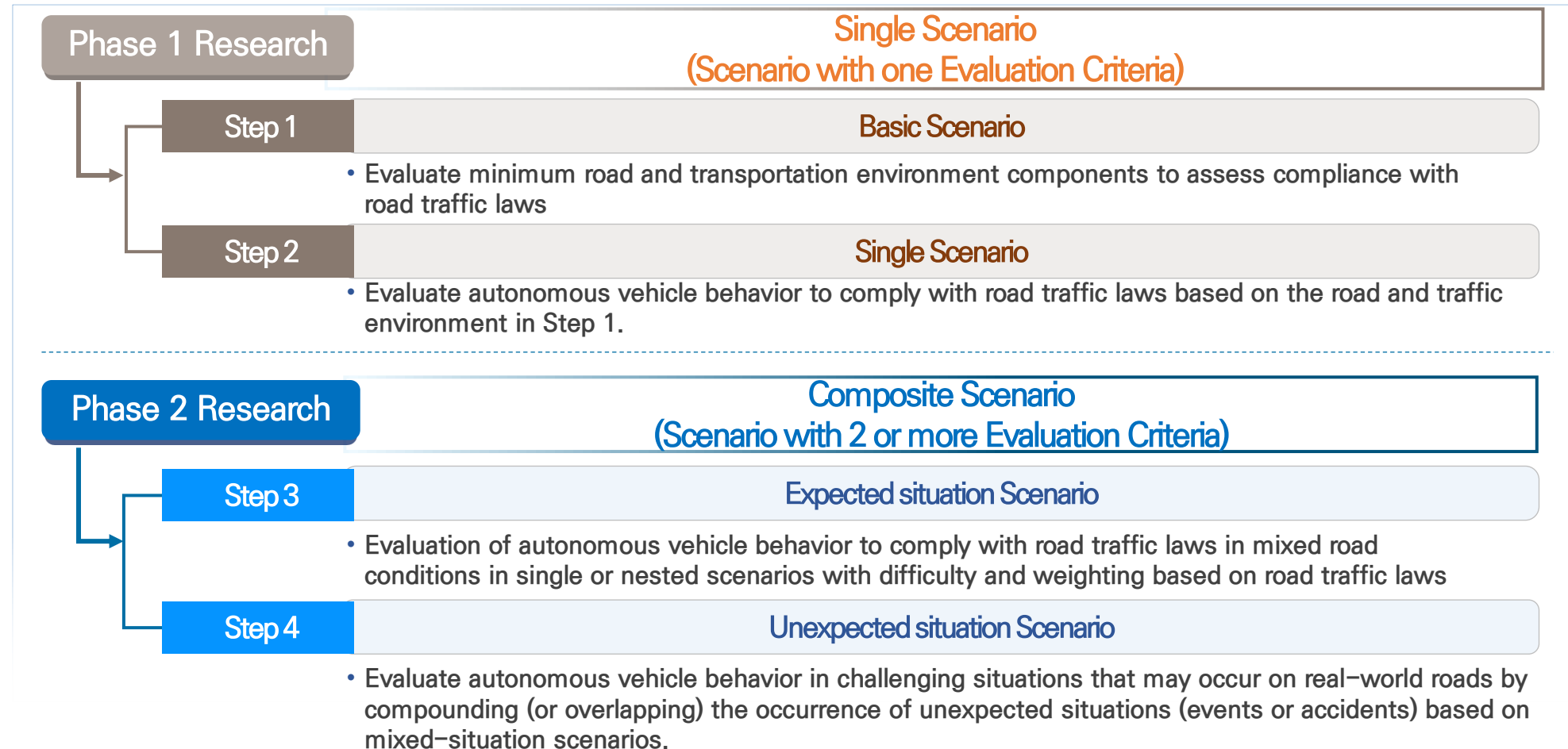
2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Creating Road Traffic Law based layers with ASAM openScenario



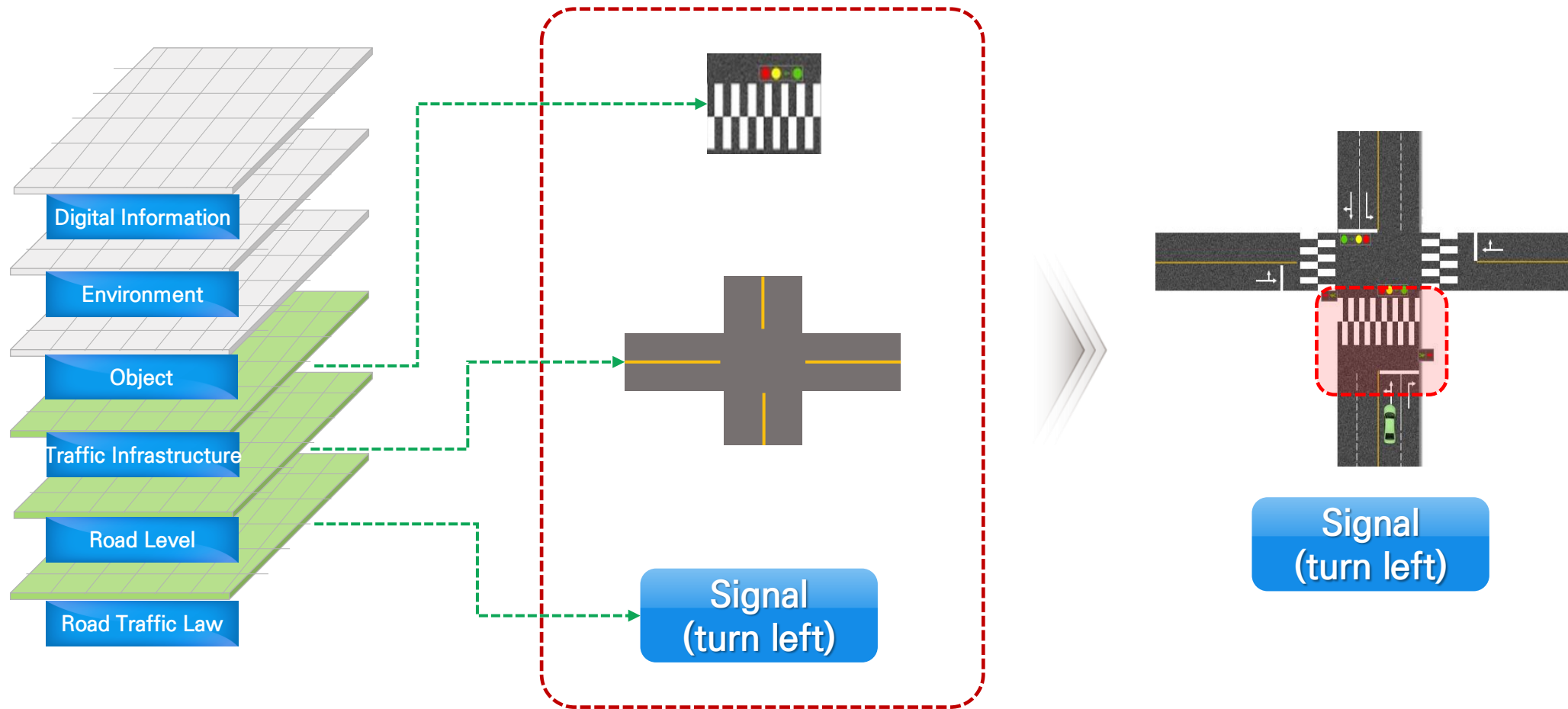
2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Road traffic law-based autonomous vehicle evaluation scenario development



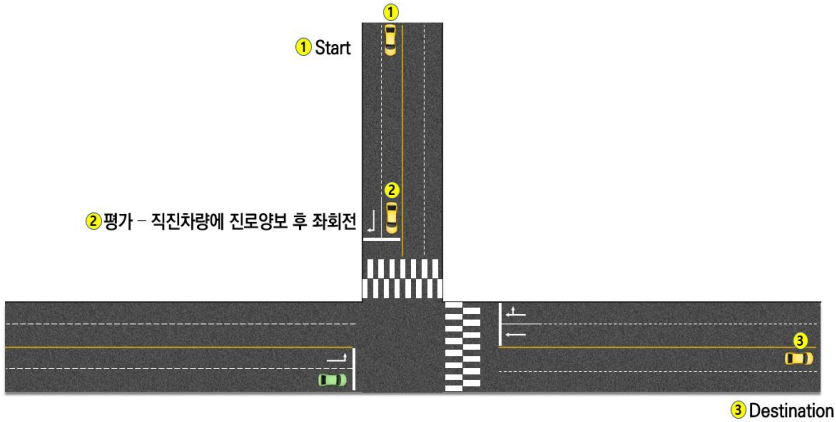
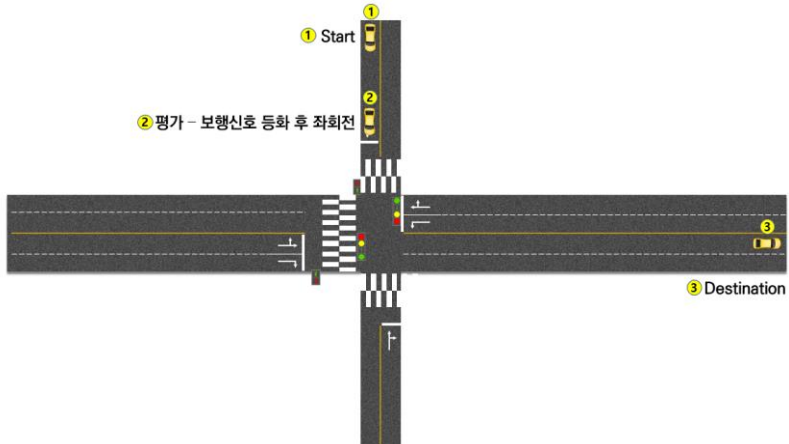
2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Sample of Basic Scenario



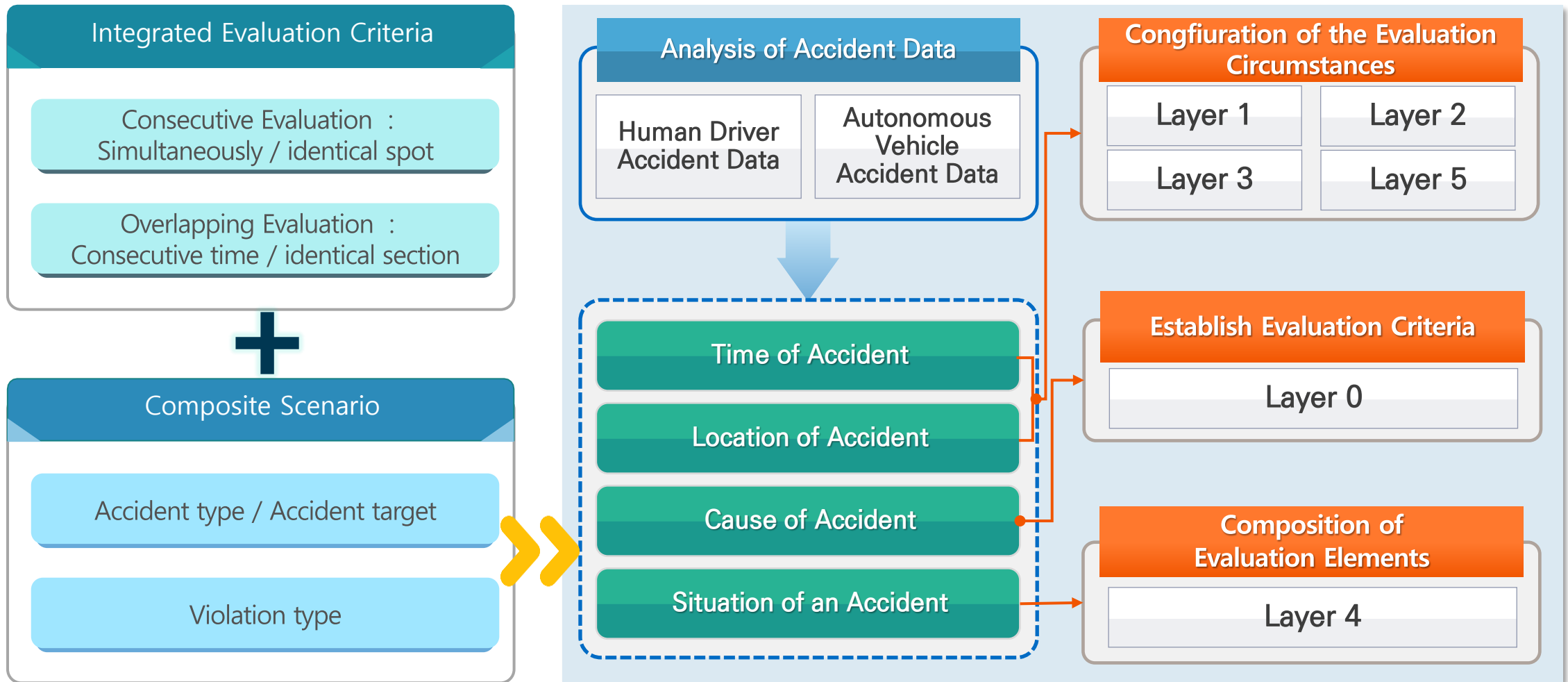
2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Sample of Single Scenario

Scenario No.	S-0005-01	
Layer 0 Code	LW-026(4)-000(0)-000(0)	
Evaluation overview	<ul style="list-style-type: none">Evaluate whether autonomous vehicles comply with the prohibition against impeding straight right turns by yielding to a straight vehicle traveling west when turning left on a roadway north of an unsignalized three-way intersection	
Evaluation Criteria	<ul style="list-style-type: none">Assessing Compliance with Obstructing a Straight Right Turn While Driving<ol style="list-style-type: none">Comply with the prohibition of obstructing straight right turns while driving : PassViolated the prohibition of obstructing straight right turn progress while driving : Fail	
Scenario No.	S-0008-01	
Layer 0 Code	LW-048(1)-000(0)-000(0)	
Evaluation overview	<ul style="list-style-type: none">Evaluate whether an autonomous vehicle complies with the duty of care by driving when the pedestrian signal on the west side of the road is green when making a left turn from the north side of an intersection with only one traffic light	
Evaluation Criteria	<ul style="list-style-type: none">Assessing compliance with safe driving while driving<ol style="list-style-type: none">Compliance with the duty of safe driving : PassViolation of the duty of safe driving while driving : Fail	

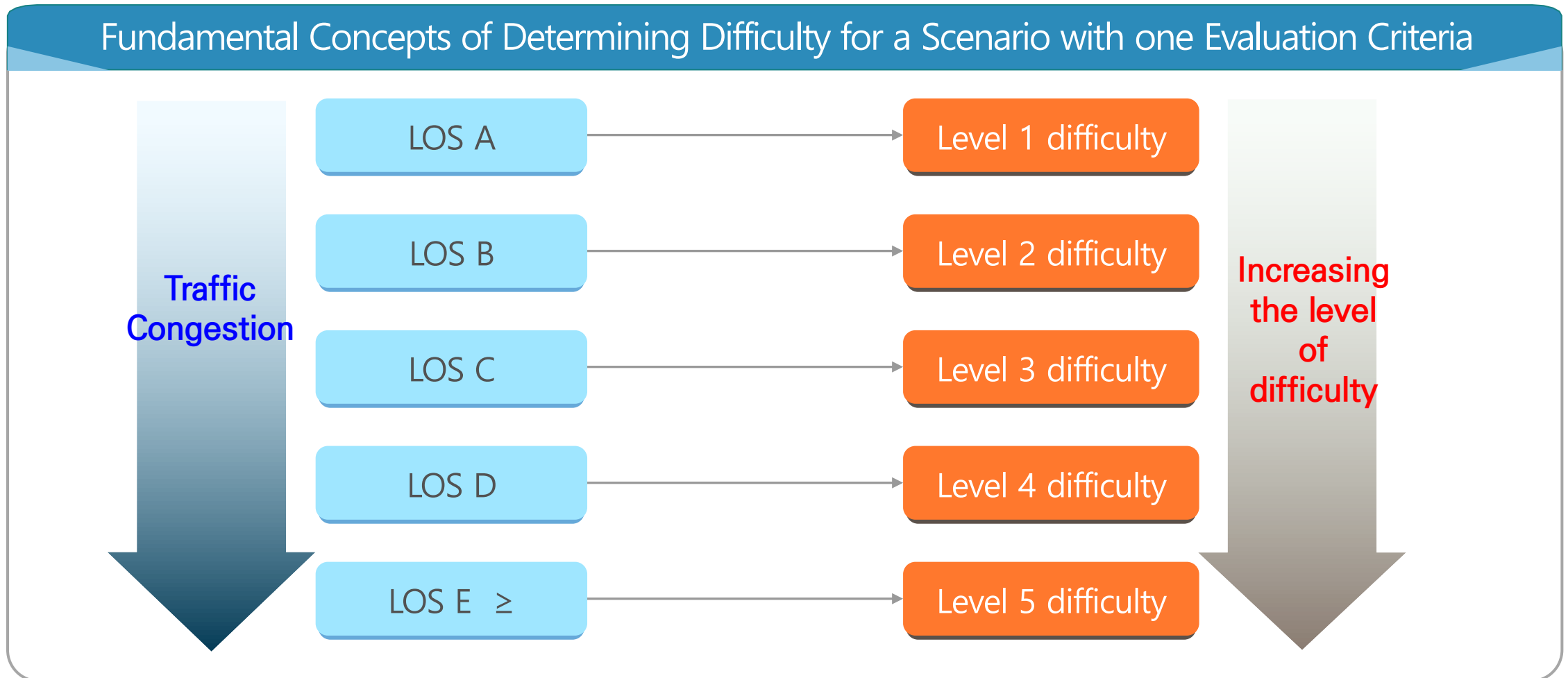
2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Composite Scenario overview



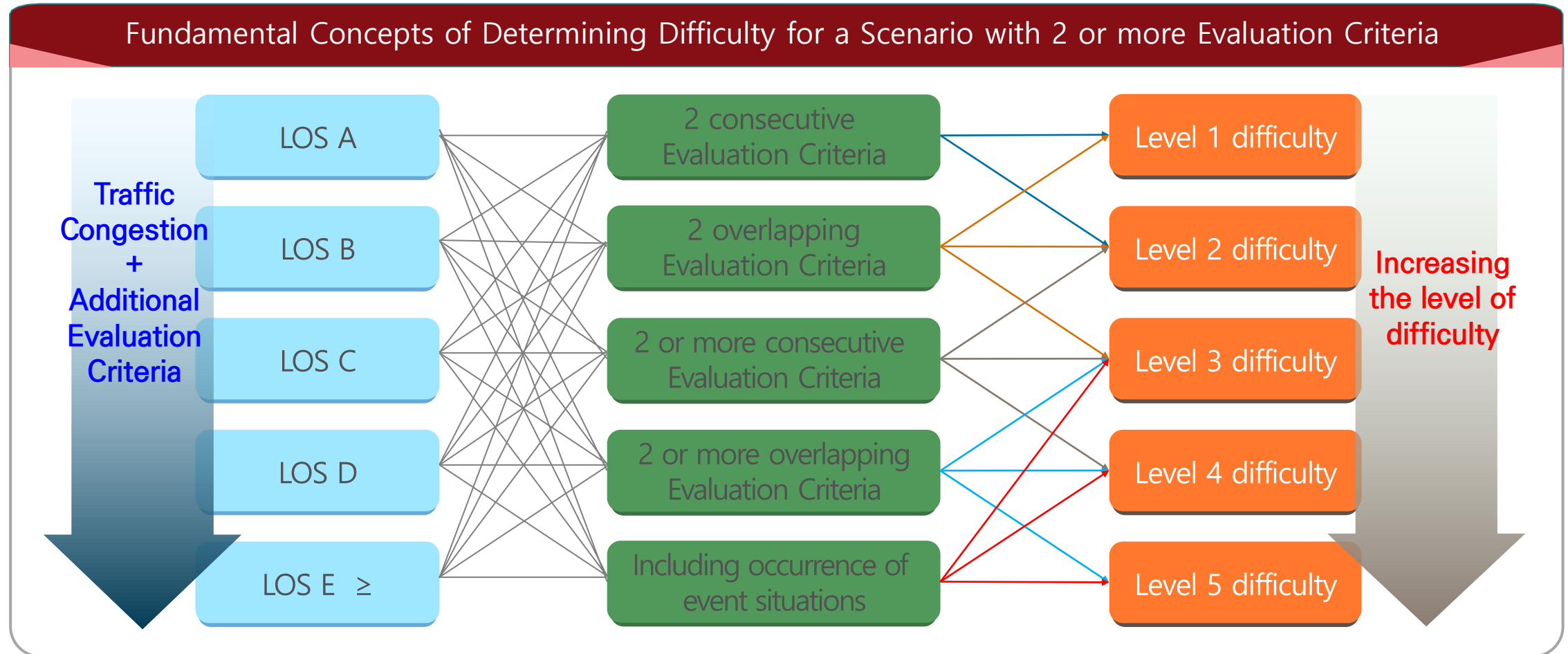
2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Concepts of Determining Difficulty



2. Scenarios for evaluating AV driving ability based on Road Traffic Laws

Concepts of Determining Difficulty



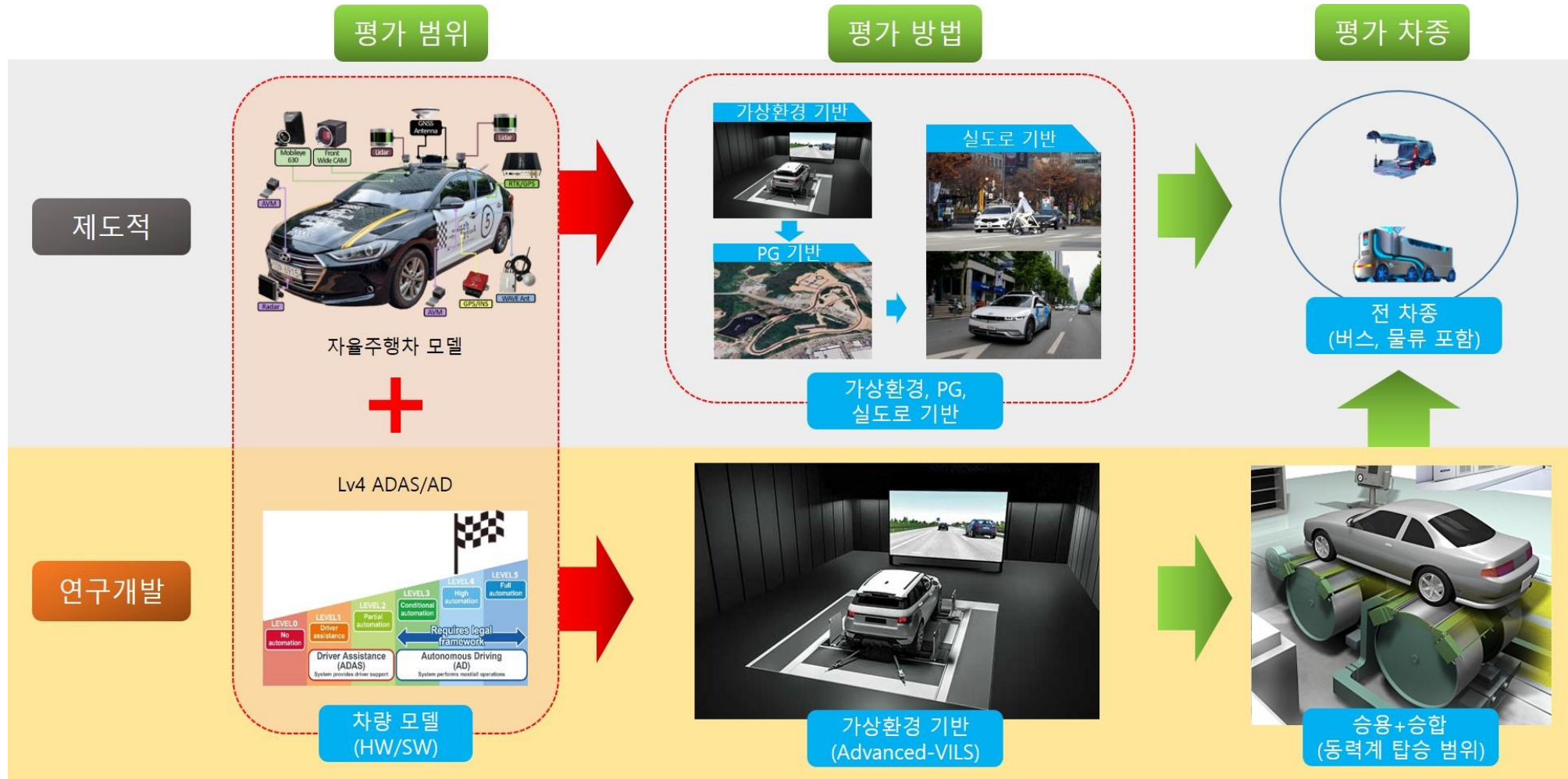
AV driving ability evaluation system using Virtual Environments

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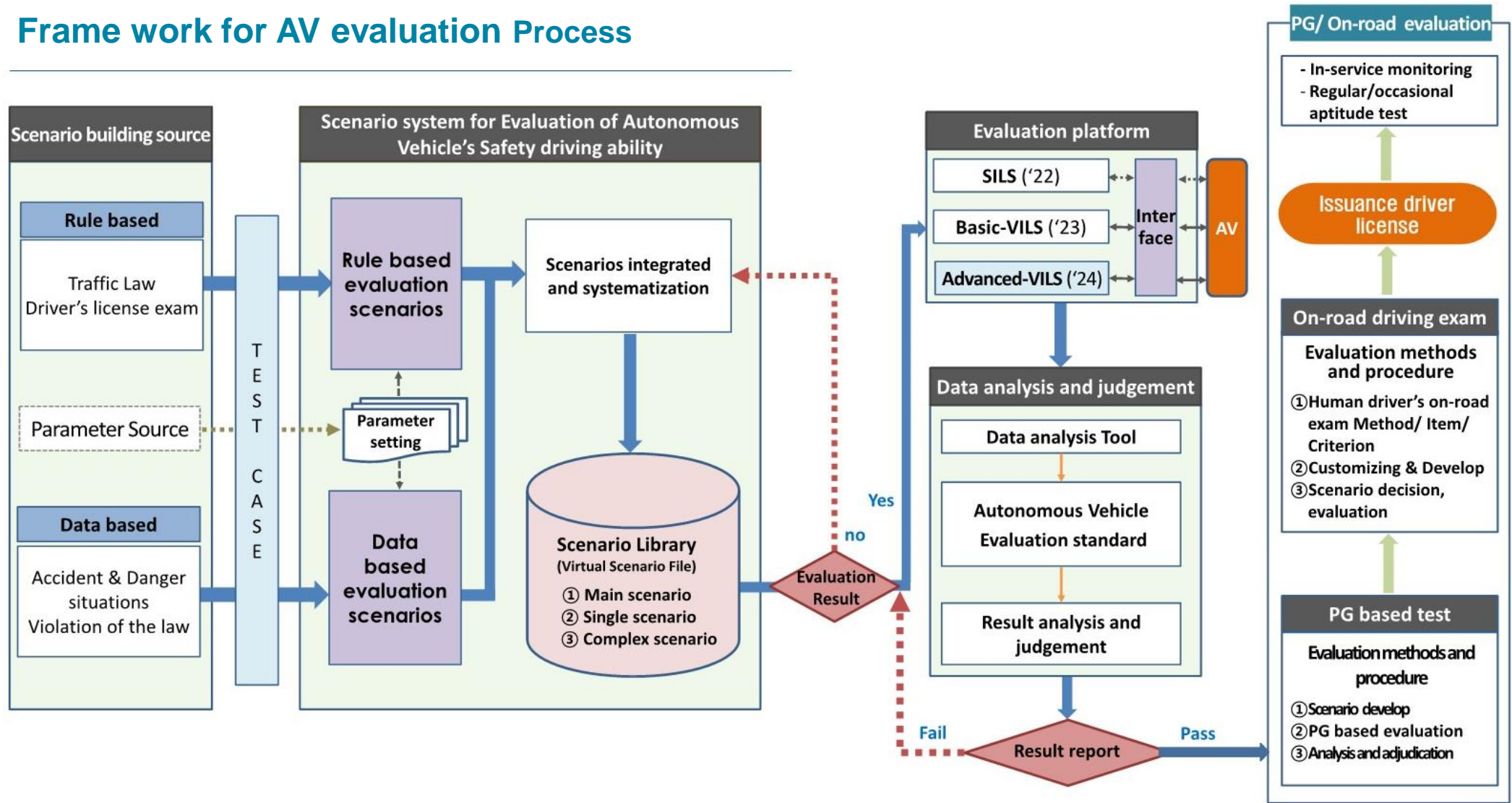
3. AV driving ability evaluation system using Virtual Environments

What and how to evaluation



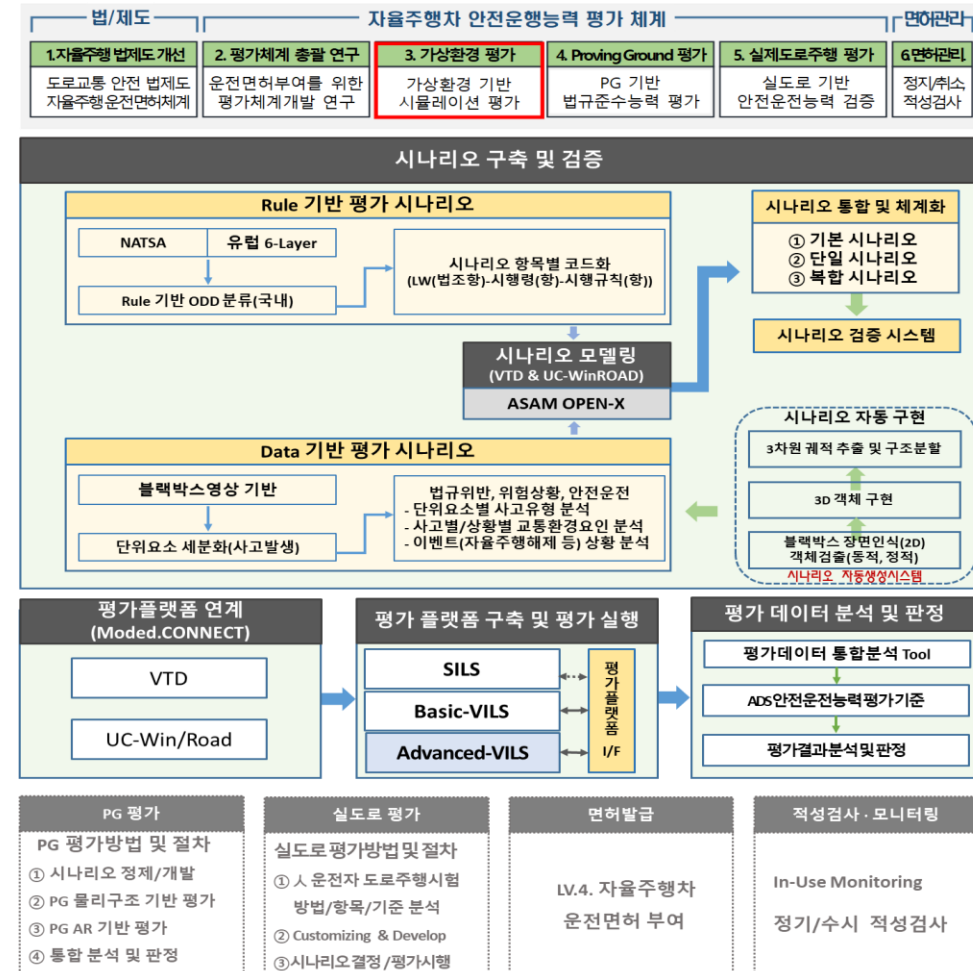
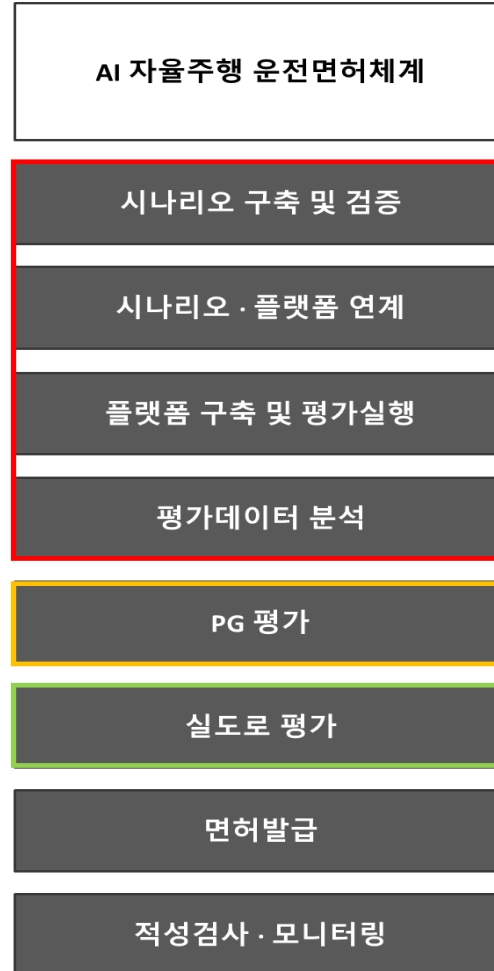
3. AV driving ability evaluation system using Virtual Environments

Frame work for AV evaluation Process



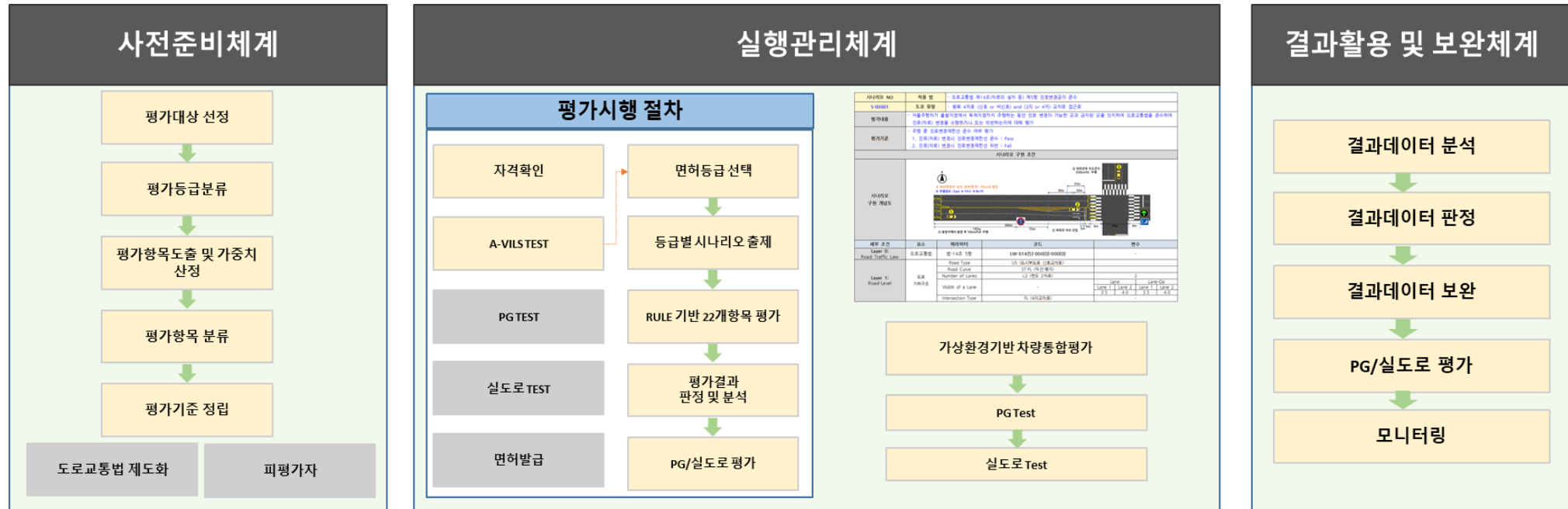
3. AV driving ability evaluation system using Virtual Environments

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 weights
- ✓ Establishment 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 grade
- ✓ 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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Researcher

4. Future research plans

Setting the direction for autonomous driving integration evaluations



Laying the foundation for the introduction of an autonomous vehicle driver's license system by establishing a three-step standard evaluation system and developing evaluation technology



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

