

Design of Infrastructure-Based Prescriptive Control Use Cases in CAV

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Speaker Introduction

- **Ki Hun Jang** received the **Ph.D. degree** in transportation engineering from Ajou University, South Korea, in 2021.
- His doctoral dissertation was titled *“A Study on the Development of Estimation Model for Emergency Vehicle Travel Time using Deep Learning Model.”*
- He is working at **ITS Korea**, where he is actively involved in various fields including **autonomous driving, data-driven analysis, and ITS innovation projects.**

1.1 Related Project Overview

Initiative
name

Korea Autonomous driving Development Innovation (Korean National Police Agency)

Project
name

Development of Transportation Safety Infrastructure Standard and
Evaluation Technology for Lv.4 Connected Autonomous Driving

Project
Period

2021.04.01 ~ 2026.12.31 (5 years and 9 months)

Reserch
Objectives

- Development of Traffic Safety Device(TSD) Infrastructure Standards Considering
Lv.4 Autonomous Cooperative Driving and Coexistence with Normal Vehicles

01

Integrated Architecture
for Autonomous Driving
TSD

02

Level4 TSD Infrastructure
Standard Development

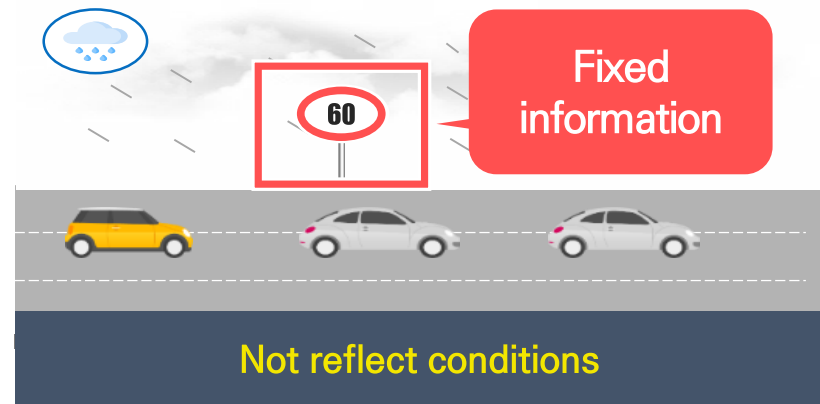
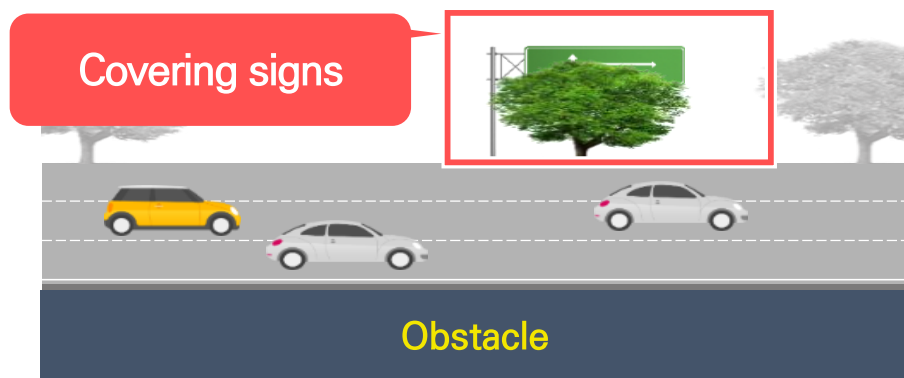
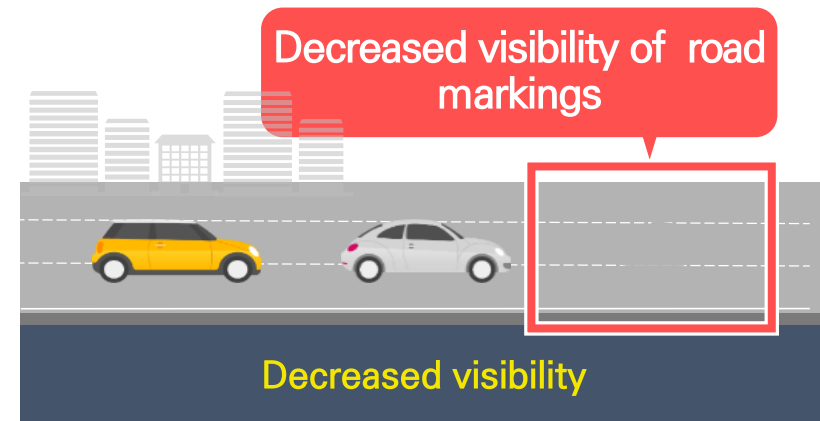
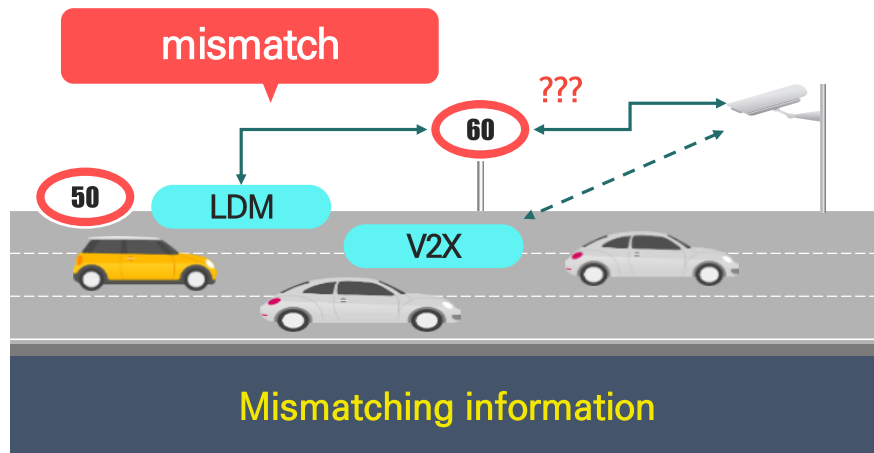
03

TSD Infrastructure
Prescriptive Control
Strategies for Cooperative
Autonomous Driving

1.1 Related Project Overview

Background

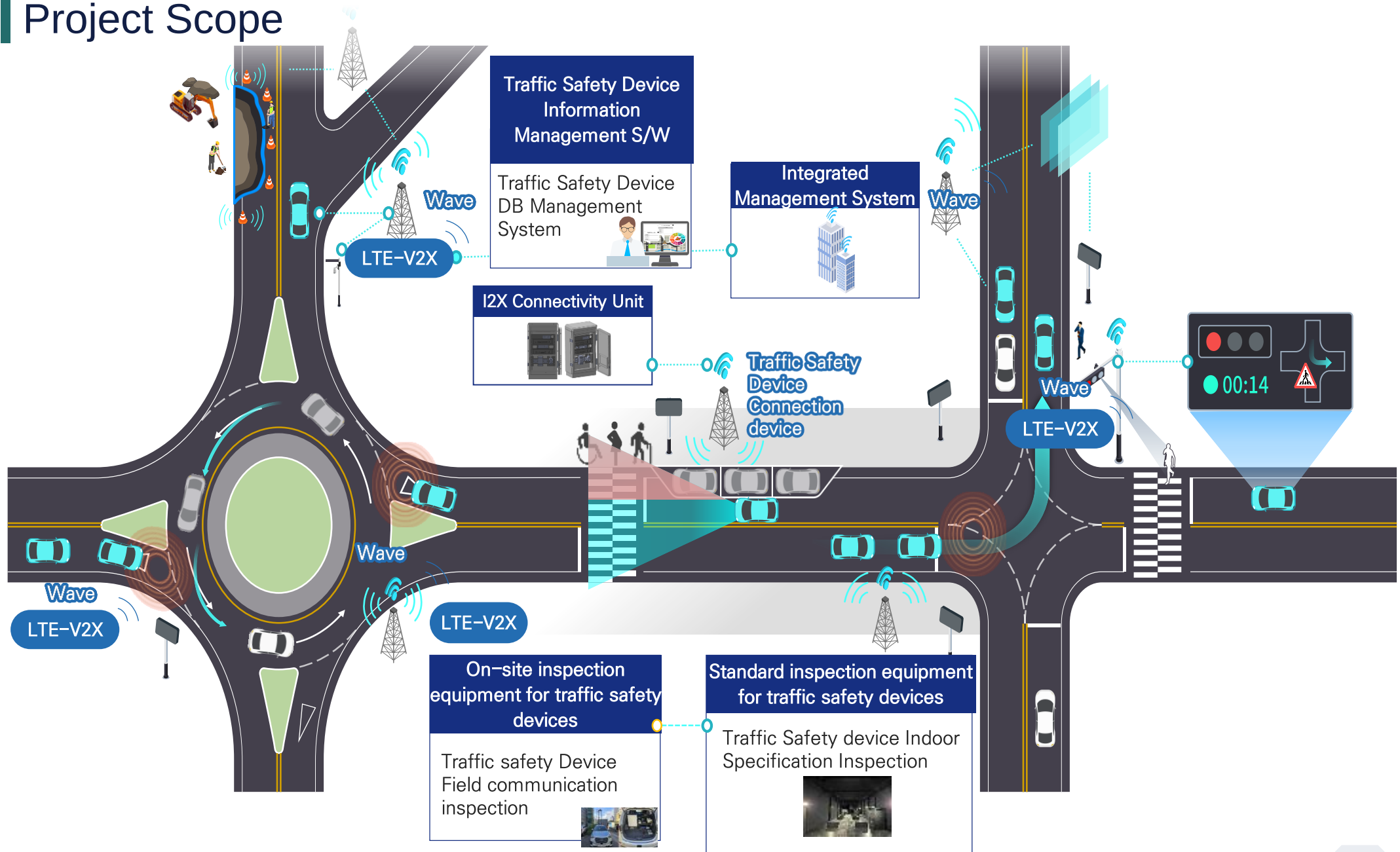
Limitations of recognizing TSD information in AV



※ Traffic safety device(TSD) : Infra to prevent car accidents and ensure smooth traffic flow (Applicable to traffic lights, safety signs, road markings)

1.1 Related Project Overview

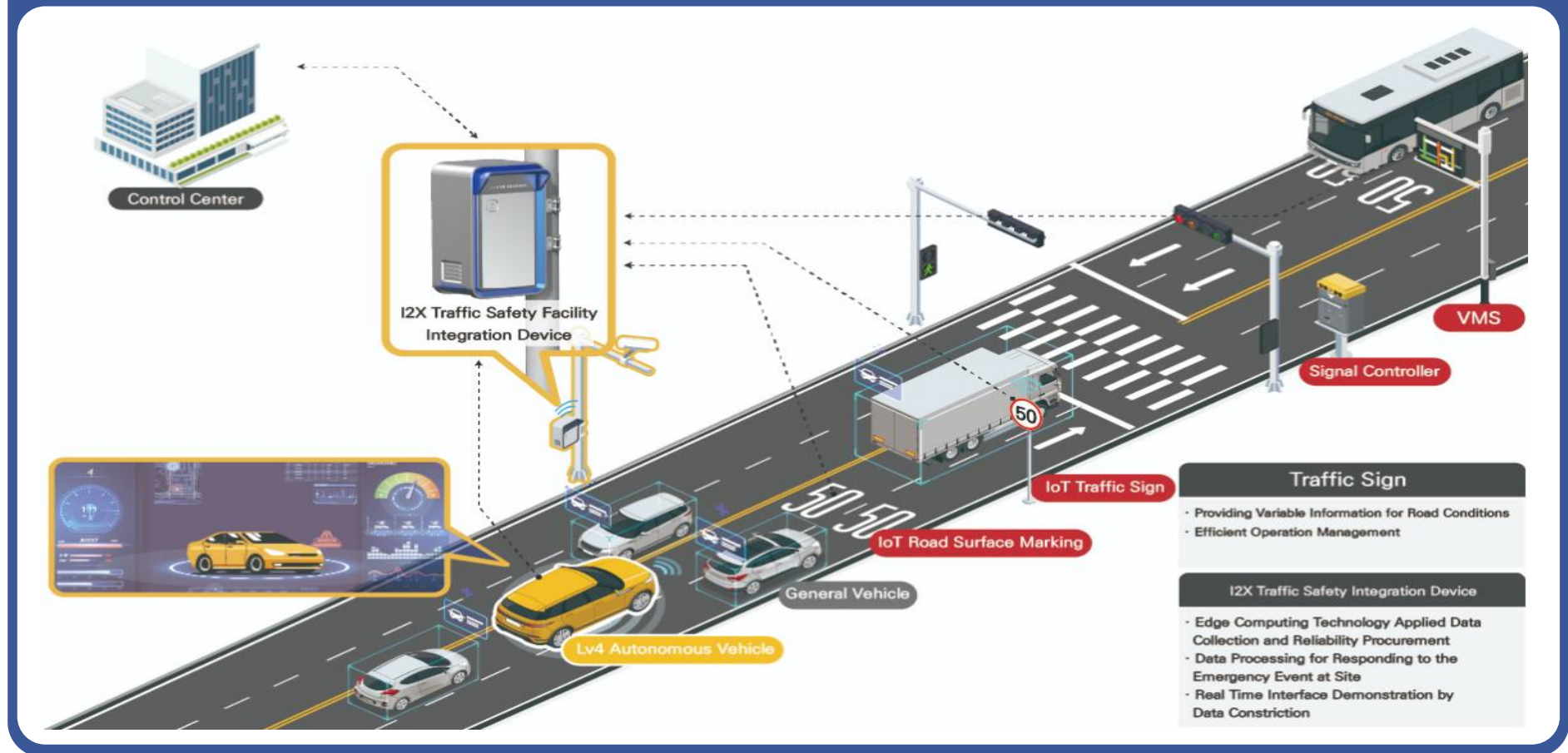
Project Scope



1.1 Related Project Overview

Project Scope

Need for information linkage between AV and TSD



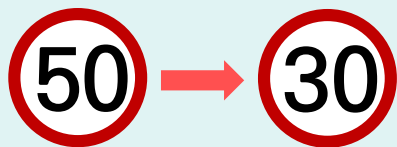
Need for Traffic Safety Device to improve automated driving safety

1.2 Research Purpose

Adverse weather conditions



Speed Limit Change



Work Zone



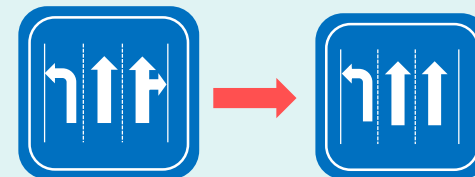
lane accessibility



Traffic Accident

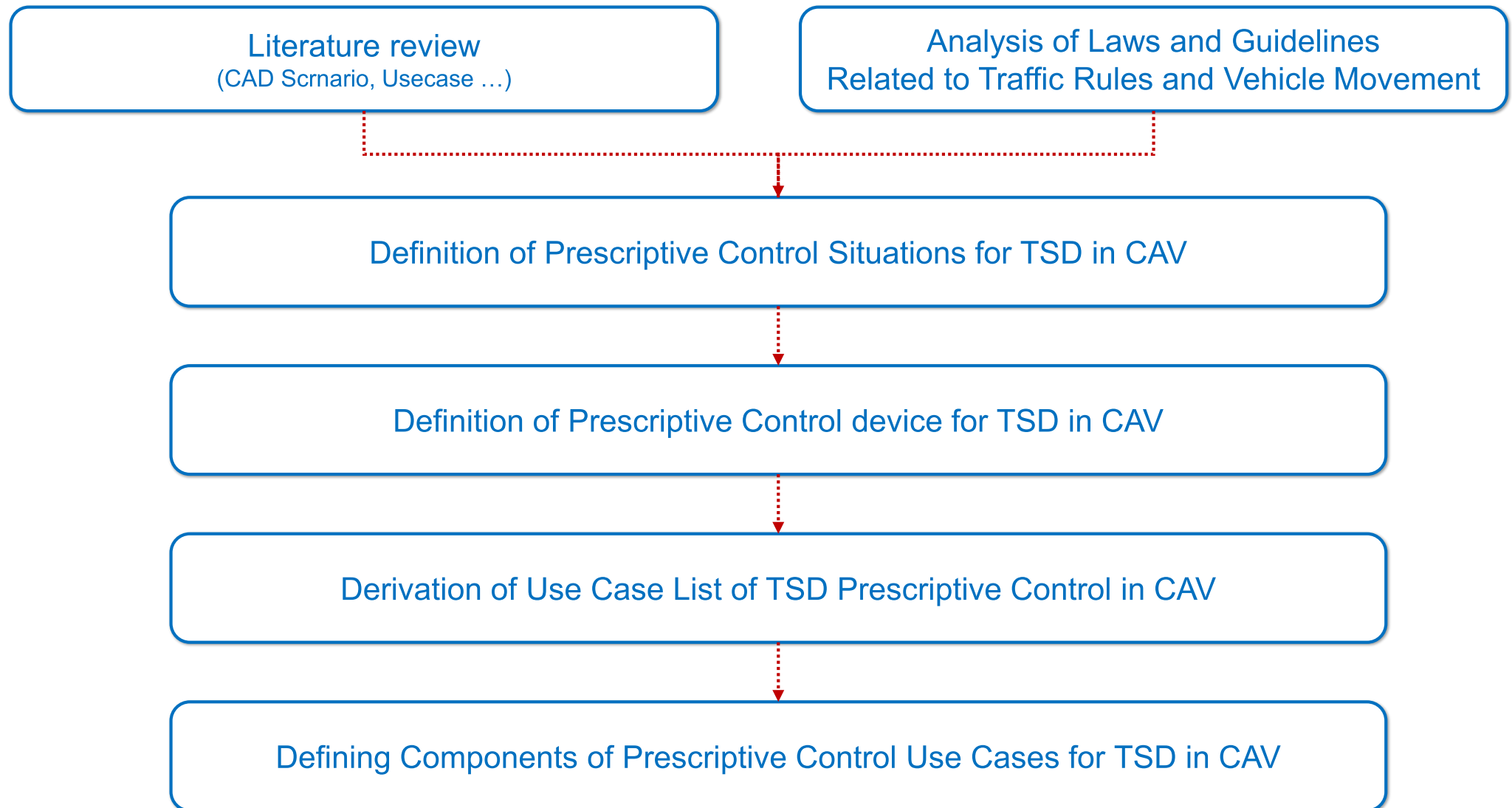


lane use modification



Need for Dynamic TSD Information Provision to Respond to Dynamic Situations

1.3 Methodology



2.1 Review

For safe AV, **providing traffic safety device information** through infrastructure is **essential**

• Literature review



- AV is supported by providing information **such as speed, lane change, priority, and signal control during events like congestion or emergencies**
- Delivered via V2I / LDM
- VMS informs normal vehicles in mixed traffic

• Laws/Guidelines



- Road Traffic Act defines rules only for human-driven vehicles
 - AV-specific regulations are not clearly defined
 - Government and police require AVs to recognize and respond to TSD via infrastructure (e.g., V2I)

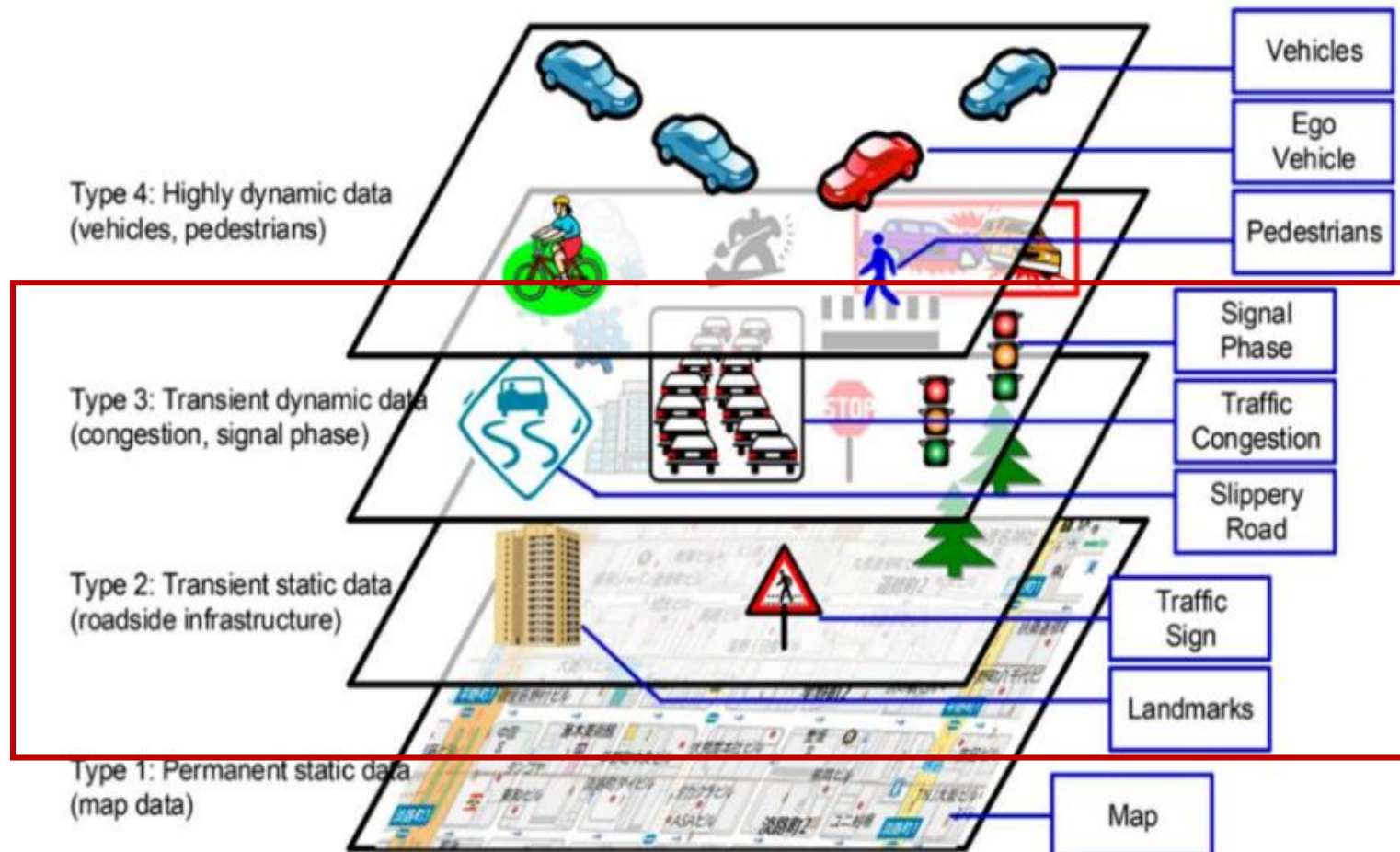
3.1 Definition of Prescriptive Control Situations for TSD

6 Situations Requiring Prescriptive Control Derived from the Road Traffic Act

Situation	Prescriptive Traffic control methods
Entering an Intersection	• Slow/Stop, Yield, Counterclockwise movement
Traffic Congestion	• Speed limit, No entry(temporarily), Shoulder driving
Traffic Accident / Obstacle	• Lane change within prohibited zone, Speed limit, No entry(temporarily)
Road Construction	• Speed limit, Center/Left side driving, No entry(temporarily)
Adverse weather conditions	• Speed reduction
Emergency Vehicles Operation	• Center/Left side driving, Priority for emergency vehicles, Shoulder driving, Crossing, U-turn, reverse driving

3.2 Definition of the Scope and Devices for Prescriptive Control of TSD

(Control Scope) Utilization of information corresponding to LDM* Layer 2 and Layer 3



*LDM (Local Dynamic Map): A system that collects, stores, and processes various traffic-related dynamic data in real time based on a high-definition map (static information), and provides services for autonomous driving and C-ITS (Cooperative Intelligent Transport Systems).

3.2 Definition of the Scope and Devices for Prescriptive Control of TSD

(Control Devices) By reviewing relevant regulations,
27 TSDs directly related to vehicle traffic were selected out of 297

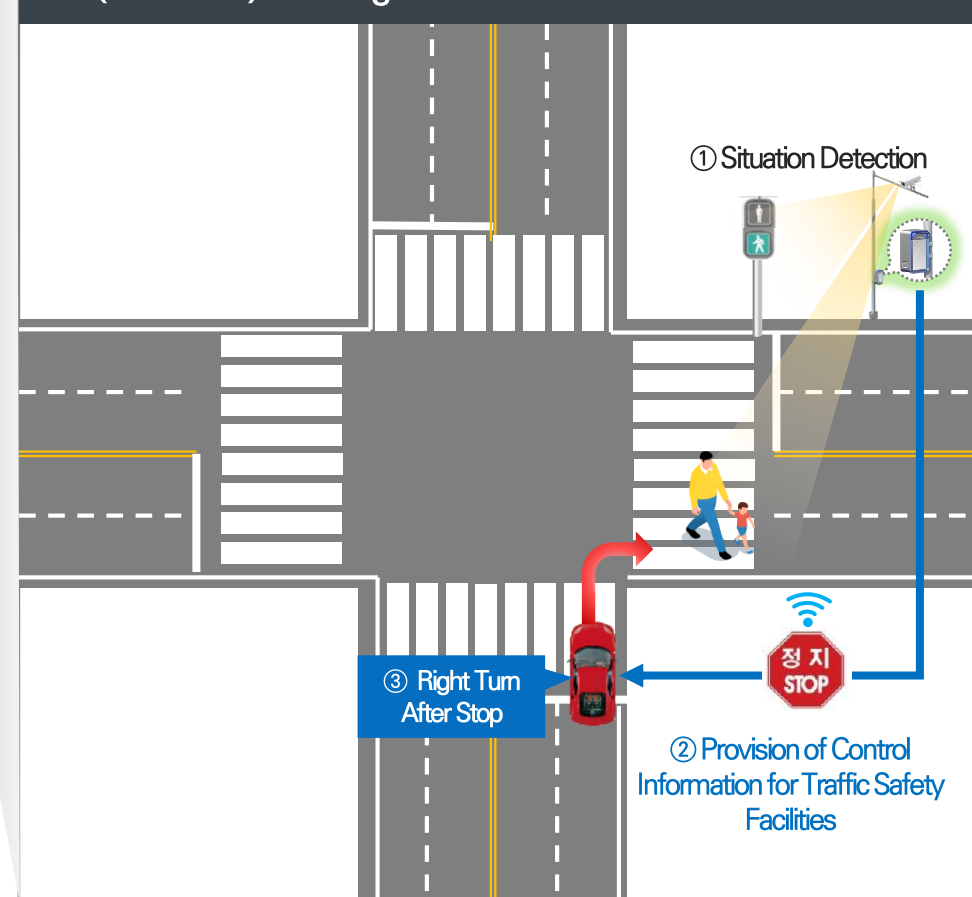
Category		Controllable Traffic Safety Devices	
Safety signs	Warning sign	• During Road Construction, Traffic Priority, etc.	 
	Regulatory sign	• Traffic prohibition, entry restriction, speed limit, stop requirement, straight-ahead prohibition, etc.	    
	Guide sign	• Go straight, right turn, left turn, U-turn, detour, one-way traffic, etc.	    
	Supplementary sign	• Distance, zone, date, time, safe speed, traffic regulations, traffic restrictions, etc.	   
Road markings	Regulatory sign	• Center line, lane, exclusive lane, straight-ahead prohibition, speed limit, etc.	    
	Guide sign	• Guidance, direction of travel, lane change, etc.	  
Traffic light		• Traffic light	 

3.3 Use Cases for Prescriptive Control in TSD

19 Use Cases Derived for TSD Infrastructure-Based Prescriptive Control

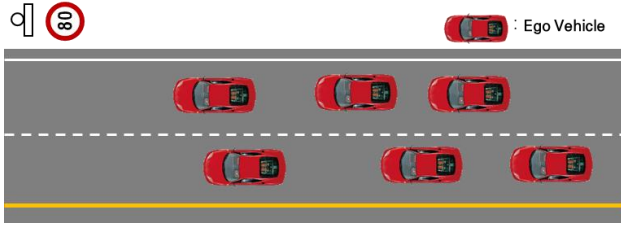
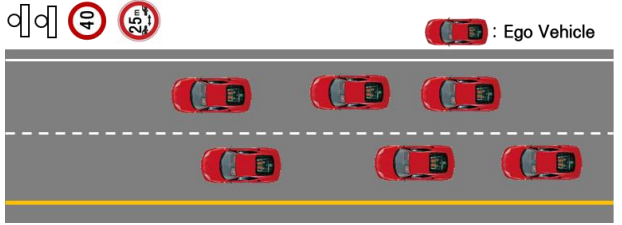
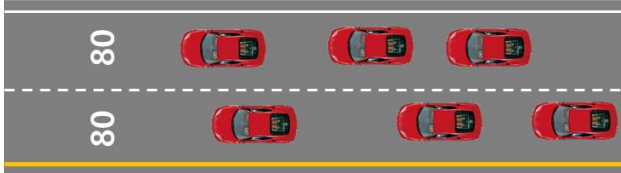
Situation	No.	Information Control	Geometric Structure Road Type	Number of Lanes (One-Way)
Entering an Intersection	1	Safe Passage Support	Intersection	One or More Lanes
Traffic Congestion	2	Variable Speed Limits and Speed Recommendations	Single-Lane Road	One or More Lanes
	3		Unsignalized Intersection	One or More Lanes
	4	Lane Change Recommendation	Signalized Intersection	Three or More Lanes
Traffic Accidents / Obstacles, etc.	5	Safe Passage Support	Unsignalized Intersection	One or More Lanes
	6	Lane Change Recommendation	Single-Lane Road	One Lane
	7			Two or More Lanes
	8			Three or More Lanes
	9	Detour Guidance (Road Closure)	Signalized Intersection	One or More Lanes
	10		Single-Lane Road	Two or More Lanes
Road Construction	11	Lane Change Recommendation	Single-Lane Road	Two or More Lanes
	12	Detour Guidance	Signalized Intersection	One or More Lanes
Severe Weather Conditions	13	Variable Speed Limits and Speed Recommendations	Single-Lane Road	One or More Lanes
	14		Single-Lane Road	One or More Lanes
	15	Detour Guidance (Road Closure)	Underpass	Two or More Lanes
Emergency Vehicle Operation	16	Lane Change Recommendation	Single-Lane Road	One Lane
	17			Two or More Lanes
	18	Safe Passage Support	Signalized Intersection	One or More Lanes
	19		Unsignalized Intersection	One or More Lanes

(Use Case) Safe Right-Turn Assistance at Intersections



3.3 Use Cases for Prescriptive Control in TSD

Adverse weather conditions – Variable Speed Limit and Speed Recommendation

Elements			Contents					
Overall Situation Diagram	Category		As-is		To-be			
	Traffic Safety Sign							
	Road Marking							
Traffic Safety Device	Type		Traffic Safety Sign		Road Markings		Traffic Light	
	Classification		Regulation		Regulation		-	
	Attributes		Maximum Speed Limit (No. 224) Keep Safe Distance (No. 223)		Speed Limit (Sign No. 517)		-	
	Attribute Information	Before Control	100km/h		100km/h		-	
		After Control	80km/h(40m) → 60km/h(30m)		80km/h → 60km/h		-	

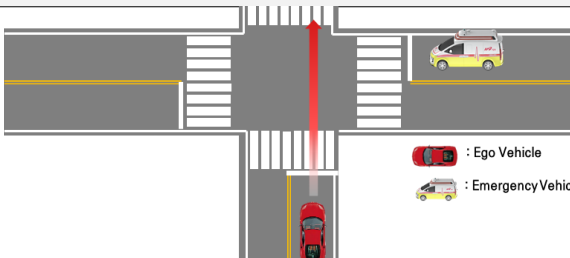
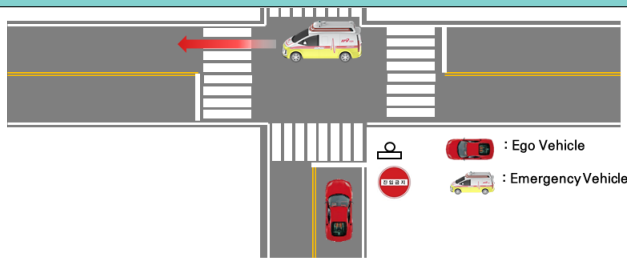
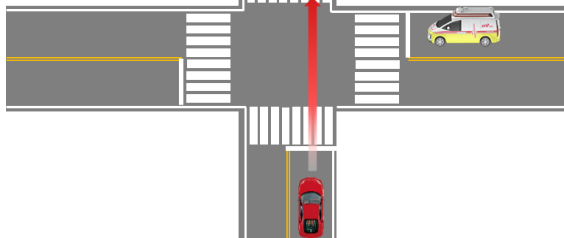
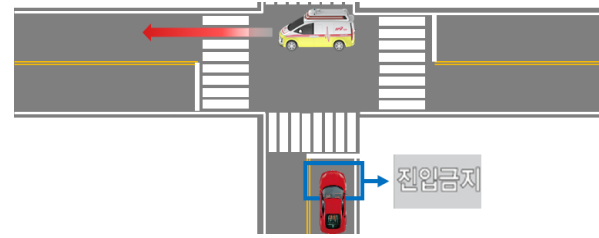
3.3 Use Cases for Prescriptive Control in TSD

Traffic Accident – Lane change instruction

Elements			Contents		
Overall Situation Diagram	Category		As-is	To-be	
	Traffic Safety Sign + Road Marking				

3.3 Use Cases for Prescriptive Control in TSD

Emergency Vehicles Operation – Safe Passage Support

Elements			Contents			
Overall Situation Diagram	Category		As-is		To-be	
	Traffic Safety Sign		 : Ego Vehicle : Emergency Vehicle		 : Ego Vehicle : Emergency Vehicle	
	Road Marking				 진입금지	
Traffic Safety Device	Type		Traffic Safety Sign		Road Markings	Traffic Light
	Classification		Regulation		Regulation	-
	Attributes		No entry(211)		No entry(546)	-
	Attribute Information	Before Control	Entry permitted		Entry permitted	-
		After Control	No entry		No entry	-

4.1 Conclusion

- Need for TSD-based Prescriptive Control to complement sensor limitations in cooperative autonomous driving
 - 6 Prescriptive control situations & 19 use cases derived based on the Road Traffic Act
- This enhances the safety and reliability of autonomous vehicles and supports the establishment of traffic operation and management strategies
 - However, real-time TSD information integration and reliable V2I communication are still required
- Future work includes message specification design, TSD priority setting, guideline development, and testbed validation.

4.2 Future Work

Define message specifications for each use case

- ☑ Plan to utilize ITIS codes within SAE J2735 messages (e.g., TIM, MAP, SPaT)

Message	TIM (SAE J2735)	
Message Components	Message Generation Time	DF_dataFrames DF_startTime_DE_MinutOfTheYear
		MinuteOfTheYear ::= INTEGER (0..527040) <i>-- the value 527040 shall be used for invalid</i>
	Message Duration	DF_dataFrames DF_duratontime DE_MinutesDuration
		MinutesDuration ::= INTEGER (0..32000) -- units of minutes
	Message Application Distance	DE_extent (ENUMERATED (0..15))
		Extent ::= ENUMERATED useInstantlyOnly (0), useFor3meters (1), useFor10meters (2), ...
	Speed Limit Change	DF_ITIS_Phrase_SpeedLimit, DE_EXT_ITIS_Codes [ITIS]
		ITIS Code 268, <num>, Kph, 8721, 13588 (속도)
		{SpeedLimit ::= SEQUENCE (SIZE(1..16)) OF SEQUENCE item CHOICE itis ITIScodes, text ITIS textPhrase}, ITIScodes ::= INTEGER (0.. 65535)
Situation	- Traffic congestion - Adverse weather conditions	

4.2 Future Work

Testbed demonstration

Location/
Road extension

Baegot-dong area, Siheung-si, Gyeonggi-do, Republic of Korea/ 9.5km (Seven arterial roads within the city)

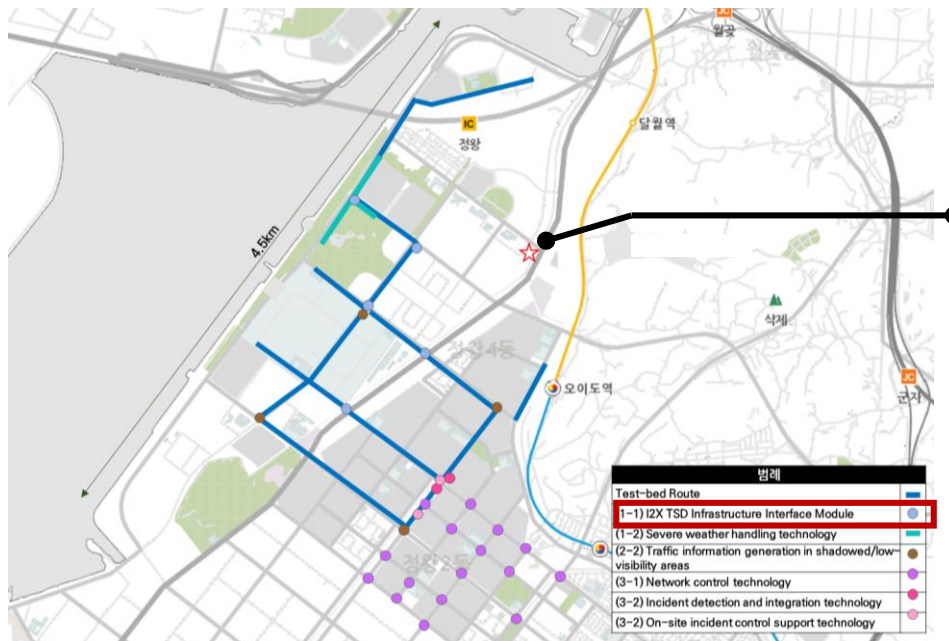
Status

Six-lane bidirectional road

Well-maintained roads (new town area)

Real-time Traffic environment monitoring

Construction
Overview



<T.B Location>



<Siheung Urban Integrated Information Center control room>

Reference

- [1] Korean National Police Agency, Guidelines for Autonomous Vehicle Driving Rules, 2022.
- [2] Korean National Police Agency, Manual for Installation and Management of Traffic Signs, 2023.
- [3] Korean National Police Agency, Manual for Installation and Management of Road Markings, 2023
- [4] Korean National Police Agency, Manual for Installation and Operation of Traffic Signals, 2023
- [5] Korean National Police Agency, Road Traffic Act, 2024.
- [6] Korean National Police Agency, Enforcement Decree of the Road Traffic Act, 2024.
- [7] Ministry of Land, Infrastructure and Transport, Level 4 Autonomous Vehicle Manufacturing and Safety Guidelines, 2020.
- [8] Ministry of Land, Infrastructure and Transport, Guidelines for Temporary Operation Permits of Autonomous Vehicles, 2022.
- [9] J. Choi, K. Min, S. Han, K. Sung, D. Lee, D. Choi, Y. Cho, and J. Kang, “Development status of autonomous driving technology through urban autonomous service tests and reconstruction of the role of 5G-linked media,” *Broadcasting and Media*, vol. 24, no. 1, pp. 63–72, 2019.
- [11] Korea Institute of Civil Engineering and Building Technology, Definition of Infrastructure Guidance Service Use Cases, 2023.
- [12] Korea Automotive Technology Institute, Seoul National University, and C&BIS, Scenario for Evaluation of TSD-Vehicle Integration, 2021. Article in a conference proceedings:
- [13] Korea Automotive Technology Institute, Operational Design Domain (ODD) Analysis Report for Autonomous Driving Systems, 2024.
- [14] Korea Intelligent Transport Systems Association, Demonstration Scenario for Cooperative Autonomous Driving on Urban Roads, 2021

Reference

- [15] Korea Intelligent Transport Systems Association, Optimization of Operational Domain System and Driving Environment Analysis, 2022.
- [16] Korea Road Traffic Authority. [Online]. Available: <https://m.blog.naver.com/koroadblog/221237819558>, accessed Oct. 29, 2024.
- [17] Korea Road Traffic Authority. [Online]. Available: <https://m.blog.naver.com/koroadblog/221237819558>, accessed Oct. 29, 2024.
- [18] National Highway Traffic Safety Administration (NHTSA), A Framework for ADS Testable Cases and Scenarios, 2019.
- [19] National Highway Traffic Safety Administration (NHTSA), A Framework for ADS Testable Cases and Scenarios, 2019.
- [20] SIP (Cross-Ministerial Strategic Innovation Promotion Program), Use Cases for Cooperative Driving Automation – Activity Report of Task Force on V2X Communication, FY2019.
- [21] The European Union Horizon 2020, MAVEN Project WP6: Integration, Implementation and Test, D6.4, 2019.
- [22] U.S. Department of Transportation (US DOT), Cooperative Automation Research: High-Level Framework of CARMA Proof-of-Concept TSMO Use Case Testing, FHWA-HRT-21-107, 2022.

Thank you for your attention!