National R&D Project

Connected and **A**utomated **P**ublic **TrA**nsport system **IN**novation **CAPTAIN** Project

October 18, 2019

Kyeong-Pyo Kang, Ph.D.
The Korea Transport Institute (KOTI)
kpkang@koti.re.kr

Outline

- Background
- Overview
- Methodology
- Service Applications & Test beds
- Summary

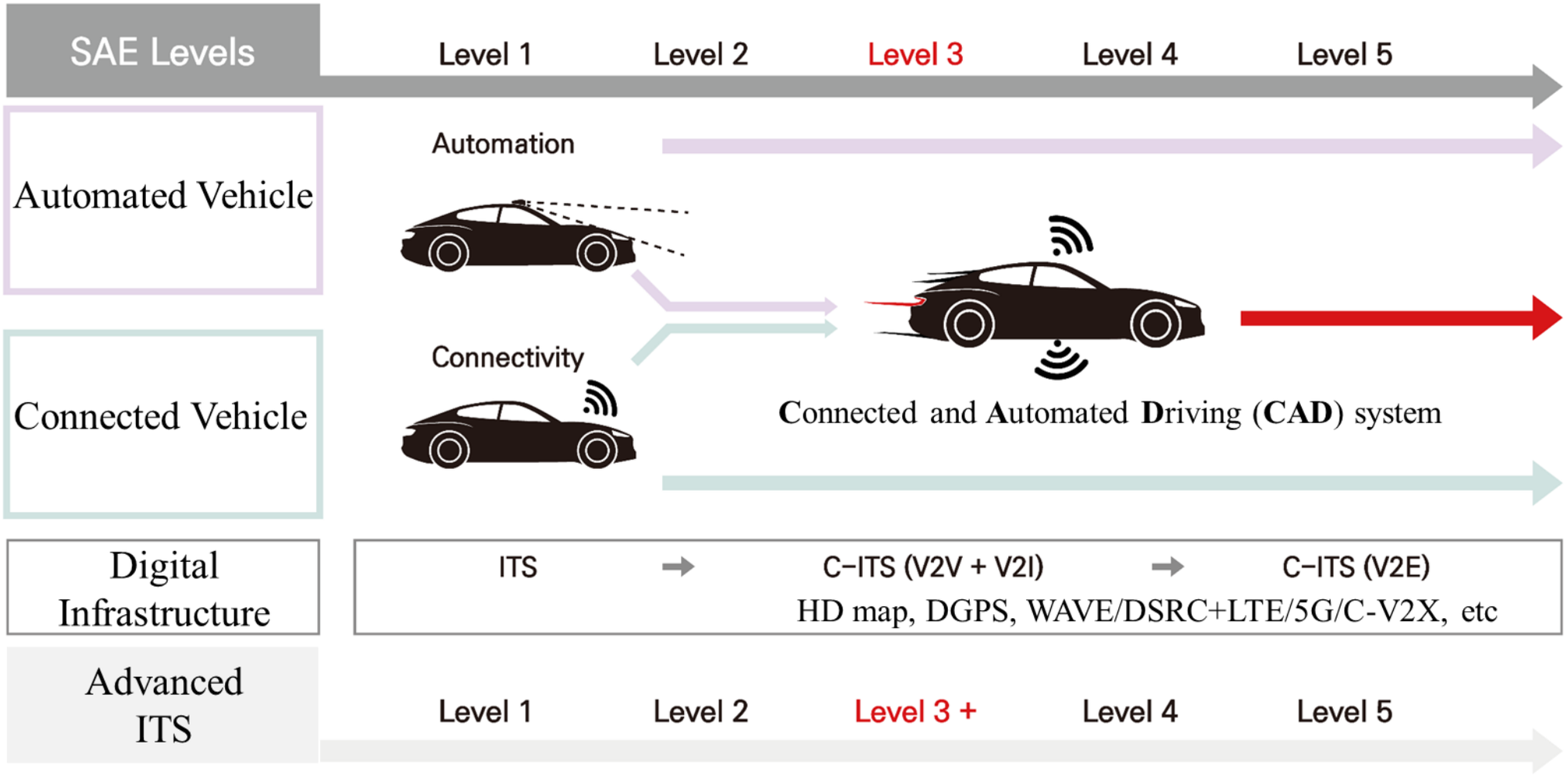
Background

- Safety problems of AV
  - Autonomous vehicle accidents

2016		2018	
Google (14 February) The first incident of an autonomous vehicle	Tesla (7 May) The first fatal crash while using autopilot mode	Tesla (23 March) A fatal accident involving a Tesla Model X crashed into a roadside barrier	Uber (18 March) The first recorded case of a pedestrian fatality involving autonomous vehicle
			
(Image source: MailOnline)	(Image source: National Transportation Safety Board, NTSB Accident Report, HAR-17/02, 2017)	(Image source: National Transportation Safety Board, NTSB Preliminary Report, HWY18FH011, 2018)	(Image source: ABC 15)
Causal Factor: Decision error Misjudgment	Causal Factor: Sensor error Recognition Error	Causal Factor: Sensor error Recognition Error	Causal Factor: Sensor error Recognition Error

Background

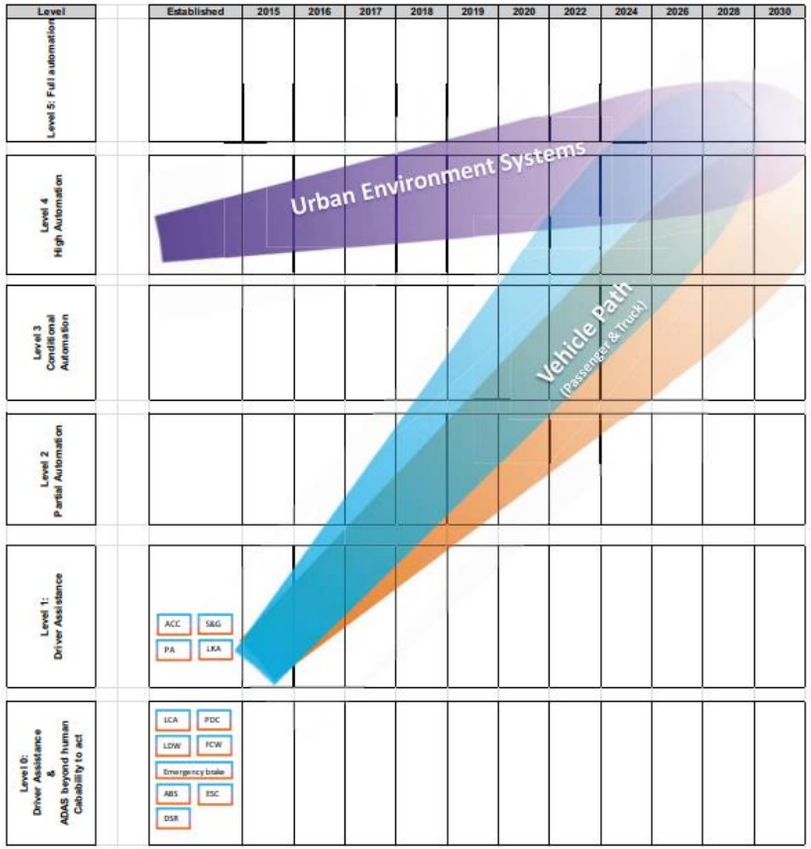
- Connectivity problem of AV
  - Integration of autonomous vehicle into CV and Digital Infrastructure(CAV)



Background

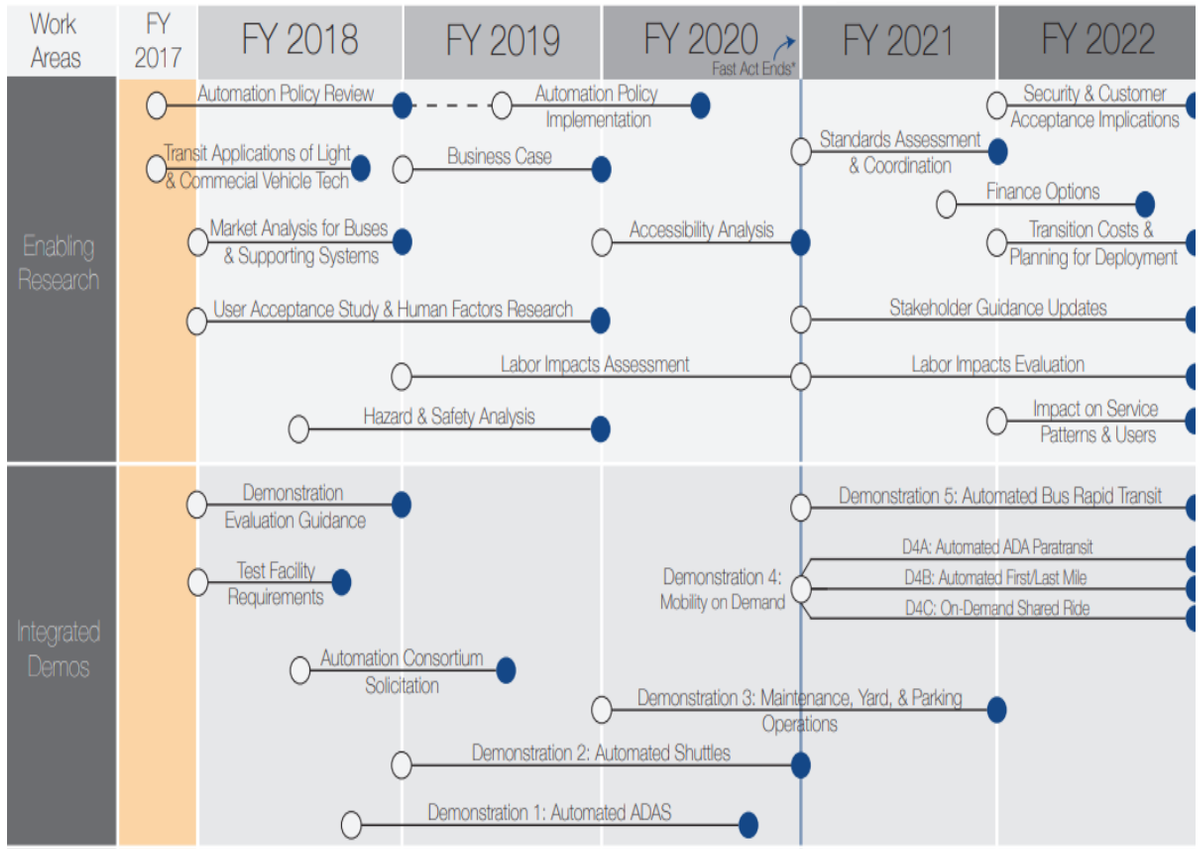
- Early deployment of AV
  - Preparing for commercialization of automated driving-based public transport in urban areas

    → Automation roadmaps for the EU and USA



<ERTRAC's automation deployment plan>

(Image source: ERTRAC, Automated Driving Roadmap, 2015)

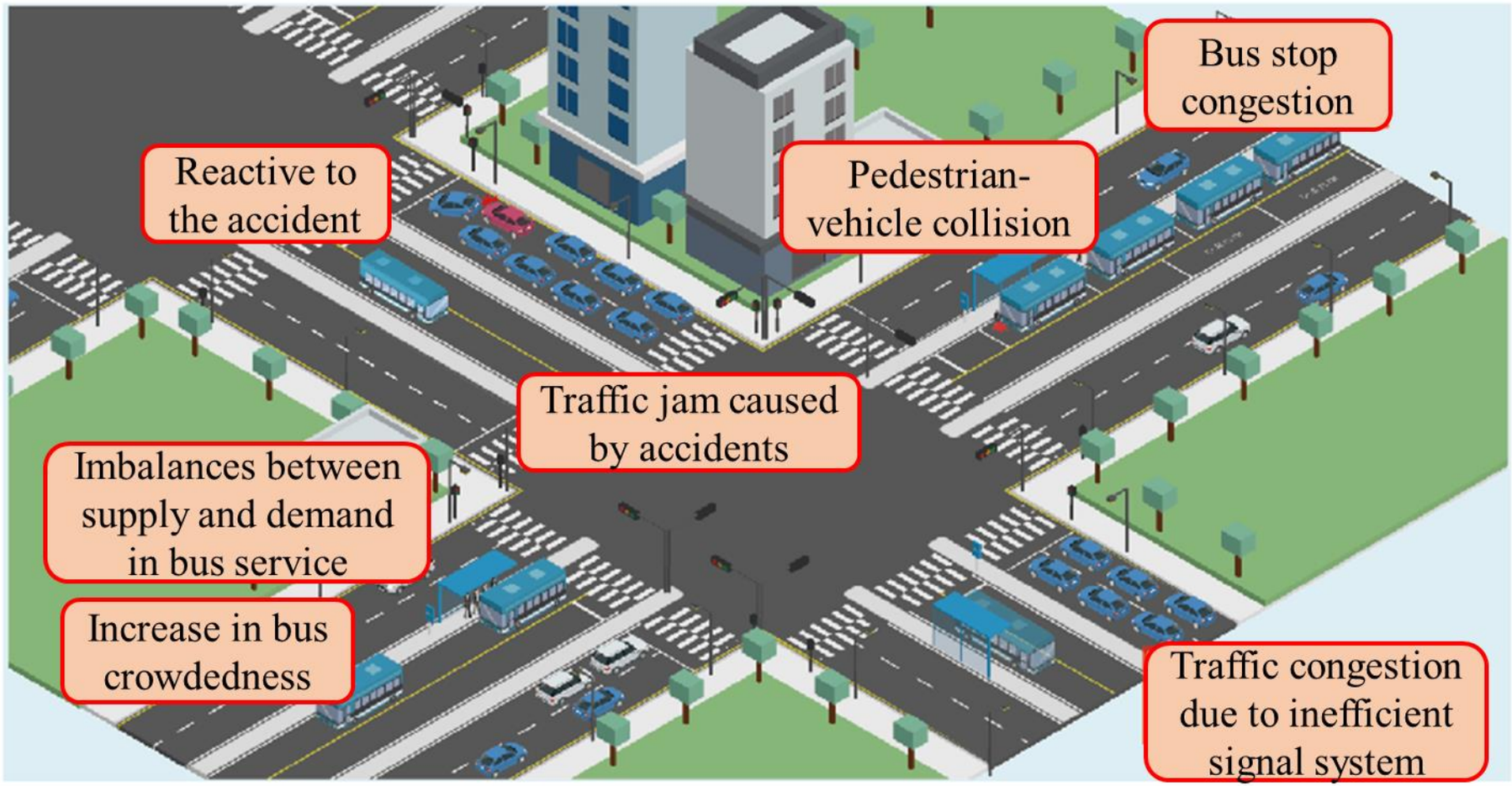


<FTA's transit automation research roadmap>

(Image source: FTA, Strategic Transit Automation Research Plan Roadmap, 2017)

Background

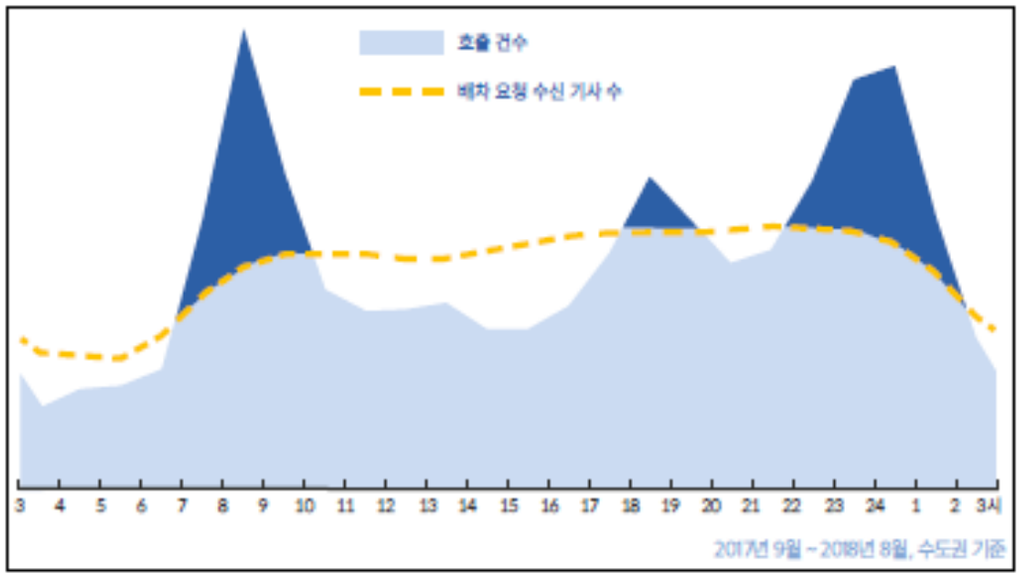
- Limitations – Current System (As-is)



- Leading to low safety caused by conflicts between pedestrians/passengers and buses in urban areas
- Resulting in low operational efficiency during morning or evening peak hours
- Showing less proactive response to emergency situations

Background

- Limitations – Current System (As-is)
  - Unbalance of demand and supply of Taxi service in Seoul metropolitan area



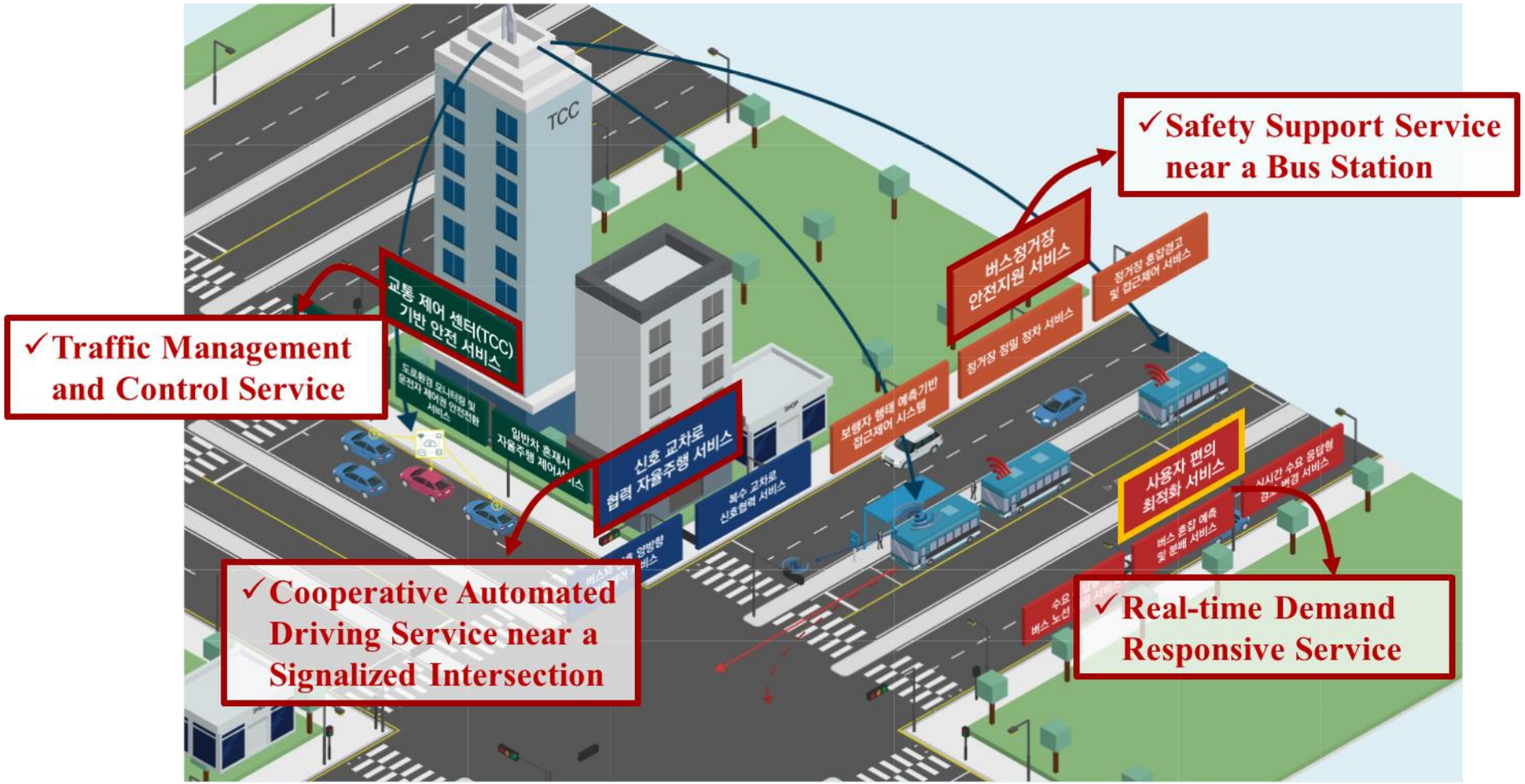
<source: Kakao mobility>

<Source: Seoul citu>

- Taxi service vs, Public transport(Transit)service
- How to replace or support the role of Taxi service by Transit?

Background

- Safety & Operational Efficiceny – Future System (To-be)



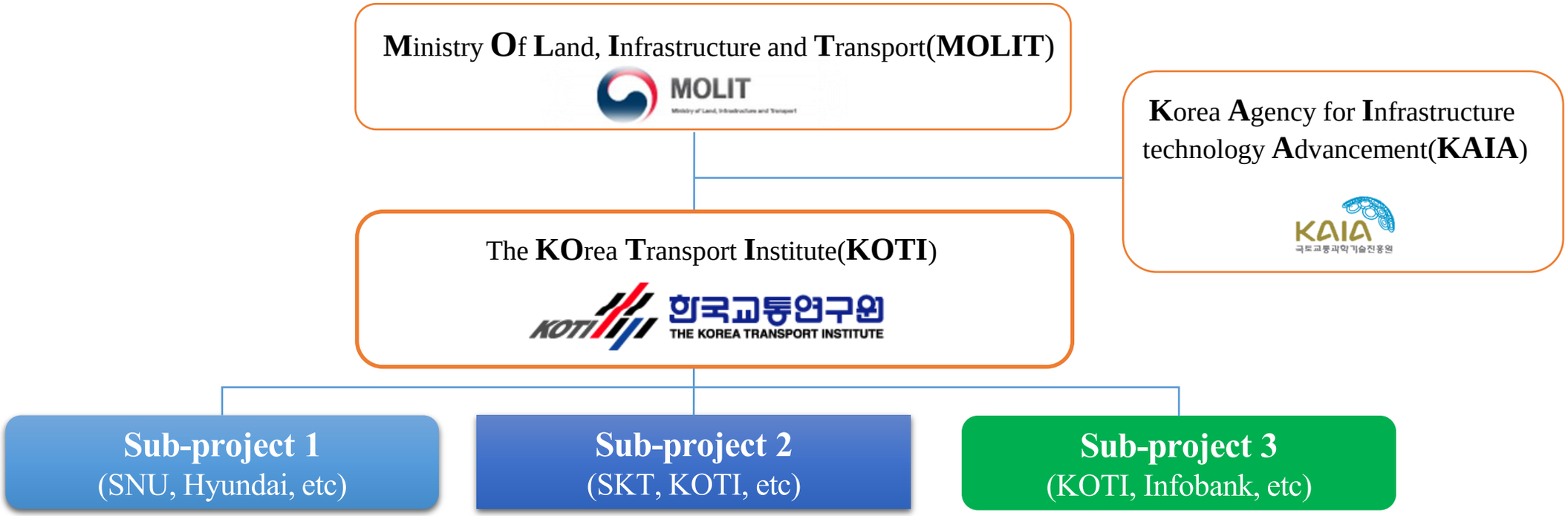
  - Providing safer driving and passenger boarding/alighting environments
  - Allowing more dynamic and flexible bus operation during peak and non-peak periods
  - Showing more proactive response to risky situations

Overview

- Goals
  - Developing a systematic framework on intelligent public transport system, including shuttle bus and transit bus, based on commercial vehicle-based CAD technology
  - Proposing novel CAD-based public transport services in terms of safety and efficiency
  - Incorporating the CAPTAIN services into public transportation system and evaluating the performances of the proposed services in terms of safety and efficiency
  - Considering an advanced operational environment for CAD-based public transport service based on hybrid V2X communications, such as WAVE/DSRC and LTE/5G/C-V2X

Overview

- Organization



- Sub-project 1: Developing an innovative technology for CAD-based bus platform
- Sub-project 2: Providing an intelligent traffic control center system integrated with digital infrastructure for CAD-based bus transit service
- Sub-project 3: Developing an advanced technology for operational test and evaluation of CAD-based bus transit service

Overview

- Periods & Budget

  – Period: 27 April, 2018 ~ 31 December, 2021

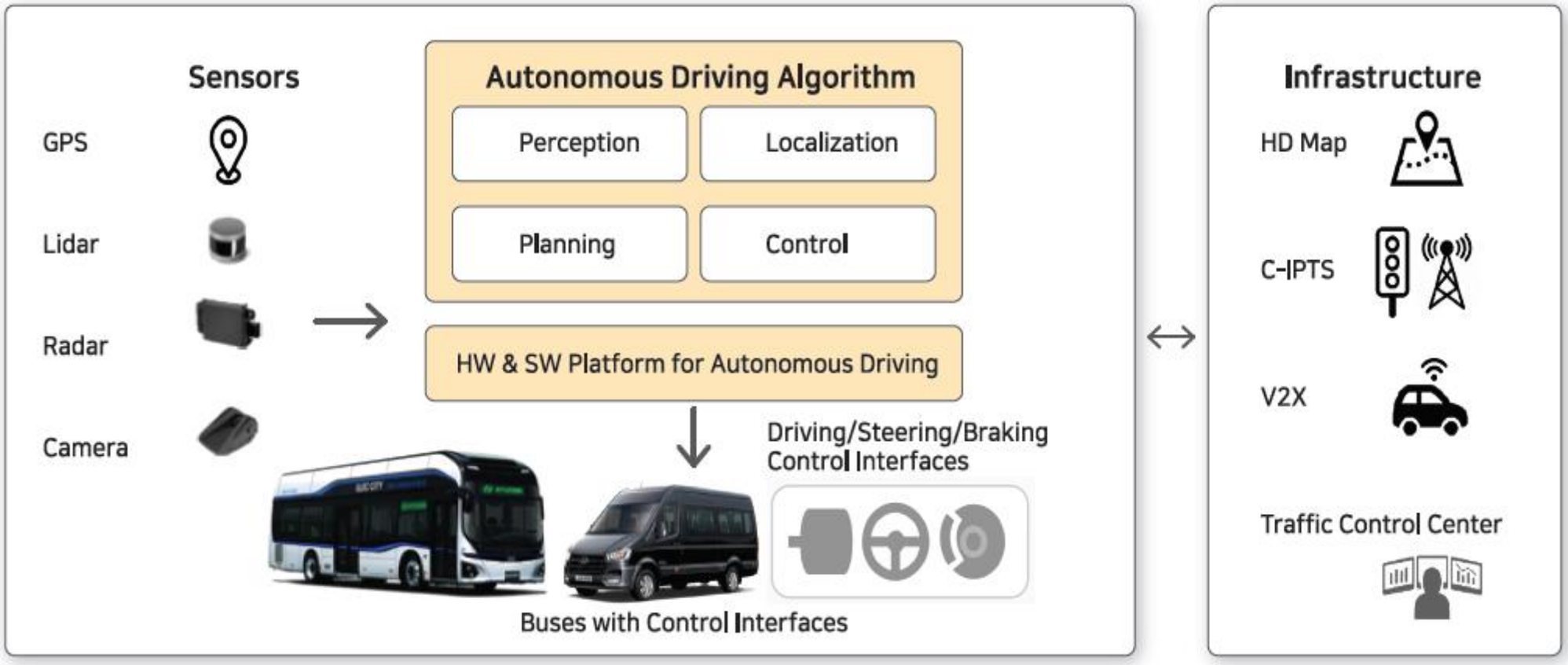
  – Budget: 30,407,884 (USD)

  – Consortium: 15 participants (Universities, Institutes, Car OEM, Mobile company, etc.)

Year 1 2018	Selecting study site and developing core technology	
Year 2 2019	Retrofitting & demonstrating CAD-based shuttle bus and system version 1.0	2 CAD-based shuttle buses
Year 3 2020	Setting up study site, developing CAD-based shuttle & transit bus and demonstrating system version 2.0	2 CAD-based shuttle buses 2 CAD-based transit buses
Year 4 2021	Providing CAD-based public transit service and evaluating its performance at the study site	3 CAD-based shuttle buses

Methodology

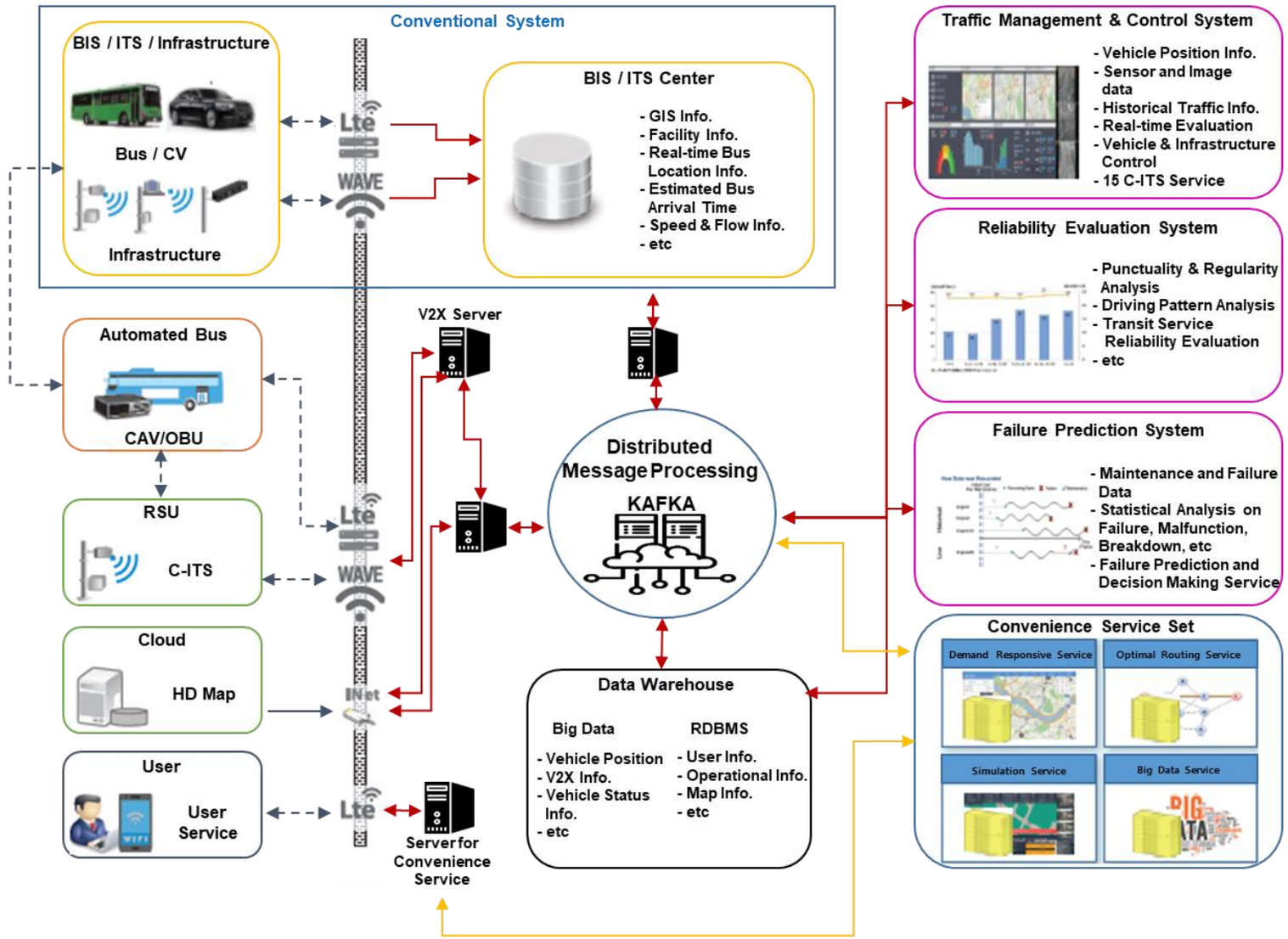
- Sub-project 1
  - Developing an innovative technology for CAD-based bus platform



<System architecture of CAD-based bus platform (HW & SW)>

Methodology

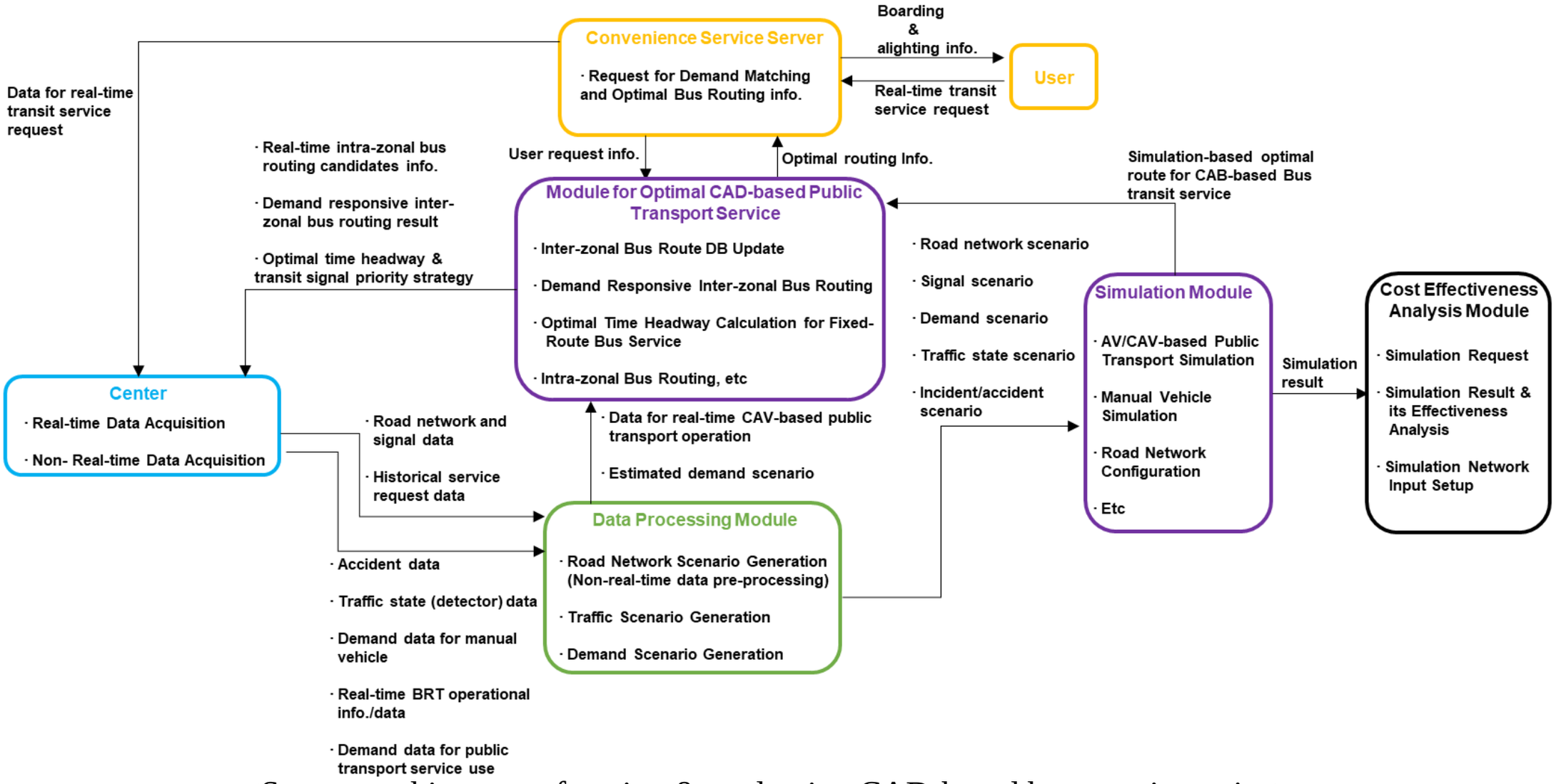
- Sub-project 2
  - Providing an intelligent traffic control center system integrated with digital infrastructure for CAD-based bus transit service



<System architecture of the proposed traffic control center>

Methodology

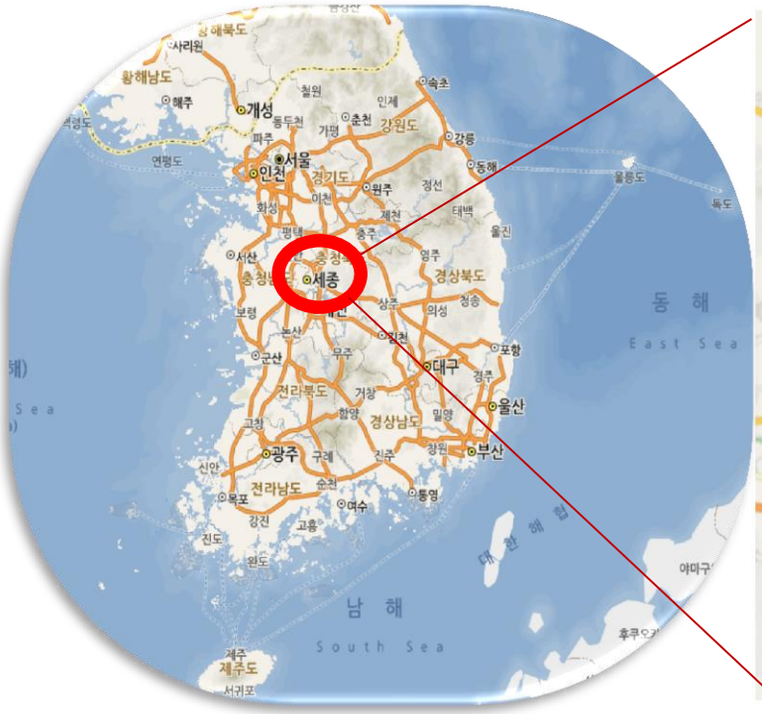
- Sub-project 3
  - Developing an advanced technology for operational test and evaluation of CAD-based bus transit service



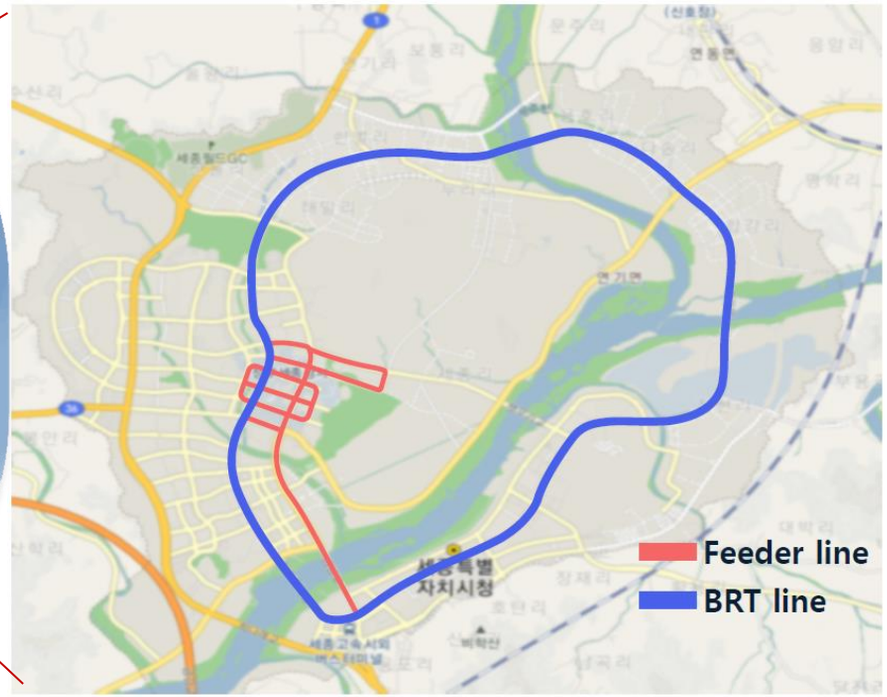
<System architecture of testing & evaluating CAD-based bus transit service>

Test beds

- Demonstrating and evaluating CAD-based public transport service
  - The CAPTAIN project includes 10 CAD services
  - The proposed services will be demonstrated in a study site located in Sejong city, South Korea



<Sejong city in South Korea>



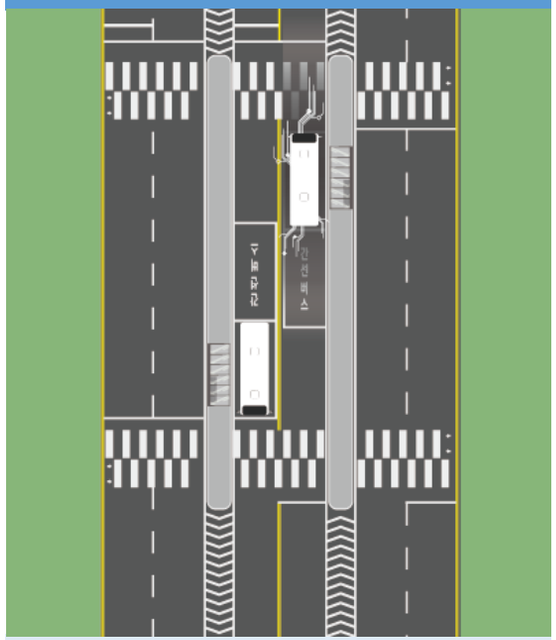
<Study site>

Feeder line: 8 km / BRT line: 23 km

Service Applications

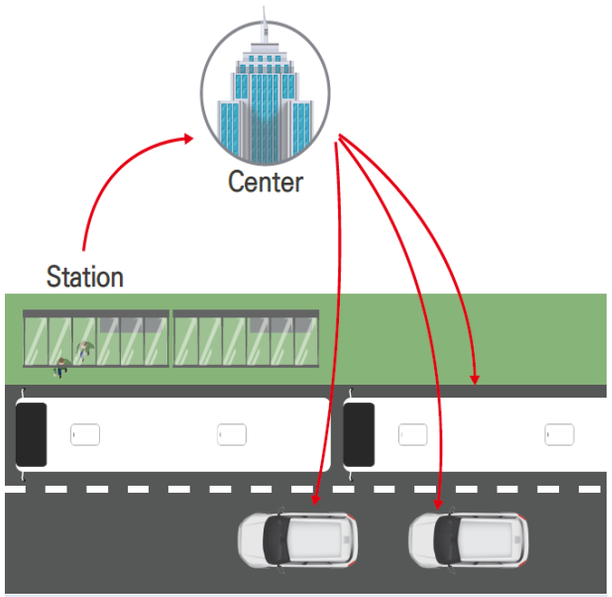
- CAD-based Public Transport Service Provision
  – CAPTAIN Service: Safety Support Service near a Bus Station

Precision-stopping control



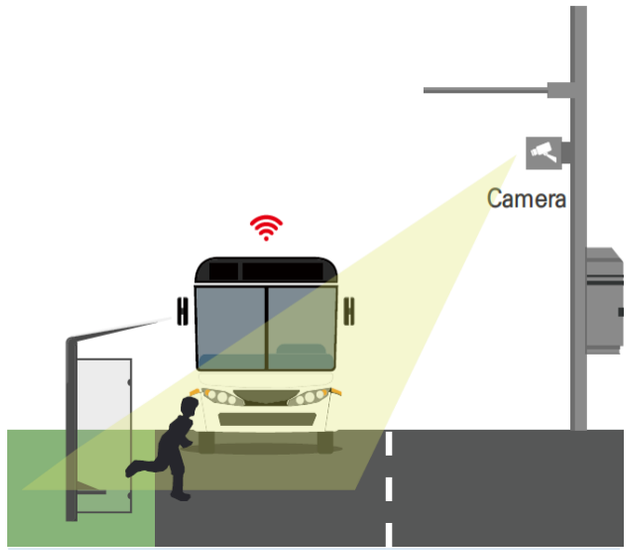
✓ Providing an automatic bus stop service based on ultra-precision control for CAD-based (shuttle & transit) bus

Bus stop congestion alert



✓ Providing an information on bus stop congestion with vehicles nearby the bus station using C-ITS and digital infrastructure

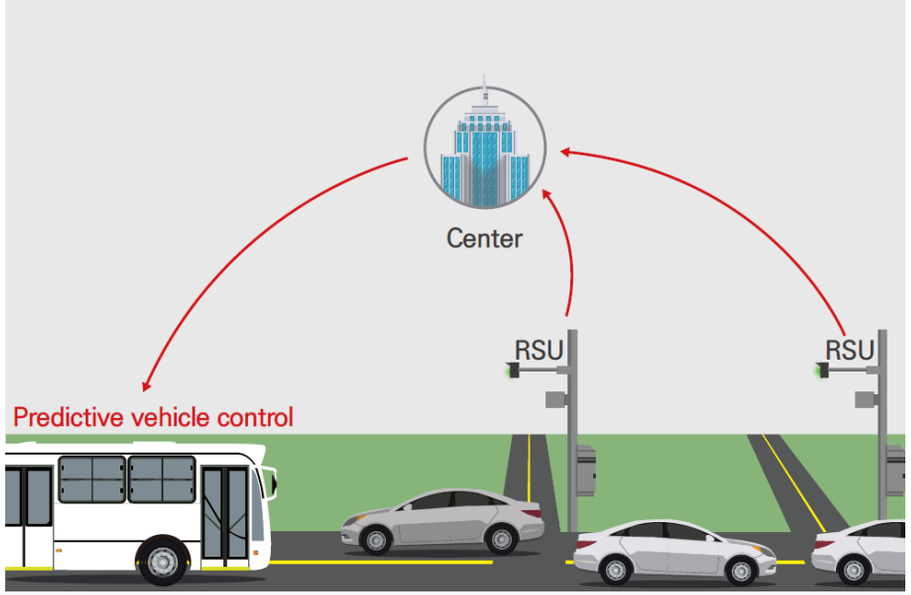
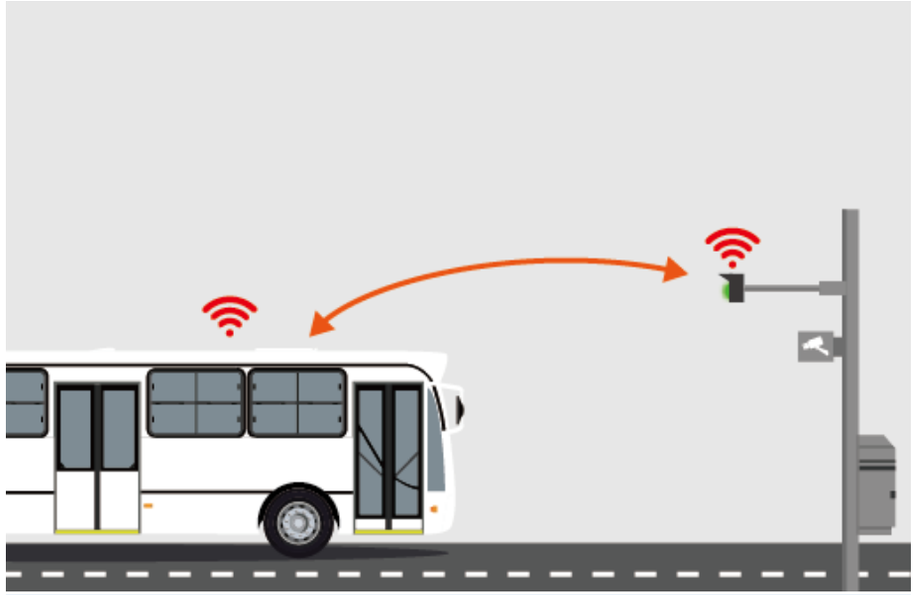
Predictive pedestrian-vehicle collision warning



✓ Providing a predictive pedestrian-vehicle collision warning service based on capturing pedestrian crossing intention

Service Applications

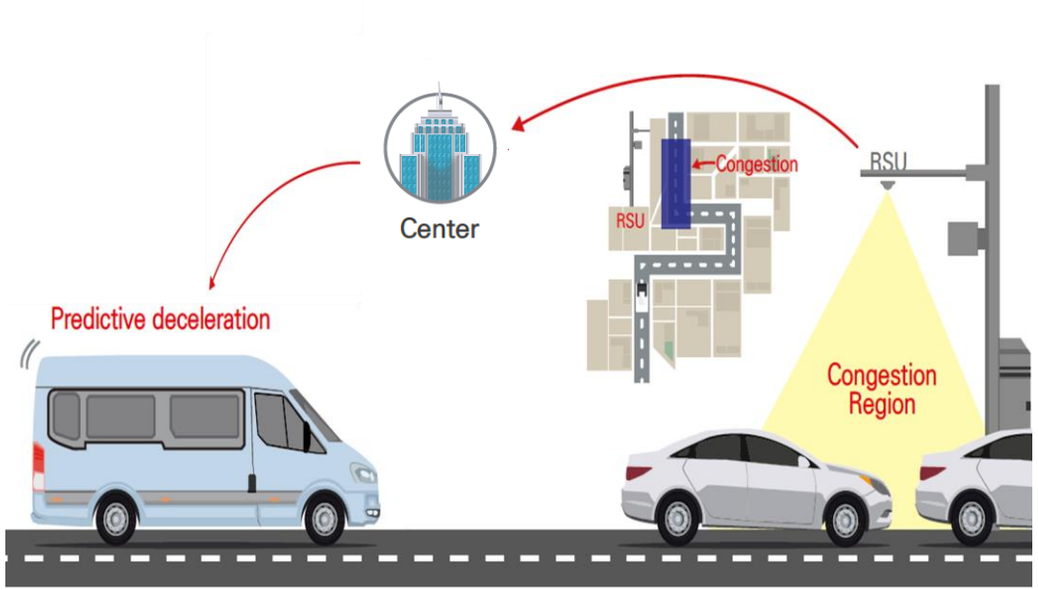
- CAD-based Public Transport Service Provision
  – CAPTAIN Service: Cooperative Automated Driving Service near a Signalized Intersection

Cooperative automated vehicle control with multiple signalized intersections	Bidirectional communication-based cooperative vehicle and signal control
	
✓ Providing an optimal speed control service considering intersection delay and signal information for multiple signalized intersections	✓ Providing a transit signal priority control service and vehicle speed control service based on bidirectional communications (V2I/I2V)

Service Applications

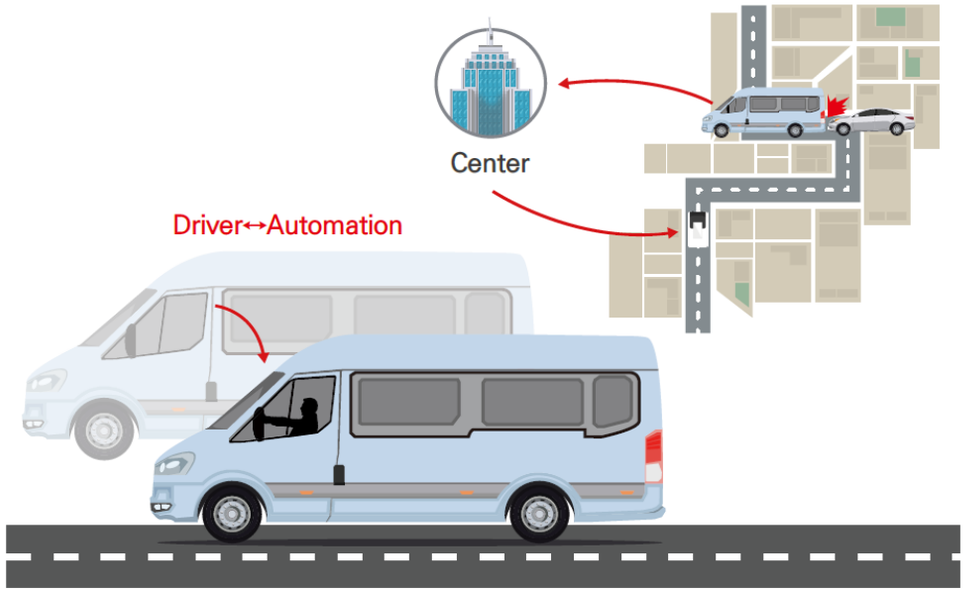
- CAD-based Public Transport Service Provision
  – CAPTAIN Service: Traffic Management and Control Service

Automated vehicle control in a mixed situation of manual vehicle and automated vehicle



✓ Providing a CAD-based vehicle control service to help smooth traffic flow in a mixed situation of manual vehicle and automated vehicle

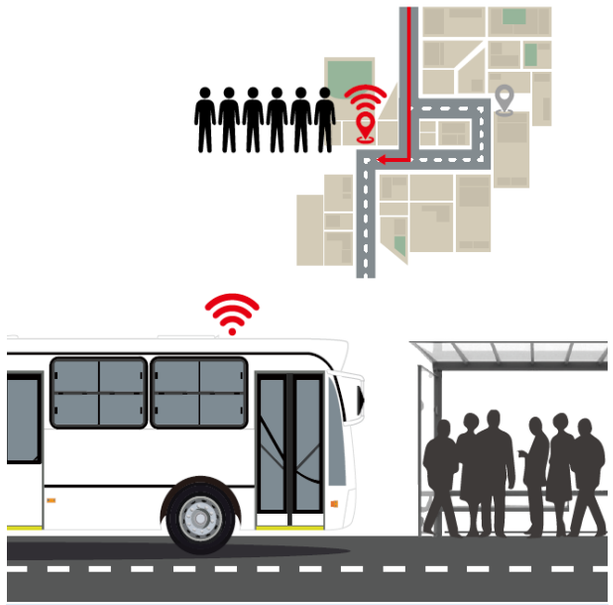
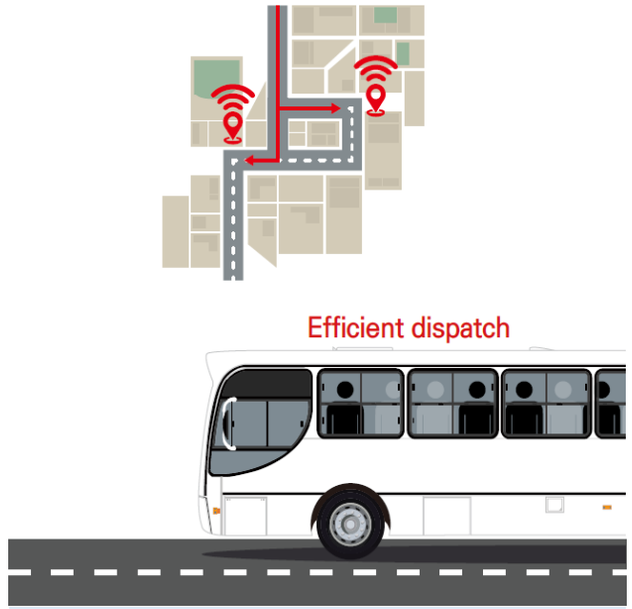
Traffic condition monitoring for automated vehicle



✓ Providing a safe *takeover* service based on monitoring the information on real-time in-vehicle sensors and roadside sensors

Service Applications

- CAD-based Public Transport Service Provision
  – CAPTAIN Service: Real-time Demand Responsive Service

On-demand bus routing	Real-time demand responsive route change	Bus crowdedness prediction
		
✓ Providing an optimal routing service for demand responsive bus service	✓ Providing a rerouting service for real-time demand on transit service	✓ Providing a bus crowdedness prediction service for efficient dispatching

Summary

- Features
  - Conducting a first pilot project of developing the commercial vehicle-based Connected and Automated Driving (CAD) technology
  - Incorporating the CAD-based technology into public transport service and system
  - Providing user-oriented Transit as a Services (TaaS) for public transport system in the South Korea
  - Verifying the performances of the proposed services based on field operational tests (to be)
  - Considering an advanced operational environment for CAD-based public transport service based on hybrid V2X communications, such as WAVE and 5G

Summary

- Key Timeline

Conducting FOTs for CAD-based bus transit services

- Demonstrating the CAPTAIN services using the CAD-based shuttle buses & transit buses
- Verifying the performance of the proposed system

Setting up the study site for Demonstrating in the Test beds

- Constructing digital infrastructure and traffic control center
- Retrofitting commercial shuttle buses & transit buses
- Demonstrating system version 2.0

Demonstrating CAD-based shuttle bus

- Retrofitting commercial shuttle bus & transit bus
- Demonstrating system version 1.0

2019 → **2020** → **2021**

Q & A

Thank you