Automated Driving System

Connected Vehicles

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<Translated Version>

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INDEX

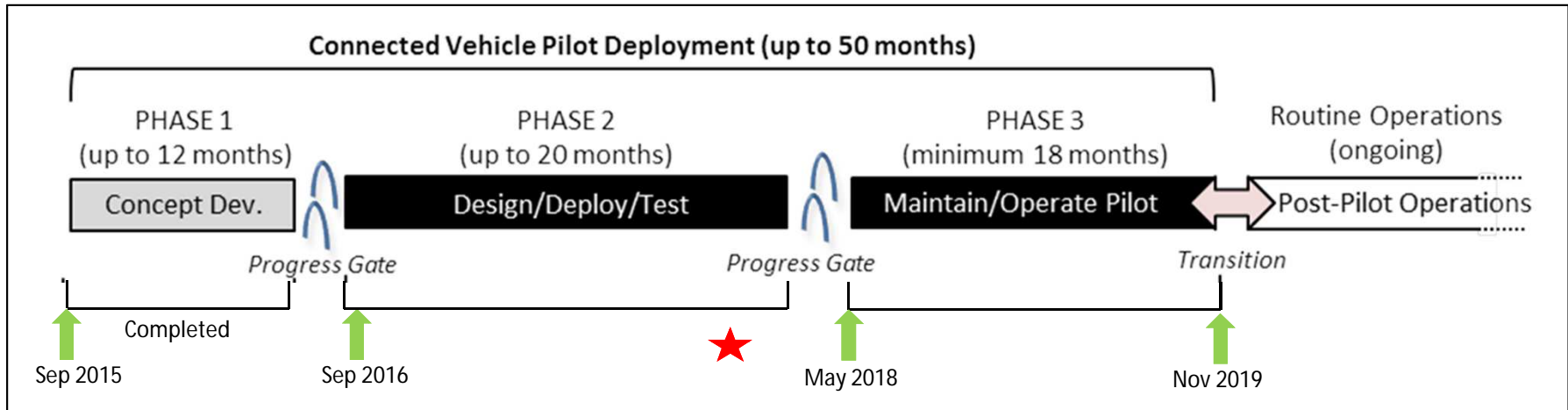**Trends in Cooperative ITS Using Wireless Communication Technology**

1. Field operational tests for cooperative ITS in the US

(1) Connected Vehicle Pilot
Deployment Program

(2) Cooperative Automation Research for
Modeling and Analysis (CARMA)

(1) Connected Vehicle Pilot Deployment Program (CV Pilot)

- Object: Reduce traffic accidents and improve transport/environment through wireless communication technology, conduct large-scale field operational tests
  Verify effects of introducing technology
- Focus : Total traffic system that includes automobiles, mobile terminals, infrastructure, traffic control operation.
- Test locations: Public roads in New York City, Tampa, and Wyoming, which all have different environments

Connected Vehicle Pilot Deployment (up to 50 months)

PHASE 1 (up to 12 months)	PHASE 2 (up to 20 months)	PHASE 3 (minimum 18 months)	Routine Operations (ongoing)
Concept Dev.	Design/Deploy/Test	Maintain/Operate Pilot	Post-Pilot Operations
	Progress Gate	*Progress Gate*	*Transition*

Completed

Sep 2015   Sep 2016   ★   May 2018   Nov 2019

Plan for field operational tests

Source: USDOT

◆New York City

- Reduce pedestrian accidents (73% of accident fatalities is pedestrians)
- Aim to reduce average vehicle speed form 30 mph to 25 mph
- Tested in Manhattan and Brooklyn

- Scale of tests

Roadside detectors	**353 units**
Taxis	**5850 units**
Buses	**1250 units**
Trucks	**400 units**
NYC official vehicles	**250 units**
Garbage trucks	**250 units**
Pedestrians	**100 units**
Pedestrian detection systems	**10 units**
Total	**8000 units**

Source: USDOT
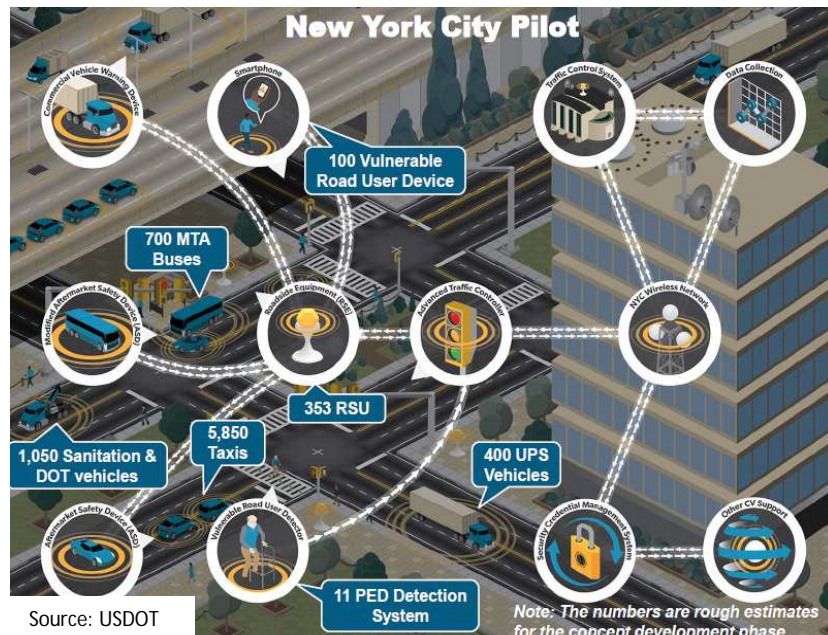
Applications

V2I/I2V Safety
- Various speed warnings
- Red light violation warning

V2V Safety
- Rear-end collision warning
- Lane change assist
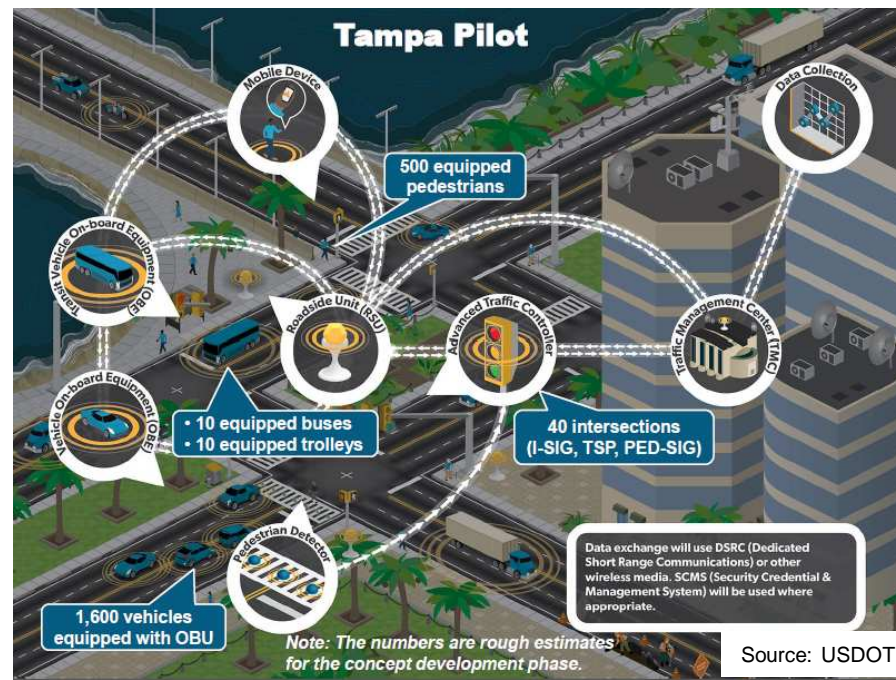- Intersection movement assist

V2I/I2V Pedestrian
- Pedestrian in signalizes crosswalk
- Mobile accessible pedestrian signal system

ID	Category	NYCDOT – CV Application
1	V2I/I2V Safety	Speed Compliance
2		Curve Speed Compliance
3		Speed Compliance/Work Zone
4		Red Light Violation Warning
5		Oversize Vehicle Compliance
6		Emergency Communications and Evacuation Information
7	V2V Safety	Forward Crash Warning (FCW)
8		Emergency Electronics Brake Lights (EEBL)
9		Blind Spot Warning (BSW)
10		Lane Change Warning/Assist (LCA)
11		Intersection Movement Assist (IMA)
12		Vehicle Turning Right in Front of Bus Warning
13	V2I/I2V Pedestrian	Pedestrian in Signalized Crosswalk
14		Mobile Accessible Pedestrian Signal System (PED-SIG)
15	Mobility	Intelligent Traffic Signal System (I-SIGCVDATA)

USDOT

◆Tampa

- Focus on automobiles, buses, trains and pedestrians during work commutes, etc.
- Have users experience the effects of reduced collisions, congestion, travel time and greenhouse gases
- Implemented in Tampa's city center

- Scale of tests

Roadside detectors	**46 units**
Private automobiles	**1600 units**
Buses	**10 units**
Trams	**10 units**
Pedestrians	**500 units**
Pedestrian detection systems	**10 units**
Total	**2176 units**

Source: USDOT

Applications

Emergency Electronic Brake Light Warning

End of Ramp Deceleration Warning

Forward Collision Warning

Intelligent Signal System

Intersection movement assist

Pedestrian in a Crosswalk Vehicle Warning

Pedestrian Mobility

Pedestrian Transit Movement Warning

Transit Signal Priority

Vehicle Turning Right in Front of Transit Vehicle

Wrong Way Entry

Roadside detectors

On-board displays

Source: USDOT

◆Wyoming

Aim to reduce accidents on highway I-80, which is 70% truck traffic.

Test V2V, V2I technology to prevent accidents in harsh environments such as wind, snow, fog, etc.

Scale of tests

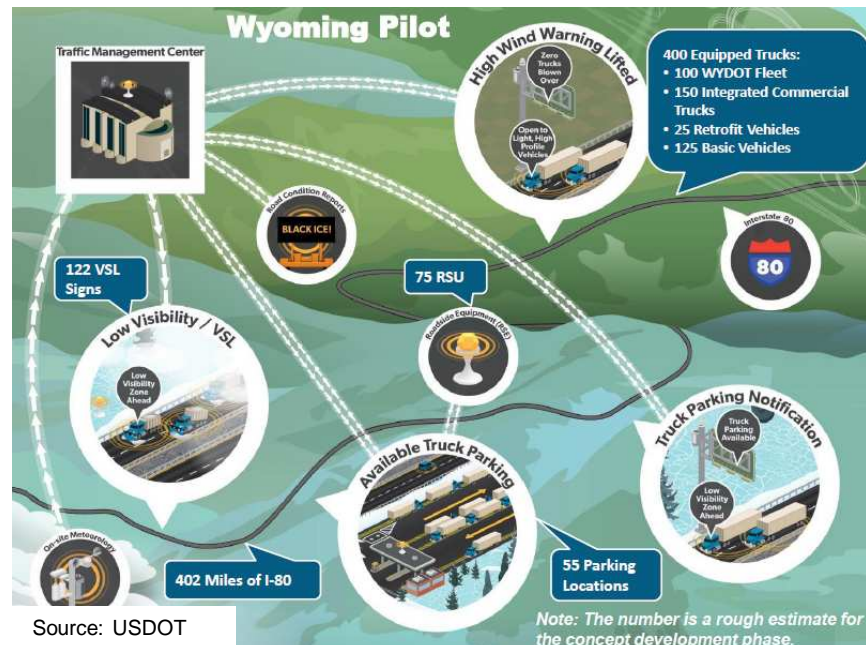|	
Roadside detectors	**75 units**
Trucks	**400 units**
Large trucks	**(150 among the above)**
Total	**475 units**

Applications

I2V   Safety

Road environment information provision
(Weather, limited speed, vehicle restrictions,
road conditions, accidents, etc.)

Road construction information
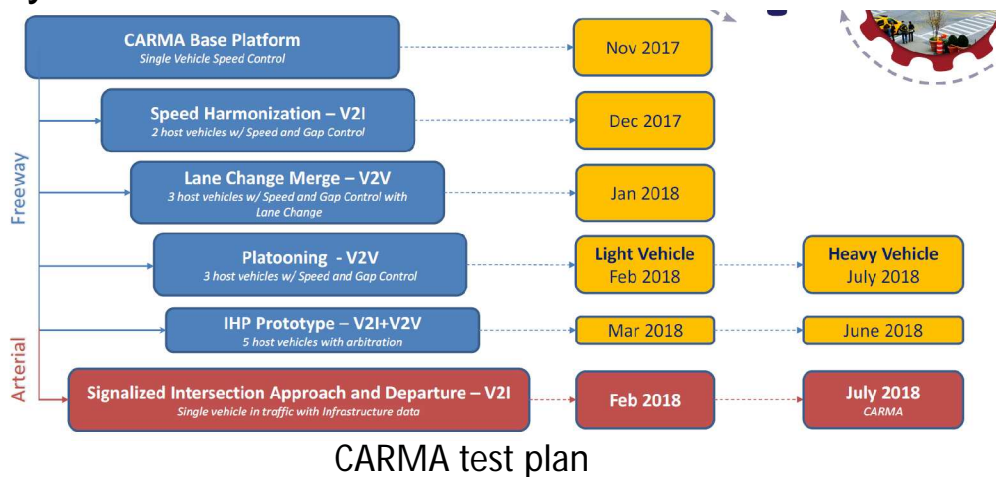
V2V   Safety

Collision warning

Source: USDOT

(2) Cooperative Automation Research for Modeling and Analysis

(CARMA)

Realize smooth automated driving on expressways and at surface street intersections with no signal through use of V2V and V2I

Objects include vehicle platooning (mix of trucks, passenger cars, SUVs), speed harmonization and merging of traveling vehicles etc.

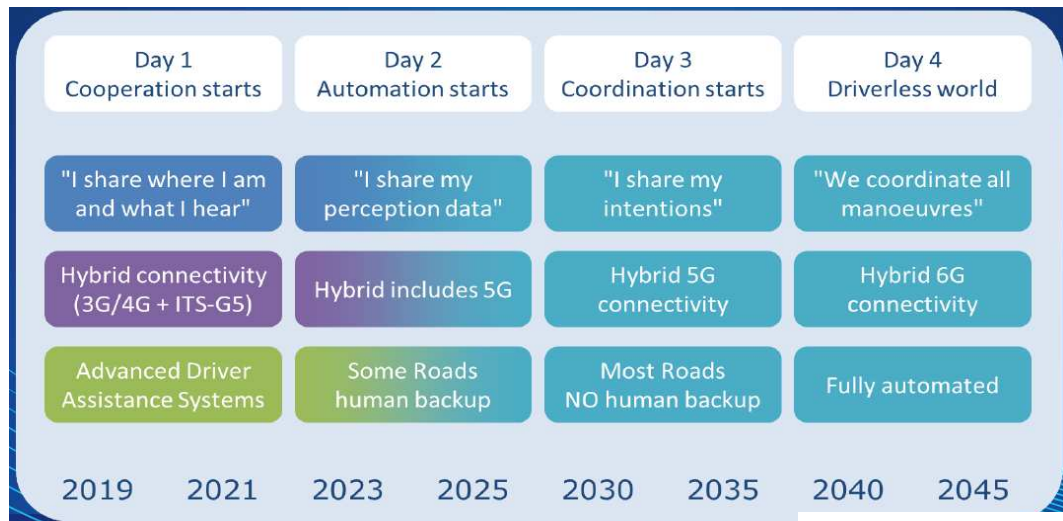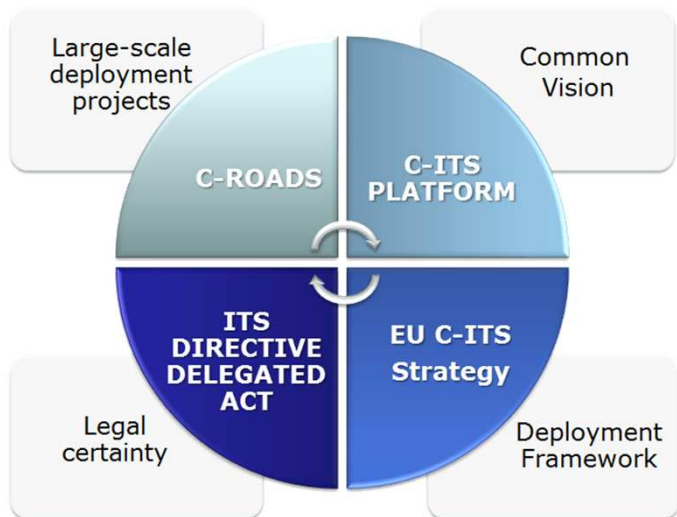Test period from November 2017 to July 2018

Source: FHWA materials

Freeway			
CARMA Base Platform Single Vehicle Speed Control	Nov 2017		
Speed Harmonization – V2I 2 host vehicles w/ Speed and Gap Control	Dec 2017		
Lane Change Merge – V2V 3 host vehicles w/ Speed and Gap Control with Lane Change	Jan 2018		
Platooning - V2V 3 host vehicles w/ Speed and Gap Control	**Light Vehicle** Feb 2018	**Heavy Vehicle** July 2018	
IHP Prototype – V2I+V2V 5 host vehicles with arbitration	Mar 2018	June 2018	
Signalized Intersection Approach and Departure – V2I Single vehicle in traffic with Infrastructure data	Feb 2018	**July 2018** CARMA	

Arterial

CARMA test plan

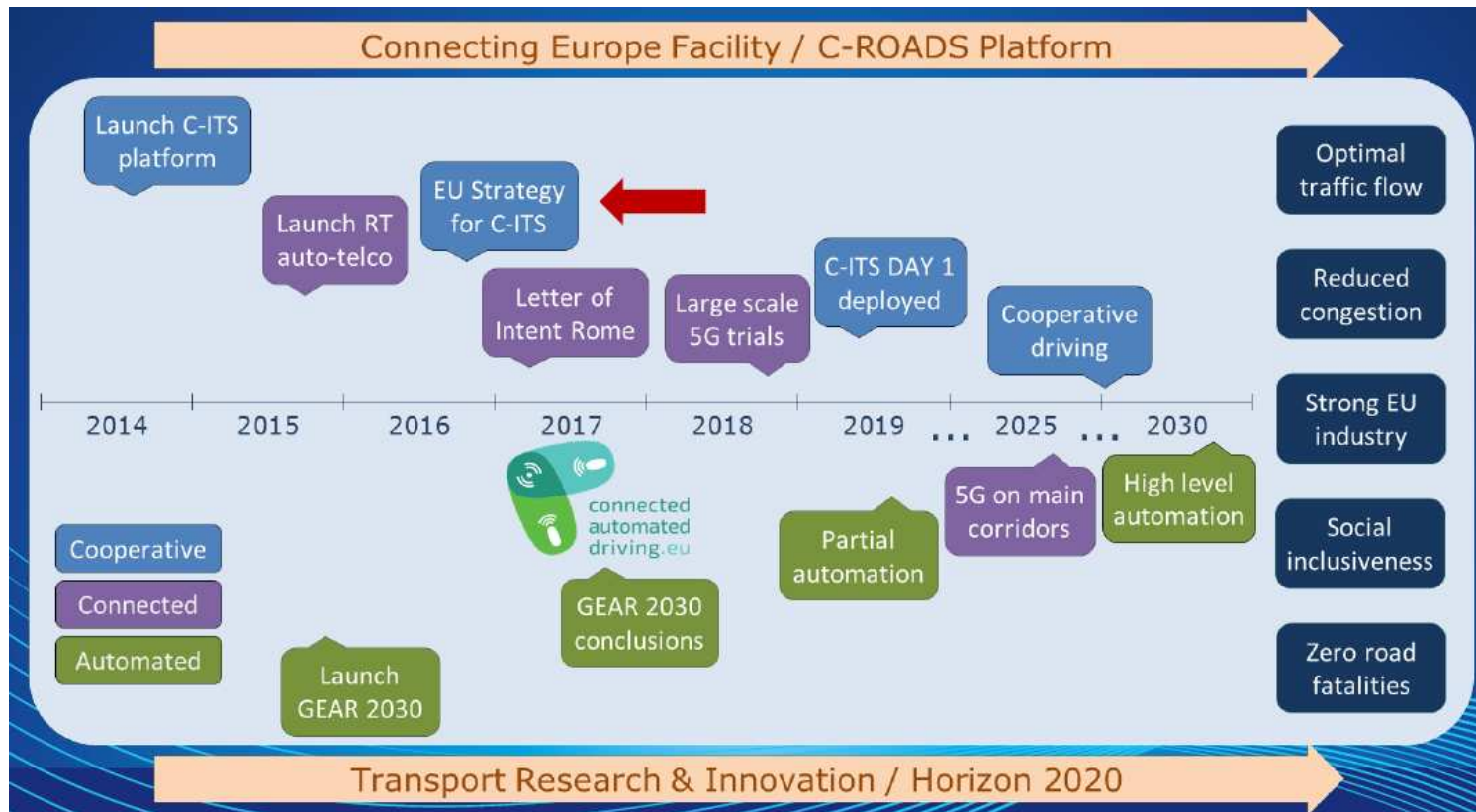## 2. Field Operational Tests for Cooperative ITS in Europe

(1) C-ITS Platform

(2) C-ROADS Pilot

◆ C-ITS Platform

Cooperative ITS project that aims to reduce traffic accidents and make traffic efficient by using communication

Established by foreseeing the future, from Day 1 to Day 4 (from safe driving support to unmanned automated driving)

Started in 2014; Day 1 will be realized in 2019

Hybrid complementation of cellular communication and DSRC (Dedicated Short Range Communication)

Day 1 Cooperation starts	Day 2 Automation starts	Day 3 Coordination starts	Day 4 Driverless world
"I share where I am and what I hear"	"I share my perception data"	"I share my intentions"	"We coordinate all manoeuvres"
Hybrid connectivity (3G/4G + ITS-G5)	Hybrid includes 5G	Hybrid 5G connectivity	Hybrid 6G connectivity
Advanced Driver Assistance Systems	Some Roads human backup	Most Roads NO human backup	Fully automated
2019 2021	2023 2025	2030 2035	2040 2045

CODECS HP

◆ Road map for C-ITS and automated driving project

◆ C-ROADS Pilot

Field operational test of Day-1 services using a C-ITS
platform (hybrid communication)
Sharing cross-border and interoperability tests results
16 countries as core members (map on right)
Field operational tests planned in 8 countries

SLOW OR STATIONARY VEHICLE(S)	ROAD WORKS WARNING	WEATHER CONDITIONS
EMERGENCY VEHICLE APPROACHING	OTHER HAZARDOUS NOTIFICATION	IN-VEHICLE SIGNAGE
IN-VEHICLE SPEED LIMITS	SIGNAL VIOLATION / INTERSECTION SAFETY	GREEN LIGHT OPTIMAL SPEED ADVISORY (GLOSA)
PROBE VEHICLE DATA	SHOCKWAVE DAMPING	

Day-1 services   Source: C-ROADS HP   Member countries

3. Application of Cooperative ITS to Automated Driving in Japan

**(1) Use case of cooperative ITS
(JAMA)**
**(2) Joint research on next-generation cooperative ITS
(MLIT)**
**(3) Examining message sets/protocols
(MIC)**

◆ JAMA is examining usage cases of automated driving using cooperative ITS

Look-ahead information from the road
Information ahead that cannot be detected using autonomous sensors is acquired through the road infrastructures, realizing smooth automated driving

Merging/lane change assist information
By acquiring information on nearby vehicles when merging, and exchanging control intentions among vehicles involved in the merge, in order to realize safe and smooth automated merging

Emergency hazard information from vehicles
Information on hazards, such as road obstacles, is gathered from the automated vehicle and sent to following vehicles

Vehicle platooning
Automated control information is mutually exchanged among platooning vehicles, realizing vehicle platooning


Source: JAMA materials

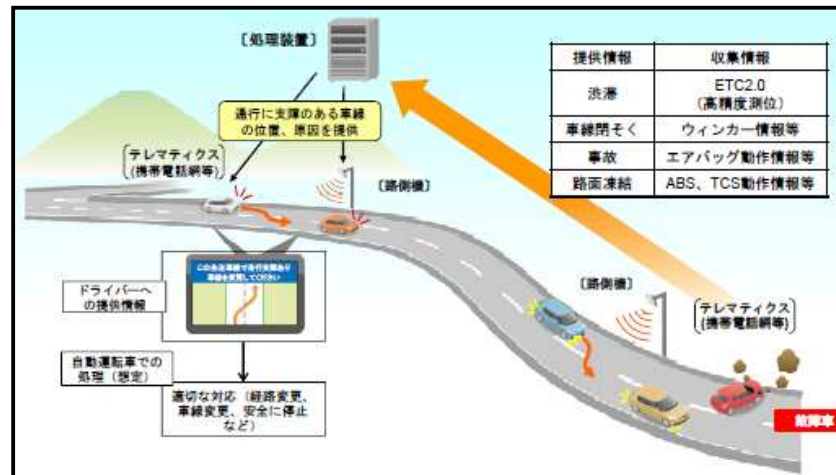**(1) Support in converging sections**
Service that supports smooth merging by providing information of congestion on the main road in merging sections, to drivers and vehicles that are merging
(2) Provision of look-ahead information
Service that lane changes, etc. are recommend in advance, by providing information (look-ahead information) of accident vehicles, etc. ahead that cannot be detected by the vehicle itself to the driver/vehicle
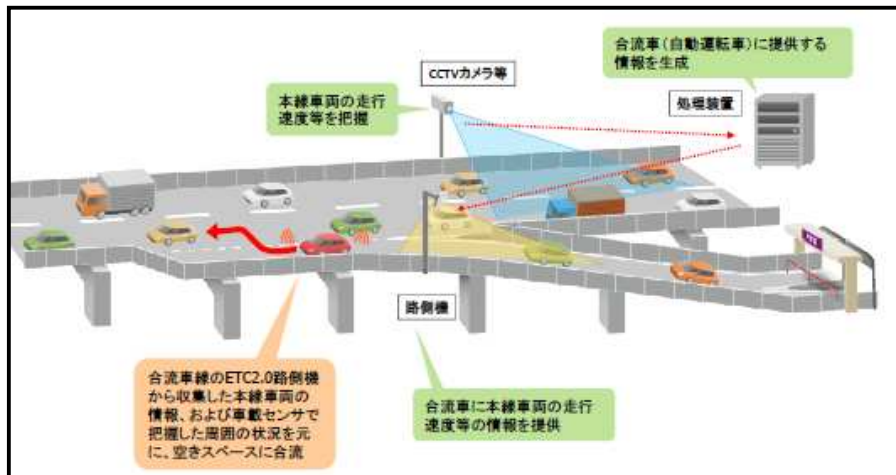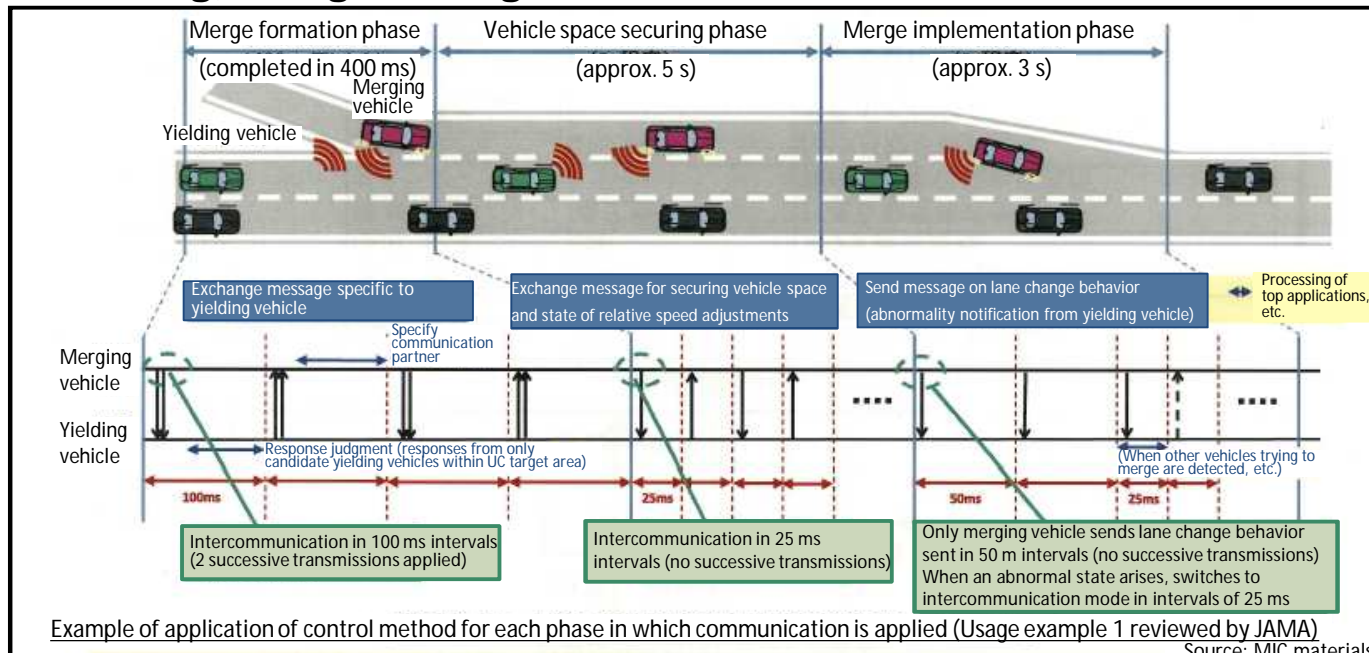

(1) Support in converging sections

(2) Provision of look-ahead information

Source: MLIT materials

Examine the vehicle-to-vehicle communication and the vehicle-to-infrastructure communication to support merging sections and provide emergency hazard information based on JAMA's use case

Establish proposals for wireless communication message sets and protocols for automated driving, using existing ITS wireless communication as a basis

Example of application of control method for each phase in which communication is applied (Usage example 1 reviewed by JAMA)

Source: MIC materials

◆ In the US, **large-scale field operational tests on public roads for safe driving support** using cooperative ITS technology will start in May of next year

◆ In Europe, field operational tests on public roads using the **C-ITS platform** are carried out in various countries and across national borders as **C-ROADS**

◆ For the C-ITS platform, a **roadmap** that anticipates **application towards automated driving** is **planned**

◆ In Japan, examinations on **applications towards automated driving based on ITS wireless communication**, which has already been put to practical use, is progressing

Thank you