

# Which Way To Go ?



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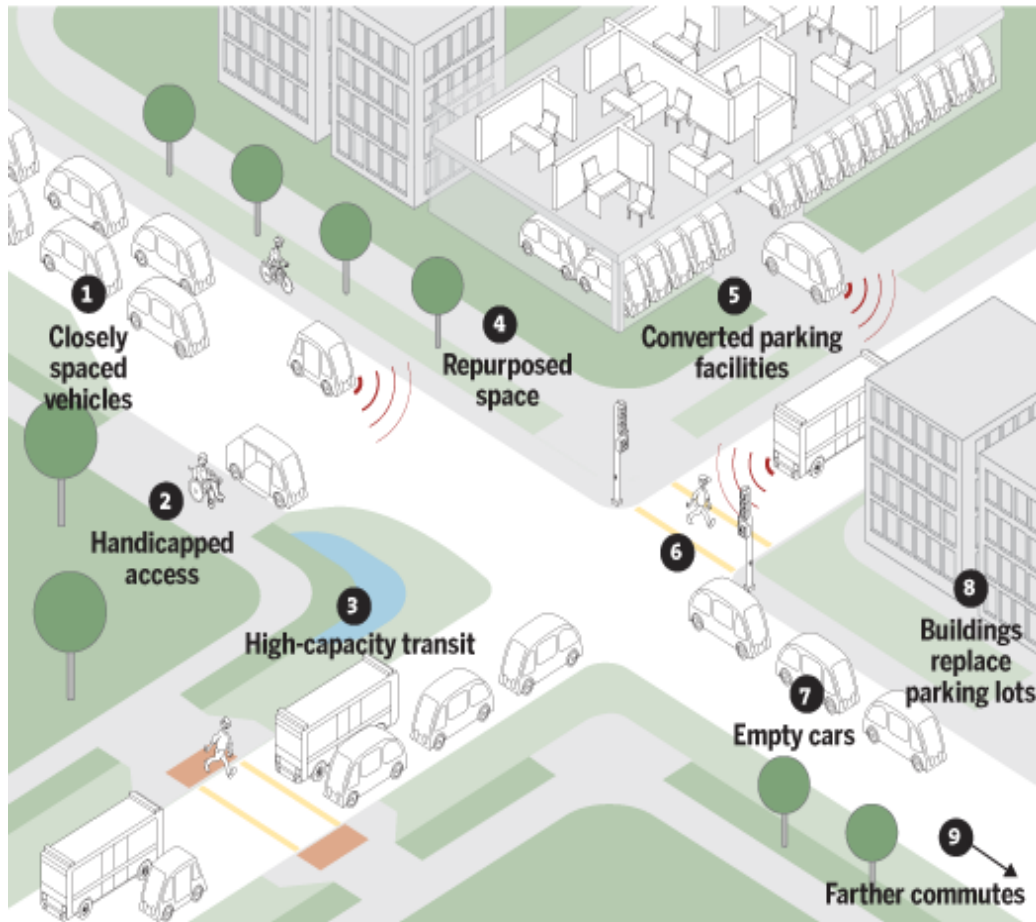
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# 1. 미래 전망

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# □ 미래 전망



## Minnesota planners begin to envision driverless future

Star Tribune  
July 31, 2017

**1.** Driverless cars can follow each other more closely and travel in narrower lanes.

**2.** Accessible autonomous cars could give people with disabilities more independence.

**3.** Buses and trains bring people into densely packed areas, like downtown.

**4.** Excess roadway could be repurposed as wider sidewalks or green space.

**5.** Parking ramps with flat levels can be repurposed as office or living space. Shared-use self-driving vehicles wait to be rented.

**6.** Vehicles would see and react to traffic signals, which could ultimately be unnecessary.

**7.** Empty cars share the roads making deliveries or en route to pick up passengers.

**8.** Excess surface parking lots could be converted to housing or other uses.

**9.** Ease of commuting may encourage long drives to exurban locales.

Source: MIT SenseLab

MARK BOSWELL • Star Tribune

# □ 미래 전망

## ※ 미국 연간 1,500조원 ?

편익항목	산정 근거/가정	편익 (조원)
연료절감액	경제운전으로 연비 20-30% 향상	182
교통사고비용 감소	전체 교통사고 원인의 90%를 차지하는 운전자 과실로 발생하는 사고건수 감소	719
생산성 증대	정상업무 생산성의 90% 수준으로 차량 탑승시간의 25%를 업무에 활용	485
교통혼잡비용 감소	교통혼잡으로 인한 통행시간 손실: 근로자 1인당 통행지체시간 연간 38시간, 시간가치 \$25	159
	교통혼잡으로 인한 연료소모량 증가: 근로자 1인당 연간 19갤런	159
합계		1,557

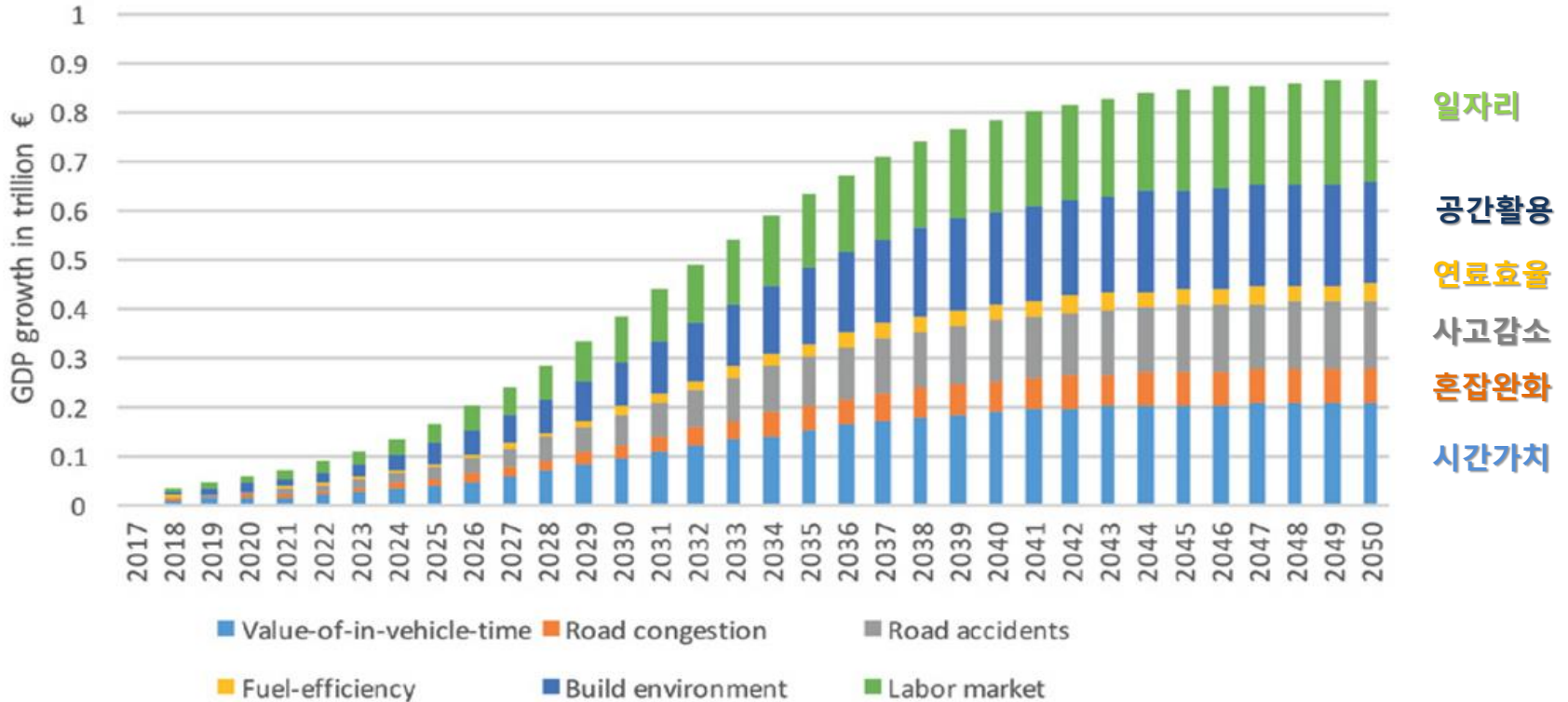
(주 : Morgan Stanley (2014). 모든 차량이 완전자율주행차로 대체된다고 가정.)

출처 : KAMA Web Journal, 2016, Vol. 326(고준호 서울연구원 교통시스템연구실 연구위원)

[http://www.kama.or.kr/jsp/webzine/201605/pages/issue\\_02.jsp](http://www.kama.or.kr/jsp/webzine/201605/pages/issue_02.jsp)

# □ 미래 전망

## ※ EU 연간 1천조원 ?



일자리  
공간활용  
연료효율  
사고감소  
혼잡완화  
시간가치

# □ 미래 전망

## ※ 영국 연간 70조원 ?

### ○ 편익 : £ 62bn

- 소비자 £ 40bn      - 생산자 £ 2bn
- 간접효과 £ 16bn    - 세수증가 £ 2bn
- 사고감소 £ 2bn

### ○ 비용 : £ 11bn

## ※ The UK Economic Opportunity, March 2015



- \* 2030년 예측
- 100% 커넥티드 카
- 75%는 레벨3, 25%는 레벨 4 또는 5

### Impact of Connected and Autonomous Vehicles in 2030

**+£51bn**  
Value added annually by 2030 (at 2014 prices)

**+1%**  
Impact on GDP (2030)

**+320,000**  
Additional jobs impact

**+25,000**  
Jobs in automotive manufacturing created

**+2,500**  
Lives saved (2014-2030)

**+25,000**  
Serious accidents prevented (2014-2030)

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## 2. 외국 동향

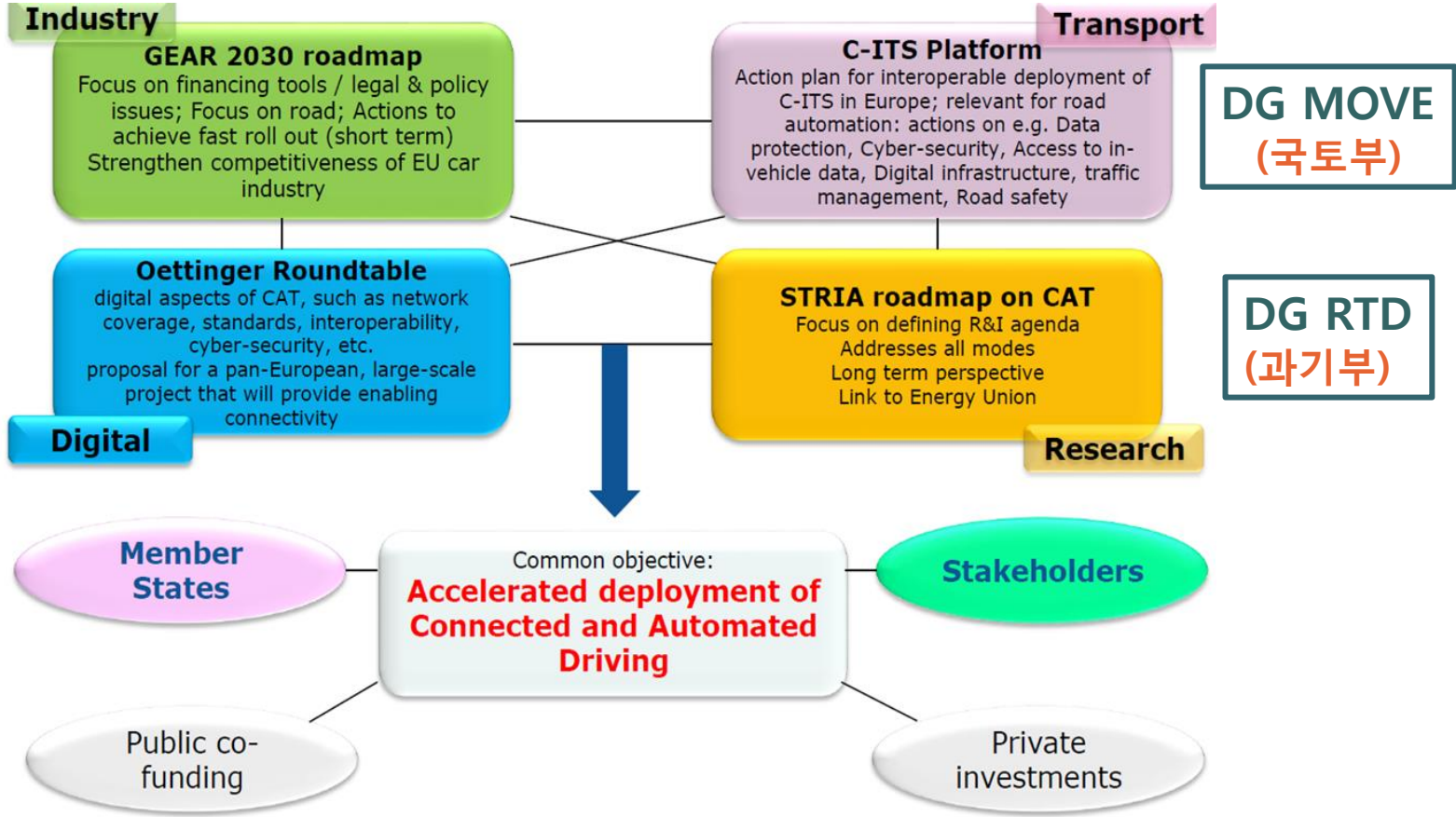
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# 2.1 EU

## EC 체계

**DG GROW**  
(산업부)

**DG CNECT**  
(정통부)



# 2.1 EU

## - EC, 28개국 장관들, 산업계 대표가 동의 & 서명



“2019년까지 C-AV(자율협력주행)을 범 유럽 차원에서 실현시키기 위해 협력한다.”

The Declaration defines the following objectives :

to work towards a coherent European framework for the **deployment** of interoperable **connected and automated driving**, which should be available, if possible, **by 2019**

I. 목표 (SHARED OBJECTIVES )

II. 안건 (JOINT AGENDA)

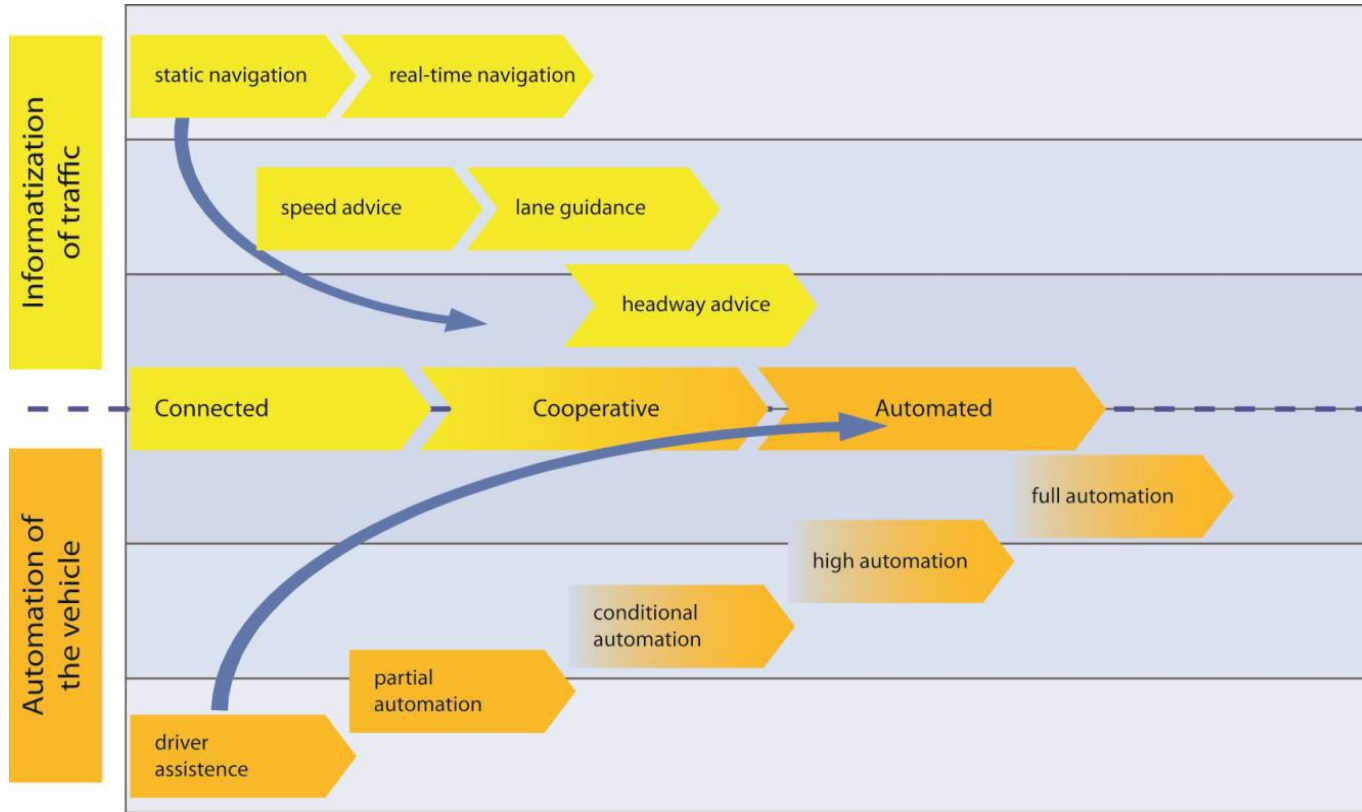
- a. 법·제도 (Coherent international, European and national rules)
- b. 데이터 (Use of data)    c. 개인정보 (Ensure privacy and data protection)
- d. 통신 (Vehicle-to-vehicle & vehicle-to-infrastructure communication)
- e. 보안 (Security)    f. 사회적 수용성 (Public awareness and acceptance)
- g. 개념정립 (Common definitions of connected and automated driving)
- h. 국제협력 (International cooperation)

III. 국가별 역할 (ACTION BY MEMBER STATES)

IV. 유럽연합 역할 (ACTION BY THE EUROPEAN COMMISSION)

V. 산업계 역할 (ACTION BY INDUSTRY)

# 2.1 EU



※ Connected includes cooperative driving : C-ITS

# 2.1 EU



## ▪ High Level Group GEAR 2030

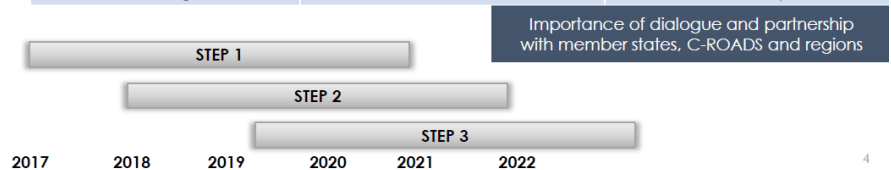
- Launched in 2016 for 2 years, composed by industry, NGOs and Member States.
- Objective: support the EU cars industry to strengthen its competitiveness
- Final report delivered in October/November 2017

## ▪ Roundtable on CAD

- High Level Roundtable involving telecom and automotive industry
- Launched in September 2015
- European Alliance between Telecom and Automotive industries (**EATA**)

### EATA roadmap

	Use cases	Communication Technologies	Sites
STEP 1	Enabling services for - Highway chauffeur (L2/3) - High density truck platooning	<u>Pre Deployment:</u> - hybrid communication : LTE, ITS G5 + LTE V, Mobile Edge Computing applications - Network slicing - LTE Broad casting: GNSS offset, hazards and life HD-map updates  <u>Studies :</u> business models responsibilities, safety concepts, Quality of service, Security and data protection Regulation and standardization	20..40 km Tracks DE, FR,NL, ES, BE 
STEP 2	As step 1 + Valet parking	<u>Pre Deployment:</u> integration step 1 technologies / studies into series architectures + 5G radio + NB IoT + Evaluation relative localization	Cross border motorways networks 
STEP 3	As step 2 Automated driving	Deployment	Commercialisation on AD authorized motorways



# 2.1 EU

## ▪ Digital Day, Rome – Letter of intent (2017.3)

- LOI to intensify **cooperation on testing** of automated road transport in cross border test sites
- Areas of cooperation: interoperability, data access and liability, future 5G connectivity
- LoI was signed by **29 European countries** (27 + Switzerland and Norway)

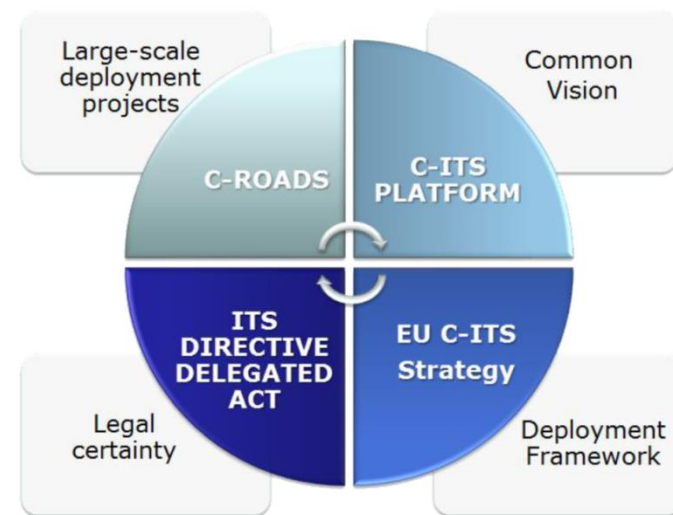
## ▪ European Strategy on C-ITS (2016.11)

- Making C-ITS a reality **from 2019**
- C-ITS Platform (phase 2)
- C-Roads : Bringing together C-ITS platform deployment initiatives to ensure interoperability

## ▪ C2C-CC and C-Roads Platform signed MoU on joint deployment by 2019 (2017.6)

- ... for preparing the deployment of initial C-ITS services across Europe **by 2019**
- ... with **hybrid communication**

\* C2C-CC : 자동차사 16, 부품사 36, 연구기관 28

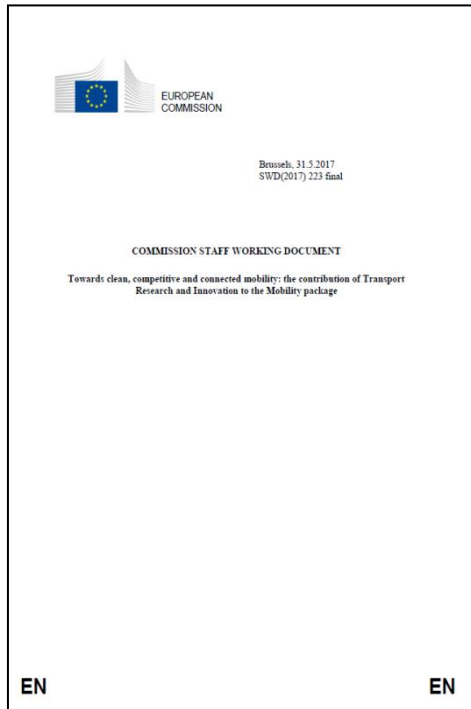


Elements of EC activities in preparing C-ITS Deployment

# 2.1 EU

## ▪ EC 도로교통분야 R&D Roadmap, 2017.5.31

- Towards clean, competitive and connected mobility: the contribution of Transport Research and Innovation to the Mobility package\*



### Contents

#### I. Summary

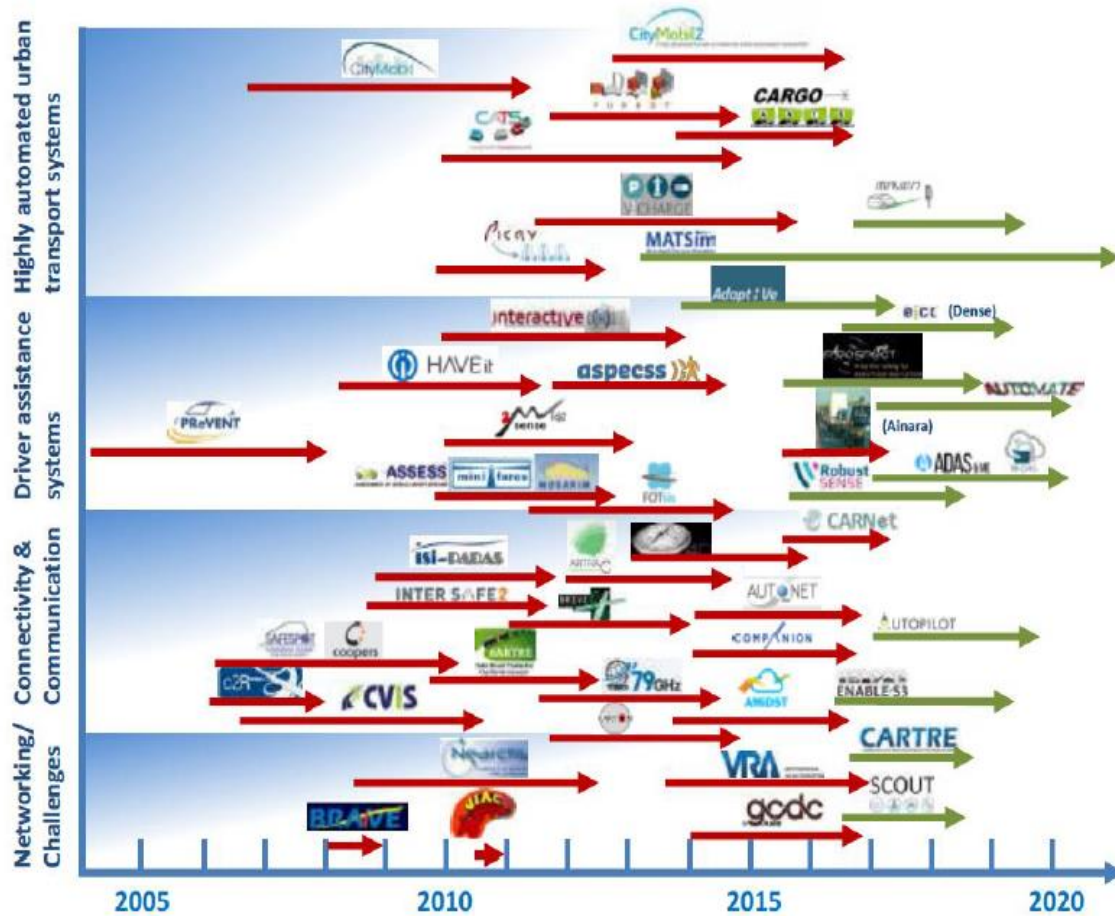
#### II. Transport research and innovation roadmaps

1. Cooperative, connected and automated transport
2. Transport electrification
3. Vehicle design and manufacturing
4. Low-emission alternative energy for transport
5. Network and traffic management systems
6. Smart mobility and services
7. Infrastructure

\* Mobility package : 2017.5 EC에서 발표한 장기전략으로 'Europe on the move'라는 제목을 사용함

# 2.1 EU

## EU Funded CAD Projects



# 2.1 EU

## ▪ H2020 - Calls on "Automated Road Transport" 2016/17

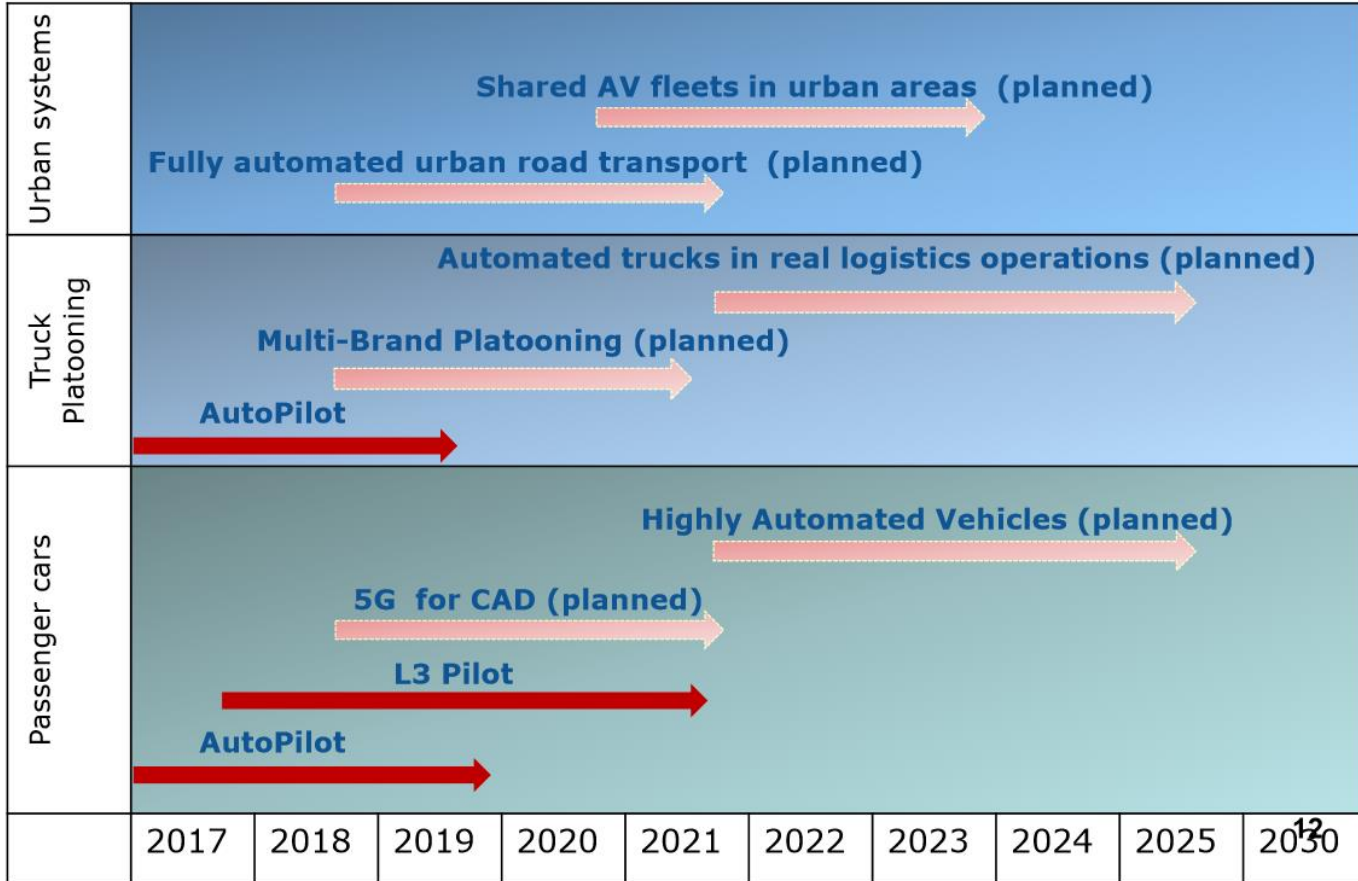
Topic	Title	Action type	Budget (EUR Mio)	
			2016	2017
ART-02	<b>Automation pilots for passenger cars</b>	IA	48M€	
ART-04	<b>Safety and end-user acceptance aspects of road automation in the transition period</b>	RIA		
ART-05	<b>Road infrastructure to support the transition to automation and the coexistence of conventional and automated vehicles on the same network</b>	RIA	13M€	
ART-06	<b>Coordination of activities in support of road automation</b>	CSA	3M4	
ART-01	<b>ICT infrastructure to enable the transition towards road transport automation</b>	IA		50M€
ART-03	<b>Multi-Brand platooning in real traffic conditions</b>	IA		
ART-07	<b>Full-scale demonstration of urban road transport automation</b>	IA		
IoT-01-2016	<b>"Internet of Things" (ICT Workprogramme)</b> • Large Scale Pilots: Pilot on "Autonomous vehicles in a connected environment" (IA)	IA	around 20M€	
GALILEO-1-2017	<b>"Applications in Satellite Navigation-Galileo" (Space Workprogramme)</b> • EGNSS Transport applications (IA)	IA		14,5M€

**CSA = Coordination and Support Action**

**IA = Innovation Action; RIA = Research and Innovation Action**

# 2.1 EU

## ▪ H2020 - Planned Large-Scale Demos



# 2.1 EU

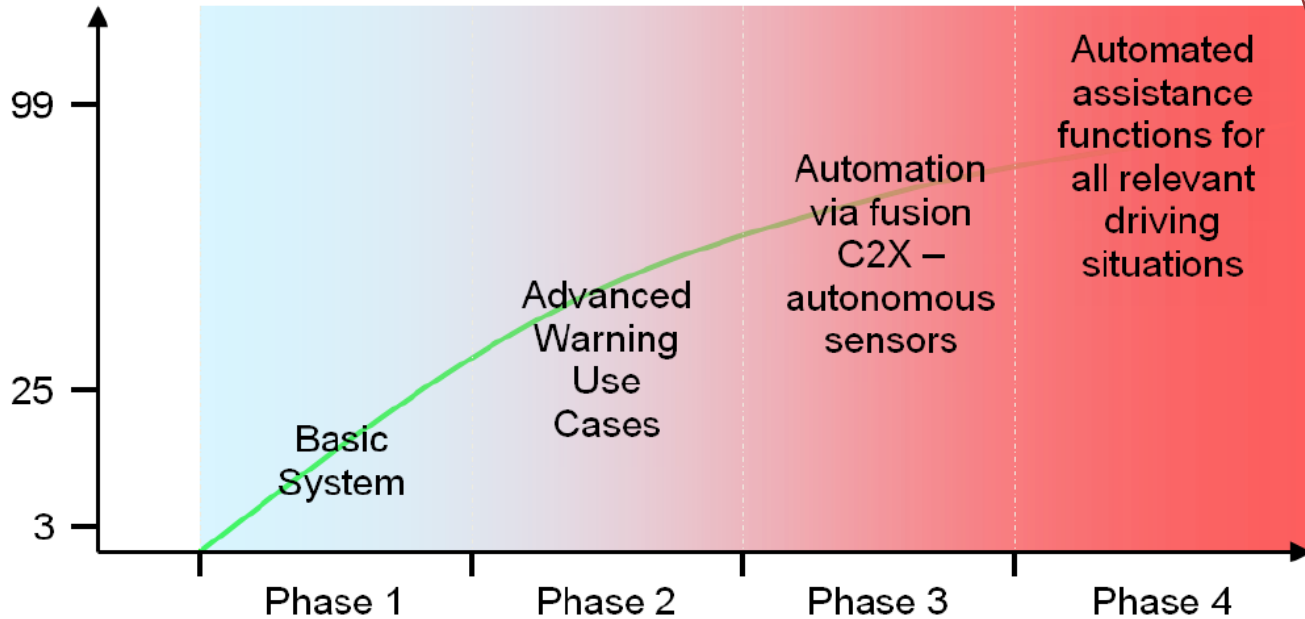
## 참고 [진행방향]



- C-ITS 1단계**
- ✓ 위치, 속도, 이벤트
  - ✓ 상대 측위
  - 통신단말기로 거리측정

- C-ITS 2단계**
- ✓ 개별개체, 주변정보
  - ✓ 절대 측위
  - 정밀지도, GPS정보

- C-ITS + 자율주행자동차 센서**
- ✓ 의도, 경로정보 → 주행계획 동기화
  - ✓ 주행의도 협상
  - (1단계) 주변차량과의 주행의도 개별적 협상
  - (2단계) 차량군내 주행의도 데이터 융합 및 **최적화\***

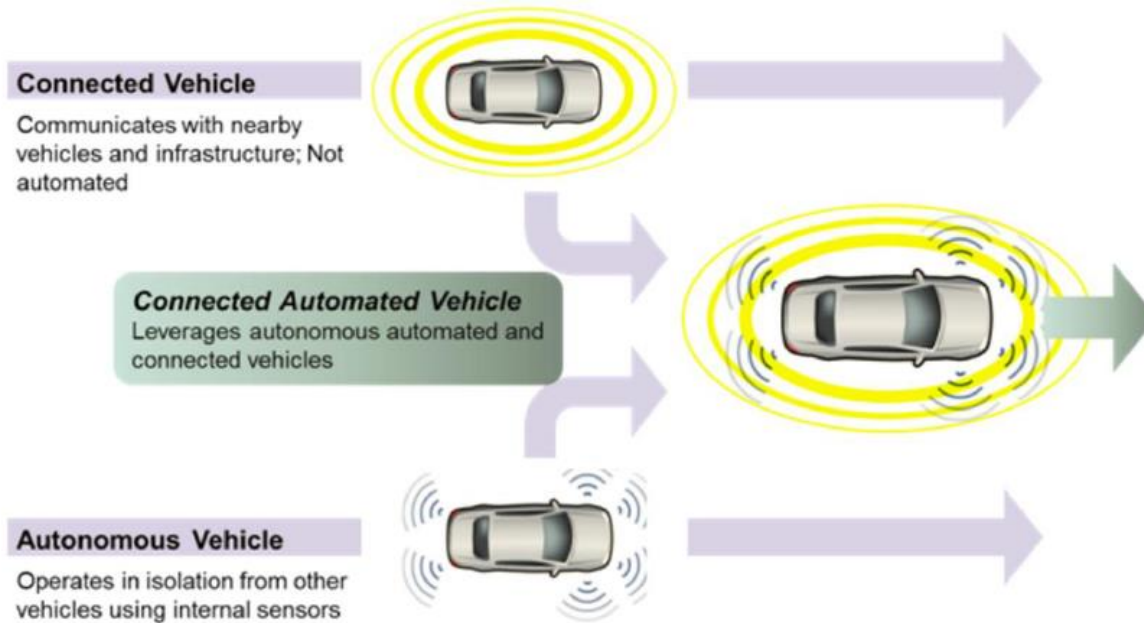


- ① 주행의도 데이터 융합
  - 교차로 제어기 또는 차량군내 마스터 차량
- ② 로컬 교통류 최적화
  - 우선 순위 결정
- ③ 광역 교통류 최적화
  - 교통센터에서 정보융합 (실시간 예측)

## 2.2 미국

### ▪ US DOT, ITS JPO

#### From Connected to Automated Vehicles



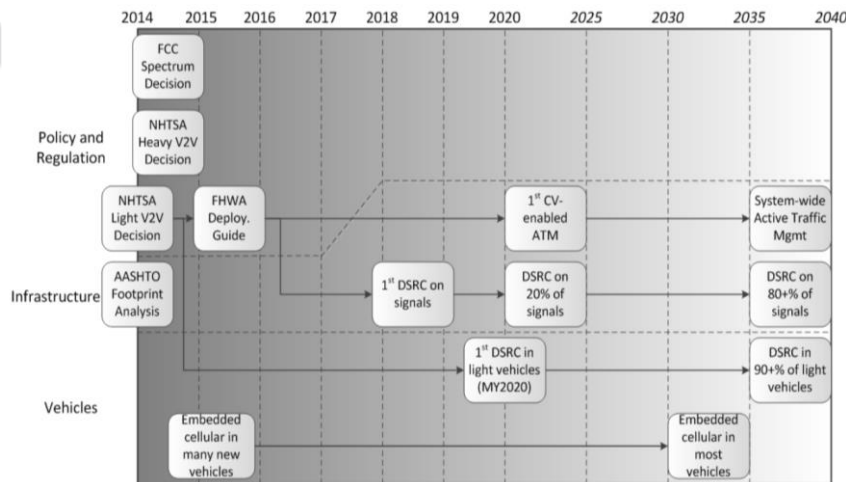
# 2.2 미국

## US DOT - CV Applications

### CONNECTED VEHICLE APPLICATIONS

V2I Safety	Environment	Mobility
Red Light Violation Warning	Eco-Approach and Departure at Signalized Intersections	Advanced Traveler Information System
Curve Speed Warning	Eco-Traffic Signal Timing	Intelligent Traffic Signal System (I-SIG)
Stop Sign Gap Assist	Eco-Traffic Signal Priority	Signal Priority (transit, freight)
Spot Weather Impact Warning	Connected Eco-Driving	Mobile Accessible Pedestrian Signal System (PED-SIG)
Reduced Speed/Work Zone Warning	Wireless Inductive/Resonance Charging	Emergency Vehicle Preemption (PREEMPT)
Pedestrian in Signalized Crosswalk Warning (Transit)	Eco-Lanes Management	Dynamic Speed Harmonization (SPD-HARM)
<b>V2V Safety</b>	Eco-Speed Harmonization	Queue Warning (Q-WARN)
Emergency Electronic Brake Lights (EEBL)	Eco-Cooperative Adaptive Cruise Control	Cooperative Adaptive Cruise Control (CACC)
Forward Collision Warning (FCW)	Eco-Traveler Information	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
Intersection Movement Assist (IMA)	Eco-Ramp Metering	Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
Left Turn Assist (LTA)	Low Emissions Zone Management	Emergency Communications and Evacuation (EVAC)
Blind Spot/Lane Change Warning (BSW/LCW)	AFV Charging / Fueling Information	Connection Protection (T-CONNECT)
Do Not Pass Warning (DNPW)	Eco-Smart Parking	Dynamic Transit Operations (T-DISP)
Vehicle Turning Right in Front of Bus Warning (Transit)	Dynamic Eco-Routing (light vehicle, transit, freight)	Dynamic Ridesharing (D-RIDE)
<b>Agency Data</b>	Eco-ICM Decision Support System	Freight-Specific Dynamic Travel Planning and Performance
Probe-based Pavement Maintenance	<b>Road Weather</b>	Drayage Optimization
Probe-enabled Traffic Monitoring	Motorist Advisories and Warnings (MAW)	<b>Smart Roadside</b>
Vehicle Classification-based Traffic Studies	Enhanced MDSS	Wireless Inspection
CV-enabled Turning Movement & Intersection Analysis	Vehicle Data Translator (VDT)	Smart Truck Parking
CV-enabled Origin-Destination Studies	Weather Response Traffic Information (WxTINFO)	
Work Zone Traveler Information		

### CV Infrastructure Deployment Milestones(USDOT/AASHTO)



• Long way to go...

- Safety (△)
- Mobility...
- Environment...
- Agency Data...

\*출처 : ITS JPO, CV Pilot Deployment Program, CV Applications.

AASHTO, National Connected Vehicle Field Infrastructure Footprint Analysis, Final Report.

# 2.2 미국

## 추진상황 : US DOT - CV Pilot

### CV Pilot Program Goals



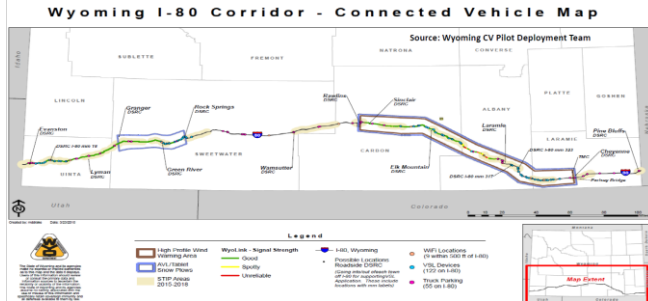
### Connected Vehicle Applications WAVE - 1

V2I Safety	Environment	Mobility
Red Light Violation Warning	Eco-Approach and Departure at Signalized Intersections	Advanced Traveller Information System
Curve Speed Warning	Signalized Intersections	Intelligent Traffic Signal System (I-SIG)
Stop Sign Gap Assist	Eco-Traffic Signal Timing	Signal Priority (transit, freight)
Spot Weather Impact Warning	Connected Eco-Driving	Mobile Accessible Pedestrian Signal System (RED-SIG)
Reduced Speed/Work Zone Warning	Wireless Inductive/Resonance Charging	Emergency Vehicle Preemption (PREEMPT)
Pedestrian in Signalized Crosswalk Warning (Transit)	Eco-Lanes Management	Dynamic Speed Harmonization (SPD-HARM)
	Eco-Speed Harmonization	Queue Warning (Q-WARN)
	Eco-Cooperative Adaptive Cruise Control	Cooperative Adaptive Cruise Control (CACC)
	Eco-Traveler Information	Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
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	Eco-Smart Parking	Dynamic Transit Operations (T-DISP)
	Dynamic Eco-Routing (light vehicle, transit, freight)	Dynamic Ridesharing (D-RIDE)
	Eco-ICM Decision Support System	Freight-Specific Dynamic Travel Planning and Performance
		Drayage Optimization
		Smart Roadside
		Wireless Inspection
		Smart Truck Parking
		U.S. Department of Transportation 13

### 뉴욕 - 트럭, 보행자 사고



### 와이오밍 - 다중추돌사고, 경제적 효과



### 탐파 - 러시아워, 역 주행, 신호정보, 환승



## 2.2 미국

### ▪ US DOT - Michigan

#### ○ Pillar 1: Connected Ann Arbor (2014+)

- 9,000 equipped vehicles
- 27 sq. miles of equipped infrastructure

#### ○ Pillar 2: Southeast Michigan Connected Vehicle Deployment (2015+)

- 20,000 equipped vehicles
- 500 equipped nodes, including highways and intersections
- 5000 devices including nomadic devices, extending to pedestrians

#### ○ Pillar 3: Ann Arbor Automated Vehicle Field Operational Test (2016+)

- **2,000 connected and automated vehicles**
- Including Level 4 automated vehicles
- 27 sq. miles of densely instrumented infrastructure

# 2.2 미국

## Research Tracks

Enabling Technologies			
Digital Infrastructure	Communications	Technology Research	

Safety Assurance			
Electronic Control Systems	Software Assurance and Reliability	Cybersecurity	Human Factors

Transportation System Performance		
CACC, Speed Harmonization, and Platooning	Lateral Control	First/Last Mile and Transit Operations

Testing and Evaluation		
Interoperability	Testing Methods	Benefits Assessment

Policy and Planning			
Standards	Federal Policy Analysis	Stakeholder Engagement	Transportation Planning

### U.S. DOT Automation Program *TRB Session 412*

Kevin Dopart  
ITS Joint Program Office, OST-R  
U.S. Department of Transportation  
January 12, 2015

**CACC  
SPD-HARM  
Platooning**

**First/Last Mile  
버스 운영**



U.S. Department of Transportation  
ITS Joint Program Office

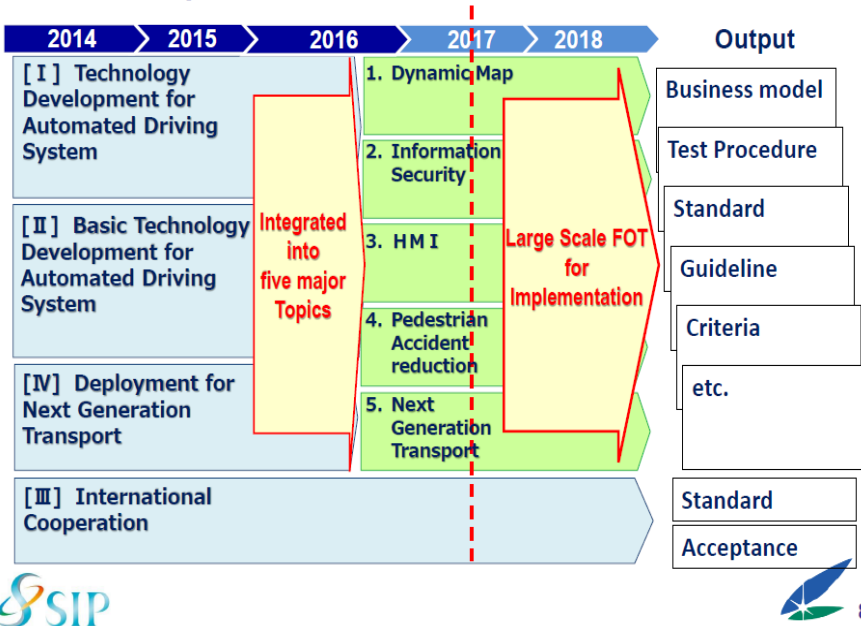
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# 2.3 일본

## ▪ 대규모 실증

### Activities

#### ■ Development to FOT



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### Field Operational Test

#### ■ Objective

- Provides an open forum for discussions and promote international standardization and R & D with 5 priority developments and social acceptability events

#### ■ Expected Participants

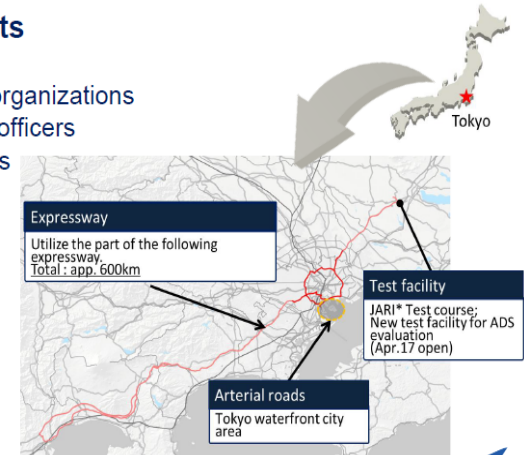
- OEMs/Suppliers
- Universities/Research organizations
- Ministries, government officers
- Foreign OEMs/Suppliers
- Journalists

#### ■ Duration

- 2017/9 – 2019/3

#### ■ Test Sites

- Expressway
- Arterial Roads
- Test Facility



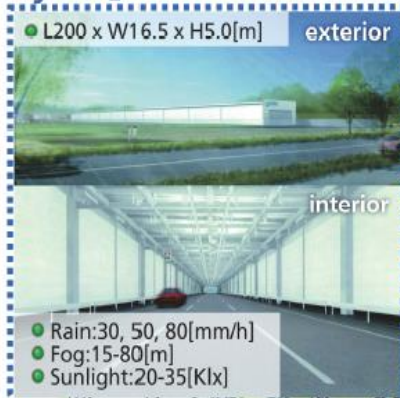
(\*JARI : Japan Automotive Research Institute)

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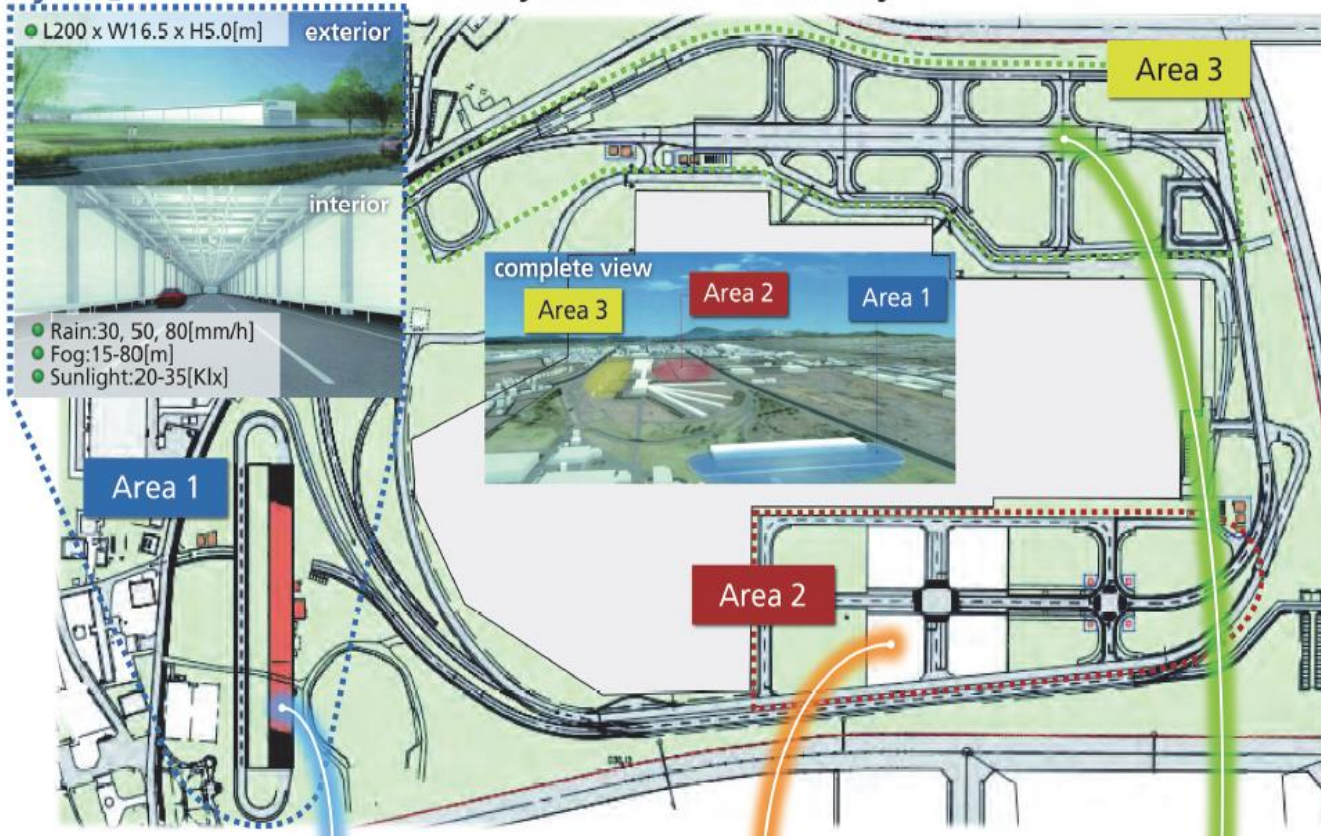
## 2.3 일본

### ■ 테스트 베드

[Layout]



Layout of New Test Facility



# 2.3 일본

## ■ 테스트 항목들

### [Test scene]

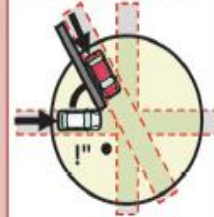
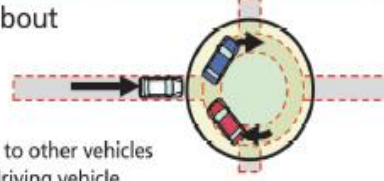
#### Area 1

Testing sensors in adverse environment/sight conditions

<ul style="list-style-type: none"> <li>● Heavy rain &amp; Splash</li> </ul>  <ul style="list-style-type: none"> <li>✓ obstacle recognition</li> </ul>	<ul style="list-style-type: none"> <li>● Dense fog</li> </ul>  <ul style="list-style-type: none"> <li>✓ traffic light recognition</li> </ul>
<ul style="list-style-type: none"> <li>● Rain&amp;Reflection</li> </ul>  <ul style="list-style-type: none"> <li>✓ lane marker detection</li> </ul>	<ul style="list-style-type: none"> <li>● Fog &amp; Sunlight</li> </ul>  <ul style="list-style-type: none"> <li>✓ traffic light recognition</li> </ul>
<ul style="list-style-type: none"> <li>● Backlight</li> </ul>  <ul style="list-style-type: none"> <li>✓ lane marker detection</li> </ul>	<ul style="list-style-type: none"> <li>● Backlight</li> </ul>  <ul style="list-style-type: none"> <li>✓ traffic light and obstacle recognition</li> </ul>

#### Area 2


Variable configuration area for intersection negotiation testing

<ul style="list-style-type: none"> <li>● Intersection</li> </ul>  <ul style="list-style-type: none"> <li>✓ Various setting                     <ul style="list-style-type: none"> <li>- crossing angle</li> <li>- blind area</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● Difference between map and road</li> </ul>  <ul style="list-style-type: none"> <li>✓ Temporary difference                     <ul style="list-style-type: none"> <li>- road work/maintenance</li> <li>- traffic restriction</li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>● Round about</li> </ul>  <ul style="list-style-type: none"> <li>✓ Negotiation to other vehicles                     <ul style="list-style-type: none"> <li>- manual driving vehicle</li> <li>- autonomous vehicle</li> </ul> </li> </ul>	

#### Area 3


Communication devices and connected vehicles testing

- Right turn collision avoidance information provision system



source: SIP(Cross-ministerial Strategic Innovation Promotion Program)

- Green-wave traffic light system



Indicate image to drivers to advise the moderate speed for passing through traffic lights

source: ITS-Japan

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## 3. 자율주행이 교통문제를 해결 ?

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# □ 교통문제 ?

## ■ 우리나라 도로교통의 사회적 비용 : 84조원 (2013 현재)

	2007	2008	2009	2010	2011	2012	2013
	▲▼≡	▲▼≡	▲▼≡	▲▼≡	▲▼≡	▲▼≡	▲▼≡
전체 (10억원)	53,788	57,781	71,263	73,003	78,634	82,264	84,116
도로교통혼잡비용(10억원)	26,172	26,903	27,706	28,509	29,097	30,315	31,420
교통사고비용(10억원)	10,184	10,630	11,582	12,823	20,311	21,194	21,820
대기오염비용(10억원)	13,054	14,378	16,621	14,984	14,043	14,690	14,109
온실가스비용(10억원)	1,273	2,924	12,306	13,527	11,889	12,333	12,835
소음비용(10억원)	3,105	2,946	3,048	3,160	3,294	3,732	3,932

출처 : 국가지표체계, [http://www.index.go.kr/potal/main/EachDtlPageDetail.do?idx\\_cd=2971](http://www.index.go.kr/potal/main/EachDtlPageDetail.do?idx_cd=2971)

## ■ 우리나라 혼잡비용 : GDP의 2.2%

구분	한국	미국	EU	영국	프랑스
혼잡비용(조원)	33 (2015)	140	100	23	25
GDP(조 달러)	1.5 <sup>1)</sup>	19.4 <sup>1)</sup>	16.4 <sup>2)</sup>	2.5 <sup>1)</sup>	2.4 <sup>1)</sup>

<표> 국가별 혼잡비용 비교

1) World Development Indicators database, World Bank, 17 April 2017

2) <https://ieconomics.com/european-union-gdp>

# □ Nightmare, why?

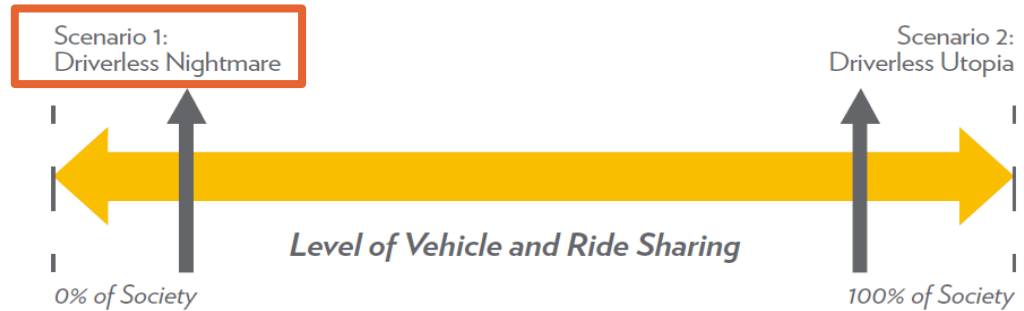
## ■ DRIVING TOWARDS DRIVERLESS: A GUIDE FOR GOVERNMENT AGENCIES

- 총 주행거리 증가 (교통량 증가)
- 도시 확장 (개별차량 주행거리 증가)
- 저속특층의 이동성 악화

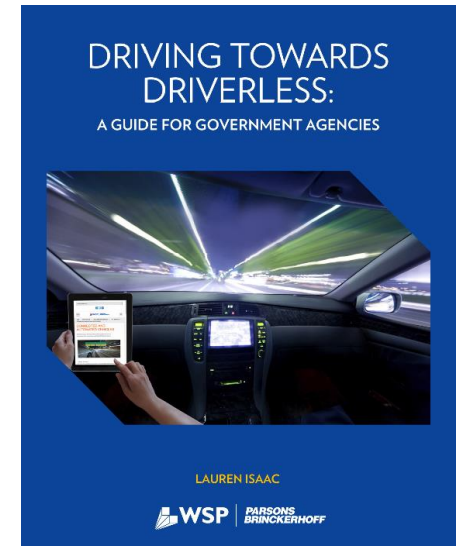
Impacts Summary of Driverless Vehicle Future Scenarios  
(Changes from Today)

	Driverless Nightmare	Driverless Utopia
Safety	↑	↑
VMT	↑	↓
GHG Emissions	↓	↓
Urban Sprawl	↑	↓
Parking Requirements	No Change	↓
Roadway Maintenance Requirements	↓	↓
Low-Income Mobility	↓	↑

\* VMT: Vehicle Miles Traveled



Ride Sharing  
≠ Car Sharing  
≠ e-Hailing



# □ Nightmare, why?

## ■ 총주행거리(Vehicle Miles Traveled) 변화

- Carnegie Mellon Univ., Corey D. Harper, 2016.4

- 신규 교통수요 유입으로 **14%/년 증가** 예측
  - 신규수요 : 무면허자, 65세 이상 노령인구, 장애로 인한 운전 불가능자
- 관련 문헌 조사 요약 : **4~40% 까지 증가** 예측

증가요인	증가율	출처
신규수요 유입 (16세 이상)	<b>최대 40%</b>	관련 서적(Brown 외, 2014)
신규수요 유입 (연령증가에 따른 주행거리 감소 고려)	<b>최대 10%</b>	Wadud 외 2016
여정시간 가치, 도로용량, 주차요금 및 거리당 요금 변화	<b>4~20%</b>	Childress, 외 2015
다음 승객을 태우기 위한 공차주행 고려	<b>평균 11%</b>	Fagnant 외 2014.

# □ Nightmare, why?

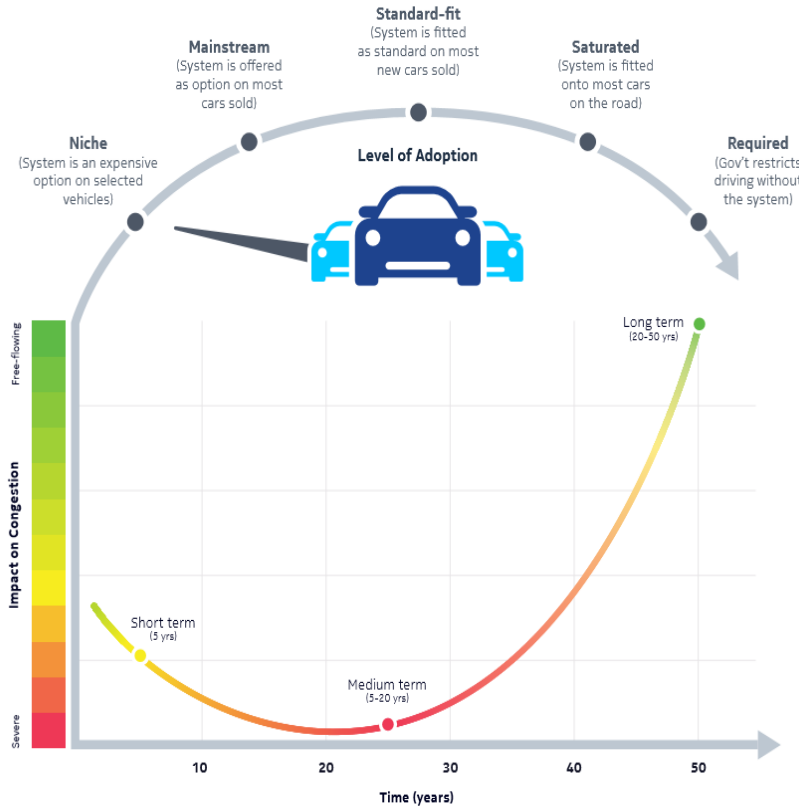
## ▪ 교차로 용량 감소 (안락함을 위한 낮은 가속 및 감속도, 25% AVs 가정)

1. 최대 가속도:  $0.58 \text{ m/s}^2$  (사람이 운전하는 차량 :  $2.8 \text{ m/s}^2$  at 20 km/h)
2. 최대 감속도:  $0.54 \text{ m/s}^2$  (사람이 운전하는 차량 :  $7.3 \text{ m/s}^2$  at 20 km/h -  $2.8 \text{ m/s}^2$ )

1. If **signal timing is left unchanged** (Scenario 1), the AVs must travel no faster than 8 mph as they approach a traffic signal, to avoid the 'dilemma zone'. **Capacity is reduced by 21%.**
2. But if **signal timing is to be changed** to accommodate the constraints on AV acc/dec (Scenario 2), very long yellow and all-red clearance times would be needed (approx. 12 and 10 s, respectively). **Capacity is reduced by 46%.**
3. An AV must assume that a leading human-driven car may unexpectedly decelerate at its maximum rate of deceleration at any point in time. If the occupant(s) wish to keep the AV strictly within the acc/dec constraints of HSR, the AV would need to maintain very long headways behind the leading vehicle (20 s at 30 mph). Introducing this constraint, **capacity is reduced by 54%.**

# □ Nightmare, why?

## ▪ 혼잡에 미칠 영향



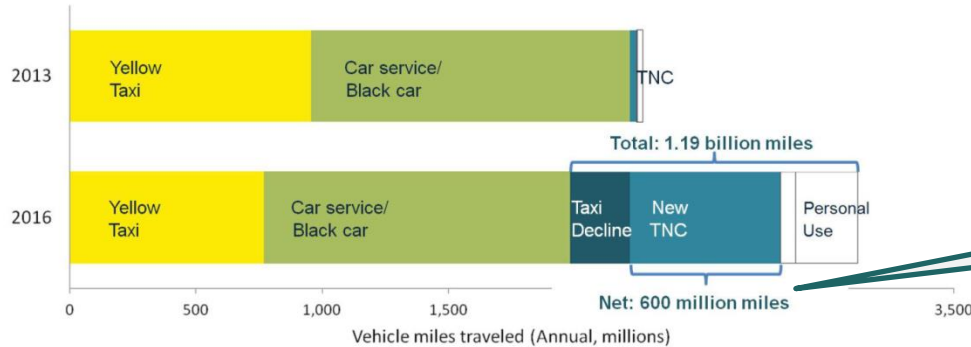
- 초기(5년 이내): ADAS 도입, 일부 개선  
- 사고감소, 혼잡 완화
- 중기(5~20년): 자율차 초기 부정적 효과  
- 인간 운전자 부적응, 기계에 대한 과신  
- 늦은 가감속, 도시화, 원거리 출퇴근  
- 고령자와 청년층의 차량 구입증가,
- 장기(20~50년): 대다수 자율차  
- 사고 무, 혼잡 무  
- 개별차량 관리 가능

출처 : How autonomous vehicles could relieve or worsen traffic congestion, HERE, 2016

<http://360.here.com/2016/07/19/autonomous-vehicles-will-go-nowhere-without-industry-collaboration/>

# ※ Uber가 정체를 해결한다 ?

## ■ New York 사례 분석, Schaller Consulting, 2017.2\*



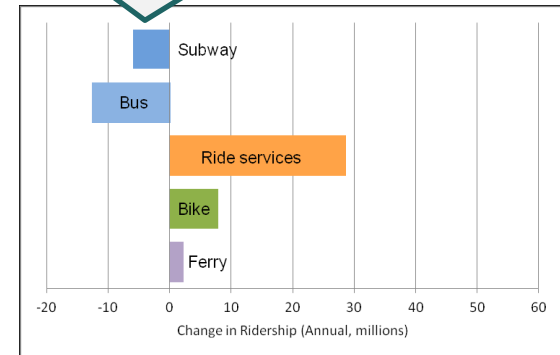
\*TNCs : Transportation Network Companies  
(Uber, Lyft, Via, Juno, Gett)

우버 등 택시운행 10억km 증가

대중교통 이용자 감소

### ○ 2013 대비 2016

- 43천대의 우버, 리프트 등 서비스 등록
- 주행거리 비중이 14%에서 19%로 증가 (전체차량 대비)
- 맨하튼 등 주요 도심의 전체 차량 주행거리 7% 증가
- 맨하튼 주간속도(daytime speeds) 11% 감소
- 대중교통의 수요가 주로 전환



\* UNSUSTAINABLE? The Growth of App-Based Ride Services and Traffic, Travel and the Future of New York City, 2017.2

<http://www.schallerconsult.com/rideservices/unsustainable.pdf>

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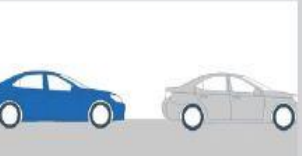


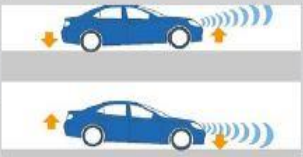
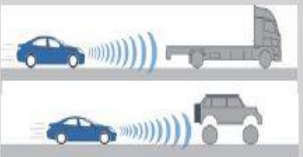

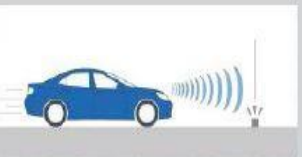
## 4. 해결해야 할 기술적 과제들

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# 4.1 단독주행 한계극복을 위한 협력 시스템

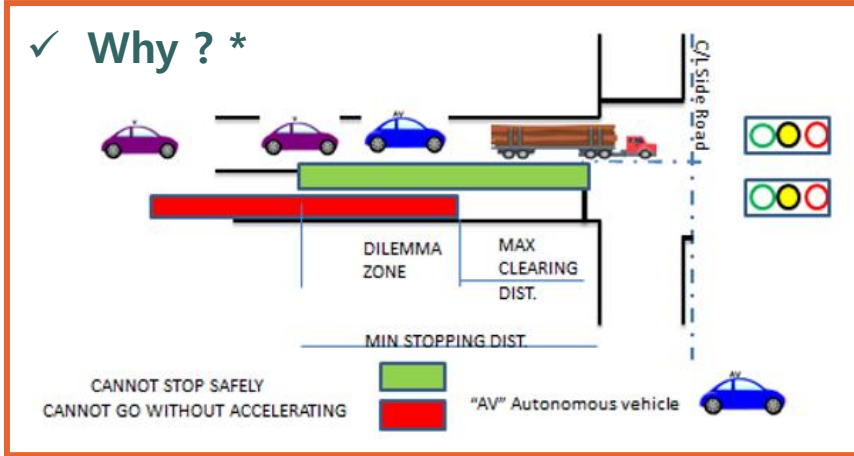
## ▪ 센서 성능저하 사례 (TOYOTA)

TSS-C PCS<sup>2</sup> may not operate in the following conditions:

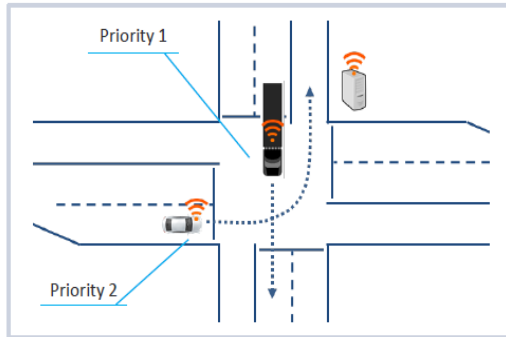
					
<p>When visibility to the front is poor due to bad weather (rain, snow, fog, dust raised by wind, sandstorm, blizzard, etc.)</p>	<p>When there is a sudden appearance in the forward direction of the vehicle</p>	<p>When driving around locations with sharp curves or undulations or for a period of time after turning due to camera recognition</p>	<p>When there is intense light from the front such as strong sunlight or high beams of a vehicle going the opposite direction</p>	<p>When a preceding vehicle cuts in front of you suddenly, abruptly steers, accelerates or decelerates, or is offset compared to your vehicle</p>	<p>When very close to the vehicle in front (distance of approximately 6.5 feet or less) or coming close to a preceding vehicle after making a lane change</p>
					
<p>Motorcycle or bicycle may not be detected</p>	<p>When driving on an up or down slope and not able to recognize a preceding vehicle</p>	<p>When vehicle angle/ stance is changing dramatically</p>	<p>If the rear-most surface of the preceding vehicle is small, low or irregularly high</p>	<p>When the camera or laser faces the wrong direction due to damage or misalignment</p>	<p>When the sensors detect something that is not a preceding vehicle</p>

# 4.1 단독주행 한계극복을 위한 협력 시스템

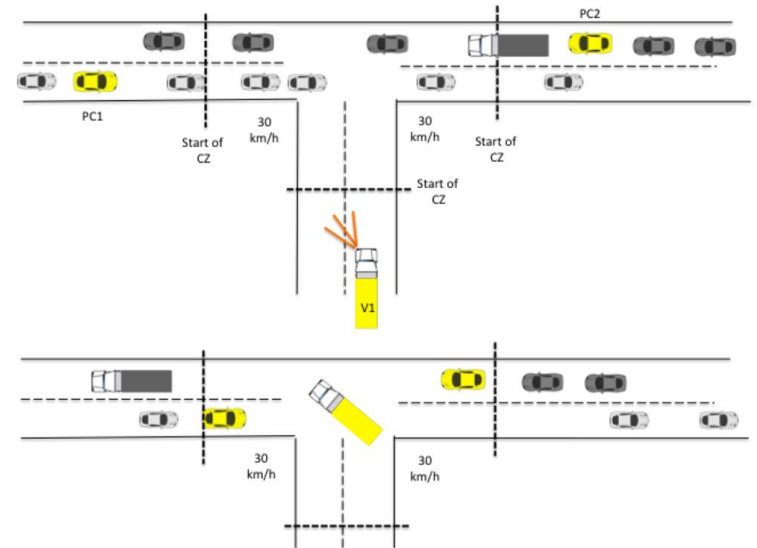
## ▪ 교차로 지원



### 1 Urban use-cases - Cooperative Intersection Control



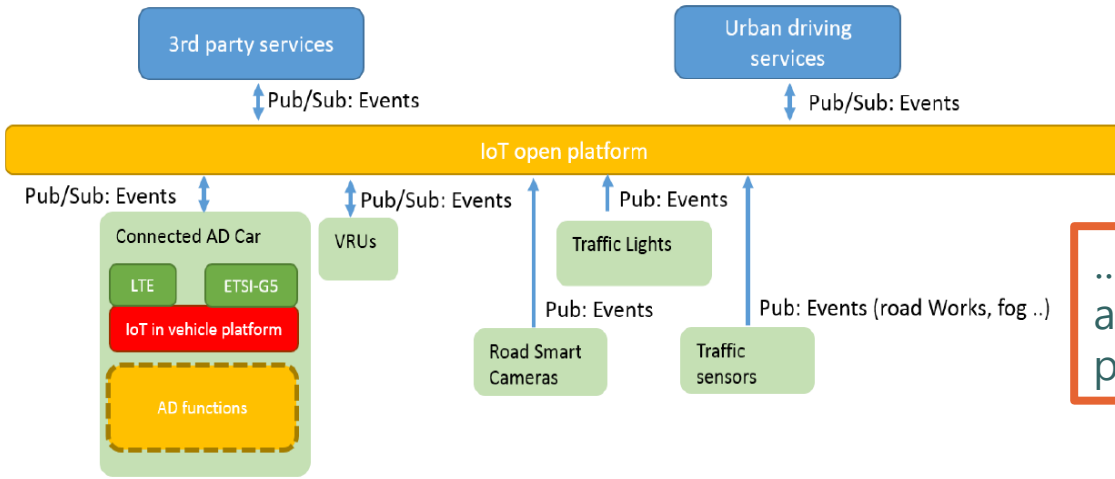
### ✓ i-GAME (2016.5) - cooperative intersection scenario



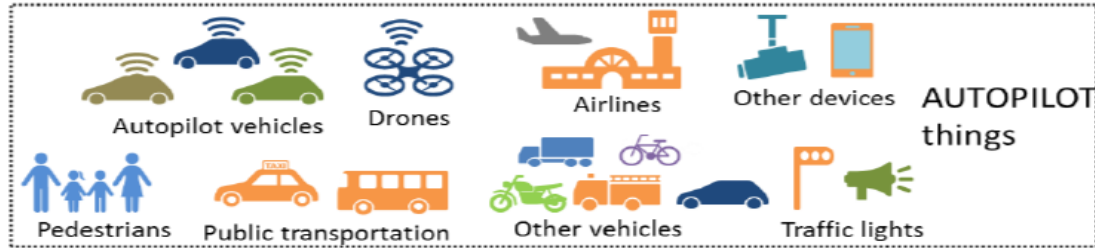
\* 출처 : Helping Autonomous Vehicles at Signalized Intersections

# 4.1 단독주행 한계극복을 위한 협력 시스템

## 인지범위 확장 - AUTOPILOT



... extending the perception range of an automated vehicle beyond what is provided by its own sensors.



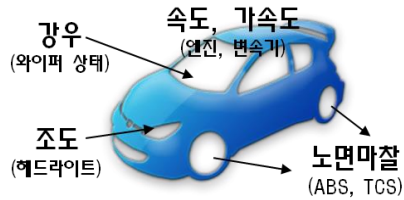
\* VRU : Vulnerable Road User  
(보행자, 자전거, 오토바이 등)

# 4.1 단독주행 한계극복을 위한 협력 시스템

## 인지범위 확장 – Probe Data, Sensor Data, See Through

### ✓ 다이내믹 데이터(PVD : Probe Vehicle Data, 차량 환경센서 데이터)

• 차량 내부센서 정보 : 위치, 속도, 가속도, 조도, 노면마찰, 강우 등



- 1) 차량 GPS 정보  
- 위치, 속도, 가속도, 방향
- 2) 도로상태 정보  
- 노면상태, 강우, 시계 등

• 차량환경센서 인식정보 : 차선인식률, 장애물 검지정보

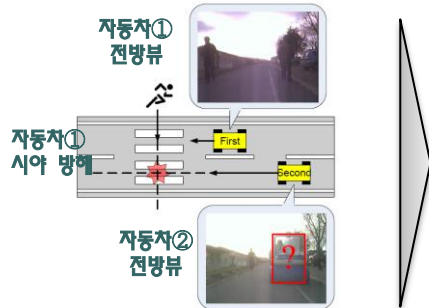


- 1) 차선 인식률  
- 자율주행 안전지원
- 2) 장애물 정보  
- 차량인식 돌발상황 정보

※ 환경센서 : 카메라, 레이더, 라이다

### ✓ 주변차량 인식정보 공유(Multi-Vehicle Cooperative Perception(Mapping))

• 차량환경센서 인식정보를 융합하여 주변차량과 협력인식 맵 생성



• 자동차 ①, ② 협력인식  
☞ ②에서 시야확보

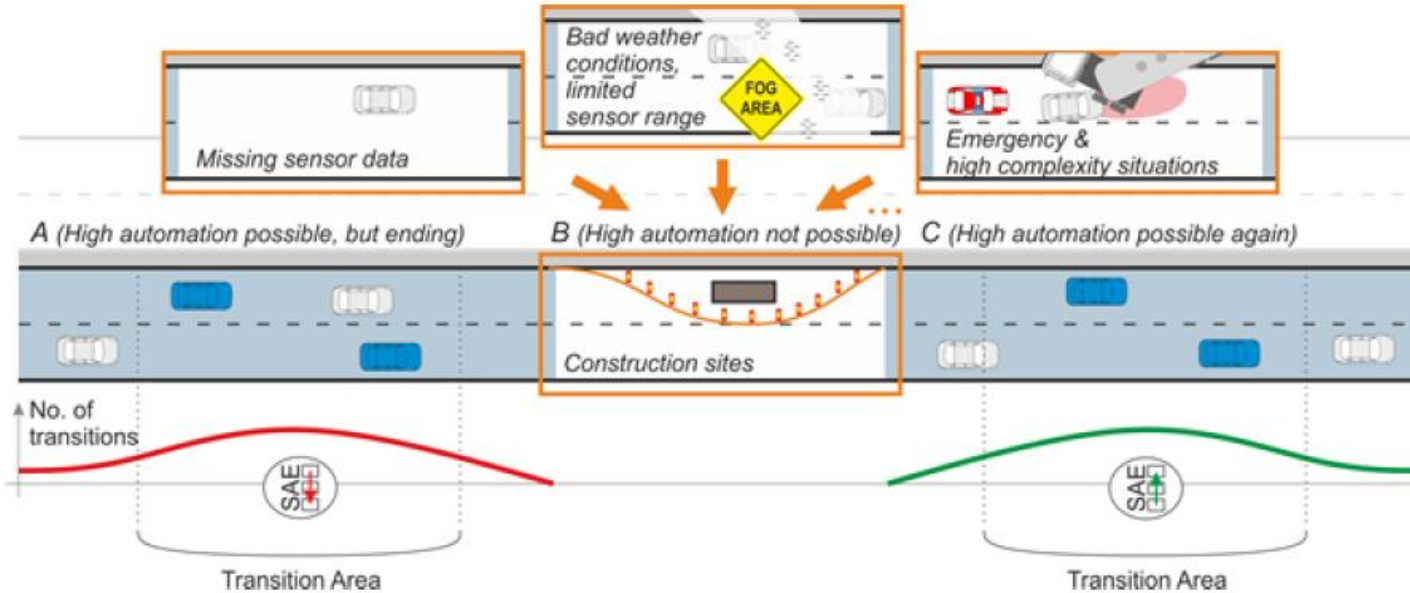


- 1) V2V 협력인식 정보  
- 주변차량을 이용 시야밖 정보 인식  
e.g. 보행자, 자전거
- 2) V2X 협력주행(Cooperative maneuvering)  
- 주변차량 센서 데이터 활용, 차량군내 융합 맵생성  
☞ 통신, 센서기반 맵매칭 기술 융복합

# 4.1 단독주행 한계극복을 위한 협력 시스템

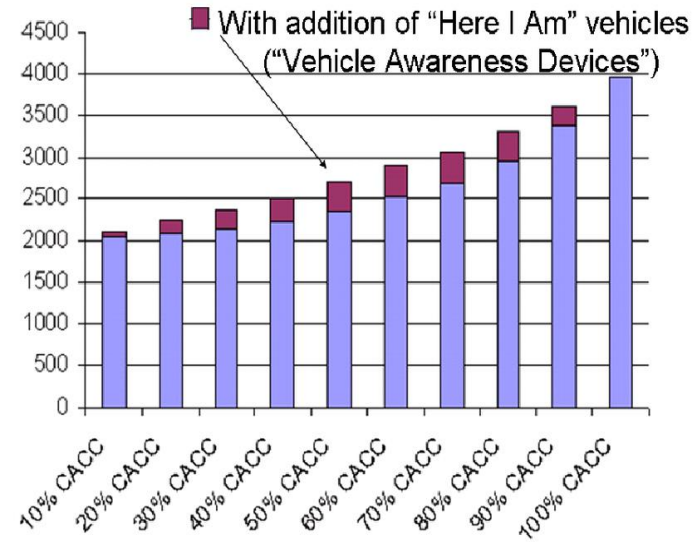
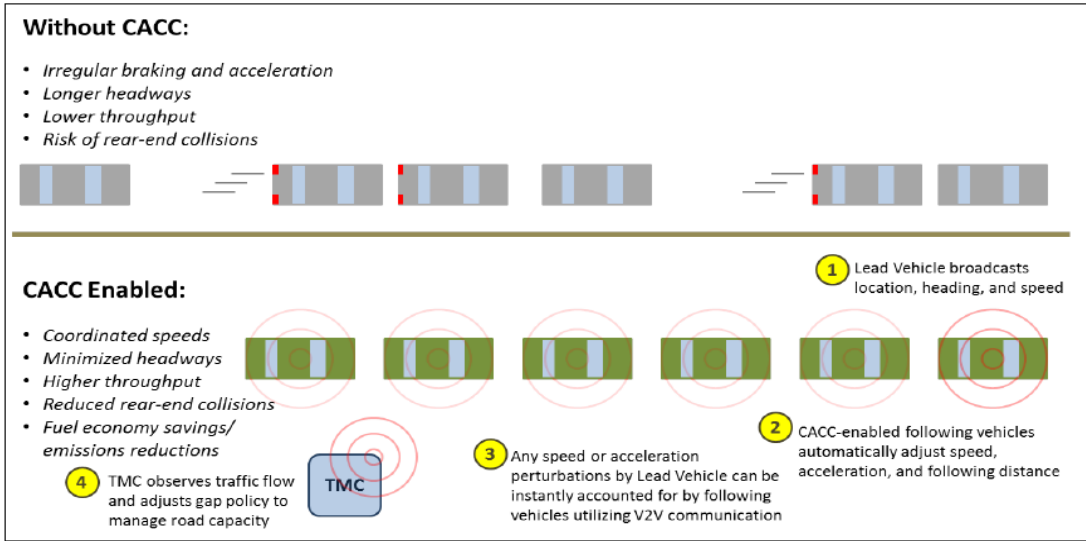
## ▪ TransAID

To develop and demonstrate **infrastructure-assisted** traffic management procedures, protocols and guidelines for smooth coexistence between automated, connected and conventional vehicles especially at **Transition Areas**.



# 4.2 그룹(근접) 주행을 통한 용량 확대

## ▪ 근접주행, CACC (Cooperative Adaptive Cruise Control)



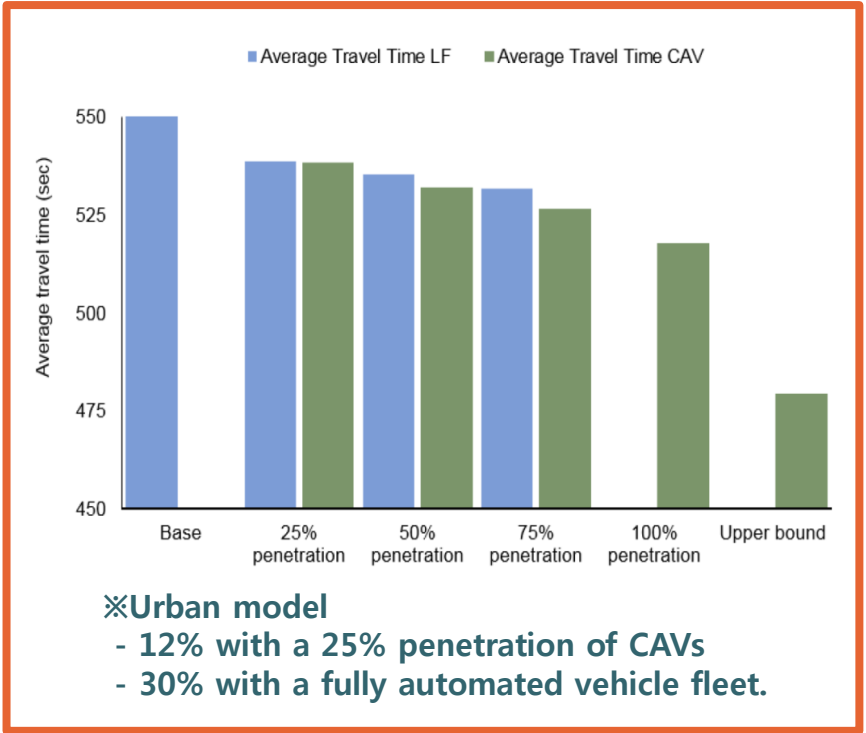
출처 : Impacts of Cooperative Adaptive Cruise Control on Freeway Traffic Flow, 2012, Shladover

※ 정체예방을 위해 차간 간격(Gap) 제어계획 수립·적용

# ※ CAV 혼입률이 정체에 미치는 영향

- Research on the Impacts of Connected and Autonomous Vehicles (CAVs) on Traffic Flow     Atkins, Summary Report , Department for Transport , May 2016

Scenario	CAV penetration Level II – IV	CAV penetration composition		
		Level II Driver assistance	Level III Mix of capability	Level IV Full automation
Base	0%	0%	0%	0%
25% penetration (1)	25%	20%	5%	0%
50% penetration (2)	50%	35%	10%	5%
75% penetration (3)	75%	50%	15%	10%
100% penetration (4)	100%	40%	20%	20%
Upper bound (5)	100%	0%	0%	100%



※ Strategic road network model

- 7% with a 50% penetration of CAVs
- 17% for 75% penetration
- 40% for a fully automated vehicle fleet

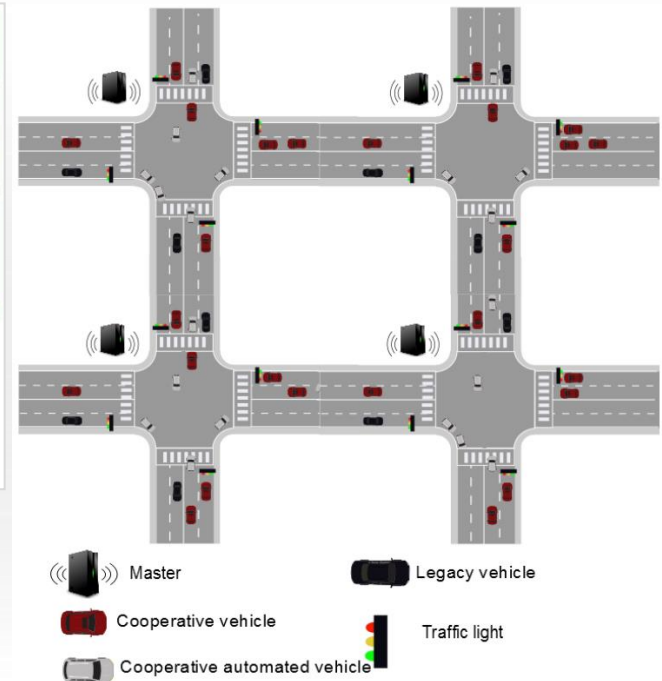
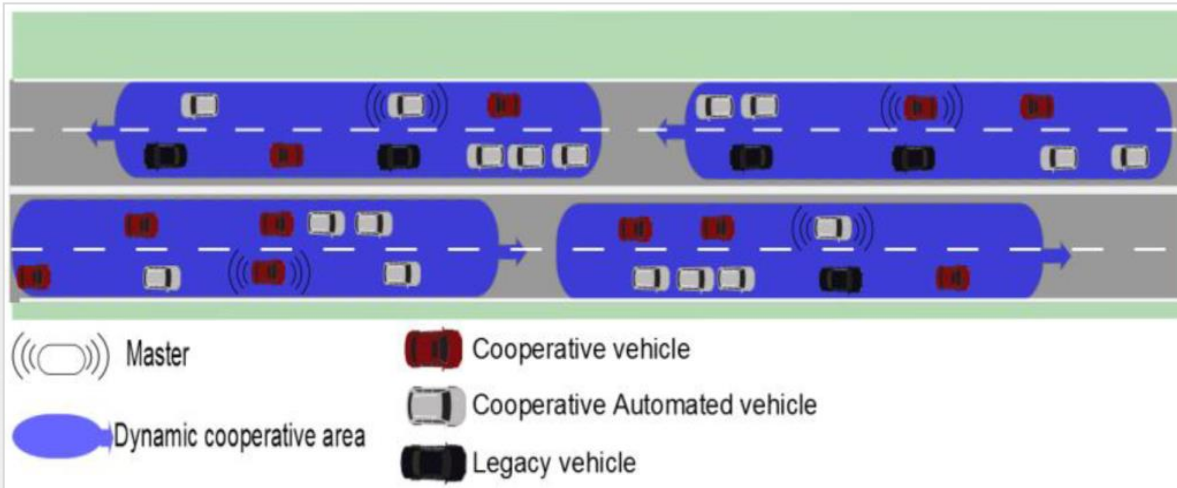
※Urban model

- 12% with a 25% penetration of CAVs
- 30% with a fully automated vehicle fleet.

# 4.3 네트워크 교통흐름 최적화

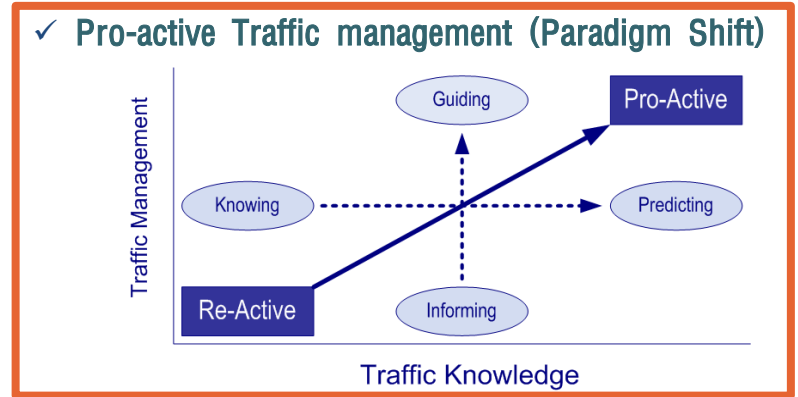
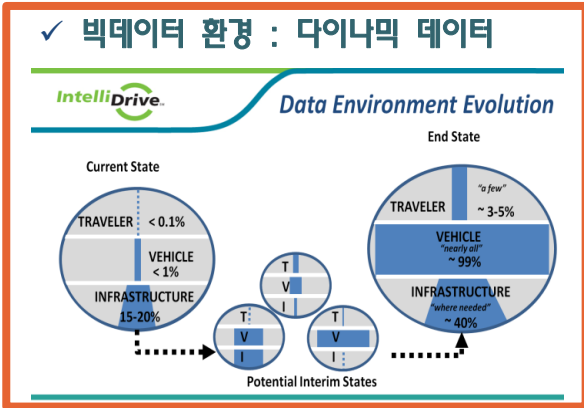
- Local ⇒ Global Cooperative System : AutoNet 2030

## Global cooperative area



# 4.3 네트워크 교통흐름 최적화

- 빅데이터 → 정체예측 → 예방적 조치 (갭, 속도, 차로, 경로 권고)

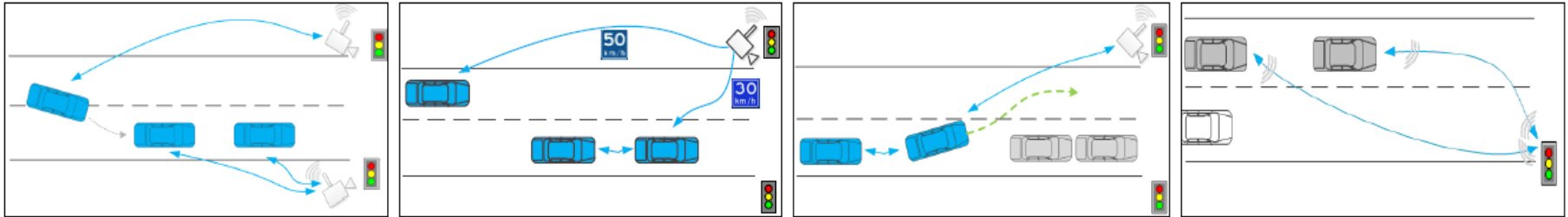


# 4.3 네트워크 교통흐름 최적화

## MAVEN – Use Cases Overview

- I2V interactions
  - Negotiation (signal timing vs. arrival pattern), speed change advisory, lane change advisory
- Traffic controllers optimization
  - Signal optimization, priority management, queue estimation, green wave
- Platoon management
  - Forming, joining, travelling in, leaving, breaking a platoon
- Conventional traffic and VRUs
  - Detection of non-cooperative vehicles, VRUs, emergency situations

속도, 차로 권고  
교차로 운영  
군집주행 관리  
VRU Detection



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## 5. ISSUES & 마무리

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# 5.1 세 번째 시프트를 준비해야 !

## From CV to C-ART

EC JRC(Joint Research Center) Report, 2017

- **Shift**
  - from conventional vehicles to connected vehicles
  - from connected vehicles to automated vehicles
  - **from automated vehicles to C-ART**
- **C-ART** is ... concept by **adding communication** ... and adding a **central coordination** ... to achieve the full potential of automated driving in terms of social, economic and environmental benefits.

### C-ART will

- **coordinate AVs along their complete journeys.**
- **allocate AVs to different routes,** optimising safety, fuel consumption and travel duration in real time.

... fast and reliable **algorithms for real time** ... organise traffic in the best way possible, ...



JRC SCIENCE FOR POLICY REPORT

The r-evolution of driving:  
from Connected Vehicles to  
Coordinated Automated Road  
Transport (C-ART)

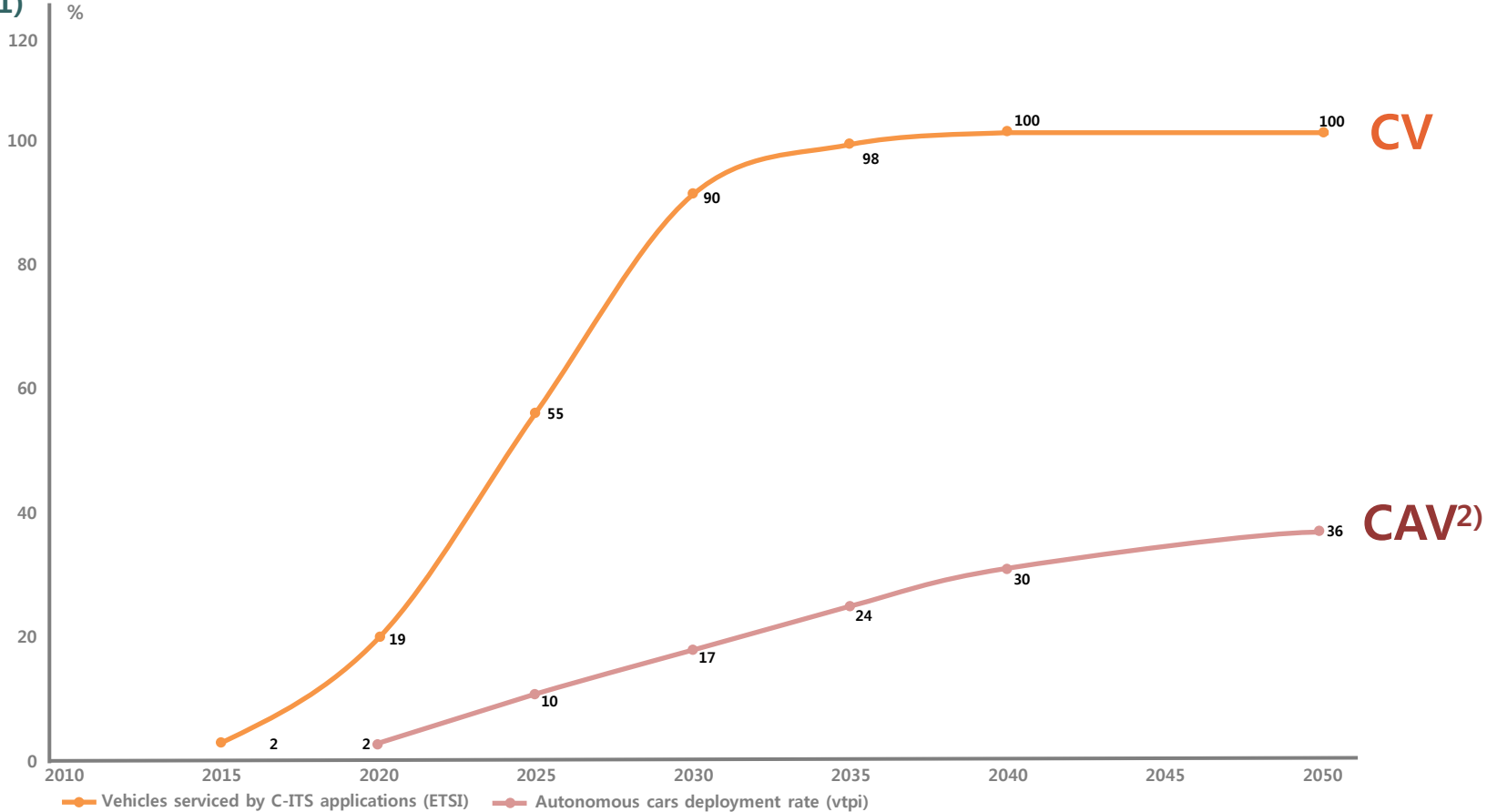
*Part I: Framework for a  
safe & efficient  
Coordinated Automated  
Road Transport (C-ART)  
system*

Alonso Raposo, M., Cluffo, B.,  
Makridis, M. and Thiel, C.  
FINAL  
2017



# 5.2 커넥티드 카 시대가 먼저 !

## ■ 도입전망<sup>1)</sup>



1) 출처 : STRIA Roadmap (Network and Traffic Management), 2016. 11.

2) 초기 일부 AV가 포함 될 것이나 미미한 수준이 될 것

# 5.3 도시 특성별로 다른 정책 필요 !

## CLEAN AND SHARED

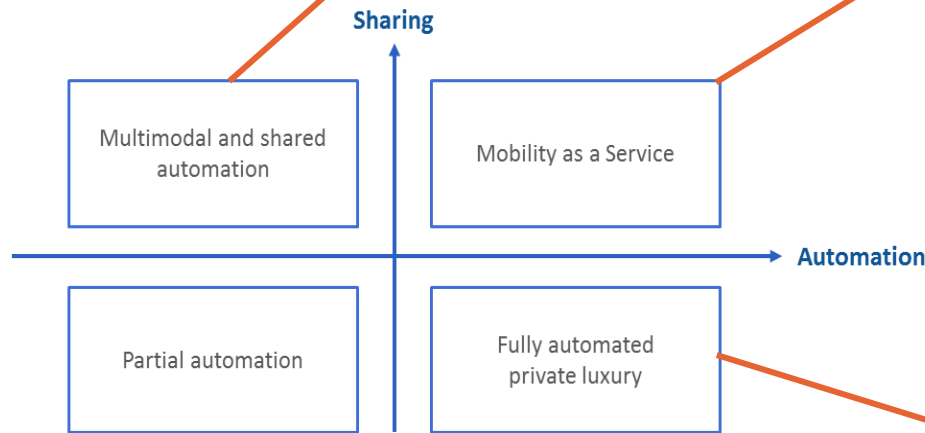
- DEVELOPING, DENSE METROPOLITAN AREAS
- 자율주행 곤란 (인프라 부족, 복잡한 환경 등)
- 친환경 차로 대체
- 차량의 개인소유 제한
- Delhi, Mexico City, and Mumbai

## SEAMLESS MOBILITY

- DENSE, DEVELOPED METROPOLITAN AREAS
- Mobility as a Service (대중교통 중심)
- 공유형 자율주행 – First & Last 1 mile
- Chicago, Hong Kong, London, and Singapore

## PRIVATE AUTONOMY

- DEVELOPED, SUBURBAN SPRAWL
- 개인 소유 자율차
- 전용도로
- 도시 중심부 대중교통 및 공유 서비스
- 혼잡 가중 (2030까지 주행거리 최대 25% 증가)



# 5.4 Cooperative 시스템 내에 VRU 통합 (V2P) !

## ■ 우리나라 교통사고 특성 (사망자)

- 여전한 골짜기수준 (?)
- VRU 65% (보행중 40%, 이륜차 25%)
- 노인사망자 38% (인구비율 13%)
- 도심도로 사망자 비율 50% ↑

Figure 1.3. Road fatalities per billion vehicle-kilometres, 2014

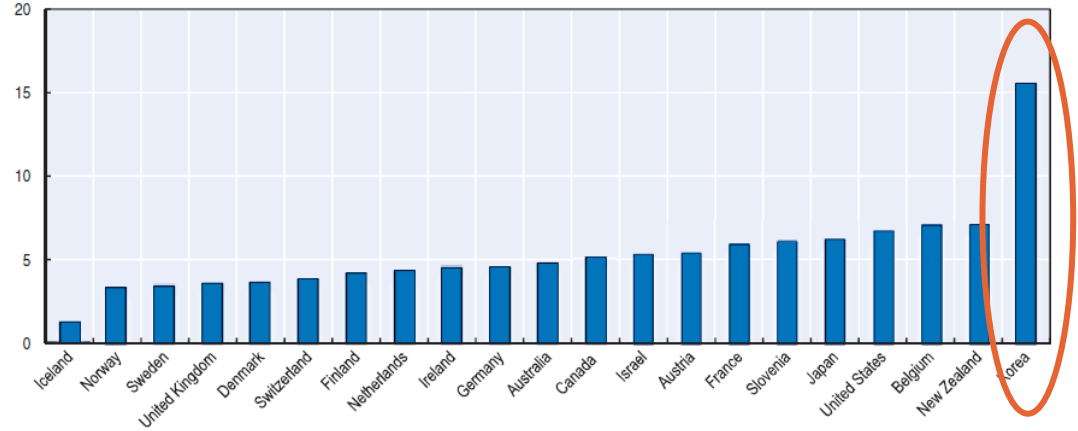


Figure 22.5. Road fatalities by road type

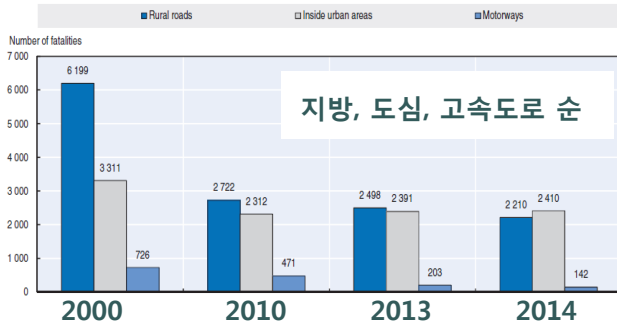


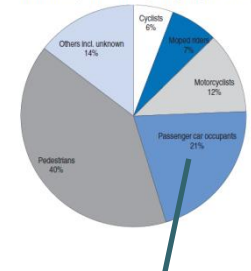
Table 22.3. Road fatalities by age group

Age	2000	2010	2013	2014	2014 % change over		
					2013	2010	2000
0-5	275	49	38	26	-31.6	-46.9	-90.5
6-9	202	49	33	18	-45.5	-63.3	-91.1
10-14	111	62	28	21	-25.0	-66.1	-81.1
15-17	263	139	87	104	19.5	-25.2	-60.5
18-20	459	149	119	109	-8.4	-26.8	-76.3
21-24	573	236	191	143	-25.1	-39.4	-75.0
25-64	6474	3068	2763	2526	-8.6	-17.7	-61.0
> 65	1853	1752	1833	1815	-1.0	3.6	-2.1
<b>Total incl. unknown</b>	<b>10 236</b>	<b>5 505</b>	<b>5 092</b>	<b>4 762</b>	<b>-6.5</b>	<b>-13.5</b>	<b>-53.5</b>

사망자 4,762명 중 고령자 1,815명(38%)

Figure 22.2 사망자 중 Use Group 별 비율

Figure 22.2. Road fatalities by road user group in percentage of total 2014



차량 탑승 중 21%

## 5.5 통신 : WAVE\* · LTE · 5G ?

### ■ 현재까지는 Hybrid (WAVE + LTE)

- 미국 : Report to Congress, FHWA, 2015.7

- **현 시점에서** 안전관련 서비스 제공을 위해 적용 가능한 기술은 **DSRC\***가 유일함
- 짧은 지연시간(Low Latency)과 빠른 접속(Fast Access)이 필요치 않은 서비스들은 Cellular 등 다른 통신 수단 적용이 가능함

\* Status of the Dedicated Short-Range Communications Technology and Applications

- EU : European Strategy on C-ITS\*, 2016.11.30

- **WAVE(EU는 ITS G5)와 현재의 이동통신망을 융합(Hybrid)하는 것이 가장 합리적**

\* "A milestone towards cooperative, connected and automated mobility"

### ■ 미래에는 ?

- **WAVE · C-V2X (Cellular V2X) · 5G & 새로운 Hybrid ?**

\* WAVE : IEEE 802.11p, 미국에서는 DSRC, 유럽에서는 ITS-G5로 명명

# 5.6 Level 3를 skip ?

Manufacturer	Level 2	Level 3	Level 4	Level 5
Audi	2016 Audi A4 2017	2018	Late 2020s	TBA
BMW	2016 BMW 7 Series	Skipped	2021	TBA
Ford	2019	Skipped	2021	TBA
Honda	2016 Honda Civic-Sedan	2020	TBA	TBA
Kia	2016 Kia Sportage	2020	2030	TBA
Mercedes-Benz	2013 Mercedes-AMG C63	Skipped	TBA	TBA
Nissan	2016 Nissan Serena	2018	2020	TBA
Renault	2016 Renault Espace	2020	TBA	TBA
Tesla	2015 Tesla Model S	Skipped	2018	TBA
Volvo	2016 Volvo XC90	Skipped	2020	TBA



포드 "5년 내 완전 자율주행  
"...GM은 점진적 개발  
연합뉴스, 2016.4

Level 3를 skip,  
**Why?**

## 5.7 마무리

- 커넥티드 되지 않은 자율주행은 존재하기 어려울 것
- CAD는 교통사고 감소를 위한 최고의 수단 - 도입노력 필요
- 혼잡 가중 불가피 - 완화를 위한 노력 필요
- 도시 특성을 고려한 정책수립이 선행되어야
- 일반차, VRU 혼재 상황을 고려

