



Development of an evaluation tool for the impact assessment of Automated Driving Systems on CO₂ emissions

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Daisuke Oshima

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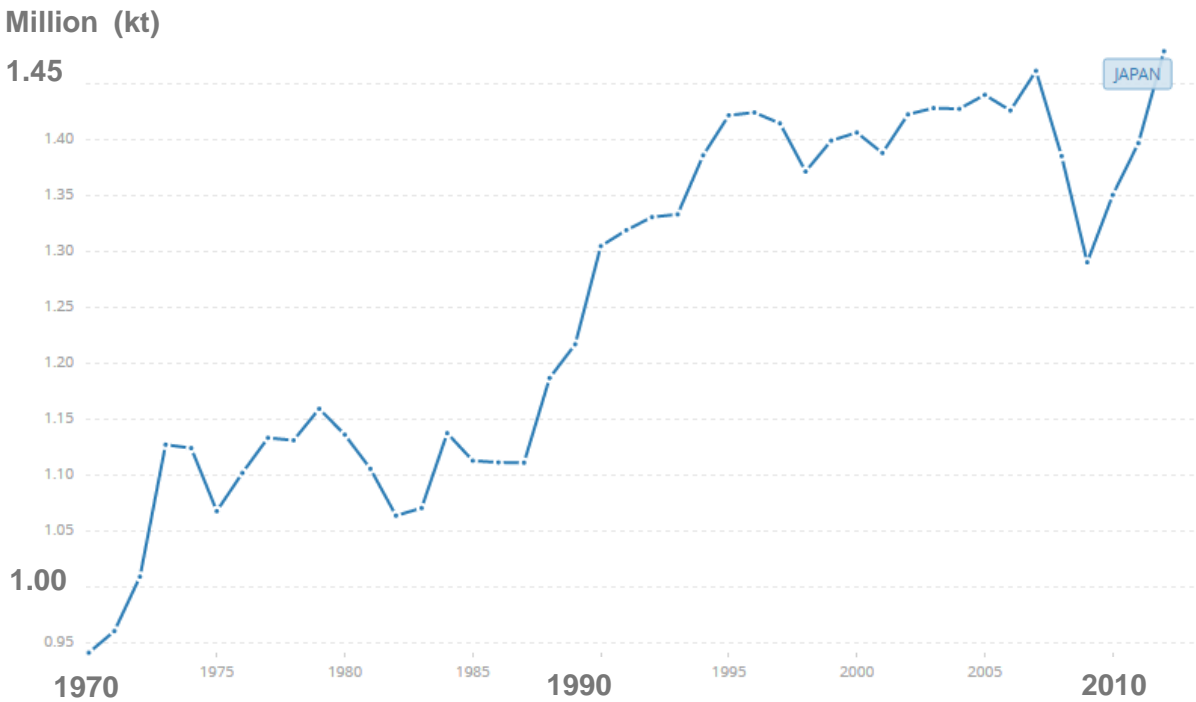
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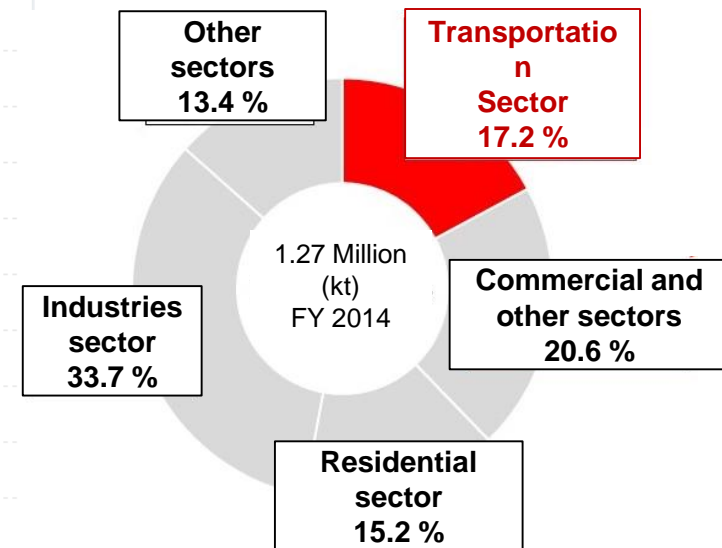
Background

- CO₂ emissions must be reduced to mitigate global warming.
- **17.2%** of CO₂ emissions is from the transportation sector and **automobiles account for 86.0%** of the transportation sector in Japan.



Source: The World Bank

Japan's CO₂ emissions



Source: Ministry of Land, Infrastructure, Transport and Tourism, JAPAN

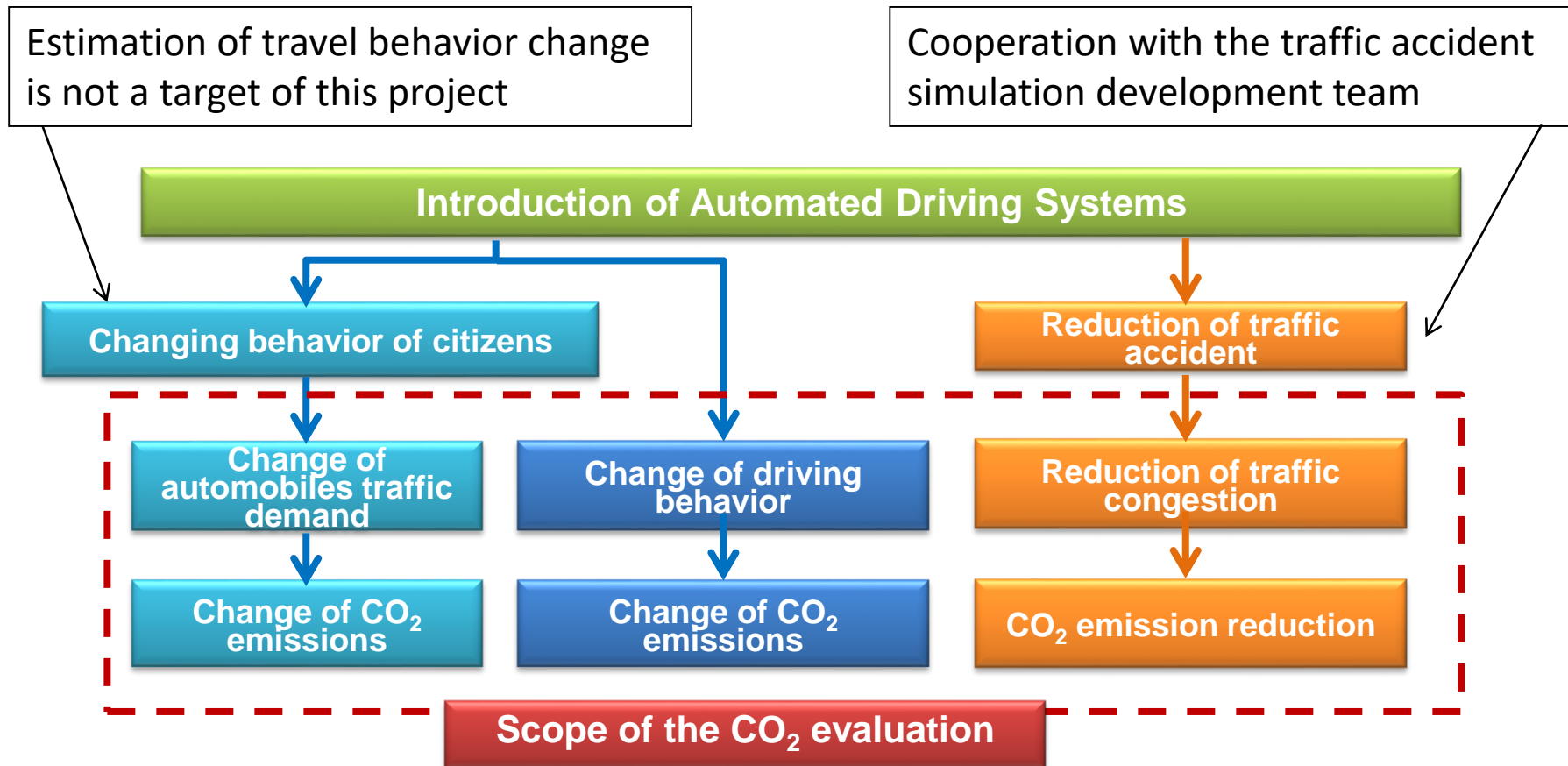
Objective

- Policy makers need to assess the effect of their policy quantitatively.
- Quantify and visualize the environmental impact of travel behavior may cause awareness of citizens and lead to change their mind.
- Automated Driving Systems may have a negative impact on traffic flow and CO₂ emissions.

Simulation conditions	Ratio of cars with ACC		
	Small vehicle Large vehicle	10% 30%	20% 50%
Reduction rate of lost time due to congestion by the introduction of ACC (spacing: middle range) to all lanes		-32%	-66%
Reduction rate of lost time due to congestion by the introduction of ACC (spacing: middle range) to the lanes other than the overtaking lane		8%	-25%

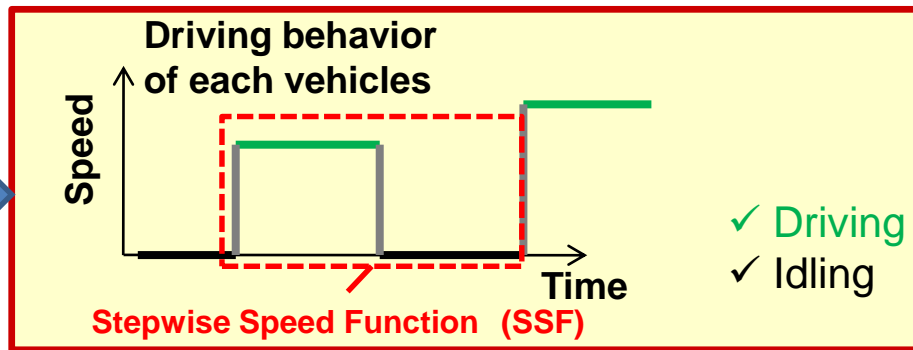
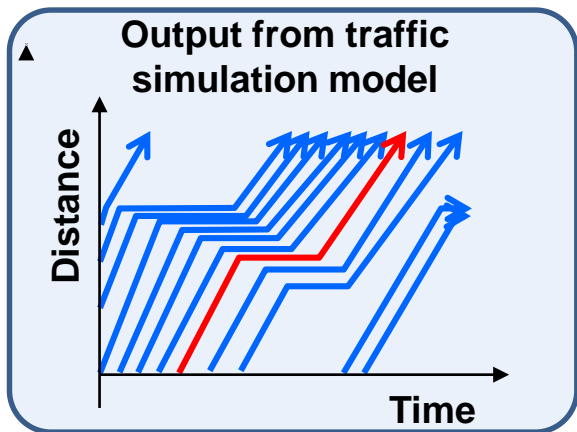
Scope of the CO₂ assessment

Impact of Automated Driving systems on CO₂ emissions by changing the traffic flow will be evaluated.



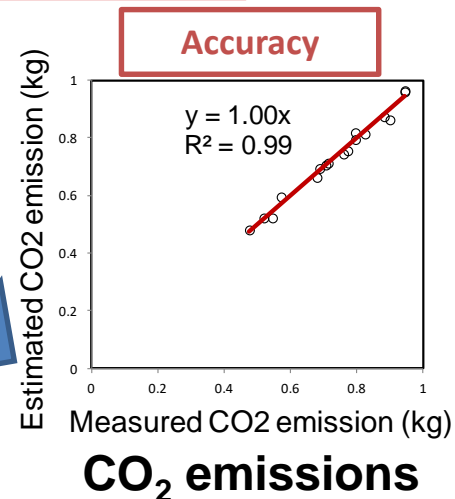
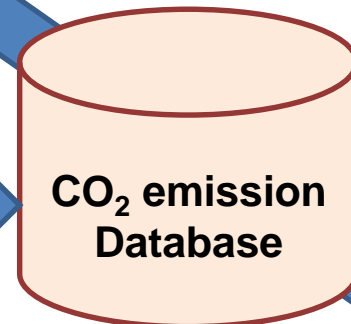
Concept of the CO₂ assessment

- Energy ITS Project (FY2008 - FY2012)
- Combination of **traffic simulation** and **CO₂ emission model**

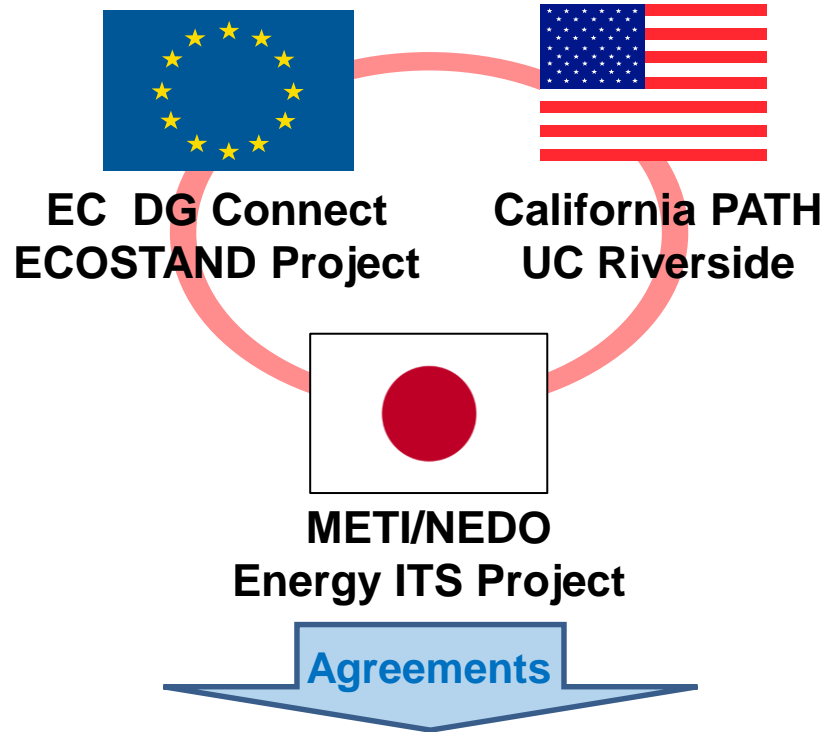


Collecting data of 8 category to represent Japanese automotive market

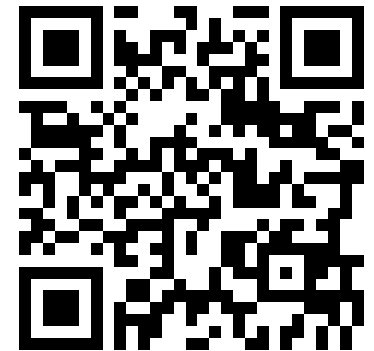
CO ₂ emission model	Motor	Categories	Traffic simulation	
			Small	Large
Gasoline		Minicar	✓	
		Passenger Car	✓	
		HEV (Hybrid Electric Vehicle)	✓	
		Mini Truck	✓	
		Light and Medium Truck	✓	
Diesel		Heavy Truck: 3.5t<GVW=<5t		✓
		Heavy Truck: 5t<GVW=<8t		✓
		Heavy Truck: 8t=<GVW		✓



International Collaboration in Energy ITS project



(↓available here)



International Joint Report
"Guidelines for assessing the effects of ITS on CO₂ emissions"

(available at)

<http://www.nedo.go.jp/content/100521807.pdf>

Assessment example (Truck Platooning)

Impact of Truck Platooning on Tomei Expressway

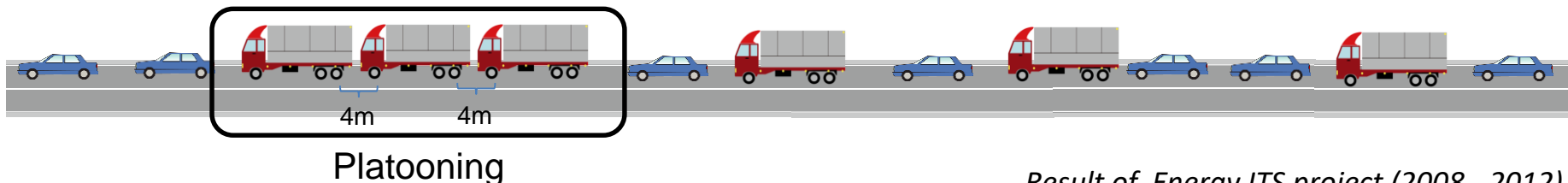
Conditions

Date: Rush hour in the weekday morning
(Nov. 12, 2008, 8:30 a.m. - 10:00 a.m.)

Route: Tomei Expressway (Yokohama-Aoba ~ Numazu)

Platooning condition: 40% of trucks form 3 vehicles platooning
with 4 meters gap

*Changing of CO₂ emissions by the traffic turbulence around an interchange is not taken into consideration.



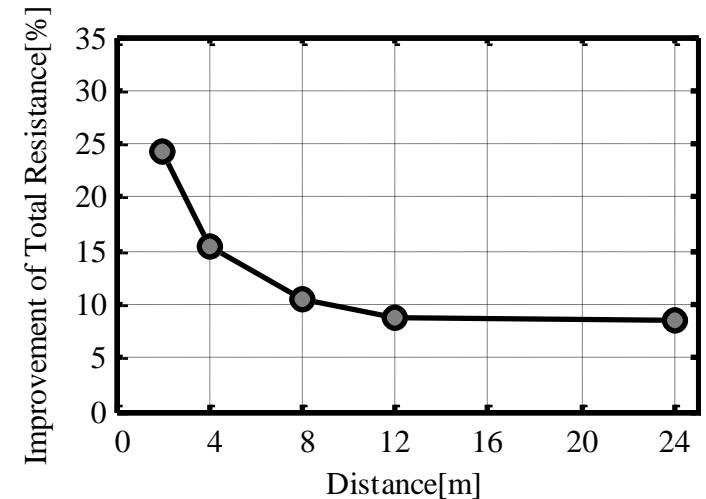
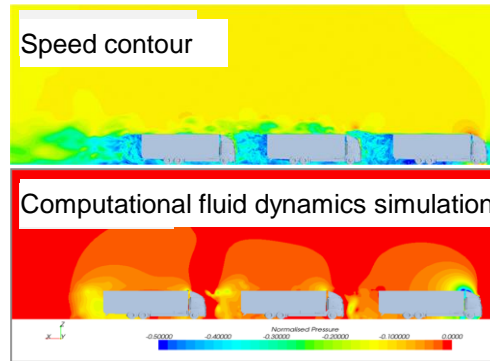
Result of Energy ITS project (2008 - 2012)

Assessment example (Truck Platooning)

I.

Improvement of fuel efficiency by reduction of air resistance

⇒ Estimated by a numerical fluid computation by another study team

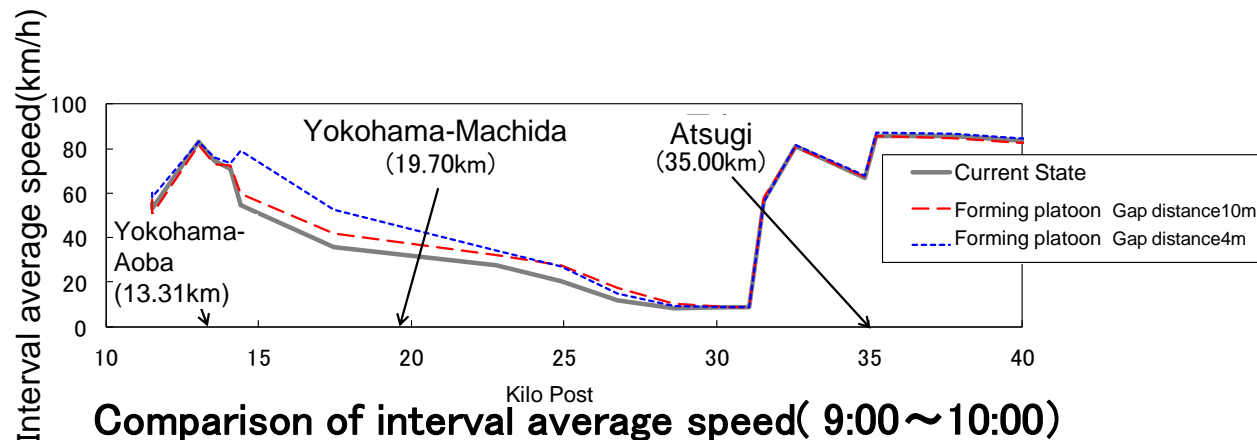


Reduction of air resistance

II.

Improvement of traffic flow (Improvement of travel speed)

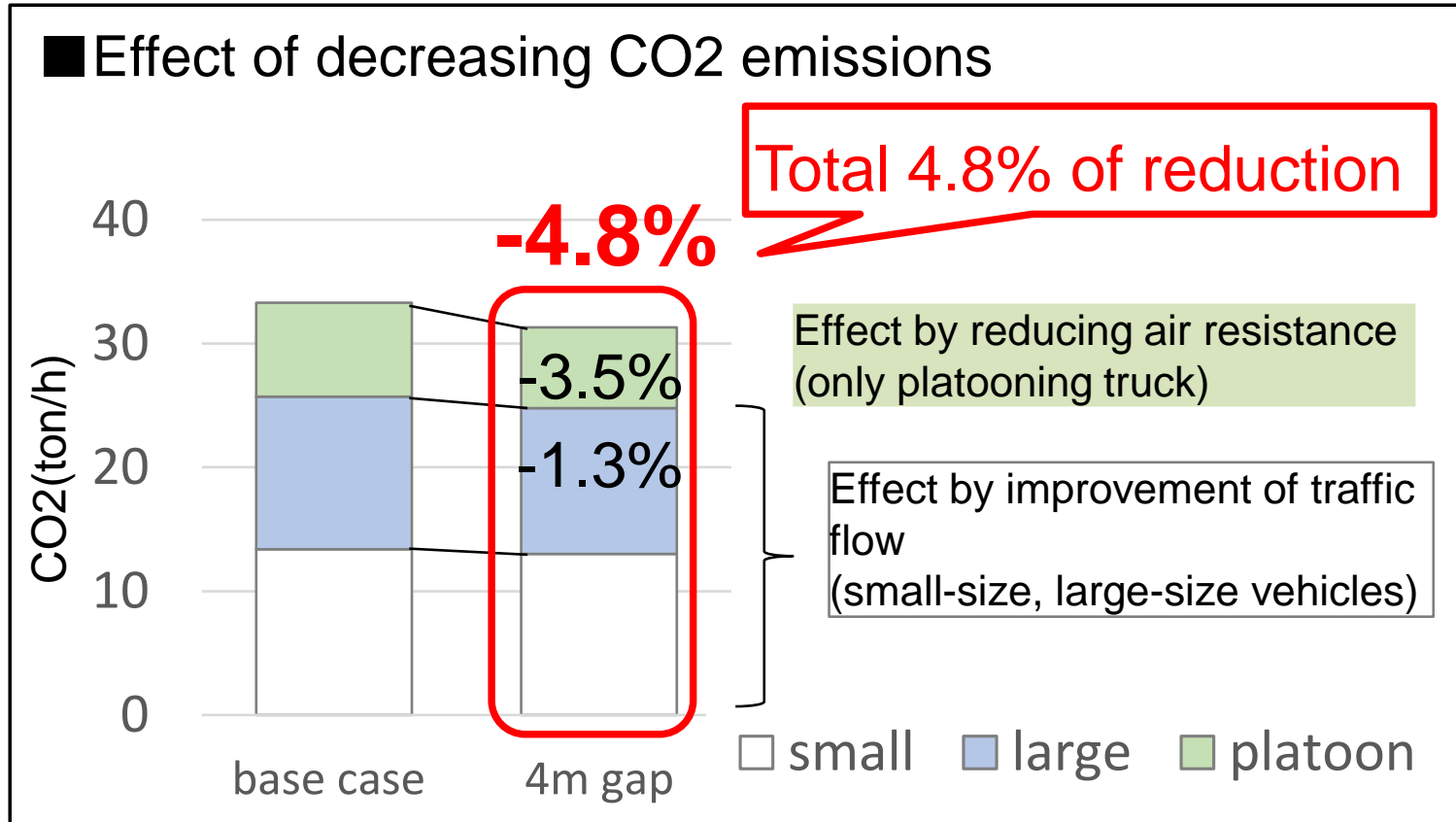
⇒ Estimated by a traffic simulation



Comparison of interval average speed (9:00 ~ 10:00)

Assessment example (Truck Platooning)

Estimated **4.8 % CO₂ reduction** in total



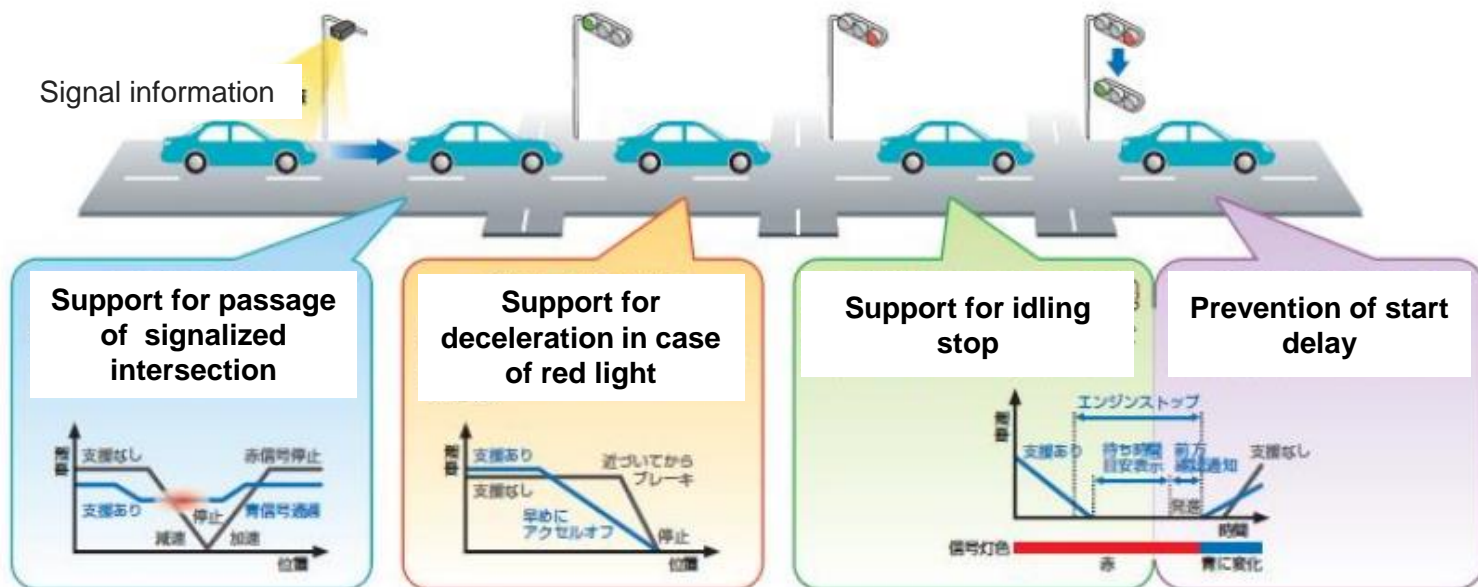
- I. Development of traffic simulation
- II. Development of CO₂ emission model
- III. Development of methodology to evaluate the impact of accident reduction on CO₂ emissions
- IV. Impact assessment in model cities
- V. International collaboration

A traffic simulation model to estimate the traffic flow by the introduction of the following automated driving systems will be developed:

- Green Wave running utilizing traffic signal information
- Advanced Rapid Transit (ART)
- Truck platooning on expressways
- Automated driving system on expressways and general roads
- Last-one-mile transport by automated car and Automated valet parking

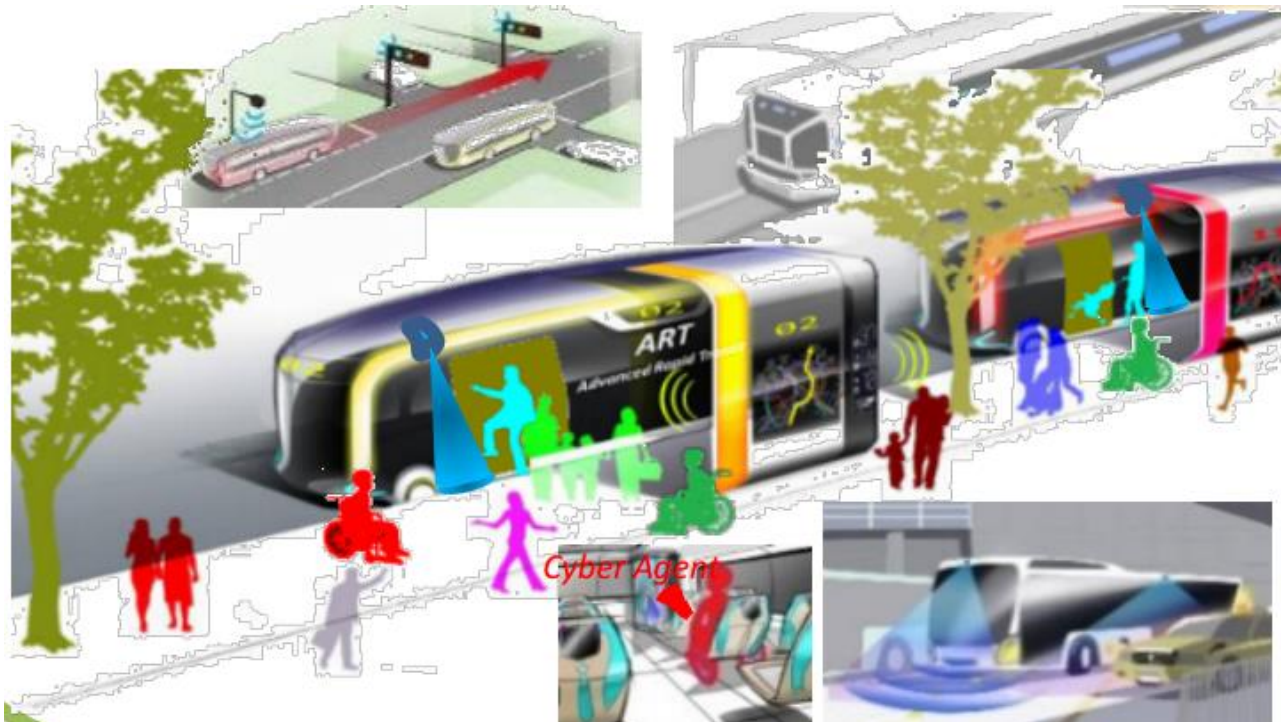
Green Wave running utilizing traffic signal information

- Support for passage of a signalized intersection
- Support for deceleration in case of red light
- Prevention of start delay
- Idling stop



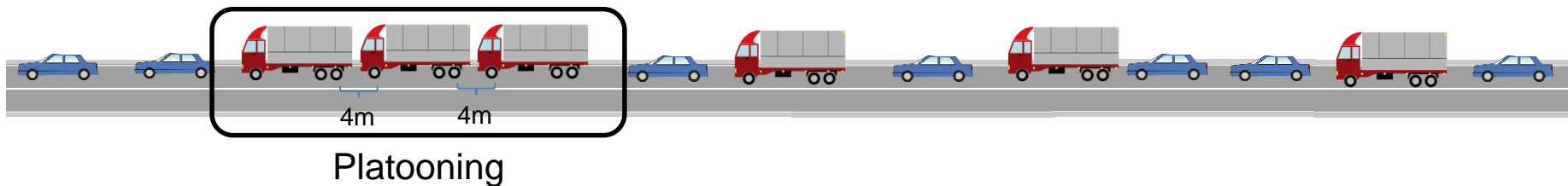
Advanced Rapid Transit (ART)

- Reduction of automobile traffic demand by usage promotion of ART (sensitivity analysis)
- Installation of dedicated lane for ART
- Smooth acceleration and deceleration of ART



Truck platooning on expressways

- Evaluation according to a realistic implementation scenario in Japan
- Three or four trucks form platooning with 4 meters gap



Automated driving system on expressways and general roads

The vehicle which installed automated driving system on expressways:

- Keep speed and reduce unnecessary speed fluctuation
- Overtaking automatically
- Merging at junctions automatically

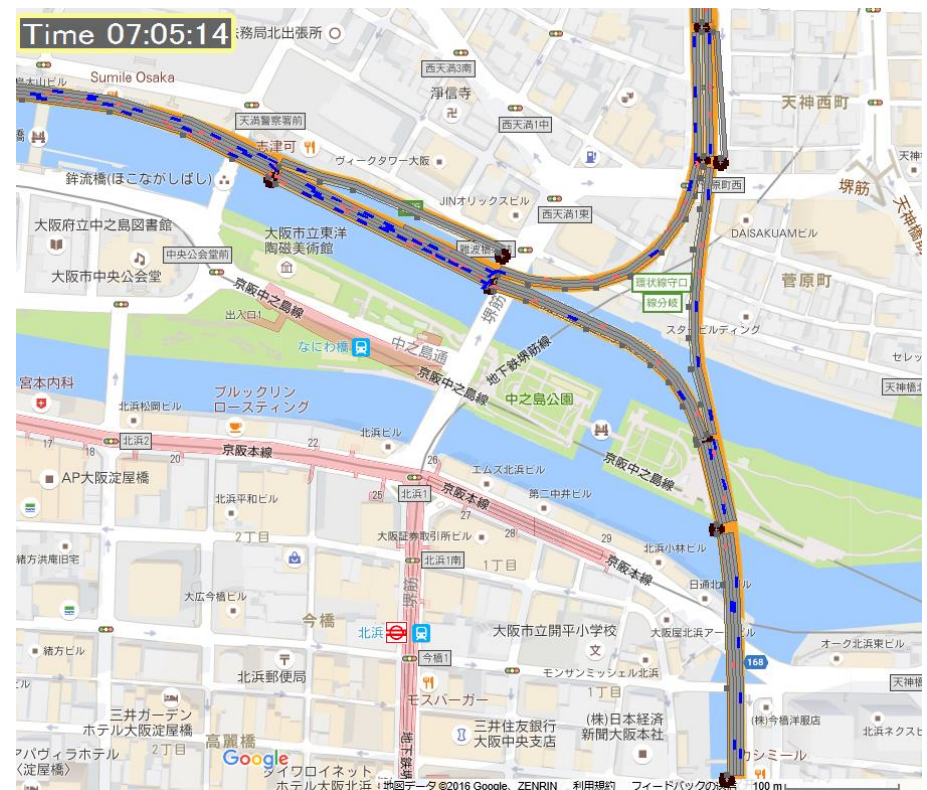
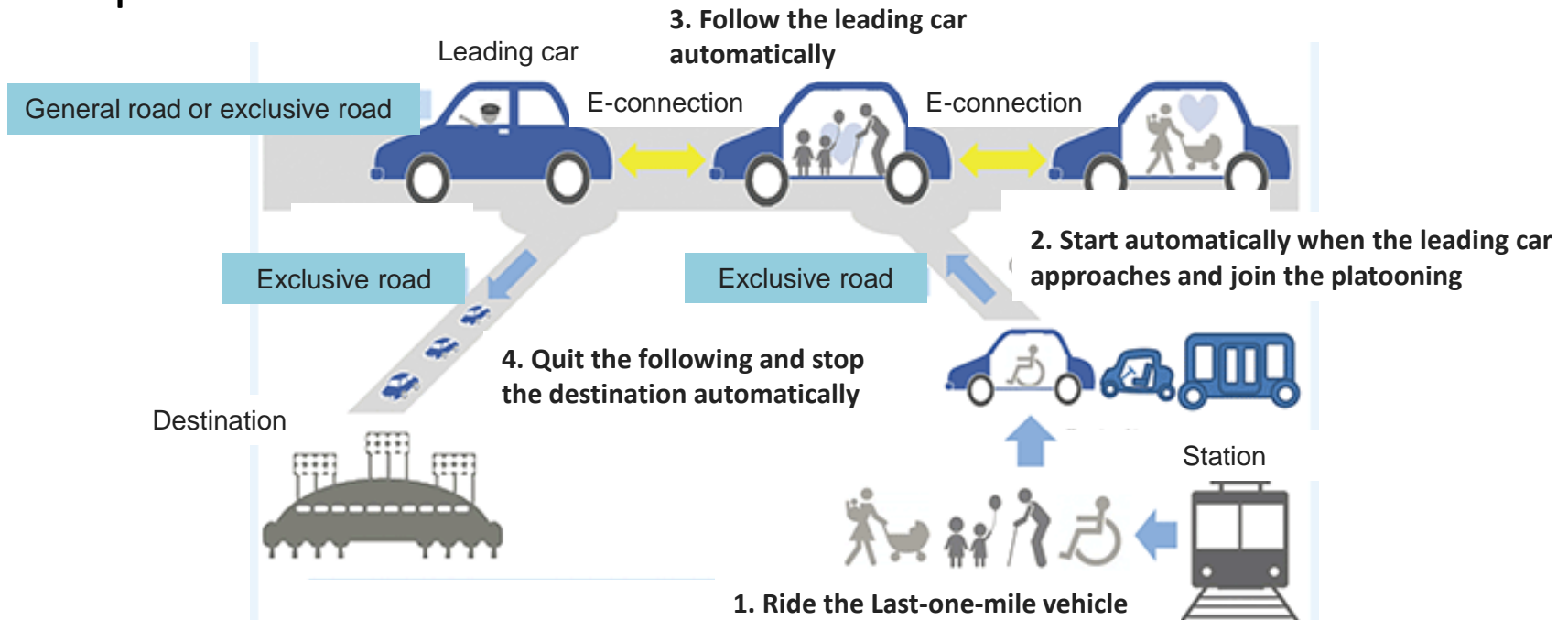


Image of traffic simulation

Last-one-mile Transport and Automated Valet Parking

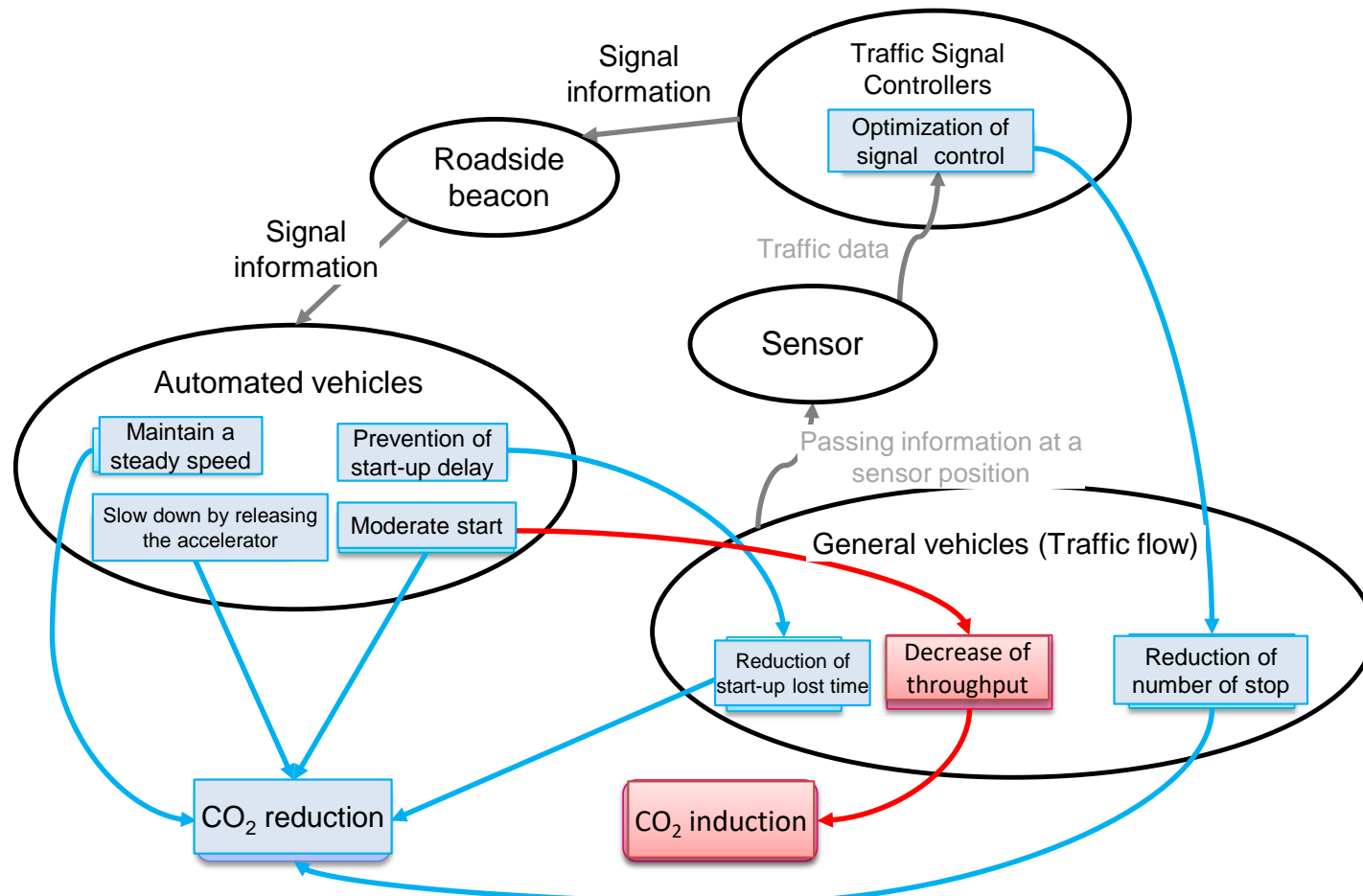
- The introduction of Last-one-mile Transport may motivate citizens to use public transport
- Automated Valet Parking may contribute to reduce traffic prowl on street



Source: Ministry of Economy, Trade and Industry 16

Development of traffic simulation

“Reference model” provides the relationships of mechanism on the impact of Automated Driving Systems in CO₂ emissions and the modeling target.

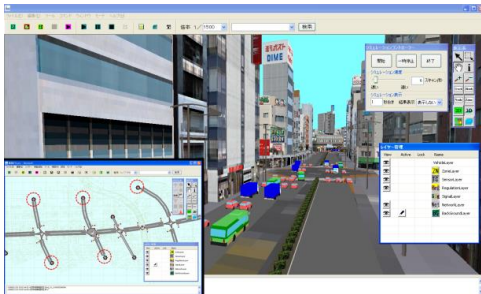


Ex. Reference model for Green Wave running

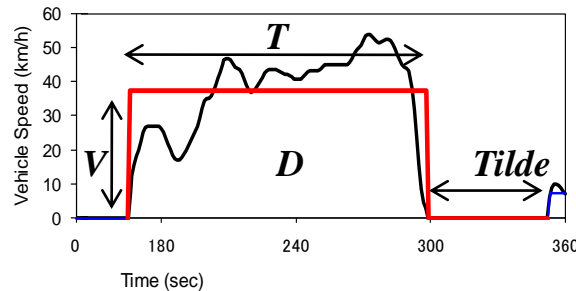
Development of CO₂ emission model

Update the CO₂ emission model by Chassis dynamometer test
 - Clean Diesel vehicle, Hybrid vehicle and Large size bus

Traffic Simulation: TS

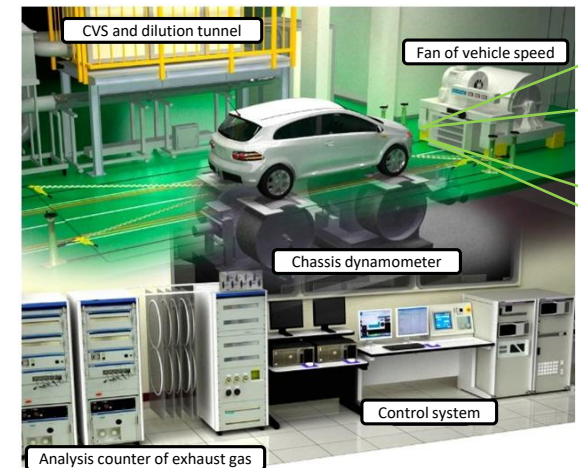


Driving data



Express driving pattern by SSF
 (Stepwise Speed Function)

Chassis dynamometer of passenger car



Emission Model: EM

$$E = C_{dist} \cdot D_n + C_{V_n^2} \cdot V_n^2 + C_{V_n} \cdot V_n + \dots$$



CO₂ emission of target area

Estimate by Multiple regression from SSF data 18

Impact of accident reduction

Reduction of traffic accidents is expected to lead to reduction of traffic congestion and CO₂ emissions



The impact of traffic accident on the traffic flow has not been much cleared

- especially general roads (not enough data)

- Combine traffic accident data and probe data
- Analyze the reduction of travel speed and the duration by comparing it in accident and normal condition

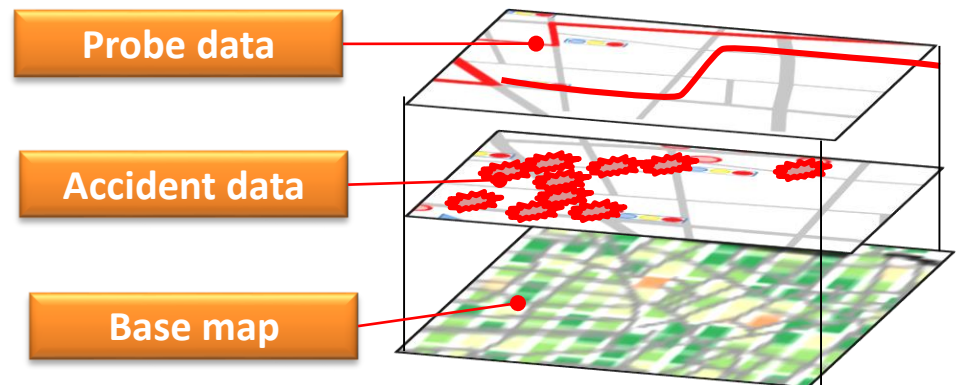
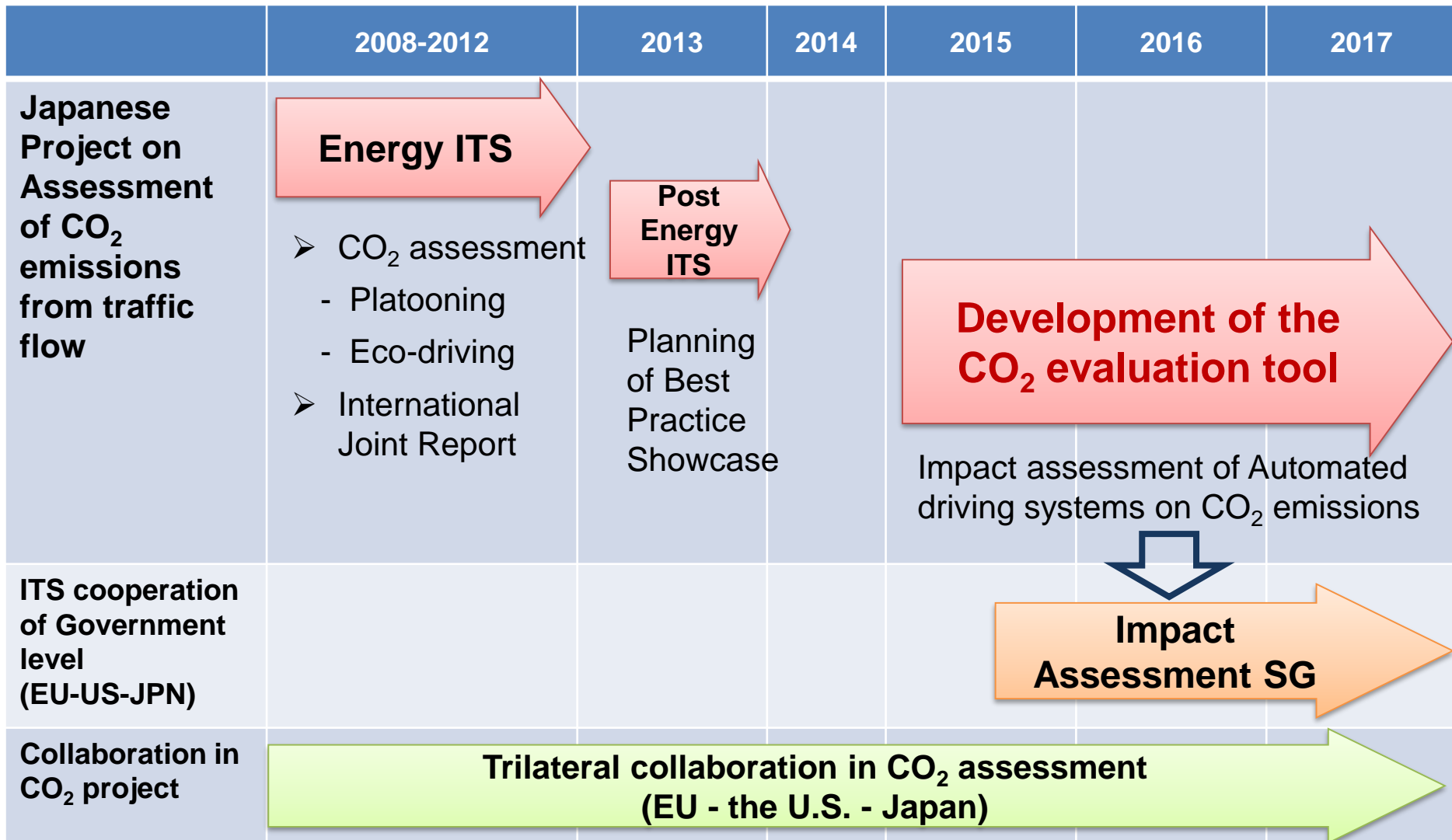


Image of the overlaying accident and probe data

International collaboration



- Background & Objective
- Concept of the CO₂ assessment
- Assessment example (Truck Platooning)
- Development of traffic simulation
- Development of CO₂ emission model
- Impact of accident reduction
- International collaboration

Thank you for your kind attention.

Contact

Daisuke Oshima

daisuke.ooshima@ss.pacific.co.jp

 Pacific Consultants

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