A Multi-agent Traffic Simulation to Predict the Impact of Automated Driving Systems on Safety

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Cabinet Office

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Safety impact assessment methodology

Automated driving systems are expected to contribute to achieve the Japanese government target to become the safest automobile transportation society in the world.

Impact Assessment Method for "Continuous Functions" （Long Operational Period）

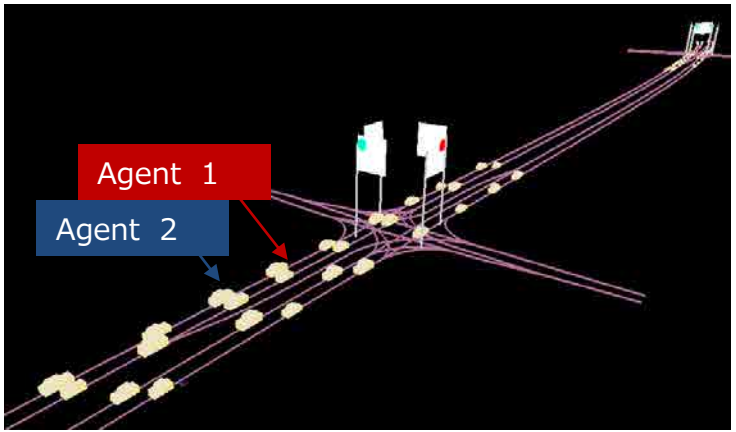
Field Operational Test

Real traffic flow

Implementation challenges

Cost
Acceptance
・・・・・
Data
(Accident)

Traffic Simulation



Virtual traffic flow

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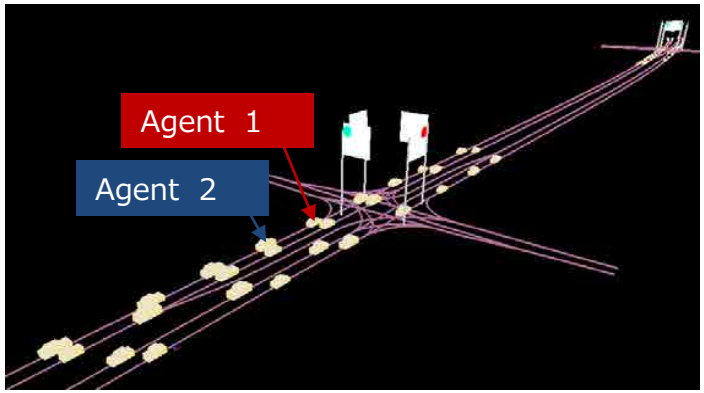
Characteristics of simulation

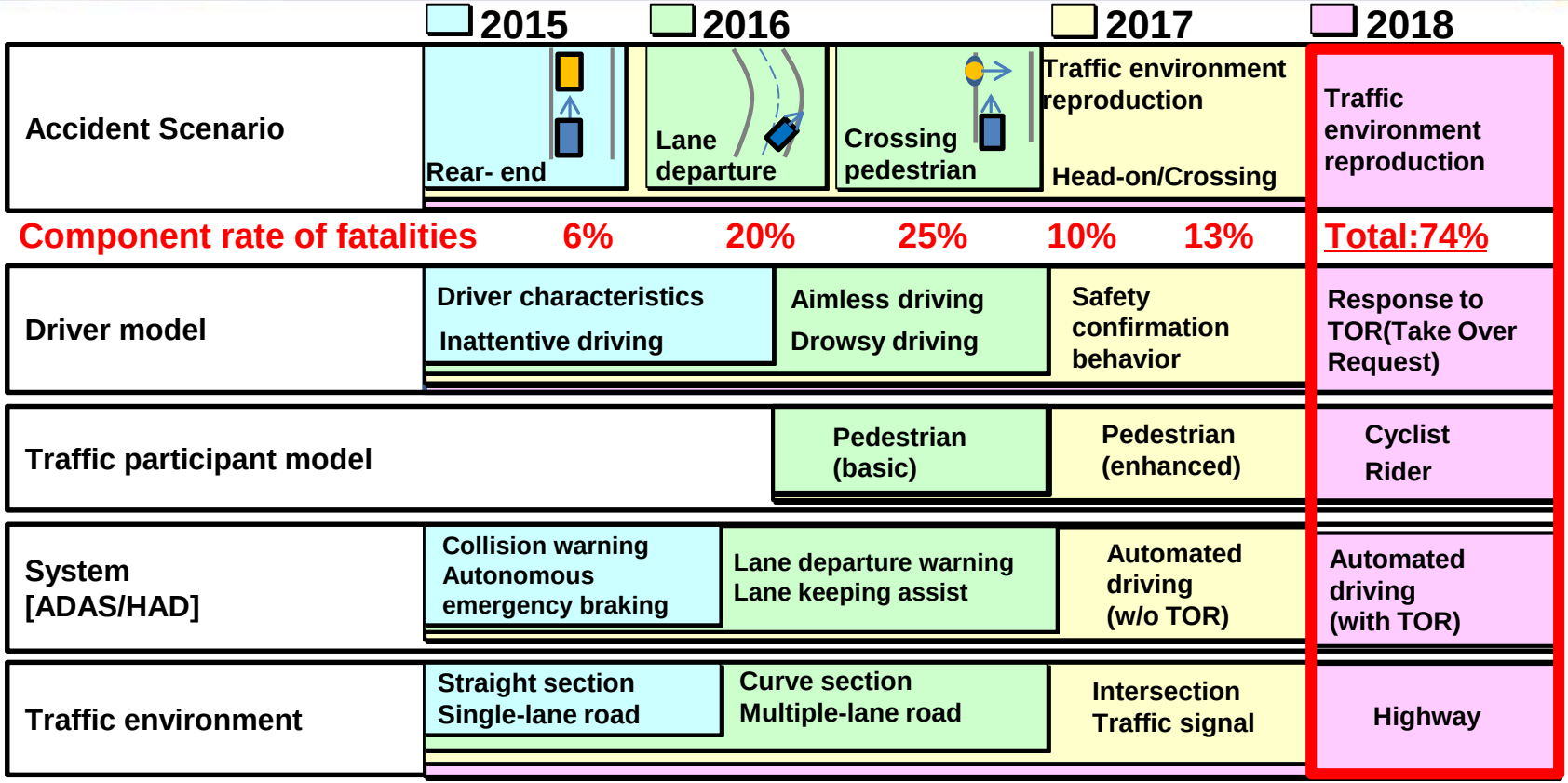
- *Keyword: Multi Agent Simulation*

1. All traffic participants (driver, pedestrian, rider...) are modeled as agents.
2. Each agent has Perception・Recognition・Decision making・Action process.
3. Agents' actions are interactively affected.



The aim of this project is to develop a multi-agent traffic simulation methodology applicable to predict the potential safety improvements of different automated driving systems.

Development of traffic simulation



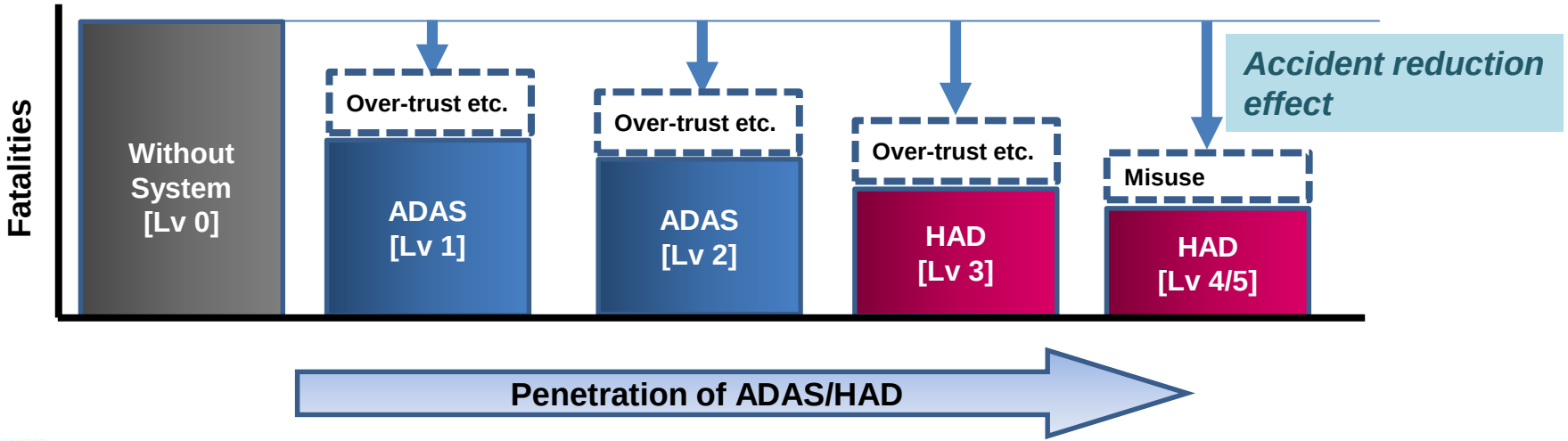
Developing simulation tool to evaluate traffic safety impact when ADAS/Automated Driving systems are deployed.

Safety impact assessment

【Image of final outcome】

【Japanese government's target】
・Fatalities: less than 2,500 in 2020

Accident reduction effects
・Fatalities
・Injuries
・Number of accidents etc.

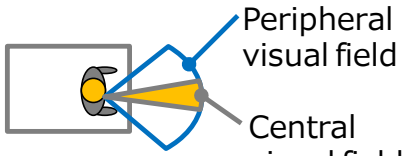


ADAS:Advanced Driver Assistant System
HAD:Highly Automated Driving

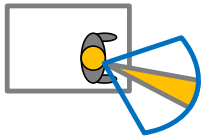
Driver Behavior Model

Perception Recognition

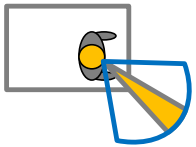
•**Driver's visual field**



Head shaking



Looking aside

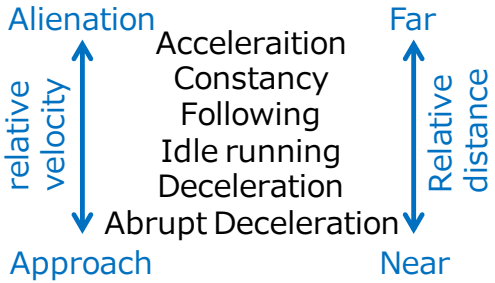


Decision making

Ego vehicle → Preceding Vehicle →

Based on relative velocity and relative distance

R.Wiedemann(1974)



Action

Based on decision making status

- **Accelerator pedal**
- **Brake pedal**
- **Steering wheel**

Driver error

- **Inattentive/aimless driving**
- **Misjudgement**
- **Inadequate operation etc.**

Driver attributes

(1)Compliance with traffic law

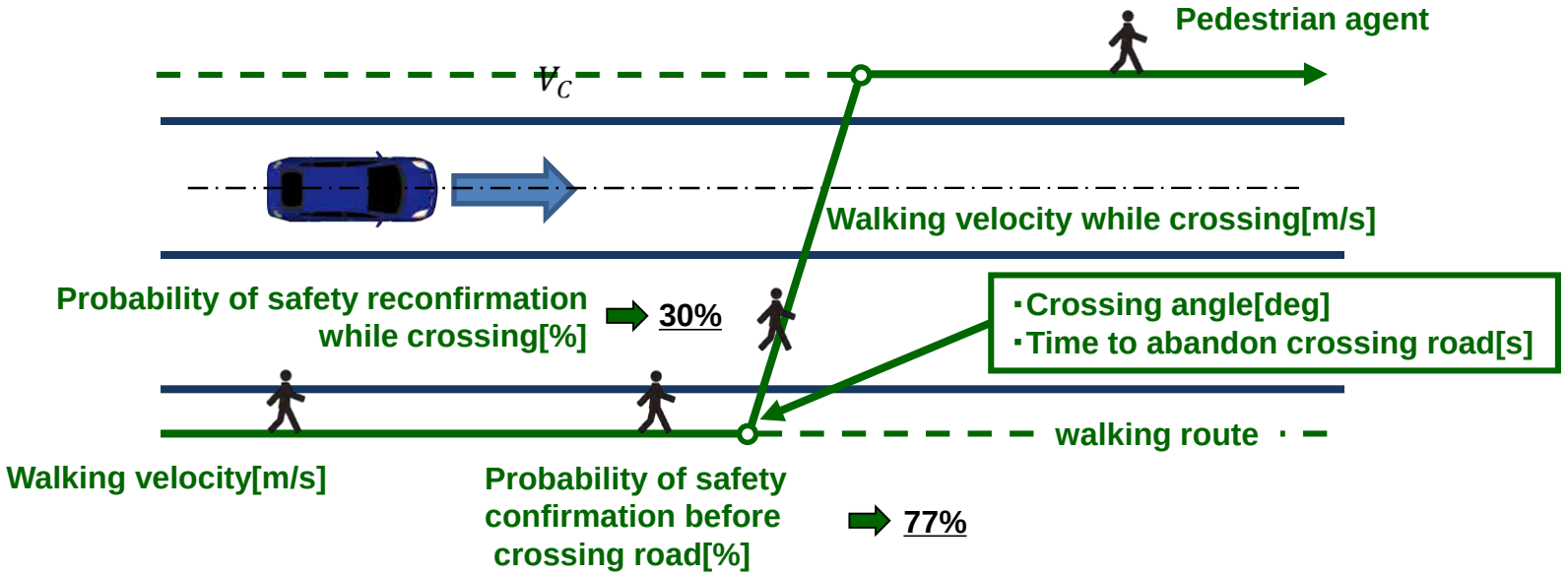
(2)Driving skill

(3)Information process ability

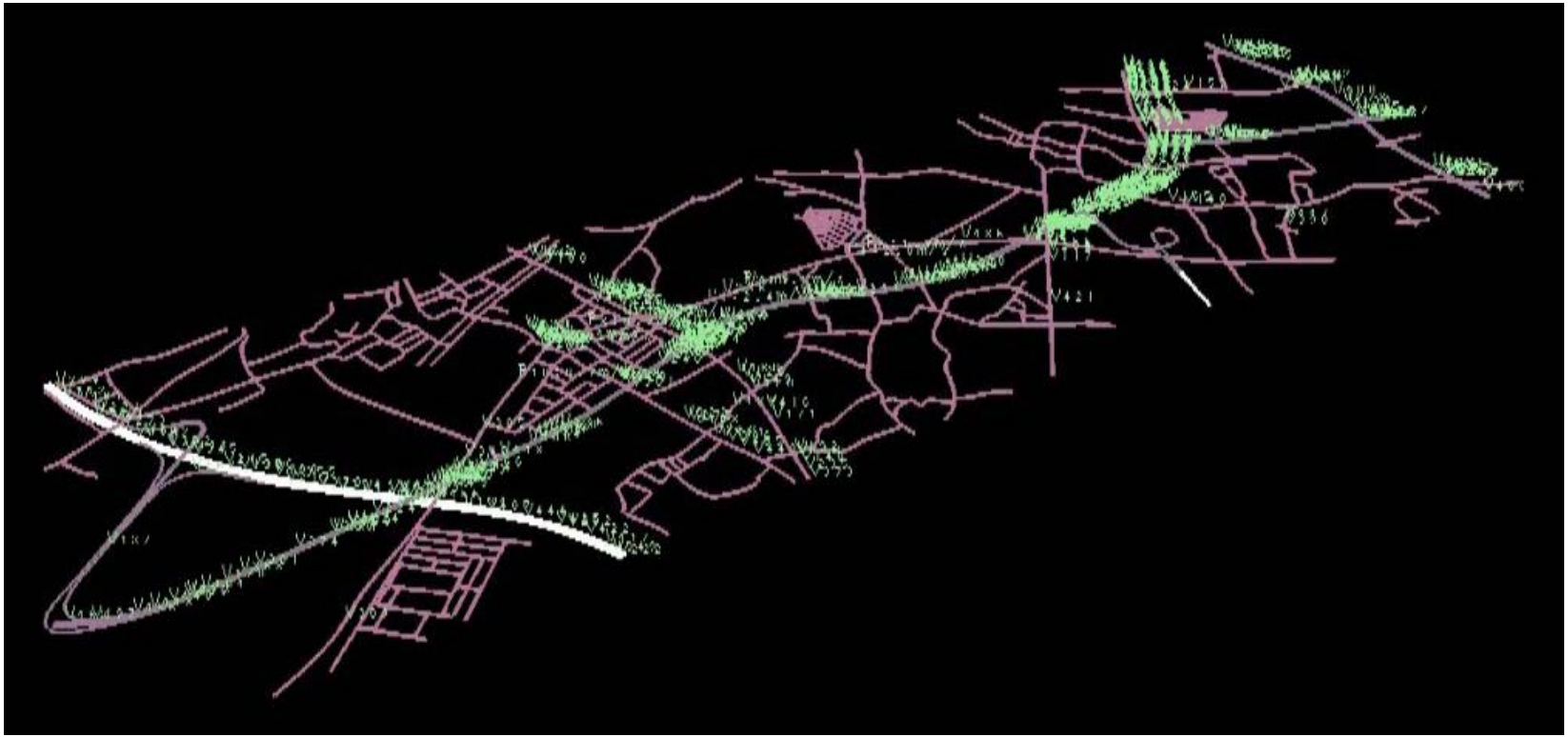
(4)Arousal level

Pedestrian behavior model

- Development of pedestrian behavior model of crossing a road
- Reflection of influence of age/sex based on fixed-point observation and examination



Simulation results



Area：6km×3km, 500 Agents including Vehicles and Pedestrians

Occurrence of typical traffic accidents

◆**Traffic accidents caused by driver error (Single, Vehicle to Vehicle, Vehicle to Pedestrian)**

HAD penetration rate in the simulation

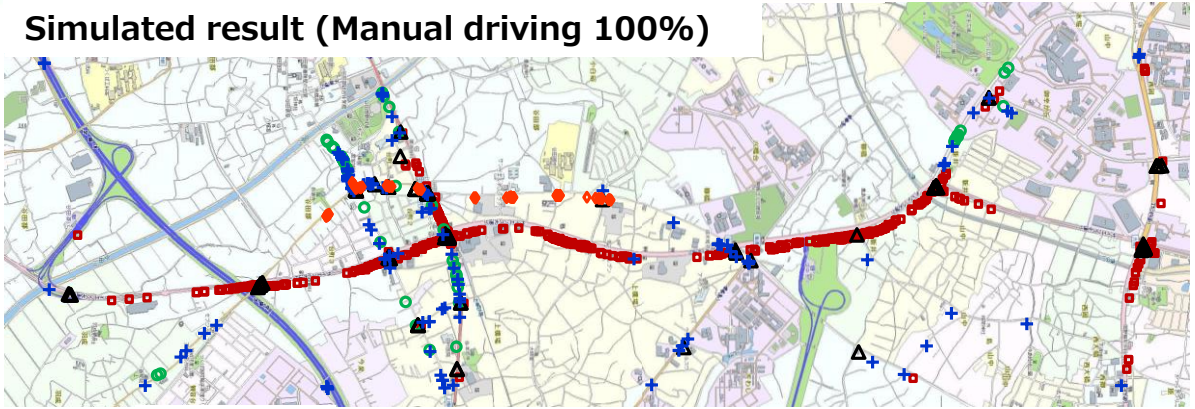
- **Manual driving, ADAS and HAD are considered**
  AEB, LDW (SAE Lv.1~2), Automated Driving (SAE Lv.3~5)

Simulation Condition		1	2	3	4	5
Manual driving		100%	50 %	25 %	25 %	
ADAS, HAD	AEB		50 %	25 %		
	AEB+LDW			50 %	50 %	25 %
	Automated Driving				25 %	75 %

AEB:Autonomous Emergency Braking
LDW:Lane Departure Warning

Simulated results in macro area

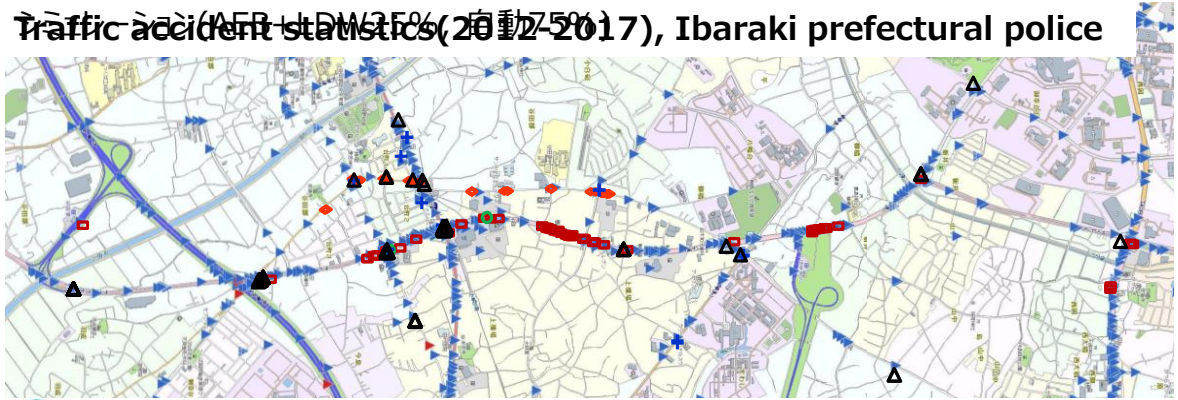
Simulated result (Manual driving 100%)



Rear-end collision
Intersection collision
Lane departure
Head-on collision
Crossing pedestrian

シミュレーション(AEB+LDW35%(自動ブレーキ75%))

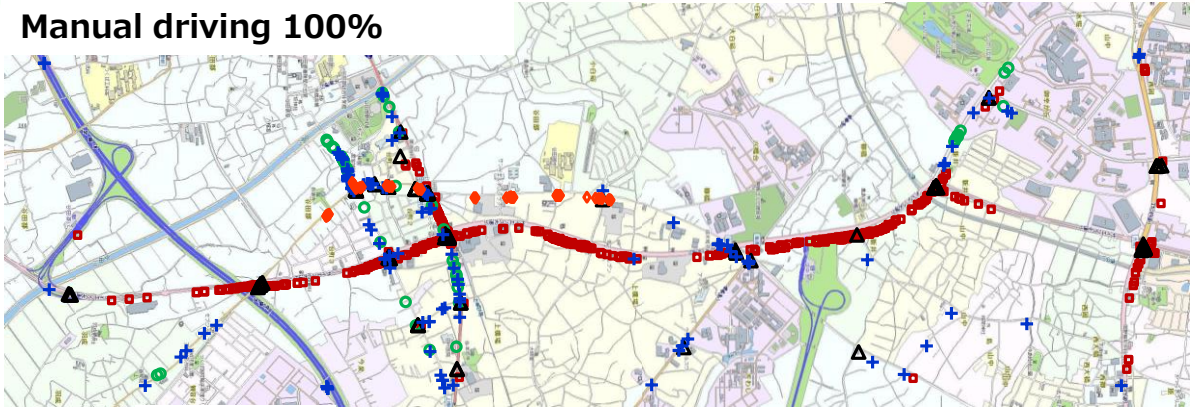
Traffic accident statistics(2012-2017), Ibaraki prefectural police



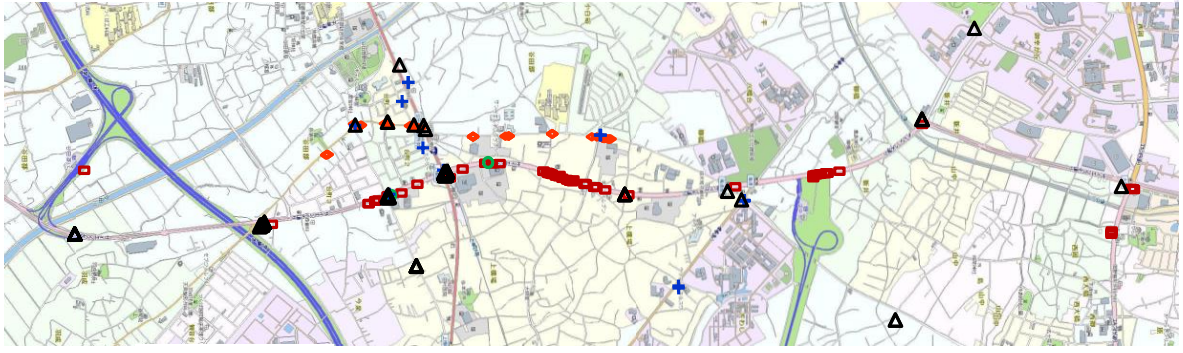
Injury accident
Fatal accident

Simulated results in macro area

Manual driving 100%



AEB&LDW 25%, Automated Driving 75%

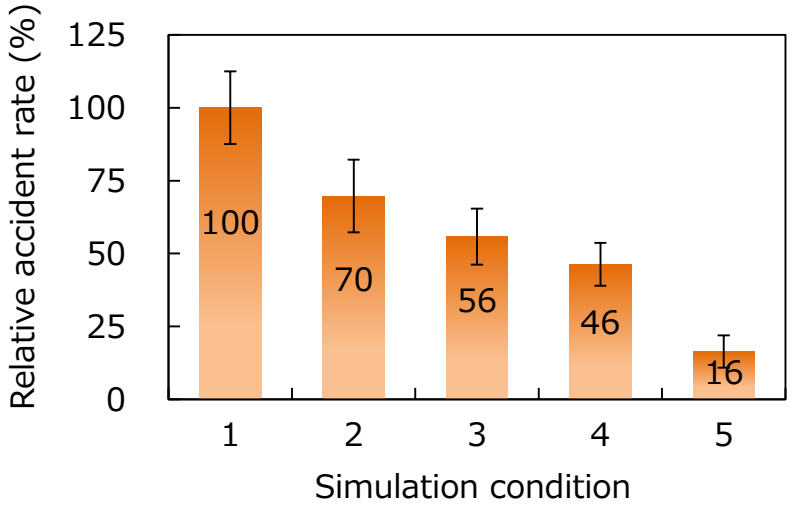


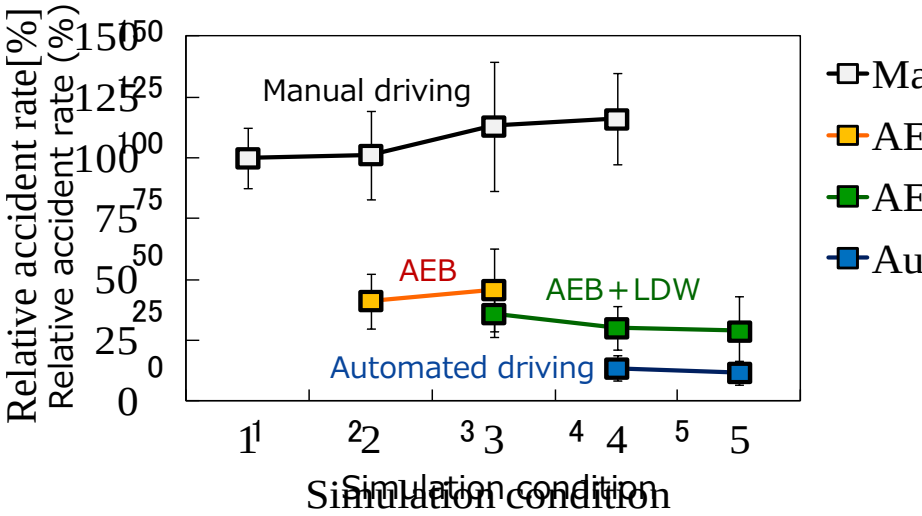
- Rear-end collision
- Intersection collision
- Lane departure
- Head-on collision
- Crossing pedestrian

AEB: Autonomous Emergency Braking
LDW: Lane Departure Warning

Different automated driving technology penetration scenarios can be set to estimate the potential impact of different technologies on safety.

Simulated results





Simulation condition
1: Manual driving (MD)100%
2: MD50%, AEB50%
3: MD25%, AEB25%, AEB+LDW50%
4: MD25%, AEB+LDW50%, Automated driving (AD) 25%
5: AEB+LDW25%, AD75%

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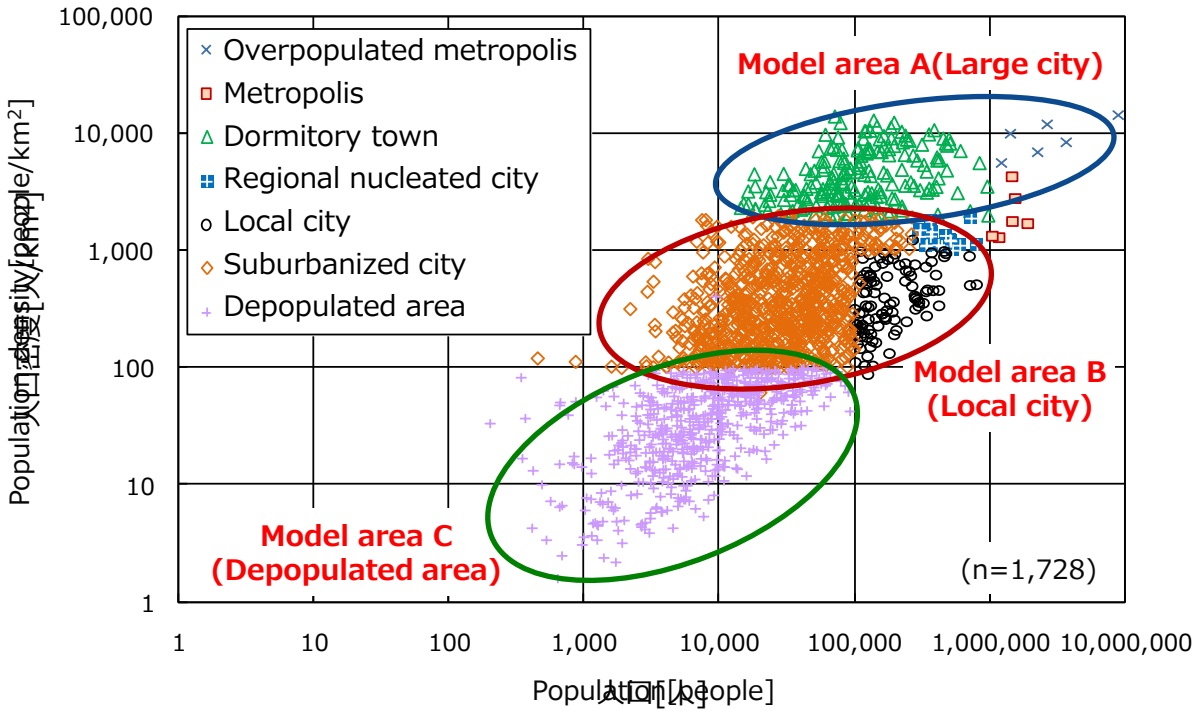
- Results should be treated considering the assumptions adopted in the calculations

Model areas for nationwide estimation

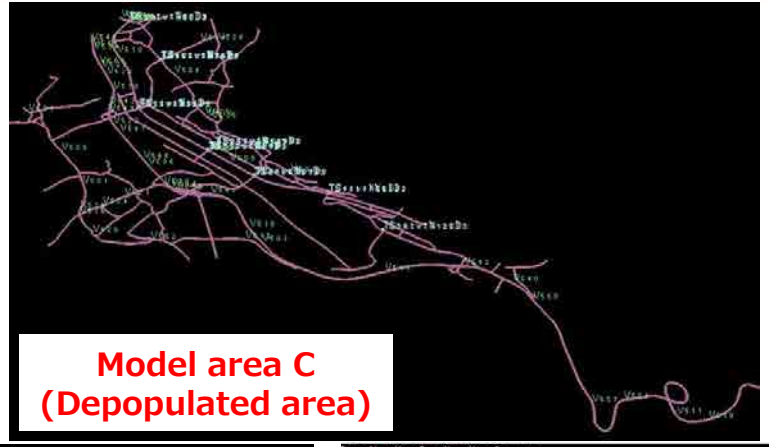
Classification of municipalities based on characteristics of population

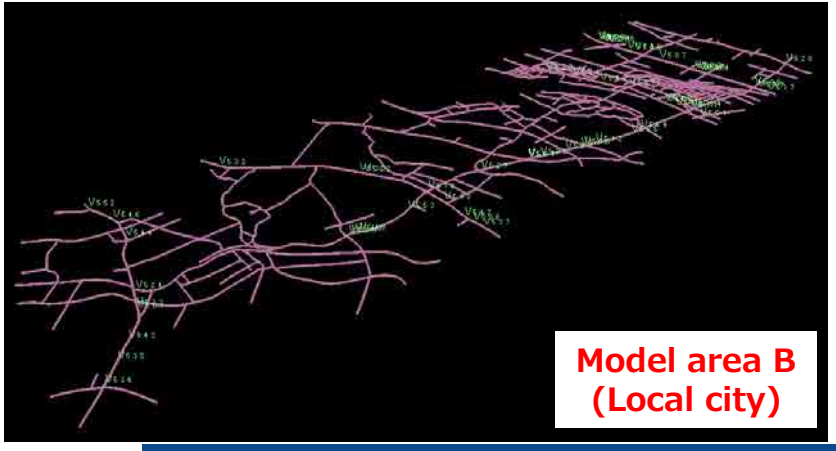
-Population:100,000,300,000,500,000, etc.

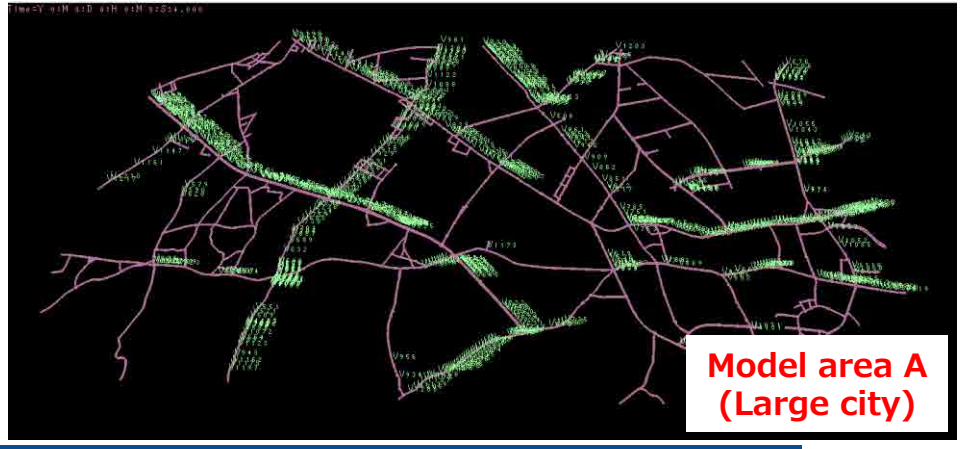
-Population density:100, 1,000, 3,000, etc.



Simulation execution of each area

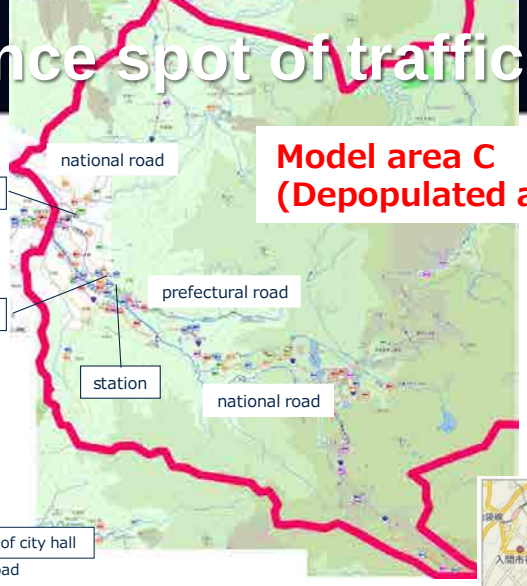




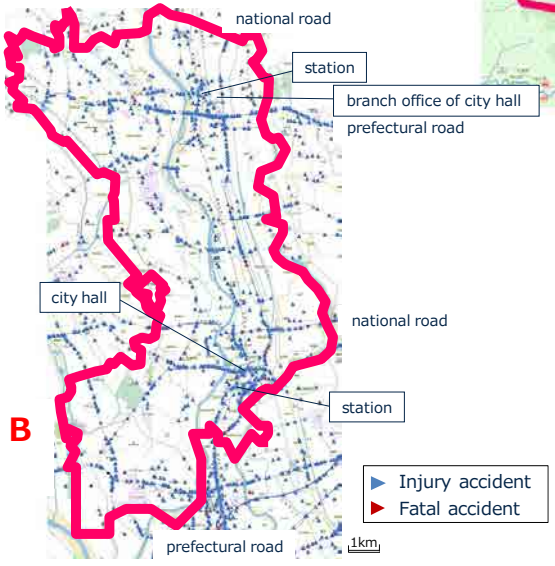


National safety impact will be estimated by expanding results of each model city

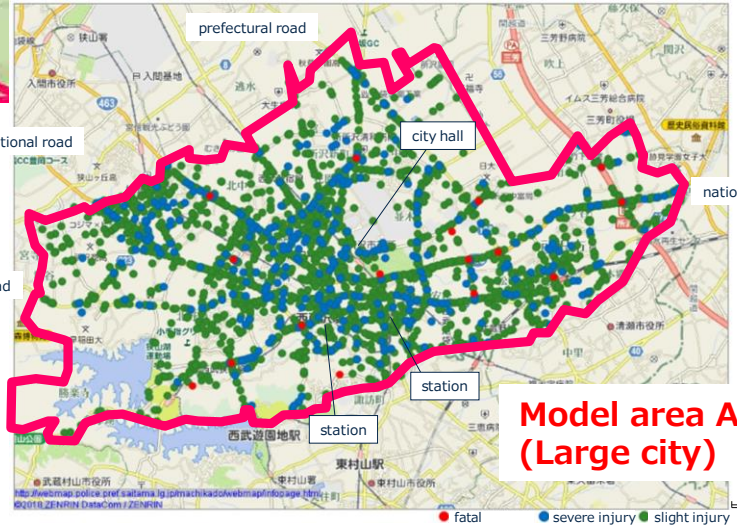
Occurrence spot of traffic accidents



Model area C (Depopulated area)



Model area B (Local city)



Model area A (Large city)

National safety impact will be estimated by expanding results of each model city

Summary

- **Novel multi-agent traffic simulation software developed and applied to a 6 x 3 km area in Tsukuba city. Over a simulated period of time including more than 500 agents (vehicles, drivers and pedestrian), the software can simulate and identify at least five types of accidents.**

- **Different automated driving technology penetration scenarios can be set to estimate the potential impact of different technologies on safety.**

- **Ongoing work:**
  - **Verification of the reliability of the simulations by comparing the accident patterns predicted by the software and those occurring in the real world**
  - **Expansion of the software's applicability to other regions in Japan for national impact safety estimations**

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Workshop
2018
Thank you