“Development of V2V, V2I Communication Technology Toward the Automated Driving systems”

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— Responsible Organizations of the SIP MIC Theme 1. —

[DENSO CORPORATION, Panasonic Corporation, PIONEER CORPORATION, The University of Electro-Communications]

This study is the result of the works supported by Ministry of Internal Affairs and Communications (MIC)

1. Activity in the SIP
   V2X for Automated Driving Systems

   V2X : Vehicle to Vehicle
   Vehicle to Infrastructure
   Vehicle to Pedestrian

2. Proof of concept, the application of V2V, V2I to the merging traffic on the freeway.

3. Advantages of the V2V, V2I at the encounter with an ambulance on the intersection.

Activity in the SIP

V2X for Automated Driving Systems

Activity in the SIP (V2X for Automated Driving Systems)

Object of the Project

- Application of the predictive information using V2X for Automated Driving Systems

Implementation

Cabinet Office
(Program Director)

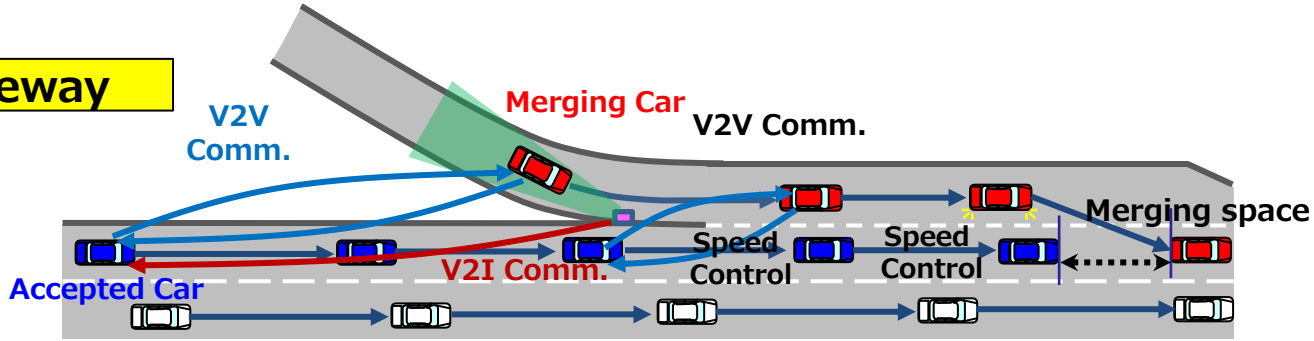
Promotion Committee

- Ministry of Internal Affairs and Communications (MIC)
  - Theme I : V2V. V2I communication toward AD.
    - DENSO
    - Panasonic
    - PIONEER
    - The University of Electro-Communications
  - Theme II
  - Theme III
- National Police Agency
- MLIT
- METI

Project Outline

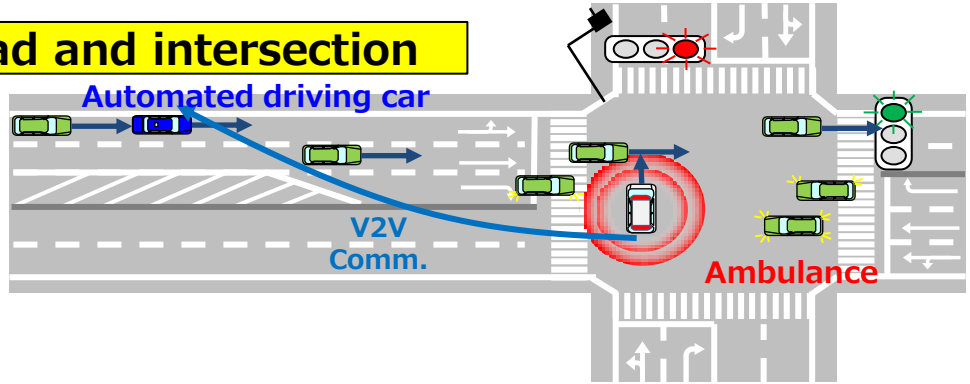
Practical images of the cooperative automated driving system

On the Freeway



The scene of the merging traffic on the freeway

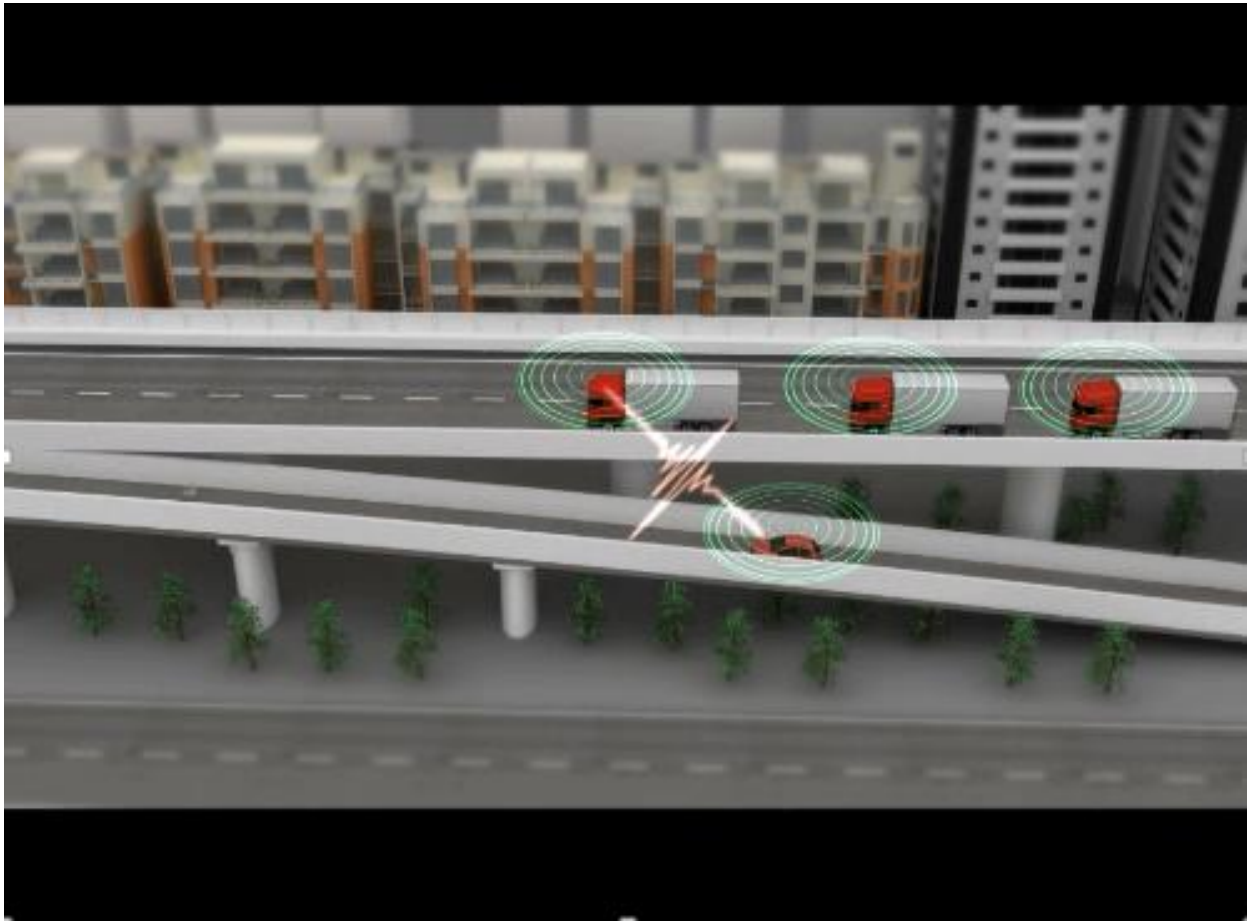
On the Public road and intersection



The scene of the meeting an ambulance on the intersection

Proof of concept, the application of V2V, V2I to the merging traffic on the freeway.

Merging traffic of ideal automated driving systems



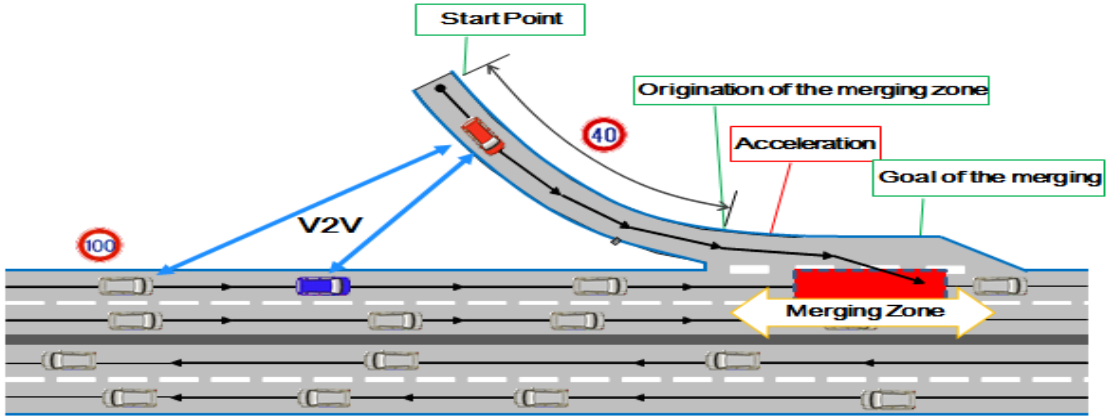
The merging traffic model-1 on the freeway

The case of V2V information usage

Based on the merging vehicle information got from the V2V and self information

【Lane vehicle】
The lane vehicle makes the merging room with the smooth acceleration and deceleration as necessary.

【Merging vehicle】
Merging vehicle takes care of the only acceleration timing.



✓ Thanks for the pre-agreement, safety seems to be achieved.

✓ V2V penetration is the given fact.

The merging traffic model-2 on the freeway

The case of V2I information usage

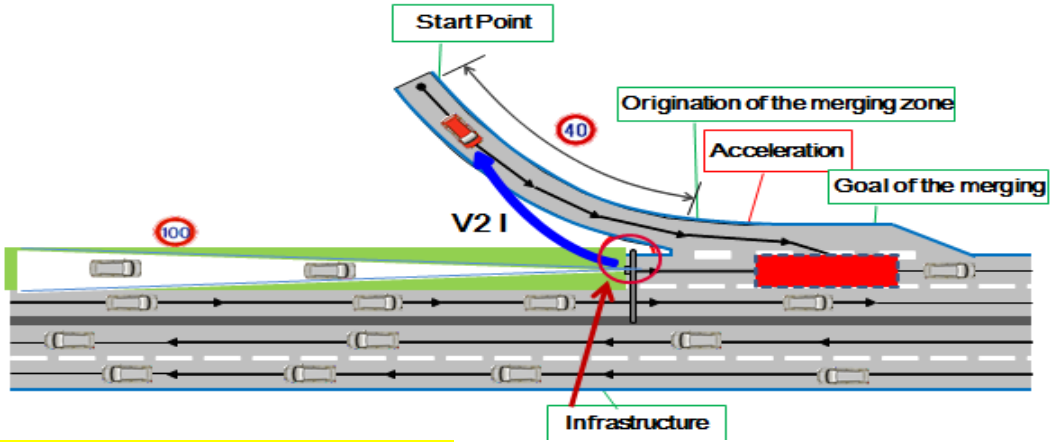
Based on the lane cruising information got from the V2I and self information

【Lane vehicle】

Specific action is not requested.

【Merging vehicle】

The merging vehicle makes the merging plan and accelerates at the moderate timing.

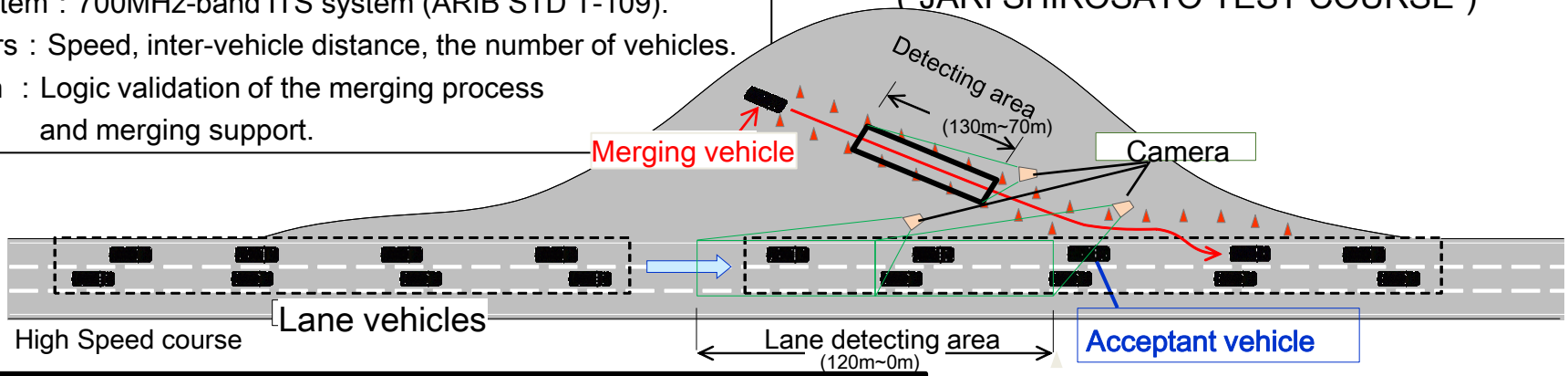


- ✓ Expectant effectiveness even in the low penetration
- ✓ Due to the non-guaranteed merging, there exists the failing risk of the merging

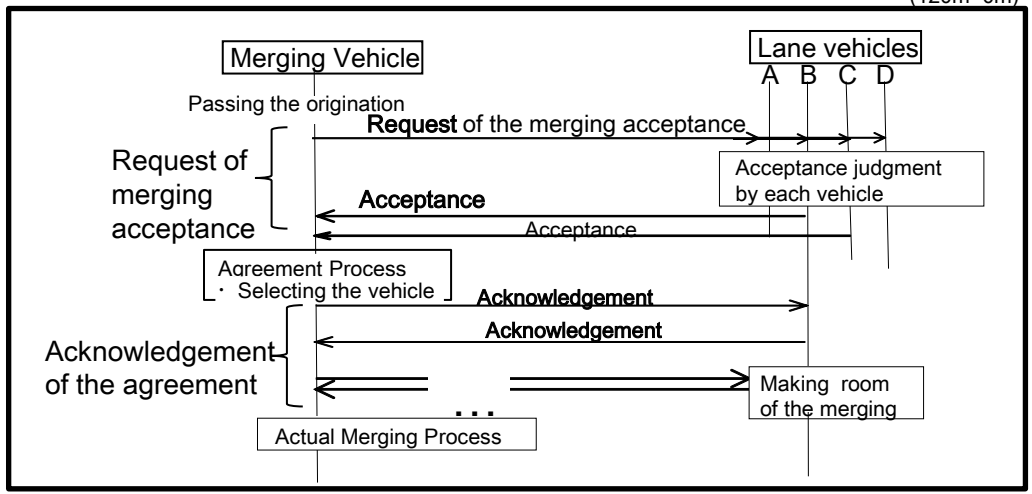
Experimental field test (V2V application)

Radio System：700MHz-band ITS system (ARIB STD T-109).
Parameters：Speed, inter-vehicle distance, the number of vehicles.
Evaluation ：Logic validation of the merging process
and merging support.

(JARI SHIROSATO TEST COURSE)



The origination of the merging zone

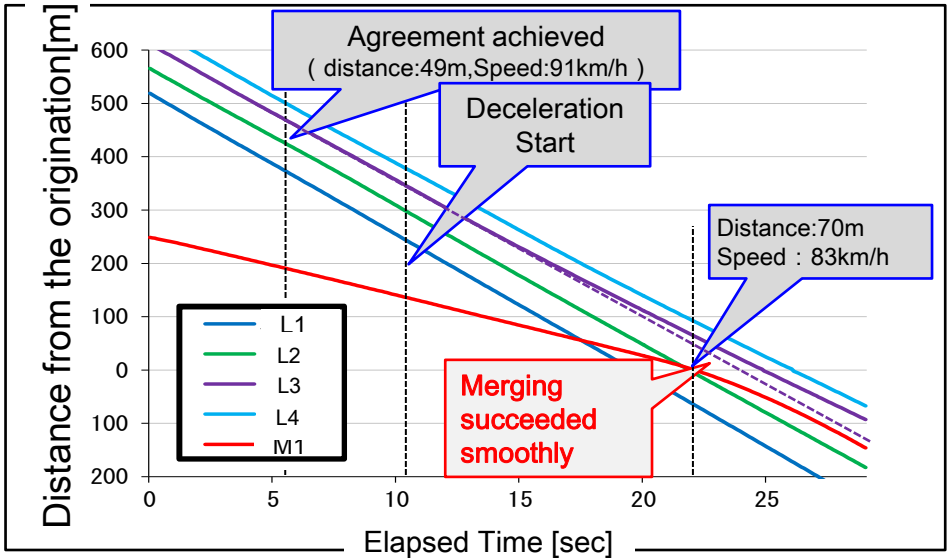


Example :
Sequence of the V2V agreement

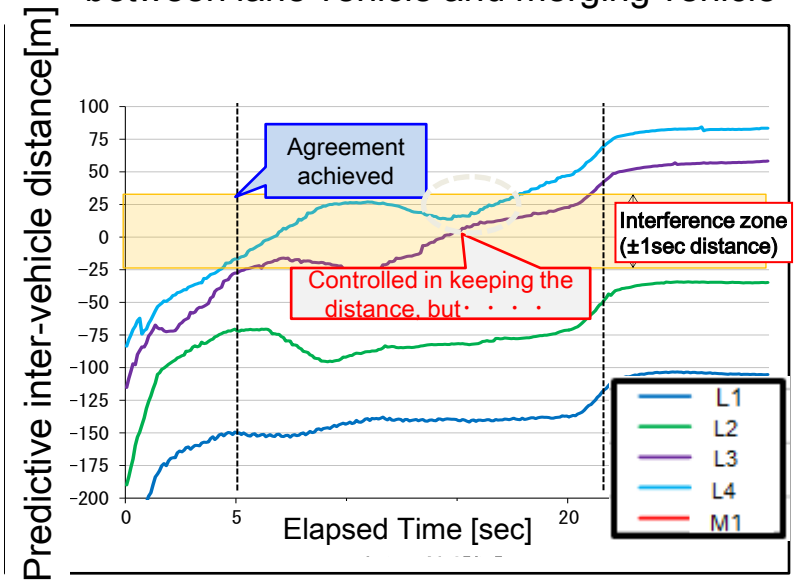
Result of the merging process by the V2V

【Experimental Condition】
Main Lane：Regular Speed = 100km/h、The number of the vehicle = 4（from the top,L1,L2,L3,L4）
Merging road：Speed = 40km/h、 The number of the vehicle = 1（M1）

Each vehicle's distance from the origination of the merging zone



Predictive inter-vehicle distance between lane vehicle and merging vehicle



Actual scene of the merging traffic on the test course

Summary - 1

V2V is effective for the merging traffic support.

On the other hand, as for the agreement,

we should take care of the all surrounding vehicles

unless the side effect develops.

Advantages of the V2V, V2I at the encounter with an ambulance on the intersection.

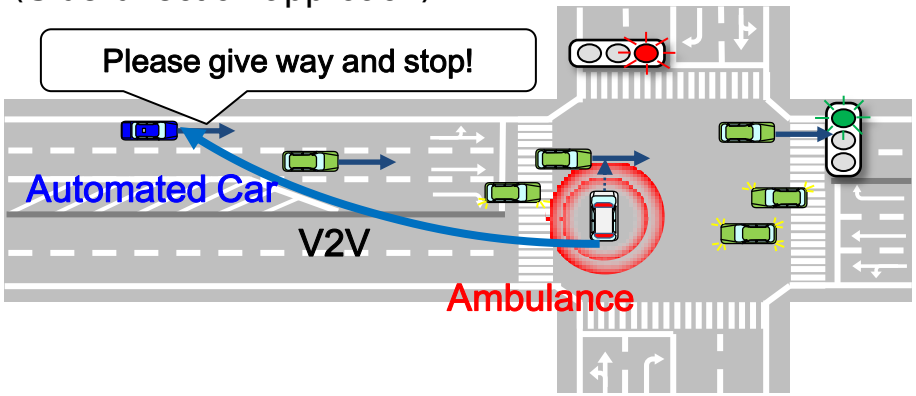
To prove the advantages of V2V, V2I

On the automated driving car encountering an ambulance

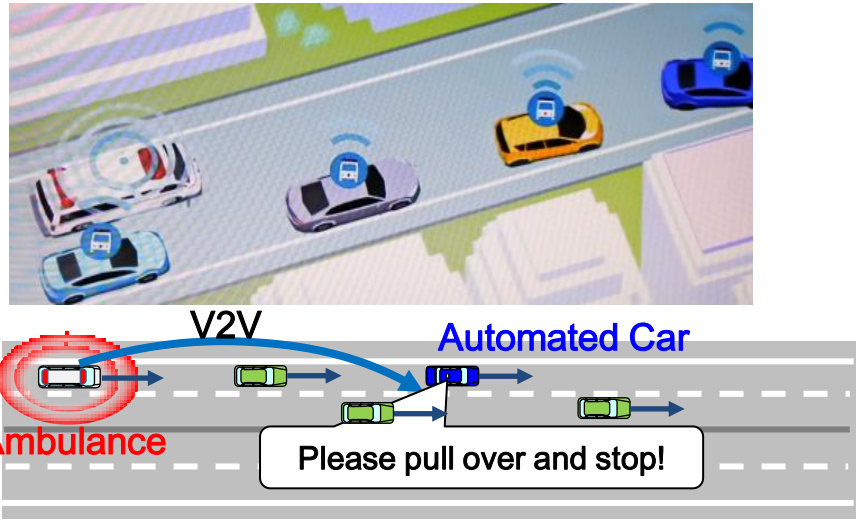
- Use-Case Study
- Comparison with other media (Siren sound, Red lamp)

< Ambulance approach >

〈Side-direction approach〉



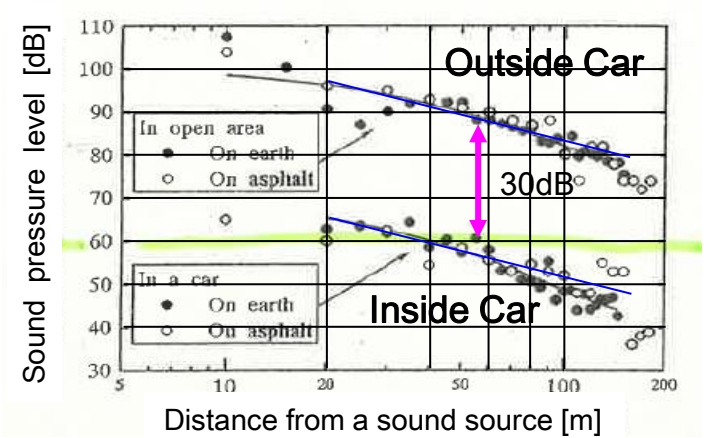
〈Backward approach〉



Are V2V, V2I technology really necessary for automated driving systems ?

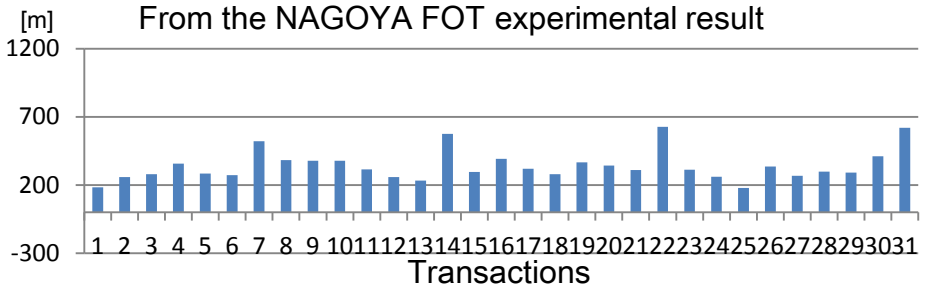
Detection by Siren sound, Red lamp and V2V

◆Detection by the Siren sound



Detective distance depends on the micro-phone equipped place.

◆Detection by V2V Communication



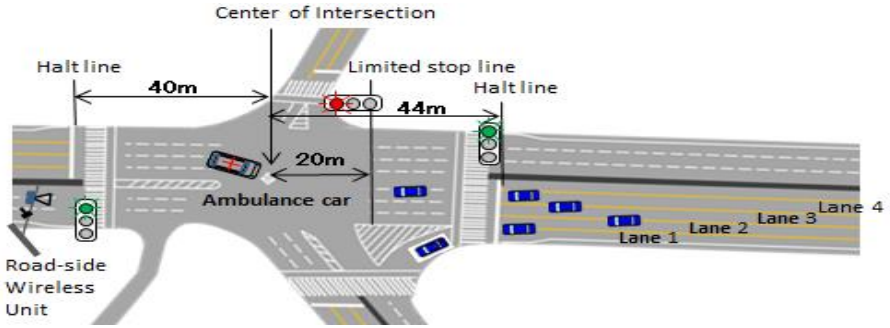
Detective distance is estimated more than 200 m.

◆Detection by the Red lamp (From the Camera Images)

As for visible recognition, light is vulnerable to the surroundings.
The red lamp could be limited to use as the complementally usage of the Siren sound.

Deceleration and stop model of automated driving car

The scene of the ambulance entering



Intersection Structure of Motoyama, Nagoya-City

[Step 1]

Collecting data of the surrounding cars by using the V2V, V2I at the ambulance entering to the intersection.

[Step 2]

Using the above data, developing the expression of mathematical model of the deceleration in order to use the simulation.

$$\frac{dv}{dt} = -a\left(\frac{s^*(v,\Delta v)}{s}\right)^{2\beta} \quad \cdots\cdots (1)$$

$$s^*(v,\Delta v) = vT + \frac{v\Delta v}{2\sqrt{ab}} \quad \cdots\cdots (2)$$

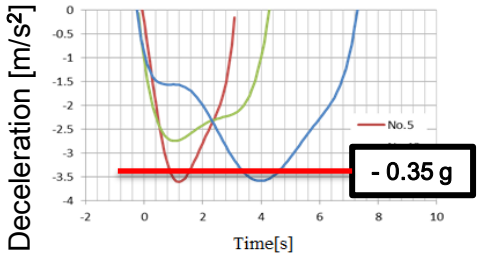
$\Delta v = v$: velocity

s^*: distance to the stop line

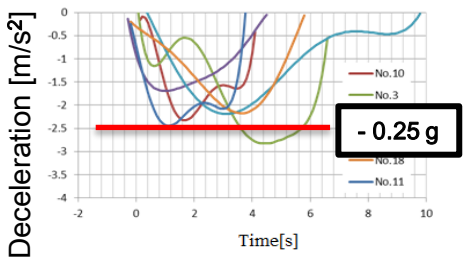
a : acceleration rate

b : deceleration rate

β : deceleration index



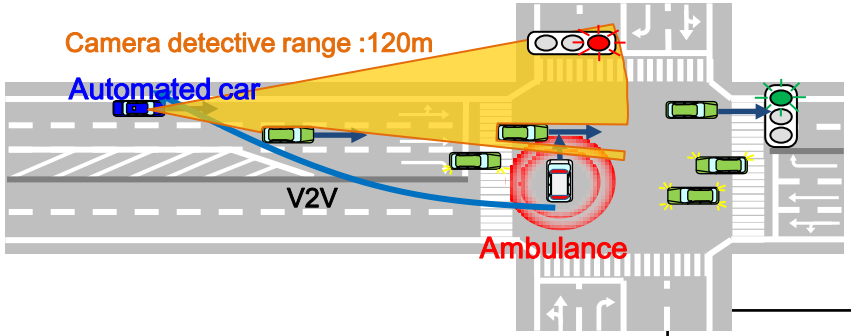
Rough stop



Smooth stop

The comparison of the giving way performance between the sensor used autonomous car and the automated driving using V2V

■ Simulation of "The success rate of the giving way"



To compare the success rate of the giving way with or without V2V.

Autonomous driving car with Camera, Microphone

Lane number	w/wo V2V	Rough stop Success rate	Smooth stop Success rate (Max deceleration less than 0.25g)
2 lane × 2 lane	Without	98%	75%
	With	100%	100%
3 lane × 3 lane	Without	92%	62%
	With	100%	100%
4 lane × 4 lane	Without	83%	54%
	With	100%	97%

Traffic condition : 20 cars/min/lane

V2V is very effective for the automated driving on the intersection of public road.

Summary-2

V2V, V2I is the very effective and valuable means

for the automated driving system.

Especially, non-automated car and emergency vehicle

are supposed to be co-existed situation with automated car.

Co-operative automated driving system brings the early recognition,

and leads the social acceptance of the automated driving system.


Thank you
SIP-adus Workshop 2017
on Connected and Automated Driving Systems