

# Prediction of the connected vehicle toward the connected and automated vehicle

November, 15, 2016

Hideaki NANBA

DENSO CORPORATION

Responsible Organization of the SIP MIC Theme 1.

- DENSO CORPORATION
- Panasonic Corporation
- PIONEER CORPORATION
- The University of Electro-Communications

# Contents

1. Expectation to the Connected vehicle
2. What's required for the communication technology in the progress phase  
“Connected vehicle -> Connected and Automated vehicle “.

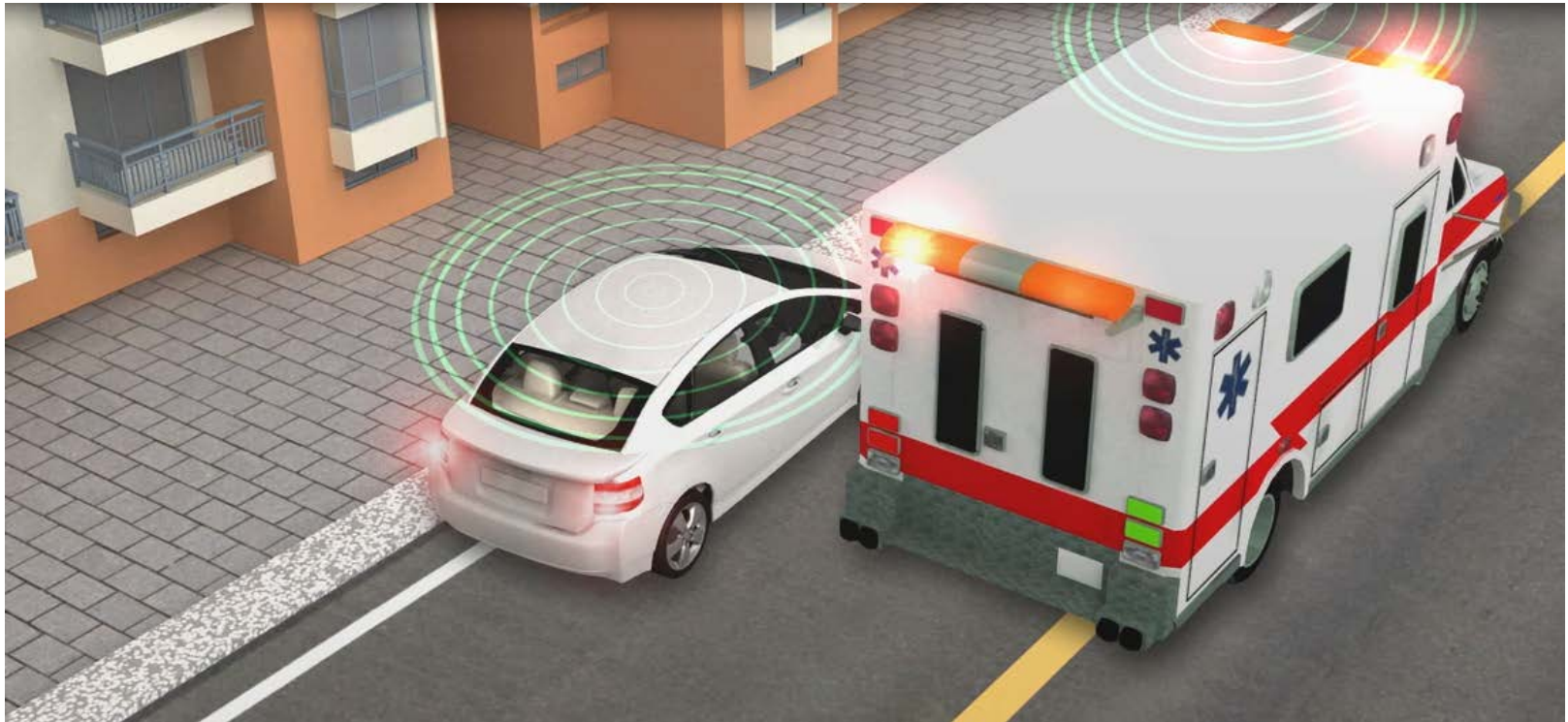
# Today's traffic scene on the main road

***DENSO***



# The Effect of ambulance car's priority driving

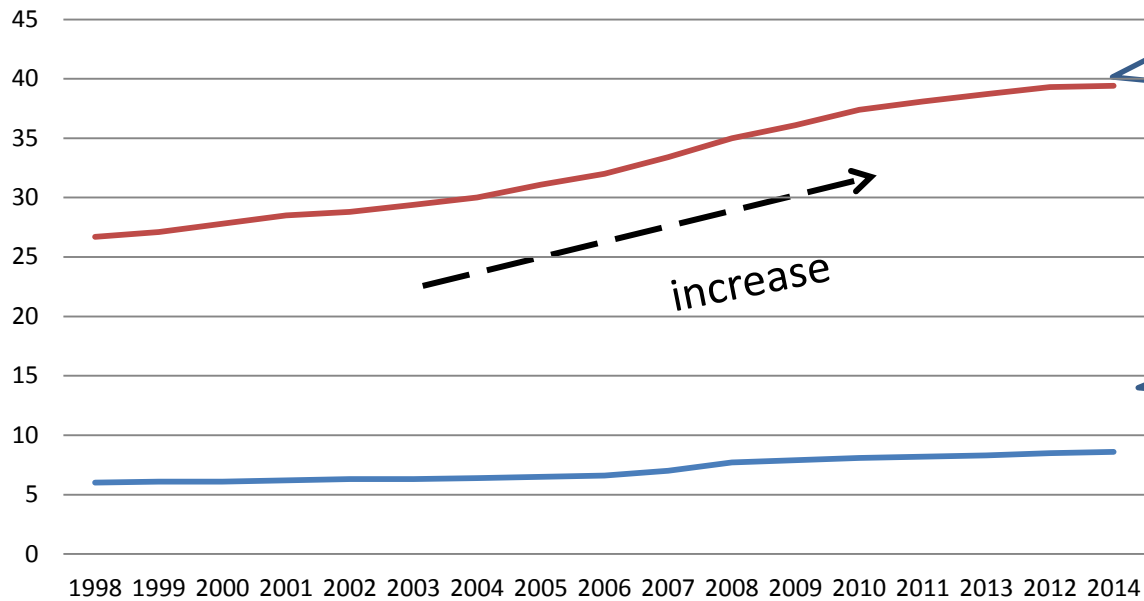
---



# Process of the ambulance car's travelling time year by year

## Time to destination

(MIN)

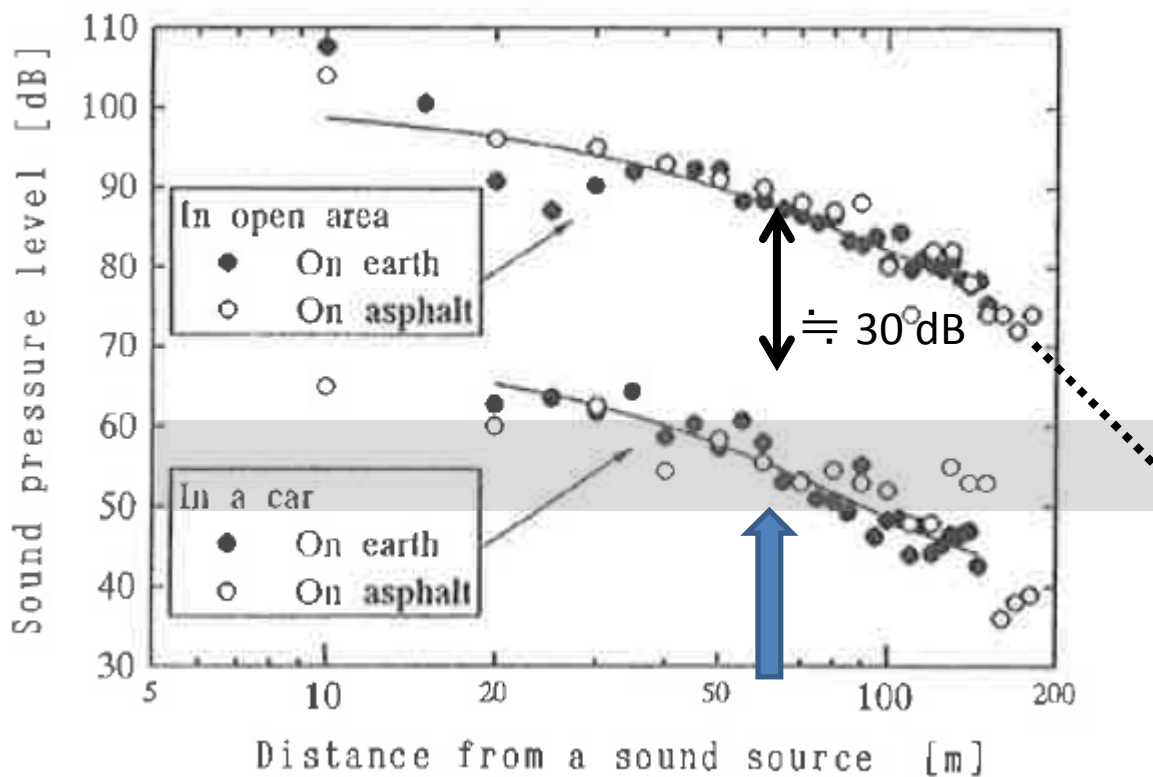


From Station  
to Client and  
to Hospital

From  
Station to  
Client

The ambulance car's travelling time is increasing year by year.

# 「Warning sound “Pi-, Po-, Pi-Po”, is it hearable ?」



From the former study ,

“The study of the warning sound notification of ambulance cars”

The Acoustical Society of Japan, no.52 (1996)

Hirohiko BABA  
(Kurume Institute of Technology)  
Masamichi EBATA  
(Kumamoto University)

Siren Specification: 770 Hz  $\leftrightarrow$  960 Hz

Measuring point (height) : 1.1 m

**The distance which the driver notifies the ambulance car is very short.**

# Applying the V2V communication to the early notification

---

## 【Question】

(1) Early notification is possible, comparison with Warning Sound ?

⇒ To compare the notified timing between the warning sound and communicated notification.

(2) Does the early notified driver take the early action to make the room for the ambulance car ?

⇒ To investigate the driver's model using the driving simulator.

(3) Is it possible to shorten the travelling time of the ambulance car ?

⇒ To look into the shortening possibility using the simulation results.

# To compare the notified timing between the warning sound & communicated notification.

## Experimental Location

The approaching ambulance car

Measuring car



## Experimental Results

Location	NAGOYA Medical Center (LOS)	
	Backward	Lateral ward
Communicated notification	554m	441m
Warning Sound notification	259m	137m

Notified point of the communicated notification is 200m ~ 300m long distance from the warning sound notification point.



# To establish the driver's model referred from the driver's data using the driving simulator.

---

75 examinee's data are gathered using the driving simulator.  
The driving simulator is equipped with V2V communication application.



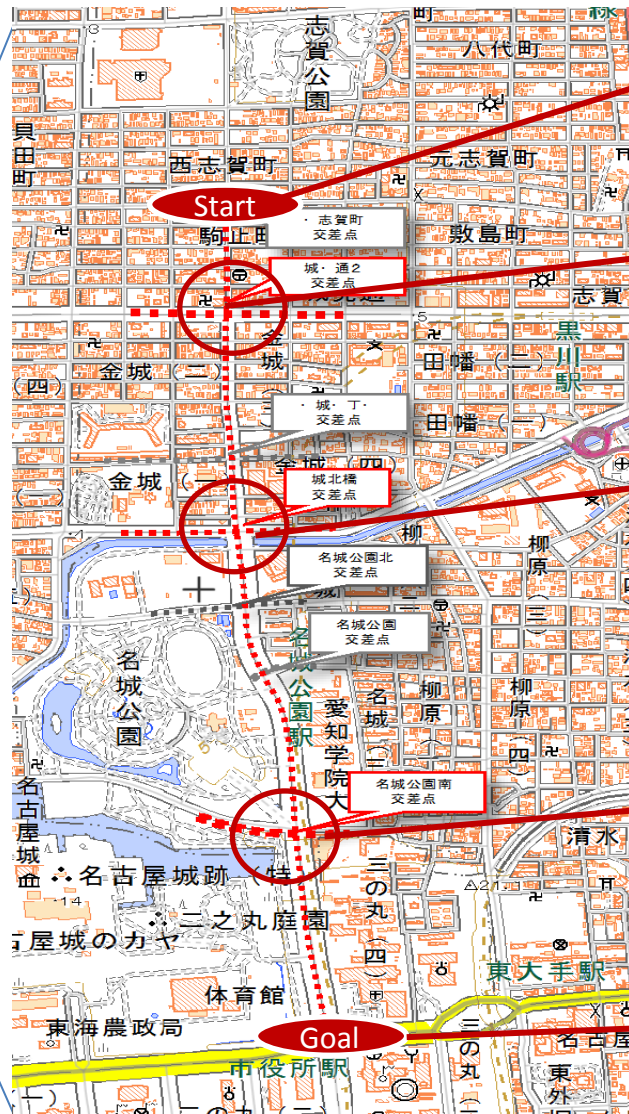
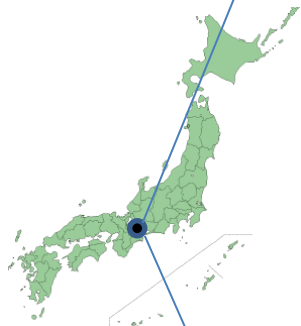
**Driving Simulator  
(UC-win/Road)**



**Outlook from the driving simulator  
and navigation screen**

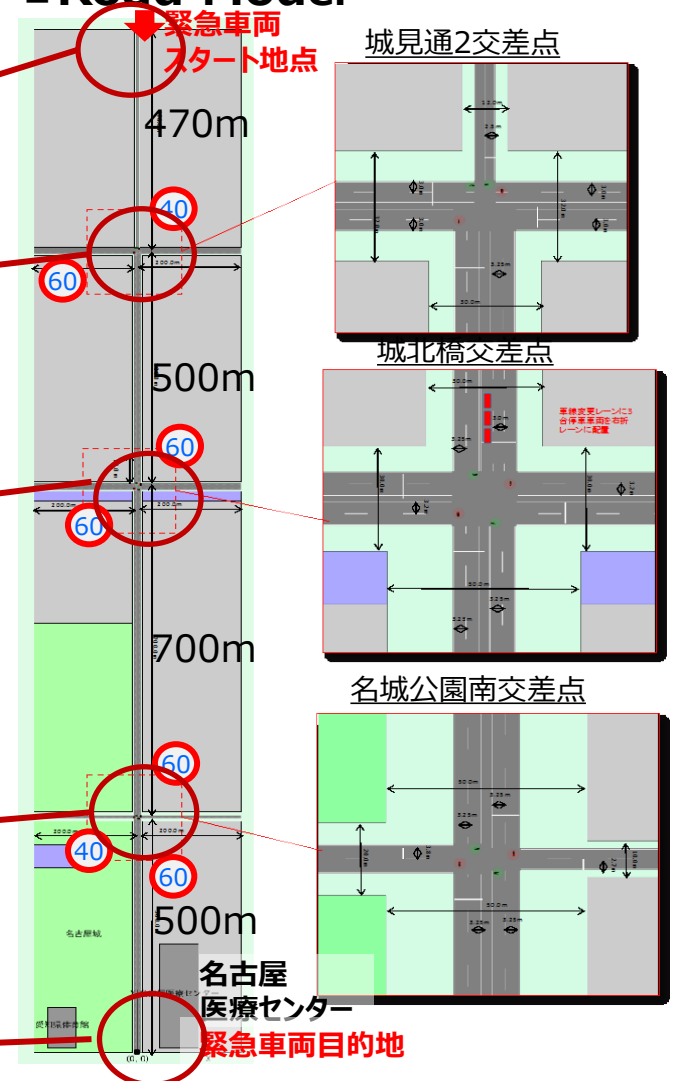
# To establish the road model for the simulation.

## Ohtsu Street in NAGOYA City



(Geospatial Information Authority of Japan)

## ■ Road Model



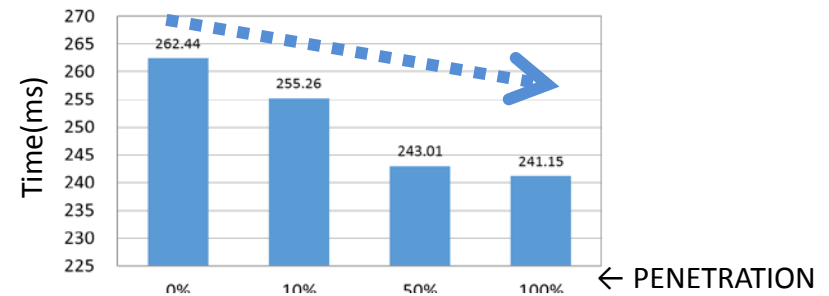
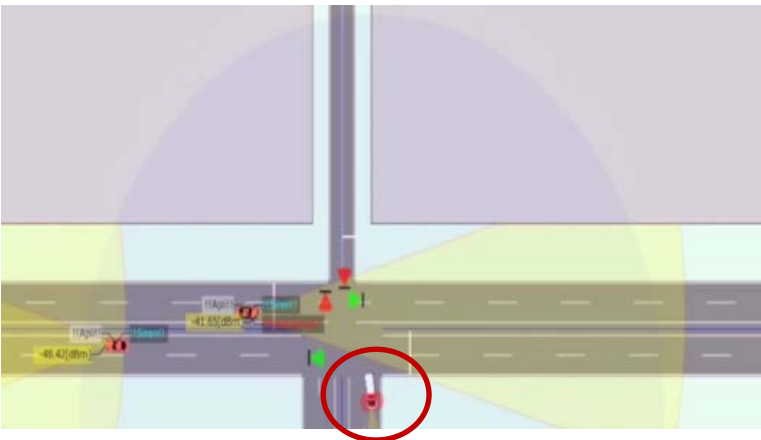
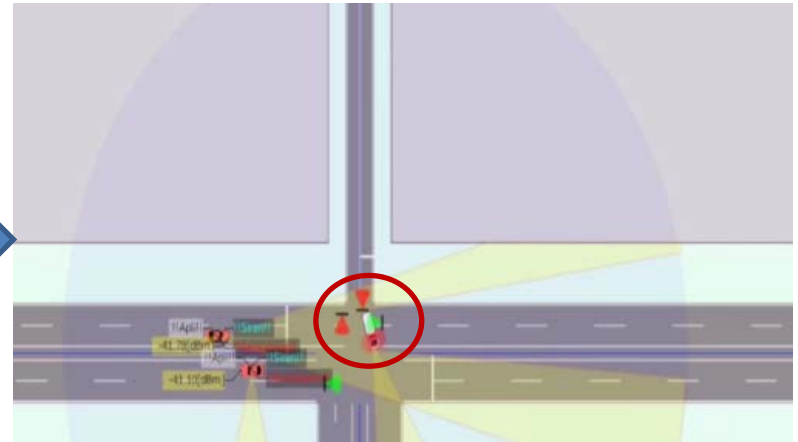
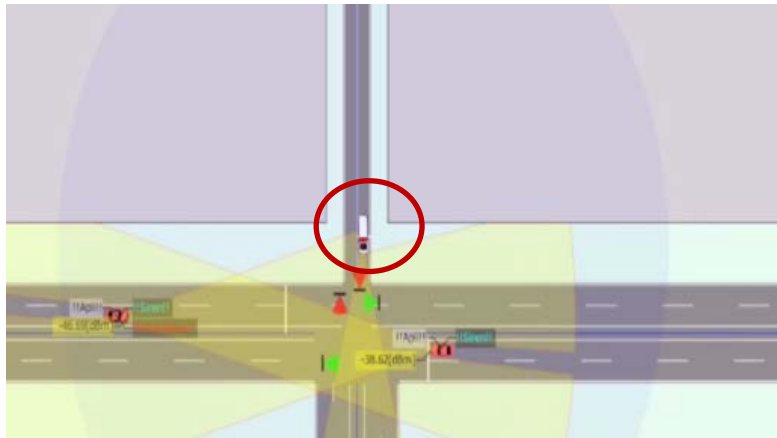
Simulation road model reflected from the real street

# To look into the shortening possibility using the simulation results.

## Conditions of the simulation

- the traffic signal interval change
- various vehicle allocations
- random vehicle appearance

■ Simulation result of the ambulance car's travelling time (Average time of 45 trials)



Simulation result shows the **possibility** of the travelling time shortened of the ambulance car, even in the specific condition.

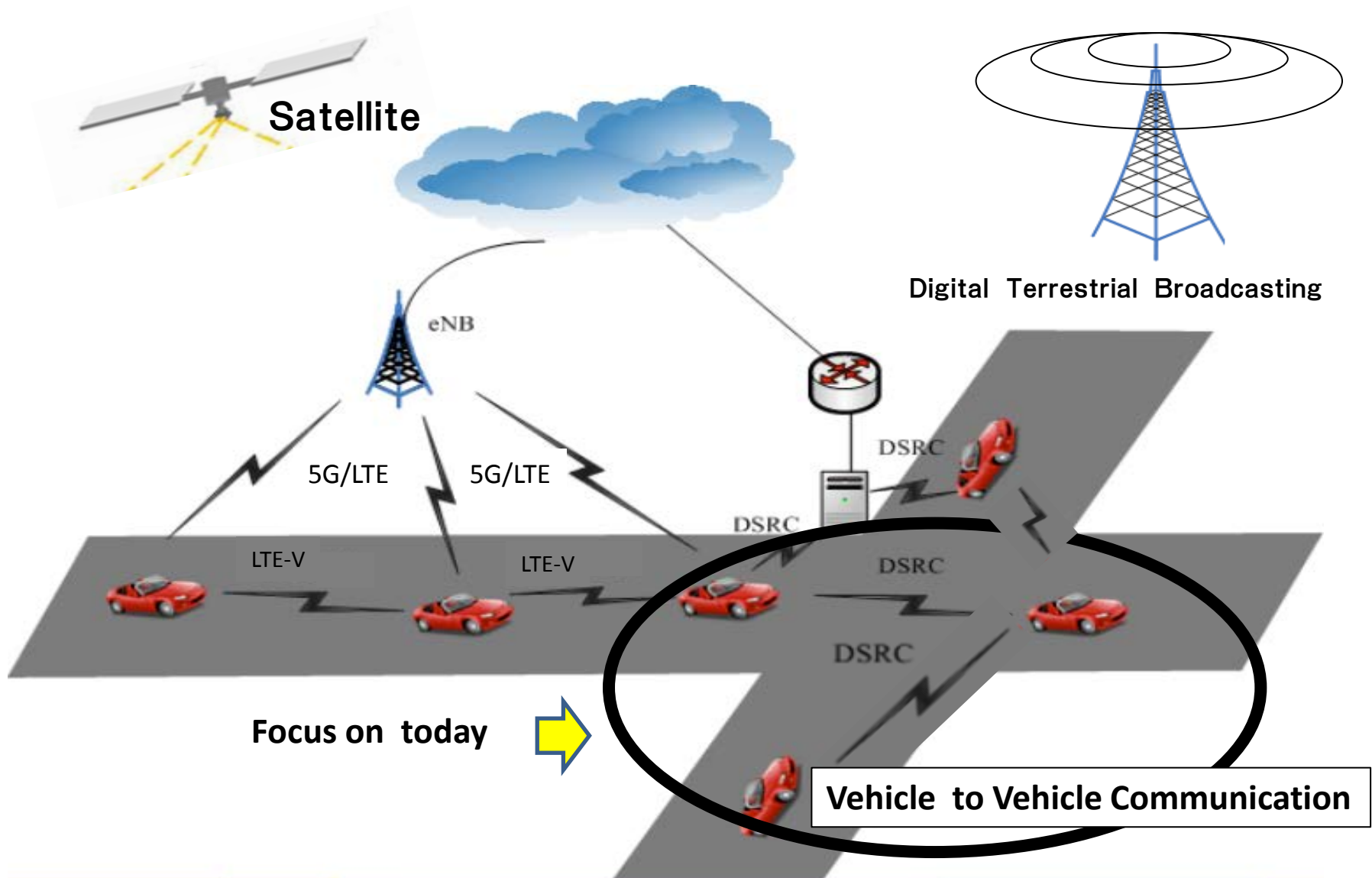
## Summary of “(1)Expectation to the Connected vehicle”

---

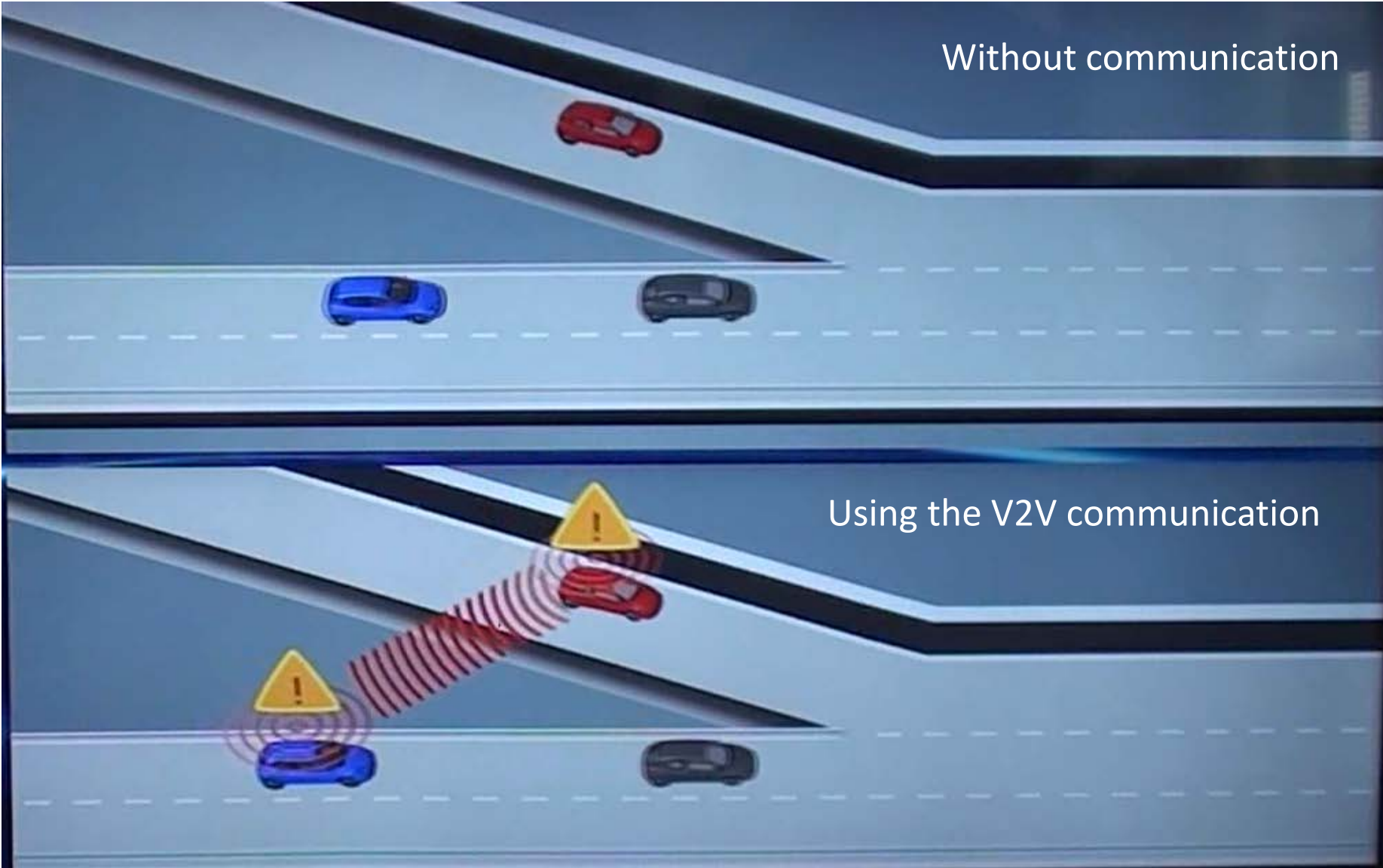
- ◆ The penetration of the connected vehicle brings in the desirable effect on the ambulance car driving.

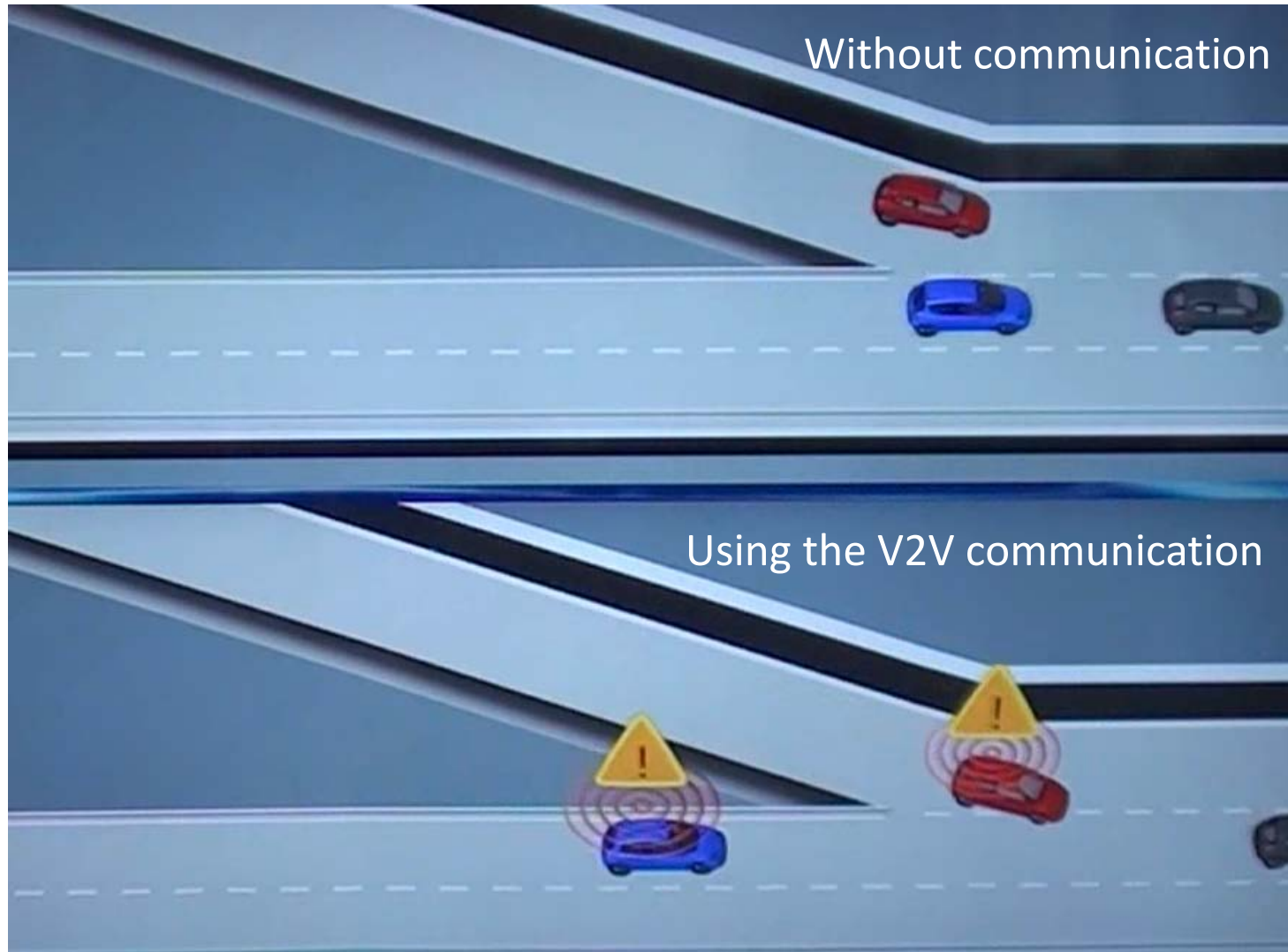
# Contents

1. Expectation to the Connected vehicle
2. What's required for the communication technology in the progress phase  
“Connected vehicle -> Connected and Automated vehicle “.



# Merging scene on the high way







# Experimental video on the real high-way

**DENSO**

--- *Merging vehicle dart in the lane smoothly* ---

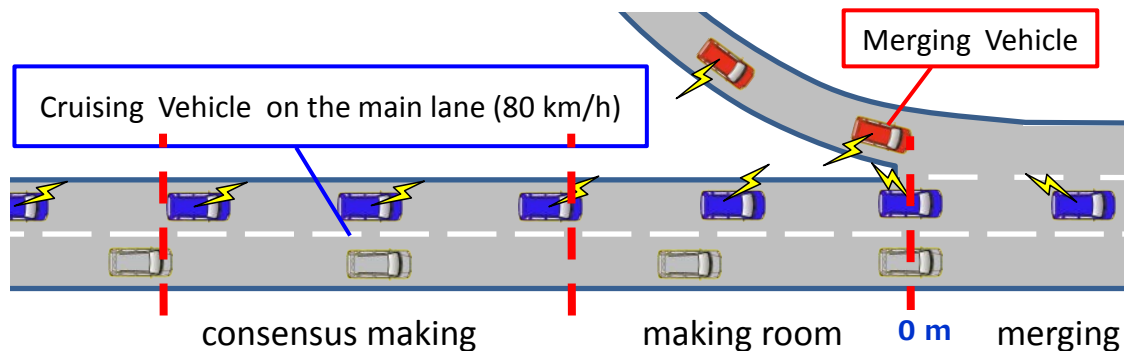


From the cruising vehicle on the main lane (80 km/h)

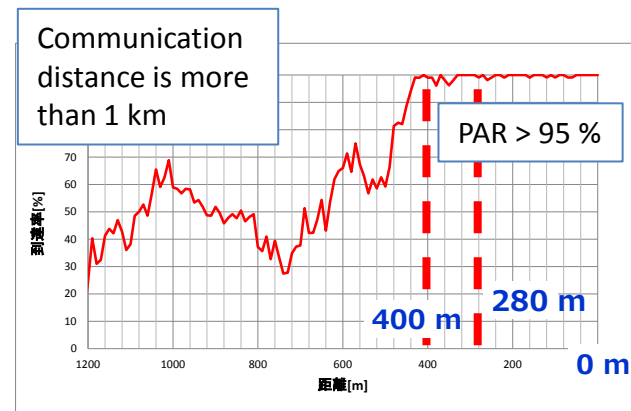
# Communication Performance in Merging Scene



【TOKAI KANJYOU EXPRESS WAY, TOYOTA KANPACHI IC】



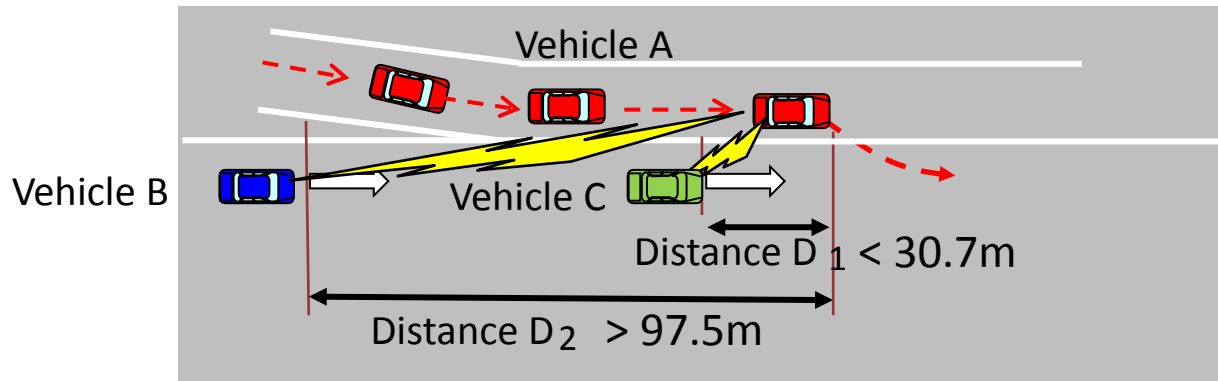
## Packet Arriving Rate in Merging Scene



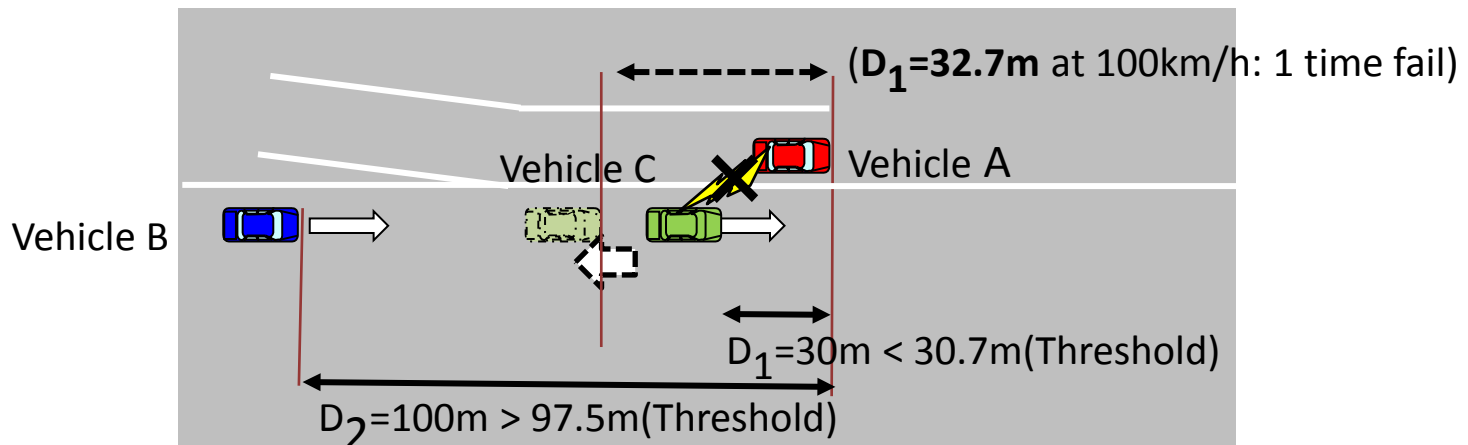
Averaged data in 24 trials

※Evaluate V2V performance at 280 meters and 400 meters ahead of the merging point

— **Vehicle A enters into between vehicle B and vehicle C** —

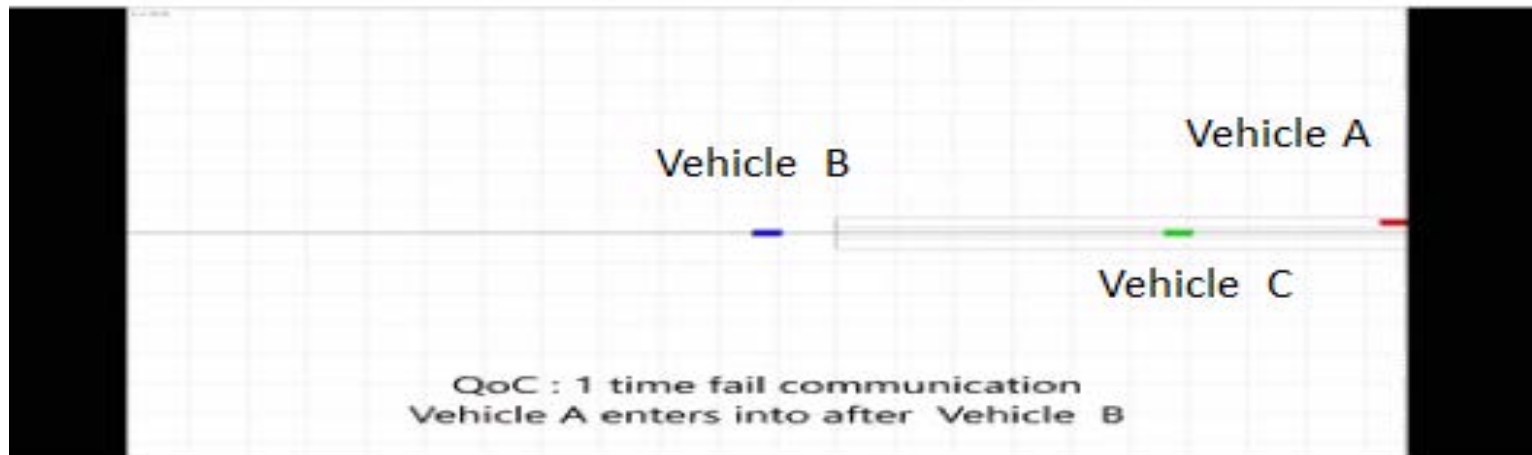
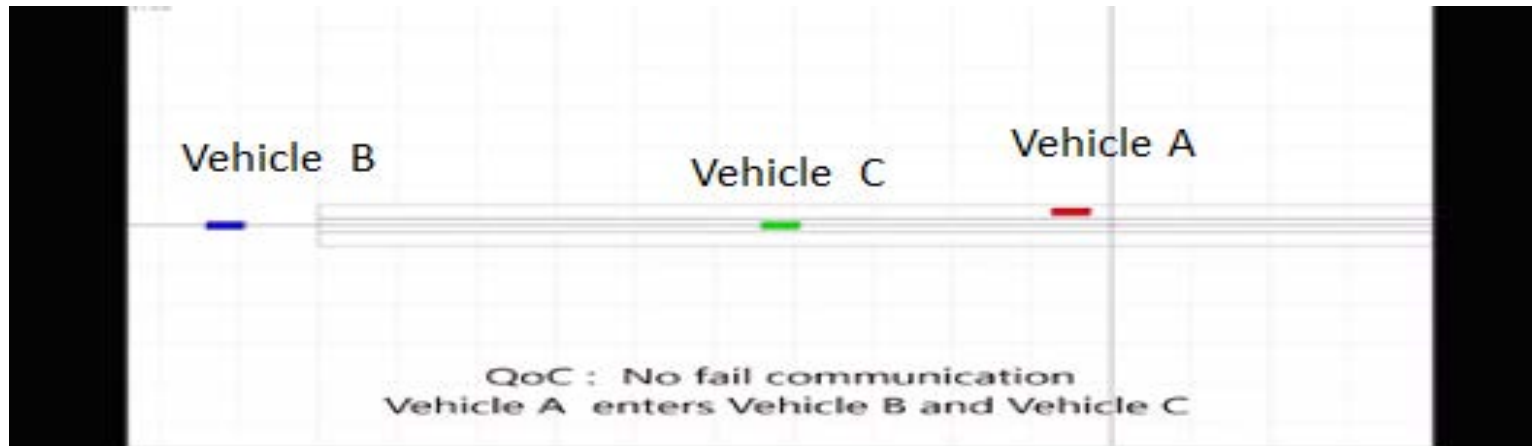


Communication-fail makes Vehicle A misunderstand the Distance  $D_1$  as longer distance.



## Simulation Rule

If  $\{D_2 > 97.5m \ \& \ D_1 < 30.7m\}$  then Vehicle A enters into between Vehicle B and Vehicle C,  
 else, then Vehicle A enters into after Vehicle B.



As for Vehicle Control Scheme, if using only communication, the connected and automated driving system faces on the dangerous scene even a few communicative deterioration.

## Summary of “(2) Requirement of Communication”

---

- ◆ For the smooth driving, Higher Communication Quality is needed for the connected and automated driving system.
- ◆ The communication technology (Connected vehicle) should be built on the autonomous driving system.

*The communication technology should be complementary used beyond the limitation of the sensor based autonomous driving system.*



***Thank you  
for your kind attention!***