Formulation of Communication Requirements for Wireless Communication for Automated Driving

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Object of the Project

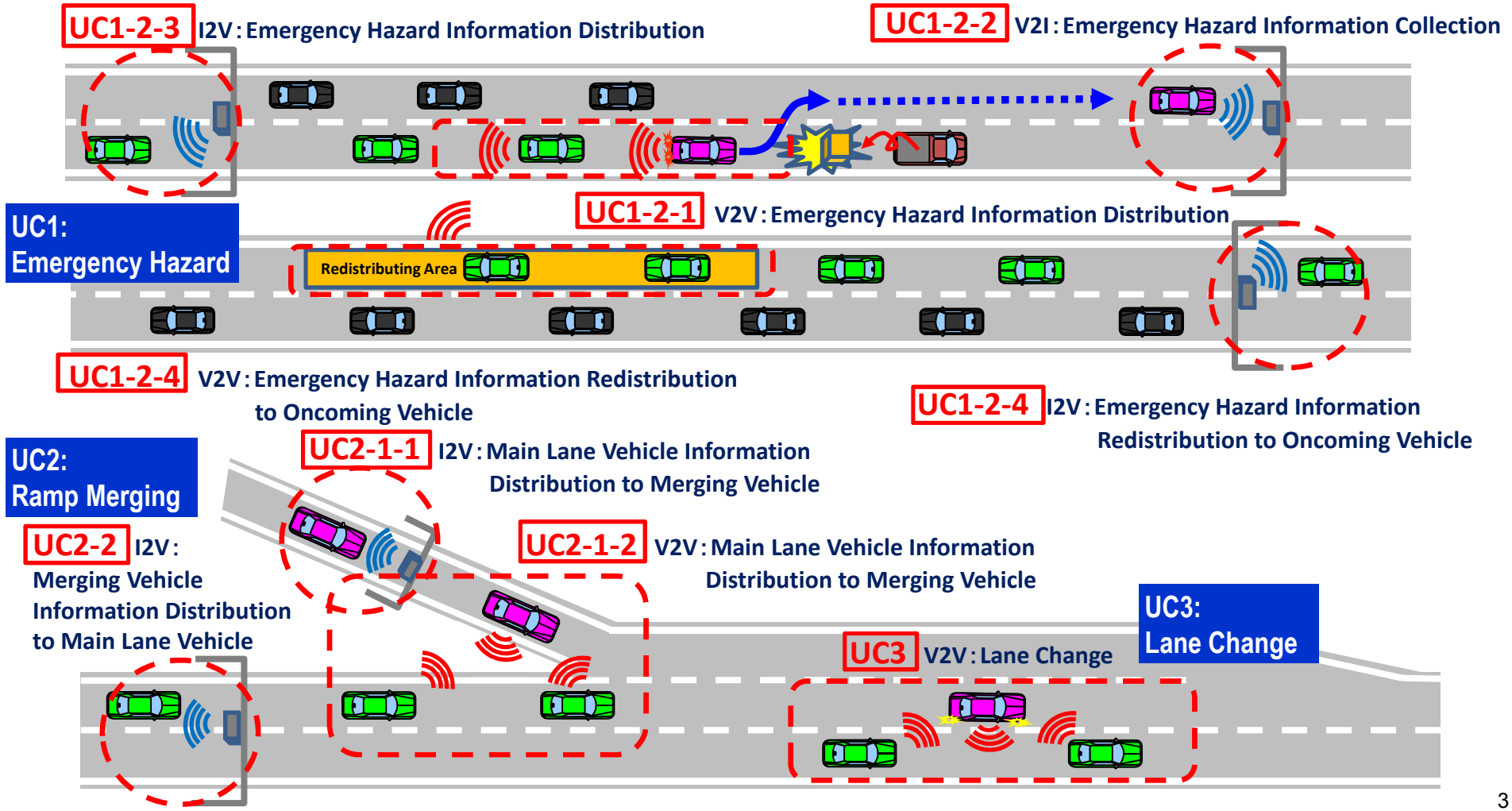
- Background
  - In Japan, some examinations for the ITS(V2V, V2I, etc.) wireless communication method for supporting the automated driving system have been proceeding in reference to use cases utilizing the wireless communication considered in the Japan Automobile Manufactures Association (JAMA).
  - In order to really apply these ITS wireless communication technologies, it is necessary to set communication requirements corresponding to each use case and formulate message-set and protocol specifications of the wireless communication for automated driving.
- Object
  - Prepare a draft protocol specification of the wireless communication for automated driving to formulate the experimental guideline.
- Outcome

  FY2017: Draft protocol specification assuming ideal communication environment (without fading, shadowing).

  FY2018: Draft protocol specification assuming real communication environment (with multi-path fading, shadowing).

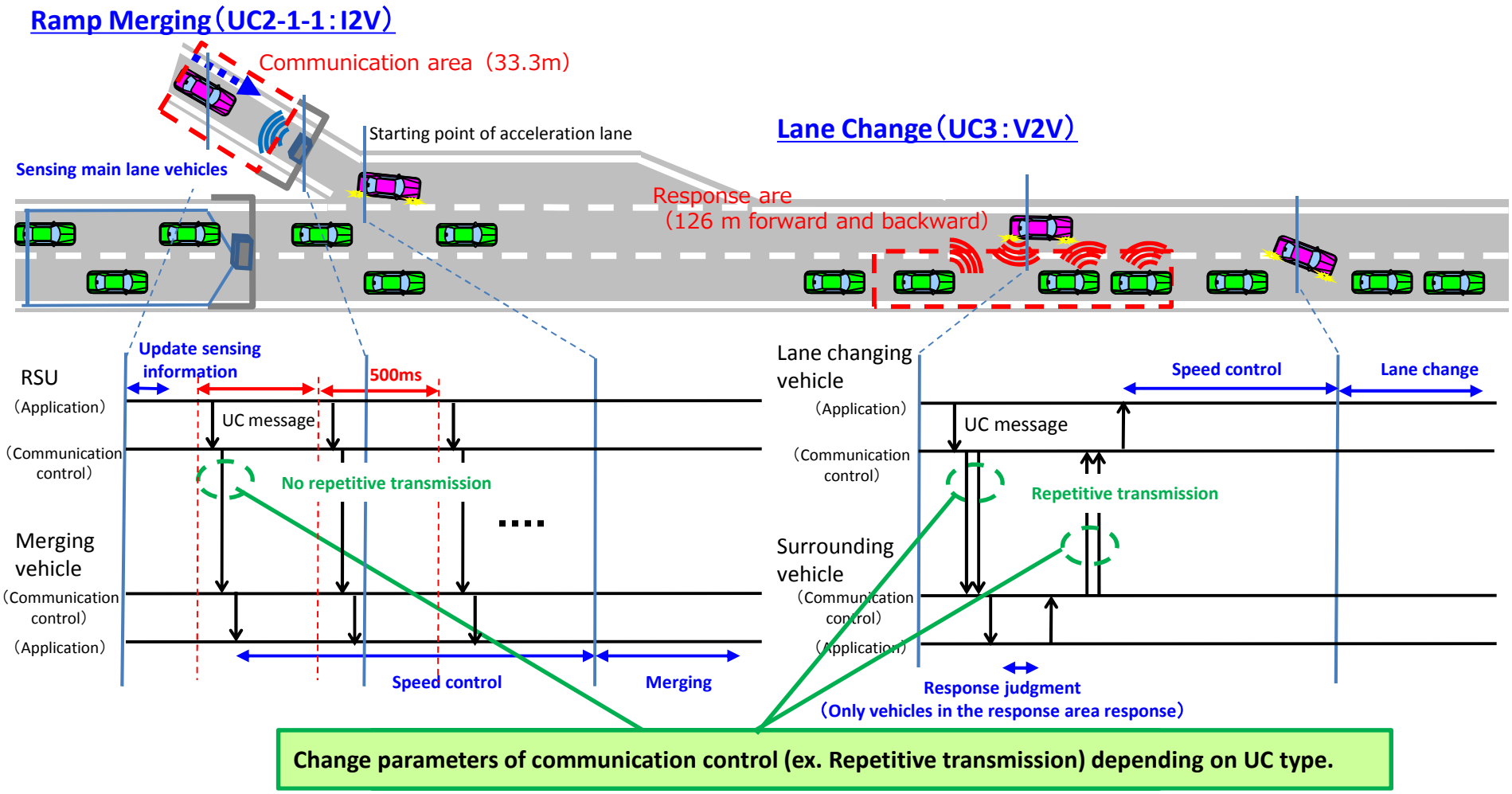
Examination of Communication Requirement —Target Use Case—

- **Investigate and discuss the JAMA's use cases, whose automated driving level are 2 or 3 on highway.**
- **Extract communication requirements of each use case in cooperation with the JAMA and the ITS FORUM.**



Examination of Message-set and Protocol —Communication Protocol—

- **Estimate the message size, which is necessary for evaluation communication quality for each use case.**
- **Examine the frame construction and the protocol of the wireless communication for automated driving.**



Examples of Communication Sequence for Each UC（Ramp Merging: UC2-1-1, Lane Change: UC3）

Evaluation of Communication Performance —Computer Simulation—

- **Evaluate the communication performance under each use case requirement by computer simulation with propagation models (path loss, multi-path fading, shadowing, etc.) assuming a real communication environment.**
- **Analyze the condition and additional functions to satisfy the target performance for wireless communication for automated driving based on the ITS wireless communication methods in Japan as follows,**
  - **ITS FORUM RC-005: Experimental Guideline for Vehicle-to-Vehicle Communications System using 5.8GHz Band**
  - **ARIB STD-T109: 700MHz Band Intelligent Transport Systems**
  - **ARIB STD-T75: Dedicated Short Range Communications (DSRC) System**

Judgement by performance evaluation

○ : Link margin > 0dB under the severe condition, PER(Packet Error Rate) < 1E-1 at the system level, & Communication delay < the required value

△ : Link margin < 0dB under the severe condition, PER(Packet Error Rate) < 1E-1 at the system level, & Communication delay < the required value

UC（Use case）			V2X	Basic communication method		
				ITS FORUM RC-005	ARIB STD-T109	ARIB STD-T75
Emergency hazard	1-2-1		V2V	△	△	
	1-2-2		V2I	○	○	○
	1-2-3		I2V	○	○	○
	1-2-4	With simple figure information	I2V	○	○	○
			V2V	○	△※3, ※4	
		Without simple figure information	I2V	○	○	○
			V2V	○	○	
Ramp Merging	2-1-1		I2V	○	○	○
	2-1-2		V2V	△※1	△※1 , ※3	
	2-2		I2V	○	○	○
Lane Change	3		V2V	△※2	○	

※1 : Tx control functions (response timing & frequency) are necessary. ※2 : Tx control function (response timing) is necessary.

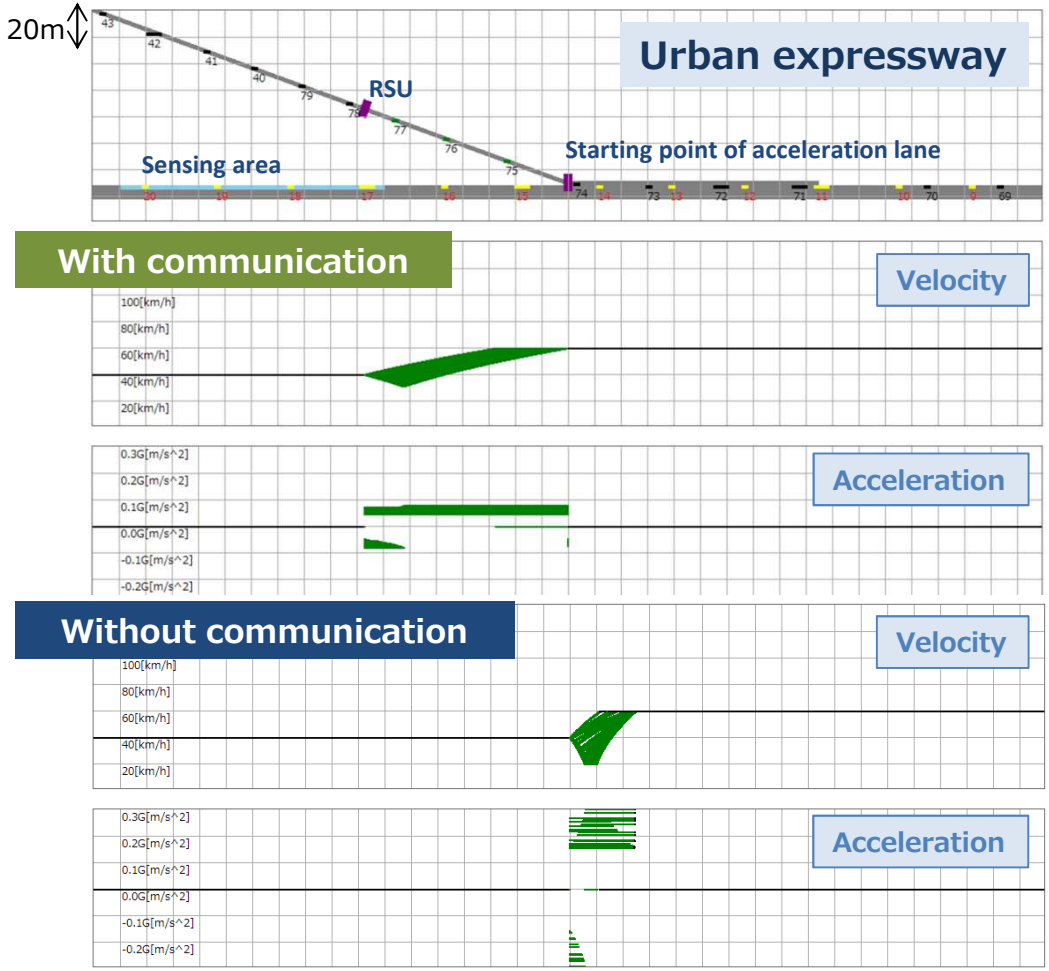
※3 : Alleviation of Tx time restriction is necessary. ※4 : Packet fragment function is necessary.

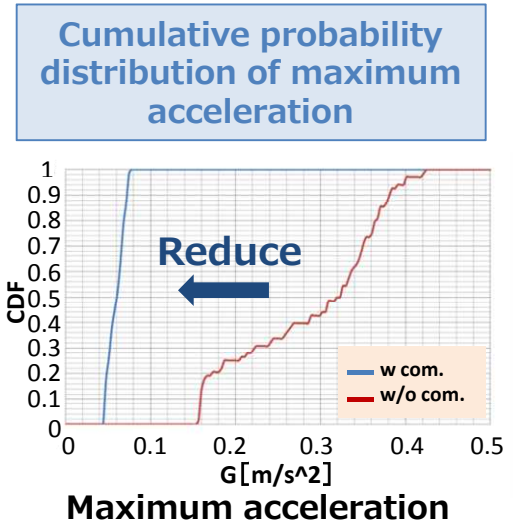
Evaluation of Improvement Effect — Traffic Flow Simulation —

- **Develop the traffic flow simulator to evaluate the stability of vehicle behavior (ex. maximum acceleration / deceleration) on the ramp merging support (UC2-1-1).**
- **Confirm the validity of infrastructure installation conditions, effect of utilizing the communication for automated driving.**

Example of evaluation result

- Urban expressway, Main lane vehicle: 60km/h, Merging vehicle: 40km/h (before speed adjustment) -





Draft Communication Specification －Main Specification－

- **Make a draft protocol specification for automated driving based on each of the conventional ITS wireless communication methods in Japan.**
- **Extract additional functions required on the application or upper layer.**

Item		Communication method		
		ITS FORUM RC-005 base **＋Additional function**	ARIB STD-T109 base **＋Additional function**	ARIB STD-T75 base **＋Additional function**
Realizable UC	V2I	1-2-2, 1-2-3, 2-1-1, 2-2		1-2-2, 1-2-3, 2-1-1, 2-2
	V2V	1-2-1, 2-1-2, 3		–
	V2I & V2V	1-2-4		–
Application	**Hopping control**	**Yes(UC1-2-1)**		No
	Transmission control	**Yes(UC2-1-2,UC3)**	**Yes(UC2-1-2)**	No
L7(Upper layer)	**Successive transmission**	**Yes**	No／**Yes(for Automated driving)**	No／**Yes(for Automated driving)**
L2(DL layer)	MAC	CSMA/CA（Random back-off）		TDMA（Slotted ALOHA）
	Retransmission	No		Yes
	Packet fragment	Yes	No／**Yes(for Automated driving)**	Yes
L1(PHY layer)	Frequency	5.8GHz band	760MHz band	5.8GHz band
	Antenna power (Max.)	10mW/MHz		Infrastructure：300mW Vehicle：10mW
	Occurred bandwidth	9MHz		4.4MHz
	Modulation	QPSK/OFDM、16QAM/OFDM		π/4 shift QPSK
	Error correction	Convolutional code（Coding rate: 1/2）		BCH code (63,51)
	Diversity(Rx)	No／Yes (for Automated driving)		No

※Add or change from the conventional ITS communication method.

Future Plan

- The outcome of this project will be utilized for the evaluation of the improvement effect by computer simulation or field test, such as stabilization of vehicle behavior and facilitation of traffic flow by applying the draft protocol specification to use cases.
- Planning for formulating the experimental guideline of the wireless communication for automated driving will be implemented at the ITS FORUM.