Proposal for traffic disturbance test scenarios for ALKS

VMAD-SG1-02-02

1. Introduction

--Why--

Validation and Verification of ADS (automated driving systems) safety requires a combination of processes and tools able to assess how the different elements of the complete system contribute to the safety of its operations in real world conditions. Traffic disturbance test scenarios play a very important role as they define the conditions in which the vehicle's operations are tested before its introduction in the market.

--What--

When validating overall performance of ADS, it is necessary to confirm that ADS shall not cause any traffic accidents resulting in injury or death that are rationally foreseeable and preventable under traffic conditions in the real world.

Rationally foreseeable scenarios are those logically introduced from traffic flow data such as fixed-camera data, on-board camera data, and traffic accident data.

Boundary conditions to divide rationally foreseeable scenarios into preventable and unpreventable scenarios should be re-assessed based on the technological development appropriately in a timely fashion. However, it is appropriate to set the ability of ADS at what general public understand as skilled human driver level without any human errors supported by state-of-the-art vehicle technologies as the first step.

Besides, this common understanding as the first step for boundary condition for ADS is favorable to be harmonized internationally.

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--How--

Traffic disturbance test scenarios fits to check safety of the intended functionality and are used both for simulation and test-track validation/verification, but not relevant for real-road testing.

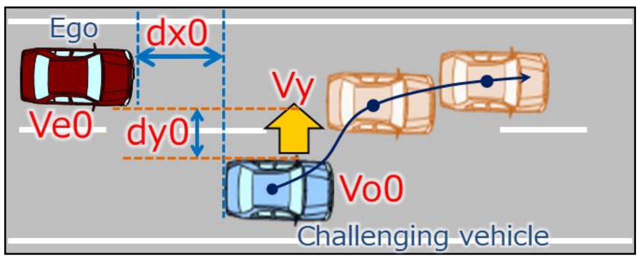
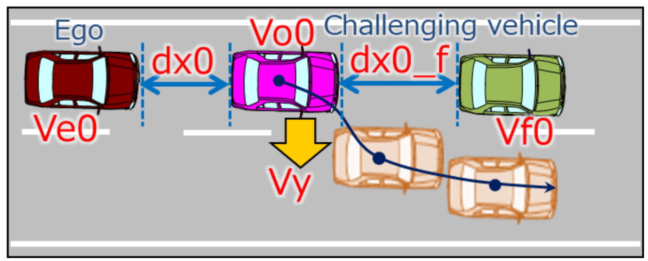
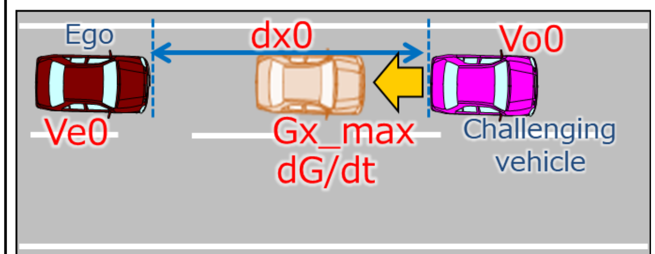
Traffic disturbance test scenarios deals with safety validation methods mainly in the area of system functions on judgment and manoeuvre on the assumption that system function on perception and vehicle dynamic performance are normal. Therefore, it is necessary to check system function on perception (whether or not surrounding vehicles within the range of defined parameters can be detected) and vehicle dynamic performance separately.

Concretely, traffic disturbance test scenarios are systematically composed of the Road geometry, Ego-vehicle behavior, and Other vehicle‘s manoeuvre.

2. Traffic disturbance test scenarios

The traffic disturbance test scenarios applicable to ALKS only include the Main roadway as the Road geometry, only lane keep as the Ego vehicle behavior, and the cut in, cut out and deceleration as the other vehicle‘s manoeuvre.

2.1. Other Vehicle’s Manoeuvre

Cut In	Cut Out	Deceleration
		

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2.2. Parameter:

Initial condition	Initial velocity	**Ve0** = Ego vehicle
		Vo0 = Leading vehicle in lane or in adjacent lane
		Vf0 = Vehicle in front of leading vehicle in lane
	Initial distance	**dx0** = Distance in Longitudinal direction between ego and leading vehicle in lane or in adjacent lane
		dy0 = Inside Lateral distance between outside edge line of ego vehicle in parallel to the vehicle's median longitudinal plane within lanes and outside edge line of another vehicle in parallel to the vehicle's median longitudinal plane in adjacent lines.
		dx0_f = Distance in longitudinal direction between front end of leading vehicle and rear end of vehicle in front of leading vehicle
Vehicle motion	Lateral motion	**Vy** = Lateral velocity
	Deceleration	**Gx_max** = Maximum deceleration G
		dG/dt = Deceleration rate

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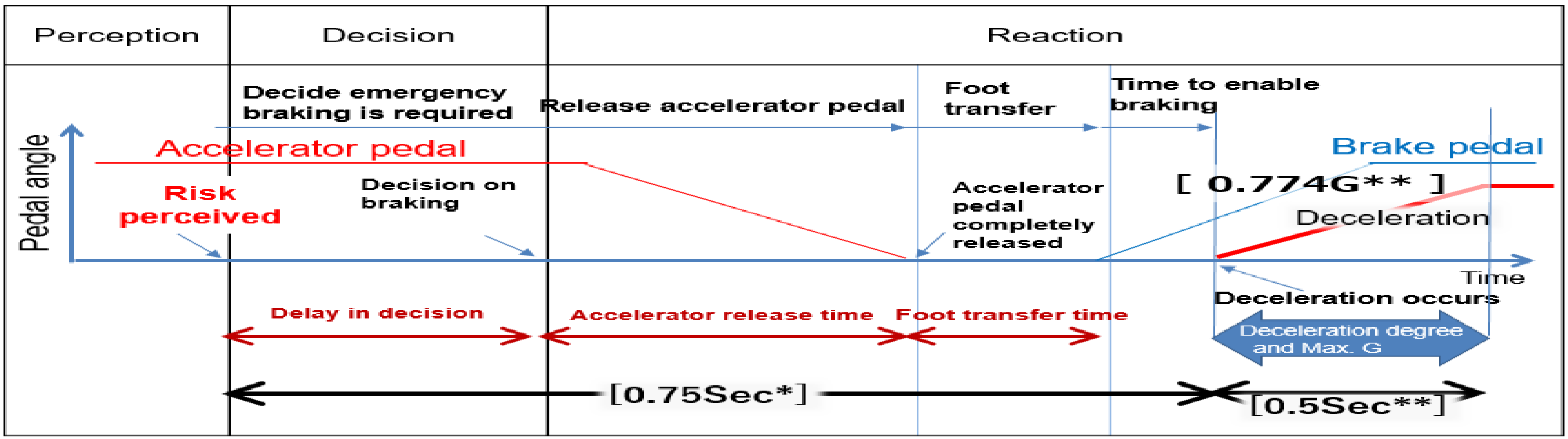
2.3. Driver model

In low-speed ALKS scenario, the avoidance capability required for the driver model is braking control only. This driver model is separated into the following three segments: “Risk perceive situation”, “Delay in time”, and “Deceleration degree and Max. G-force

Driver model for Cut in / Cut out / Deceleration



*/ = 0.75sec is a common data in Japan.

**/ = 0.5sec and 0.774G are a data from experiments of NHTSA and Japan. (Coefficient of road friction is 0.6.)

-For Cut in scenario:

Risk perceived position of side vehicle is determined by lateral movement speed of it.

-For Cut out scenario:

Risk perceived position of leading vehicle is determined by lateral movement speed of it.

-For Deceleration scenario:

Risk perceived timing of leading vehicle is determined by deceleration rate of it.

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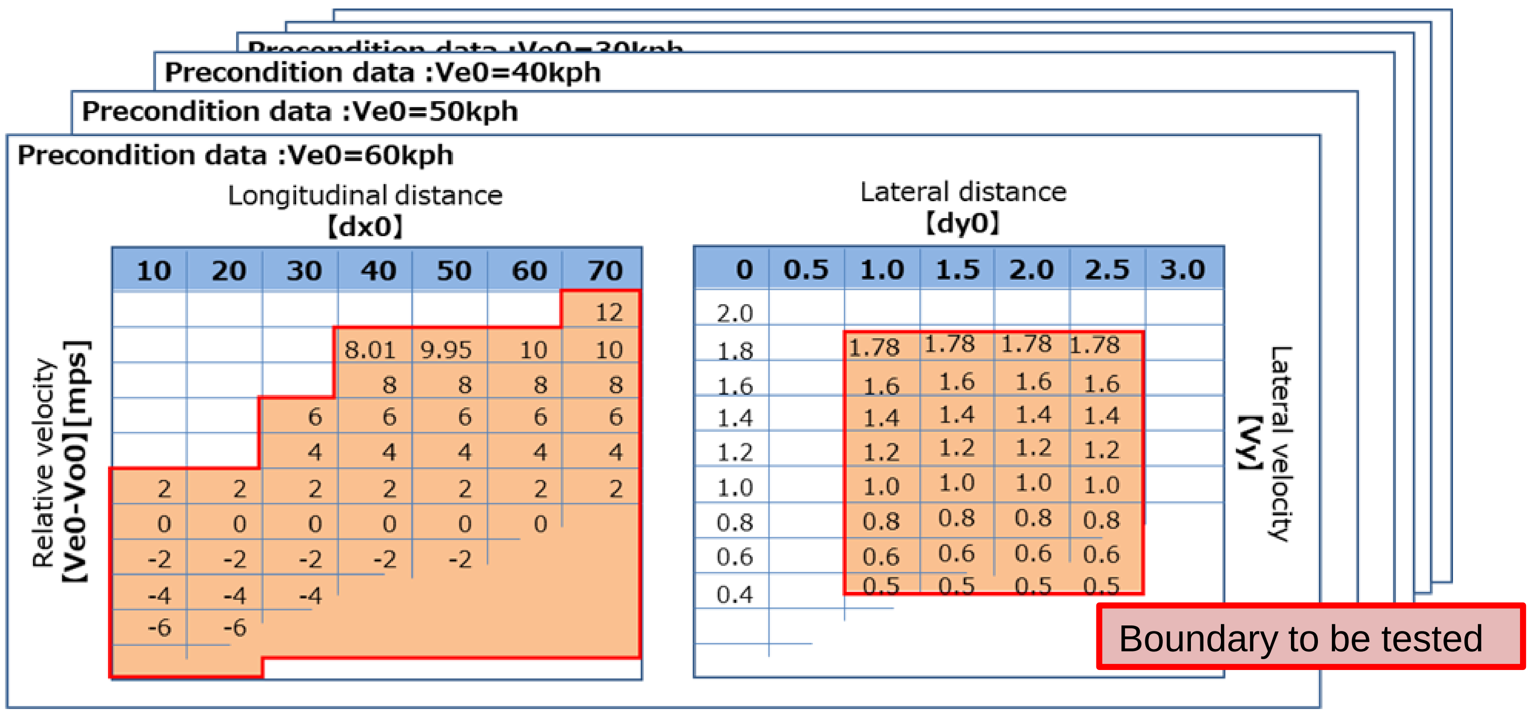
2.4 Data sheet

Data sheet for checking if ADS avoid collision within any combination of each parameter within the vehicle speed which ALKS is enable to work

2.4.1 Cut in

(Data sheets image)

This data sheet includes Ve0, Vo0, dx0, dx0, dy0 and Vy.



10	20	30	40	50	60	70
						12
			8.01	9.95	10	10
			8	8	8	8
		6	6	6	6	6
		4	4	4	4	4
2	2	2	2	2	2	2
0	0	0	0	0	0	
-2	-2	-2	-2	-2		
-4	-4	-4				
-6	-6					

0	0.5	1.0	1.5	2.0	2.5	3.0
2.0						
1.8		1.78	1.78	1.78	1.78	
1.6		1.6	1.6	1.6	1.6	
1.4		1.4	1.4	1.4	1.4	
1.2		1.2	1.2	1.2	1.2	
1.0		1.0	1.0	1.0	1.0	
0.8		0.8	0.8	0.8	0.8	
0.6		0.6	0.6	0.6	0.6	
0.4		0.5	0.5	0.5	0.5	

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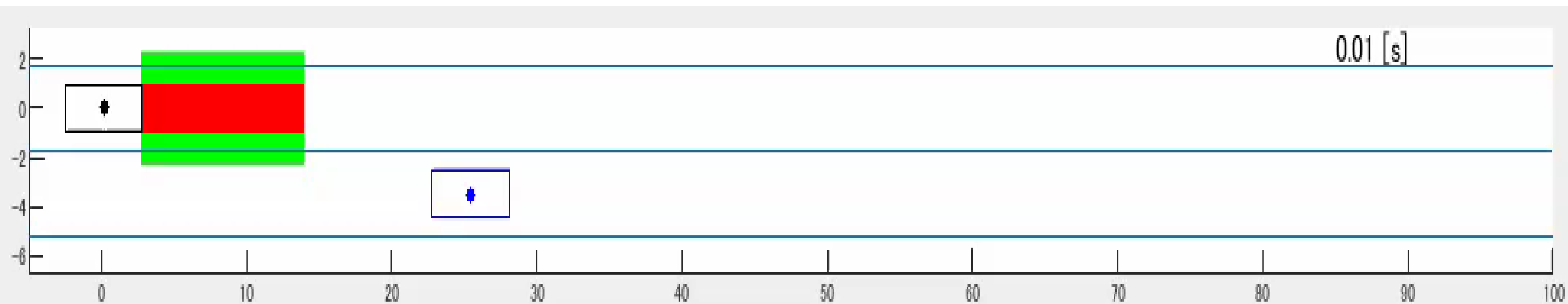
Sample Simulation: Cut in (1)

Initial condition				Vehicle motion
Initial velocity		Initial distance		Lateral motion
Ego vehicle 【Ve0】	Challenging vehicle 【Vo0】	Longitudinal distance 【dx0】	Lateral distance 【dy0】	Lateral velocity 【Vy】
60kph	40kph	20m	3.5m	0.5m/s



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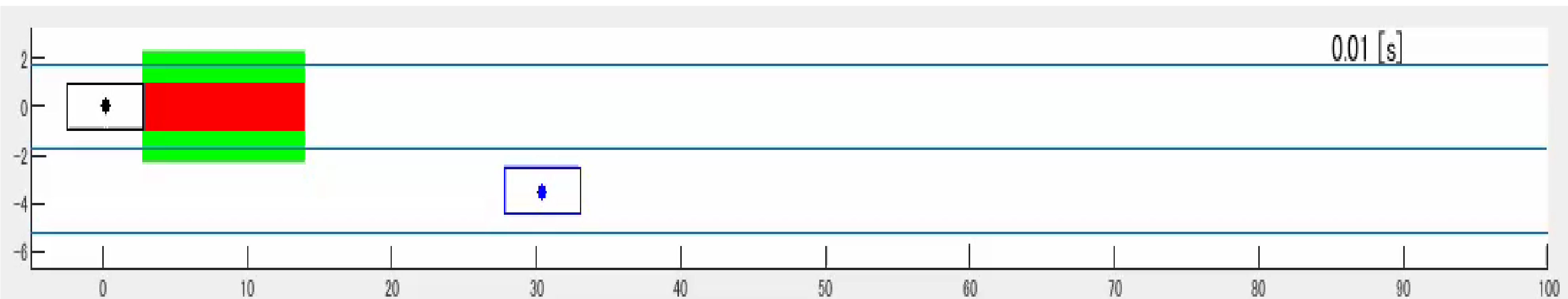
Sample Simulation: Cut in (2)

Initial condition				Vehicle motion
Initial velocity		Initial distance		Lateral motion
Ego vehicle 【Ve0】	Challenging vehicle 【Vo0】	Longitudinal distance 【dx0】	Lateral distance 【dy0】	Lateral velocity 【Vy】
60kph	40kph	25m	3.5m	0.5m/s



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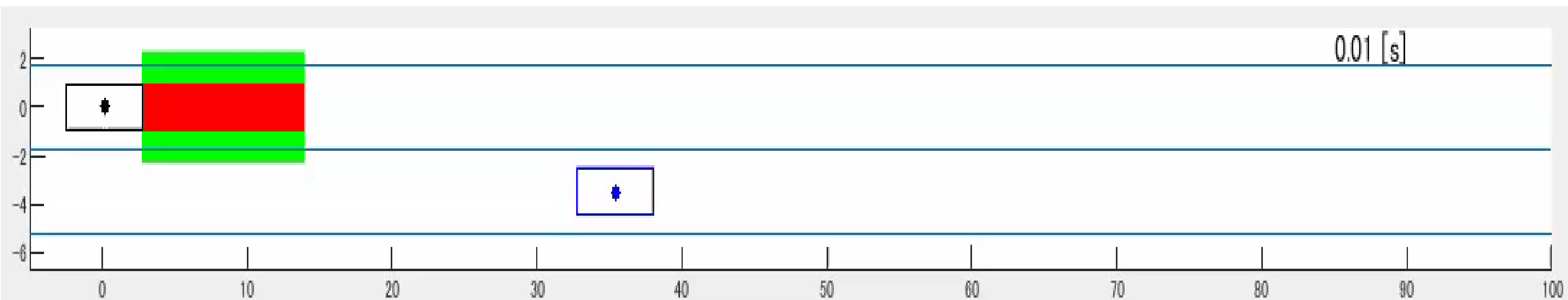
Sample Simulation: Cut in (3)

Initial condition				Vehicle motion
Initial velocity		Initial distance		Lateral motion
Ego vehicle 【Ve0】	Challenging vehicle 【Vo0】	Longitudinal distance 【dx0】	Lateral distance 【dy0】	Lateral velocity 【Vy】
60kph	40kph	30m	3.5m	0.5m/s



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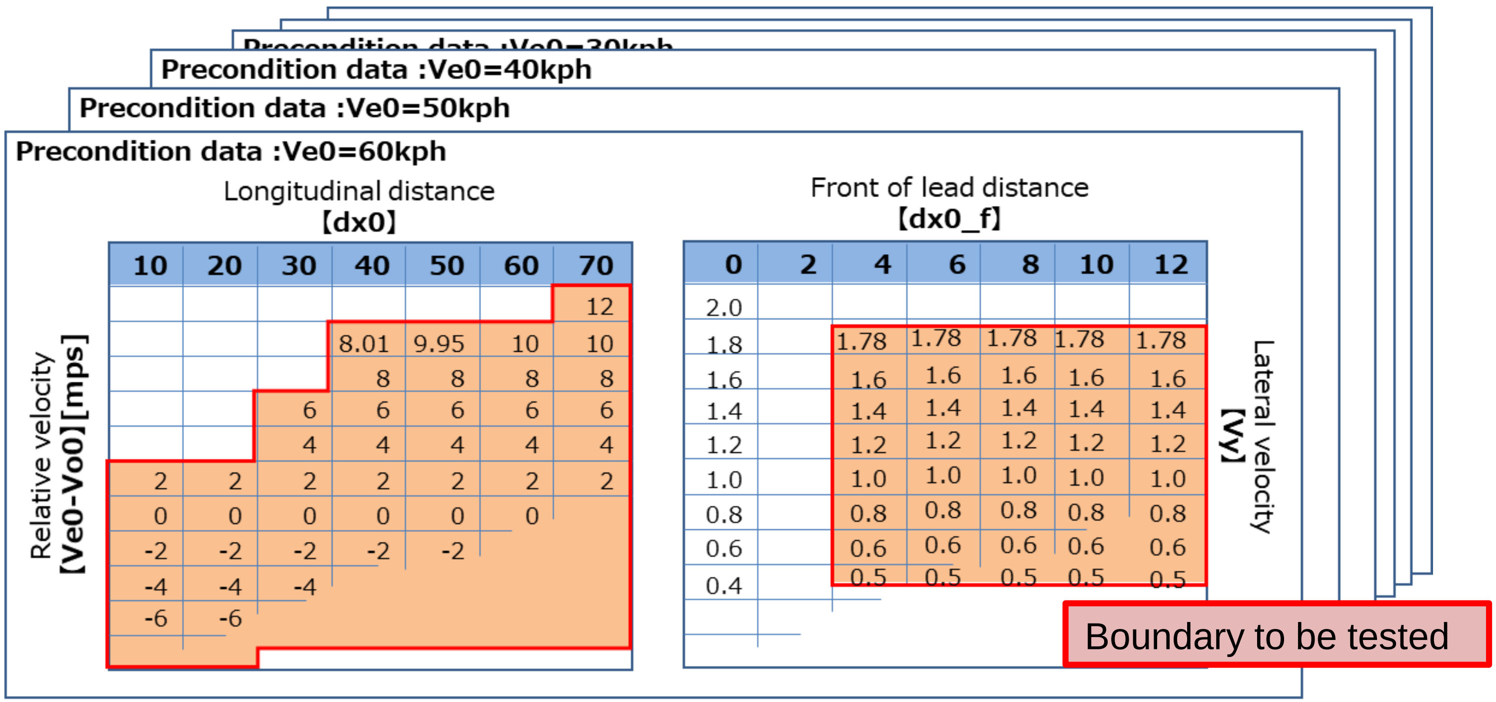
2.4.2 Cut out

(Data sheets image)

This data sheet includes Ve0, Vo0, Vf0, dx0, dx0_f and Vy



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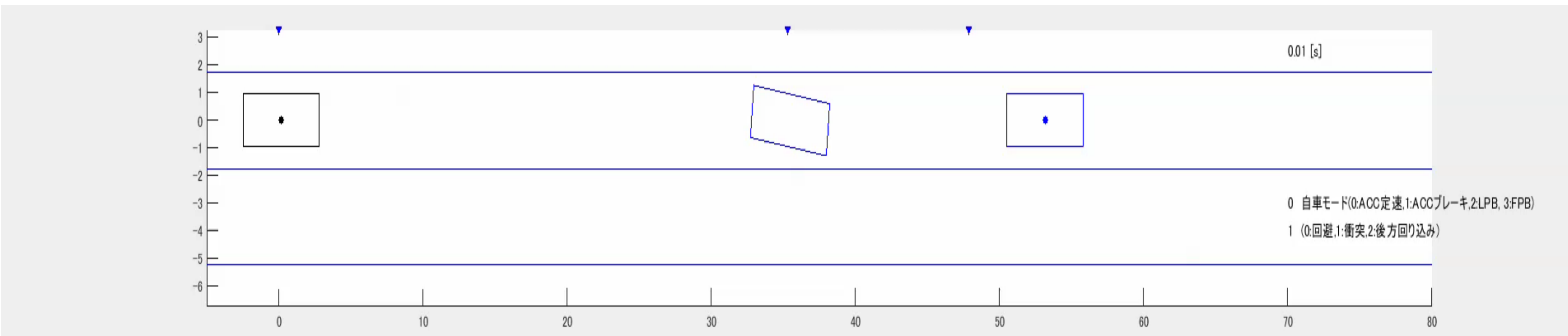
Sample Simulation: Cut out

Initial condition					Vehicle motion
Initial velocity			Initial distance		Lateral motion
Ego vehicle 【Ve0】	Challenging vehicle 【Vo0】	Front of read 【Vf0】	Longitudinal distance 【dx0】	Front of lead Distance 【dx0_f】	Lateral Velocity 【Vy】
60kph	60kph	0kph	30m	α	2.1m/s



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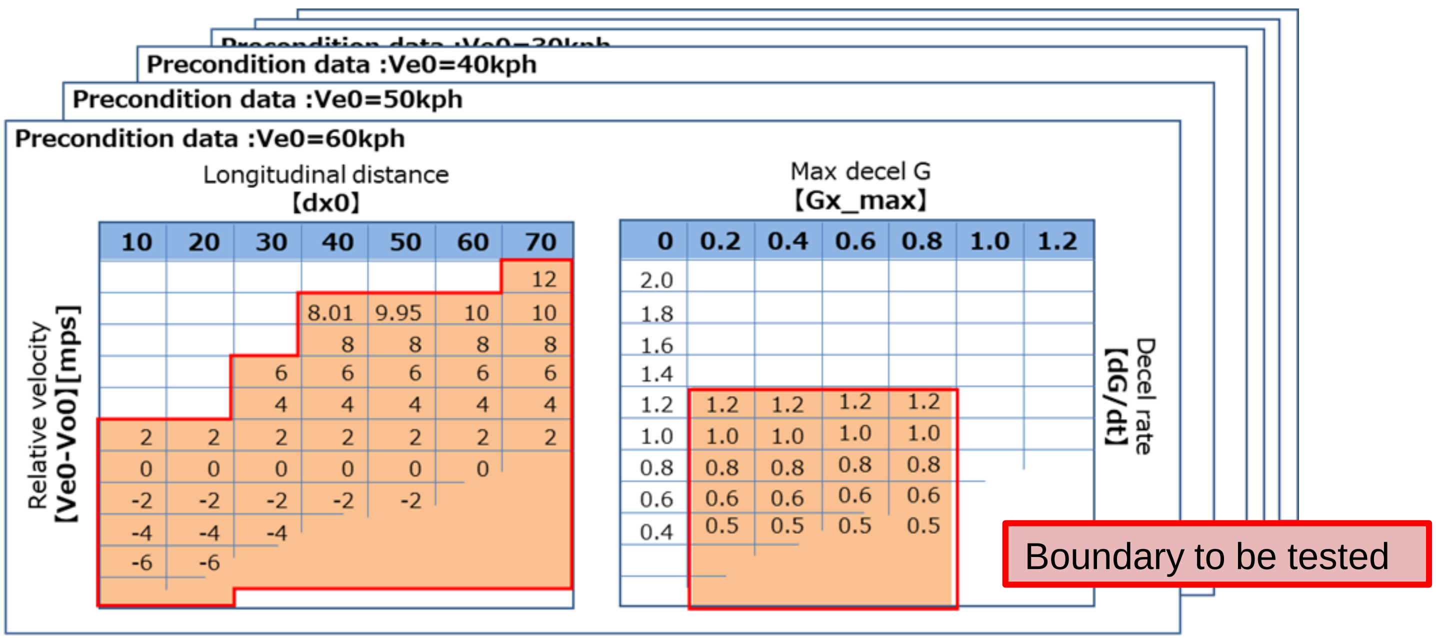
2.4.3 Deceleration

(Data sheet image)

This data sheet includes Ve0, Vo0, dx0, Gx_max and dG/dt.



10	20	30	40	50	60	70
						12
			8.01	9.95	10	10
			8	8	8	8
		6	6	6	6	6
		4	4	4	4	4
2	2	2	2	2	2	2
0	0	0	0	0	0	
-2	-2	-2	-2	-2		
-4	-4	-4				
-6	-6					

0	0.2	0.4	0.6	0.8	1.0	1.2
2.0						
1.8						
1.6						
1.4						
1.2	1.2	1.2	1.2	1.2		
1.0	1.0	1.0	1.0	1.0		
0.8	0.8	0.8	0.8	0.8		
0.6	0.6	0.6	0.6	0.6		
0.4	0.5	0.5	0.5	0.5		

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Sample Simulation: Deceleration

Initial condition			Vehicle motion	
Initial velocity		Initial distance	Deceleration	
Ego vehicle **【Ve0】**	Challenging vehicle **【Vo0】**	Longitudinal distance **【dx0】**	Max decel G **【Gx_max】**	Decel rate **【dG/dt】**
60kph	60kph	50m	1G	∞(※)