



Current status and next steps towards
harmonized automated driving safety
assurance

J Antona-Makoshi

H Imanaga, S Kitajima, N Uchida



S Taniguchi

K Ozawa, E Kitahara



Global trend for AV social acceptance



Informal document WP.29-177-19
177th WP.29, 12-15 March 2019
Agenda items 2.3 and 17

Framework document on automated/autonomous vehicles

Safety vision (pg.1)



Automated vehicles shall not cause any traffic accidents resulting in injury or death that are reasonably foreseeable and preventable

Aim

To develop a comprehensive engineering process for AD system safety assurance that addresses all reasonably foreseeable safety relevant scenarios.

(Start with SAE Level 3 in motorways and gradually expand to higher levels and urban environments)

Safety Approach



Scenario approach

Scenario Structure

Perception

Perception disturbance



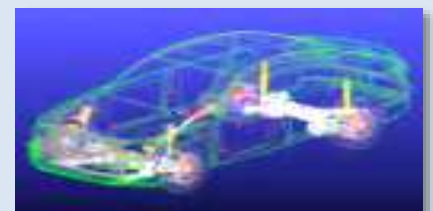
Judgement

Traffic Disturbance



Control

Vehicle disturbance



Traffic disturbance scenarios

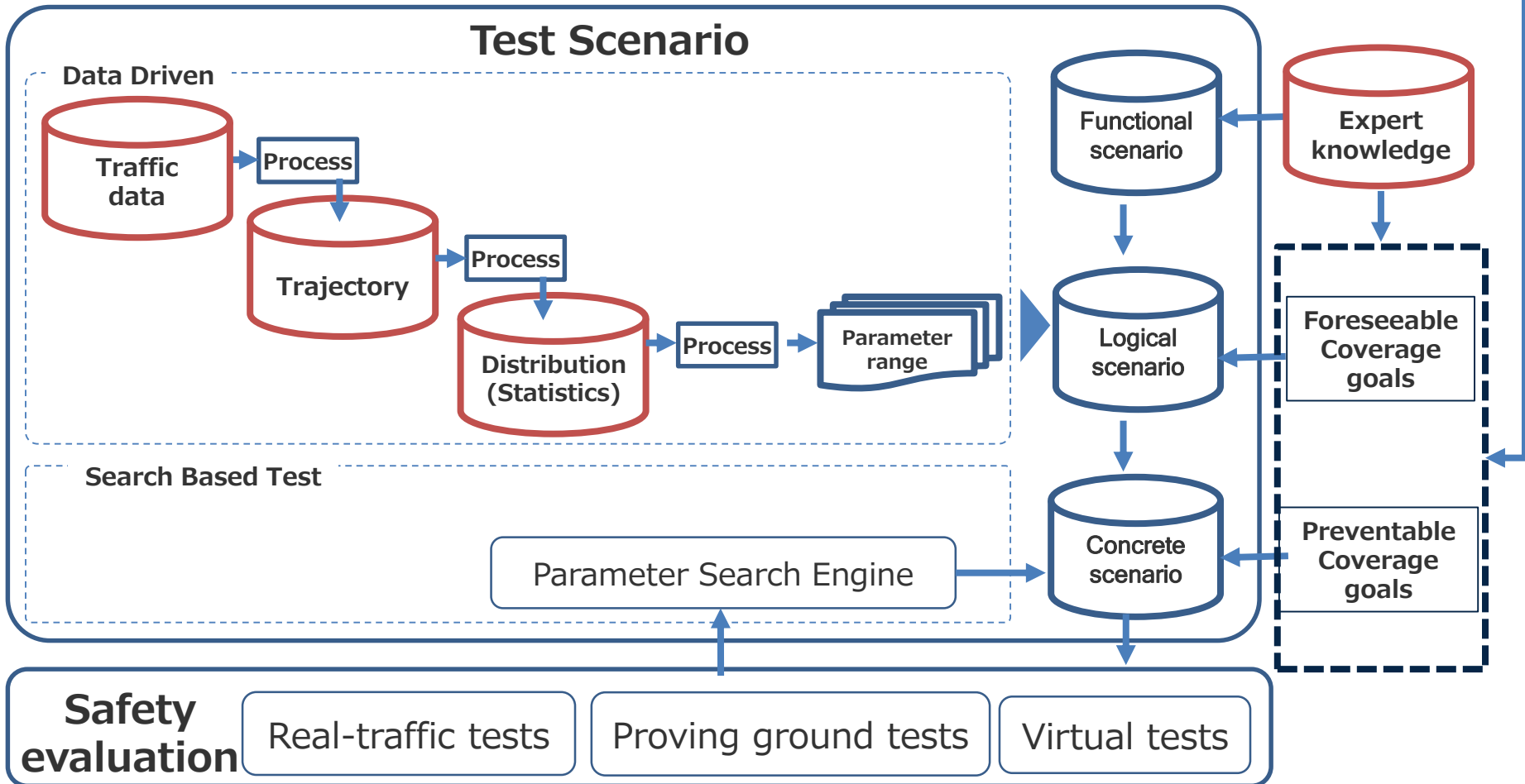


Surrounding vehicle position & motion

Road geometry and Ego-vehicle motion		Road geometry	Ego-vehicle behavior	Surrounding vehicle position & motion							
				Cut in	Cut out	Acceleration	Deceleration (Stop)	Sync			
Main roadway	Lane keep	No.1	No.2	No.3	No.4						
	Lane change	No.5	No.6	No.7	No.8	No.9					
Merging zone	Lane keep	No.10						No.11			
	Lane change	No.12	No.13	No.14	No.15	No.16					
Departure zone	Lane keep	No.17						No.18			
	Lane change	No.19	No.20	No.21	No.22	No.23					
Ramp	Lane keep	No.24	No.25	No.26	No.27						
	Lane change	No.28	No.29	No.30	No.31	No.32					

Engineering framework

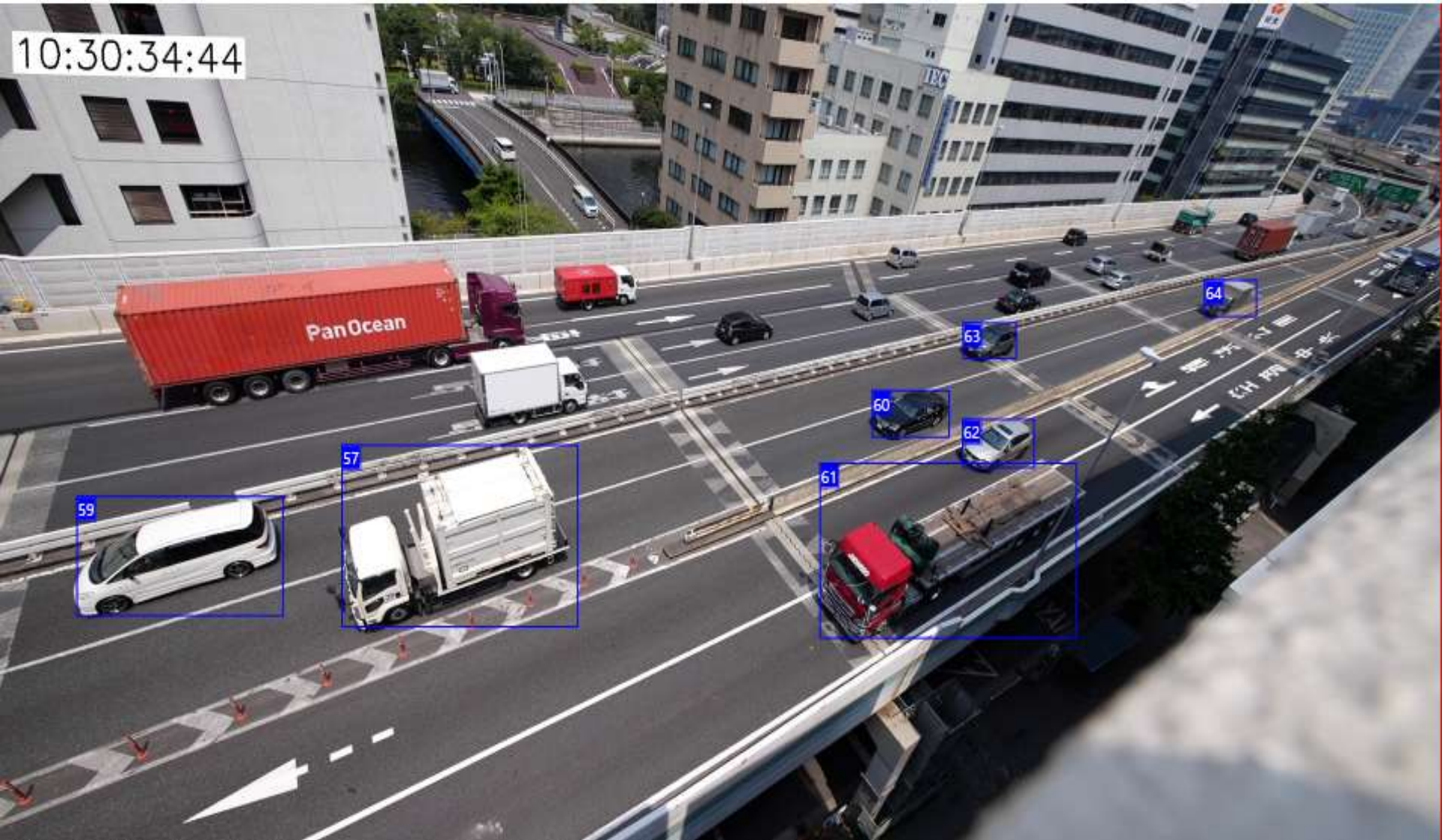
Socially acceptable top safety goals defined by authorities



Data acquisition/processing (instrumented vehicles)

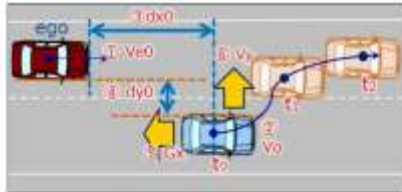


Data acquisition/processing (fixed cameras)

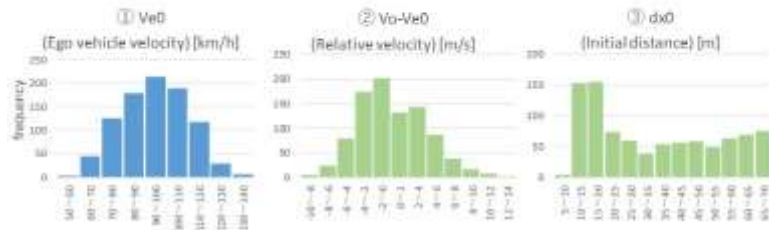


Derivation of scenario parameter ranges

① Data accumulation



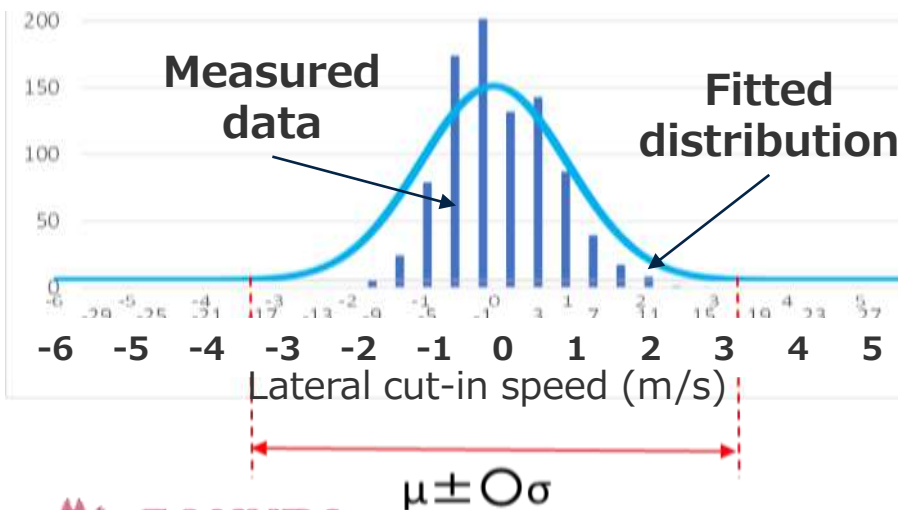
Scenario dependent parameter definition and automatic extraction



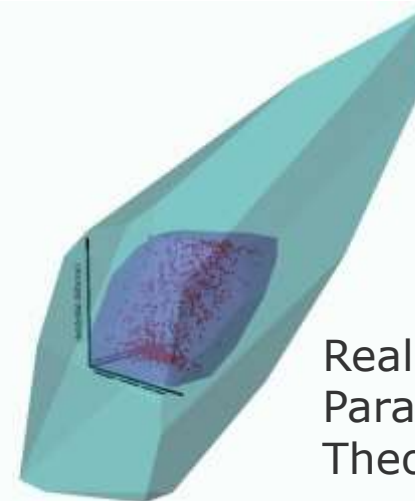
② Parameter correlation analysis

	① Ego-vehicle velocity	② Relative velocity	③ Initial distance	⑤ Lateral velocity
① Ego-vehicle velocity		Correlation	Correlation	No correlation
② Relative velocity	Correlation		Correlation	No correlation
③ Initial distance	Correlation	Correlation		No correlation
⑤ Lateral velocity	No correlation	No correlation	No correlation	

③ Parameter extrapolation



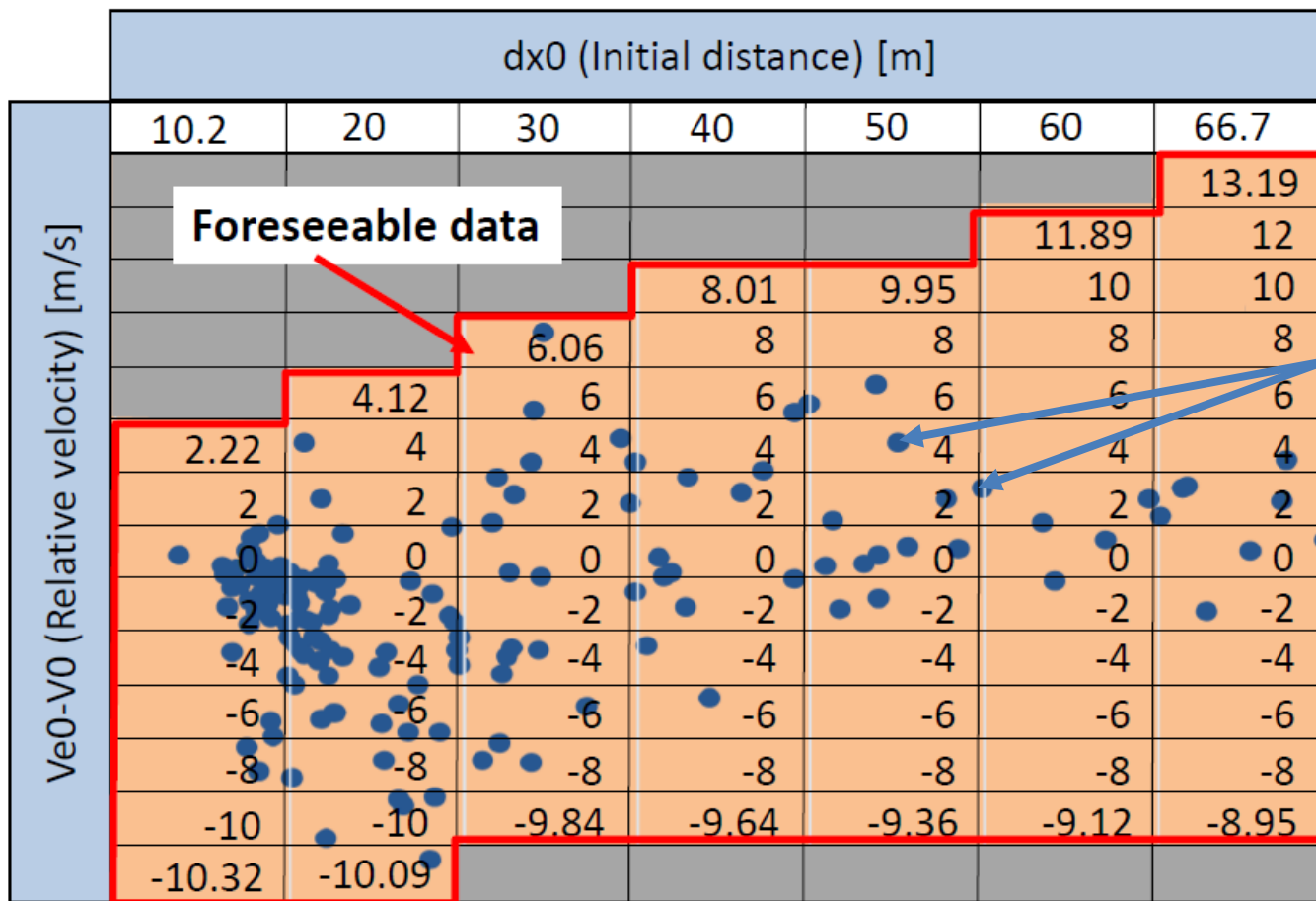
④ Parameter spaces



Real-world data
Parameter correlation
Theoretically foreseeable

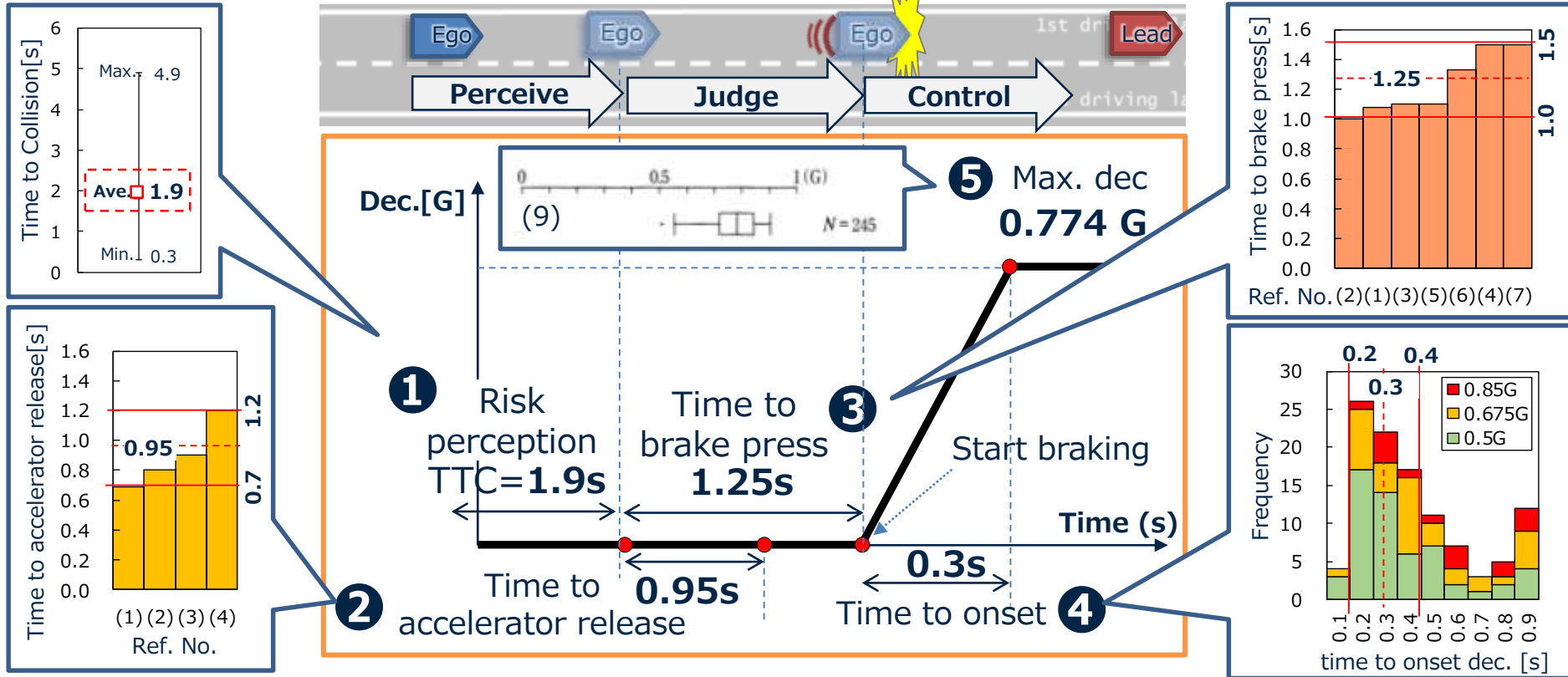
Rationally foreseeable parameters ranges

Precondition data : $V_{e0}=80\text{kph}$, $V_y=1.72\text{m/s}$



Measured data

Experienced driver braking model



(1) Olson et al. 1986, (2) Lechner et al. 1991, (3) McGehee et al. 2000, (4) Mazzae et al. 2003, (5) Barrett et al. 1968, (6) Broen et al. 1996, (7) Lerner 1993, (8) McLaughlin et al. 2009 (NHTSA), (9) Makishita et al. 2001

Virtual test results

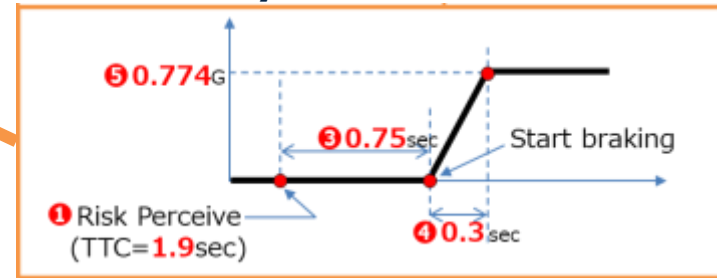
Simulation Results (Ve0=80kph, Vy=1.72m/s)

dx0(Initial Distance) [m]

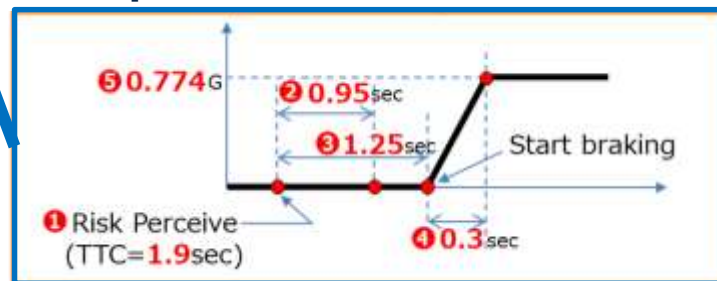
	10.2	20	30	40	50	60	66.7
							x ✓ 13.19
						x ✓ 11.89	x ✓ 12
				x ✓ 8.01	x ✓ 9.95	x ✓ 10	x ✓ 10
			✓ 6.06	x ✓ 8	x ✓ 8	x ✓ 8	x ✓ 8
		✓ 4.12	✓ 6	✓ 6	✓ 6	✓ 6	✓ 6
x x	2.22	✓ 4	✓ 4	✓ 4	✓ 4	✓ 4	✓ 4
x x	2	✓ 2	✓ 2	✓ 2	✓ 2	✓ 2	✓ 2
✓	0	✓ 0	✓ 0	✓ 0	✓ 0	✓ 0	✓ 0
✓	-2	✓ -2	✓ -2	✓ -2	✓ -2	✓ -2	✓ -2
✓	-4	✓ -4	✓ -4	✓ -4	✓ -4	✓ -4	✓ -4
✓	-6	✓ -6	✓ -6	✓ -6	✓ -6	✓ -6	✓ -6
✓	-8	✓ -8	✓ -8	✓ -8	✓ -8	✓ -8	✓ -8
✓	-10	✓ -10	✓ -9.84	✓ -9.60	✓ -9.36	✓ -9.12	✓ -8.95
✓	10.32	✓ 10.09					

✓ : Non-crash, ✗ : Crash

AD system function



Experienced human driver



Database preparation

The screenshot displays a database design tool interface. The main area shows a hierarchical tree diagram of a database schema. The root node is '交通参加者' (Traffic Participants), which branches into three main categories: '交通参加者種別' (Traffic Participant Types), '交通参加者位置' (Traffic Participant Positions), and '交通参加者属性' (Traffic Participant Attributes). '交通参加者属性' further branches into 'カテゴリー' (Category), 'カテゴリーパラメータ' (Category Parameters), and 'カテゴリー方向' (Category Direction). 'カテゴリー' includes 'カテゴリー種別' (Category Types) and 'カテゴリーパラメータ' (Category Parameters). 'カテゴリーパラメータ' includes 'カテゴリーパラメータ' (Category Parameters) and 'カテゴリー方向' (Category Direction). 'カテゴリー方向' includes 'カテゴリー方向' (Category Direction) and 'カテゴリーパラメータ' (Category Parameters). 'カテゴリーパラメータ' includes 'カテゴリーパラメータ' (Category Parameters) and 'カテゴリー方向' (Category Direction). 'カテゴリー方向' includes 'カテゴリー方向' (Category Direction) and 'カテゴリーパラメータ' (Category Parameters). The bottom part of the screenshot shows a table with columns: 'ObjectID', 'RoadID', 'Y number', 'OV Behavior', 'Is', 'Name', 'Y OV_Pos', 'Y OV_Behavior', 'Y Units', 'Image', 'Description', 'ExtDescription', 'OV_Pos', 'Classification', 'Number', and 'Selector'. The table contains three rows of data related to lane keeping and parallel vehicles.

ObjectID	RoadID	Y number	OV Behavior	Is	Name	Y OV_Pos	Y OV_Behavior	Y Units	Image	Description	ExtDescription	OV_Pos	Classification	Number	Selector
L3-01-3-01-00-000-1028	g1-1	2	1 Lane keeping	0	1 Lane-keeping (L)	Decelerate(Stop)	Yes			Lane-keeping@p vehicle lane-keeping Lane-keep. Lane-keep.		g1 Lane-keep	048	交通参加者種別: RoadID, g1-1, 道路状況, 道路状況, 道路状況	
L3-01-3-01-00-000-3038-e1	g1-1	1	1 Lane-keeping	0	1 Parallel-vehicle (PH)	Default-1	Yes			Lane-keeping@p vehicle lane-keeping Parallel v. Lane-keep v.		g1 Lane-keep	047	交通参加者種別: RoadID, g1-1, 道路状況, 道路状況, 道路状況	
L3-01-3-01-00-000-3038-e2	g1-1	3	1 Lane-keeping	0	1 Parallel-vehicle (PH)	Colnd-2	Yes			Lane-keeping@p vehicle lane-keeping Parallel v. Lane-keep v.		g1 Lane-keep	048	交通参加者種別: RoadID, g1-1, 道路状況, 道路状況, 道路状況	

Global strategy



WP29/GRVA/VMAD



ISO/TC22/SC33/WG9
30 supporting countries



Summary

- ◆ **AD safety assurance methodology.**
- ◆ **Data driven engineering framework.**
 - **Scenario structure**
 - **Foreseeable parameter range derivation from traffic data**
 - **Preventability definitions supported by virtual tests with both experienced human driver and AV function models.**
 - **Database preparation**
- ◆ **Coordinated global strategy for specific standardization and regulatory efforts.**