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METI
Ministry of Economy, Trade and Industry

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Safety Assurance KUdos for Reliable Autonomous Vehicles

Current status and next steps towards harmonized automated driving safety assurance

J Antona-Makoshi

H Imanaga, S Kitajima, N Uchida

JARI
JAPAN AUTOMOBILE RESEARCH INSTITUTE

S Taniguchi

K Ozawa, E Kitahara

JAMA

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

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Scenario approach

Scenario Structure

- Perception
  - Perception disturbance

- Judgement
  - Traffic Disturbance

- Control
  - Vehicle disturbance

Traffic disturbance scenarios

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

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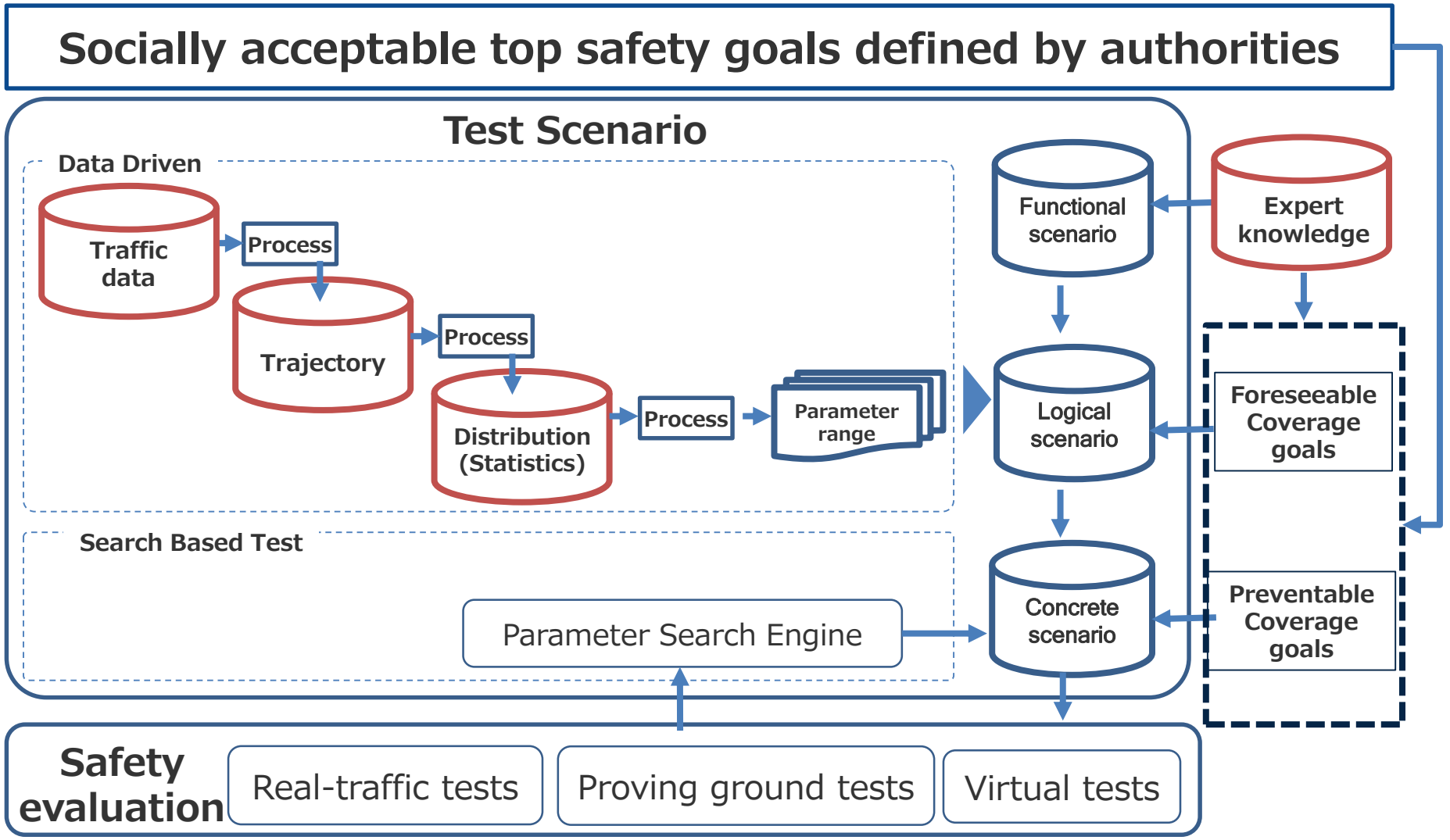
Engineering framework



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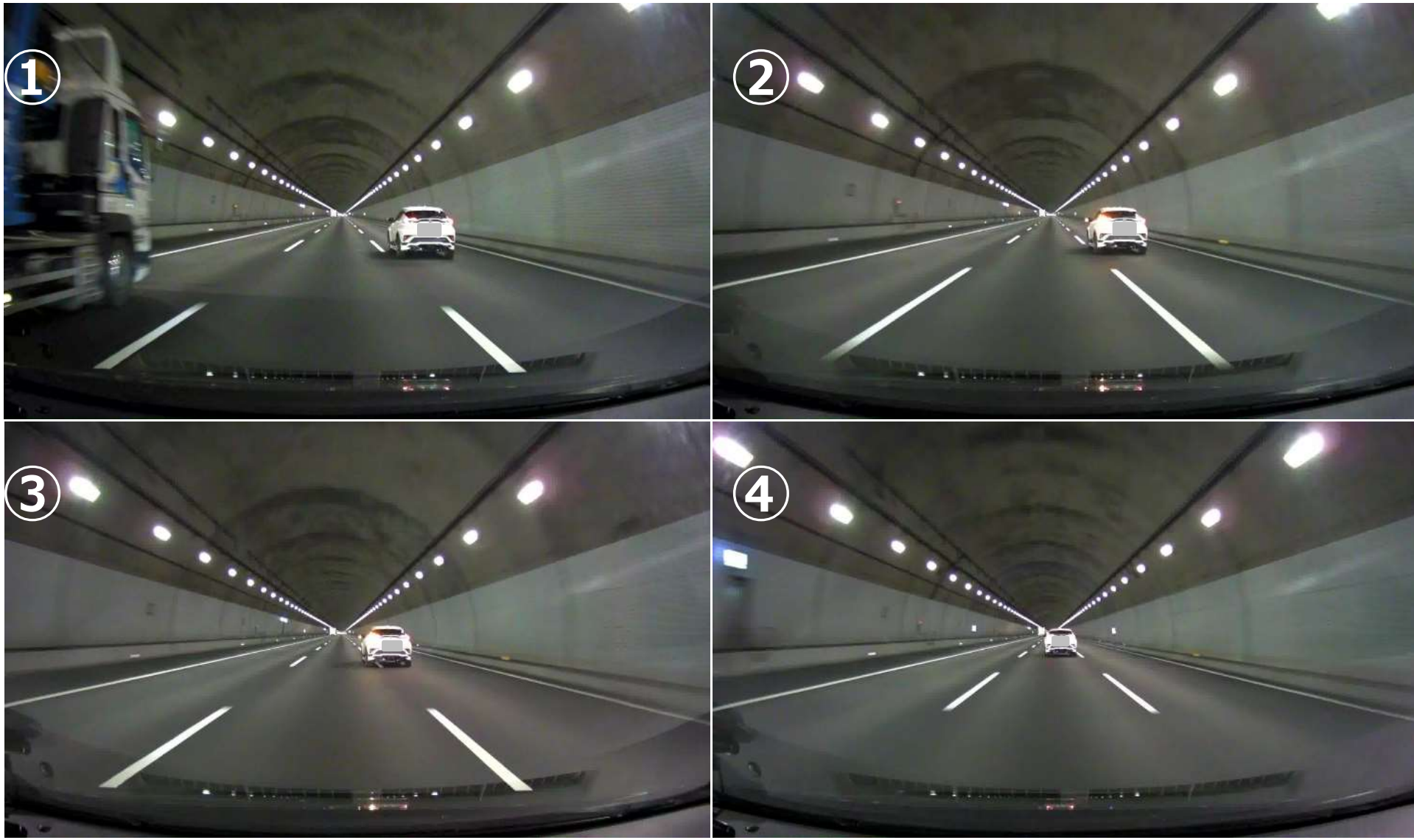
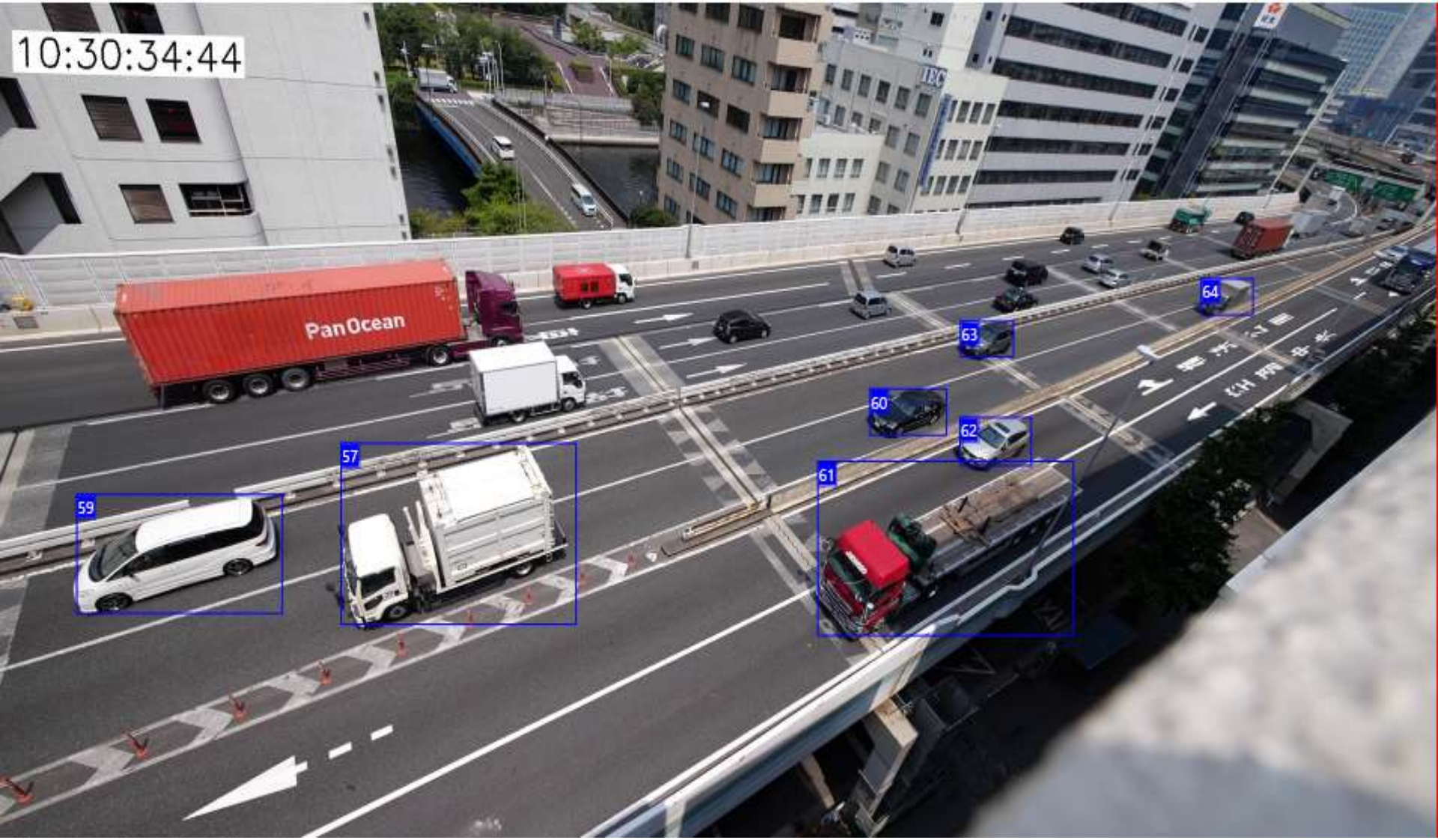
Data acquisition/processing (instrumented vehicles)

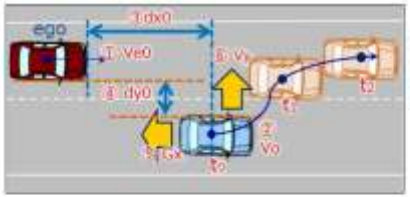


Data acquisition/processing (fixed cameras)

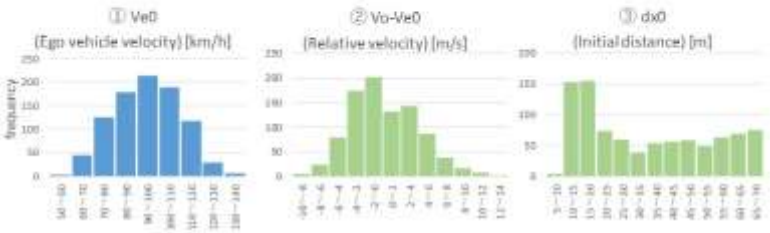


Derivation of scenario parameter ranges

① Data accumulation



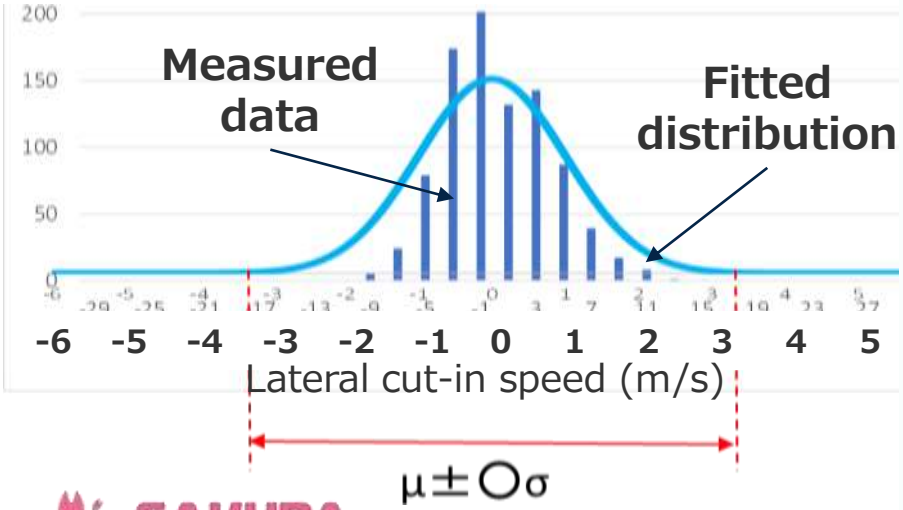
Scenario dependent parameter definition and automatic extraction



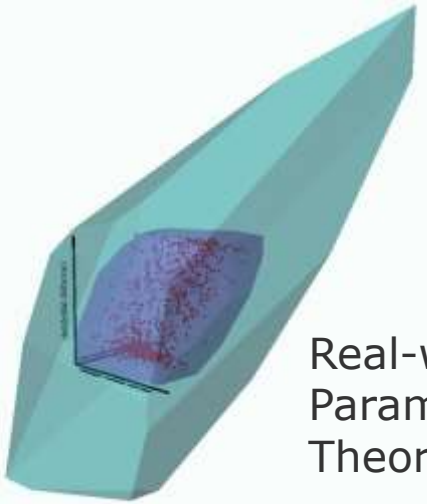
② Parameter correlation analysis

	① Ego-vehicle velocity	② Relative velocity	③ Initial distance	⑥ Lateral velocity
① Ego-vehicle velocity		Correlation	Correlation	No correlation
② Relative velocity	Correlation		Correlation	No correlation
③ Initial distance	Correlation	Correlation		No correlation
⑥ Lateral velocity	No correlation	No correlation	No correlation	

③ Parameter extrapolation



④ Parameter spaces



Real-world data
Parameter correlation
Theoretically foreseeable

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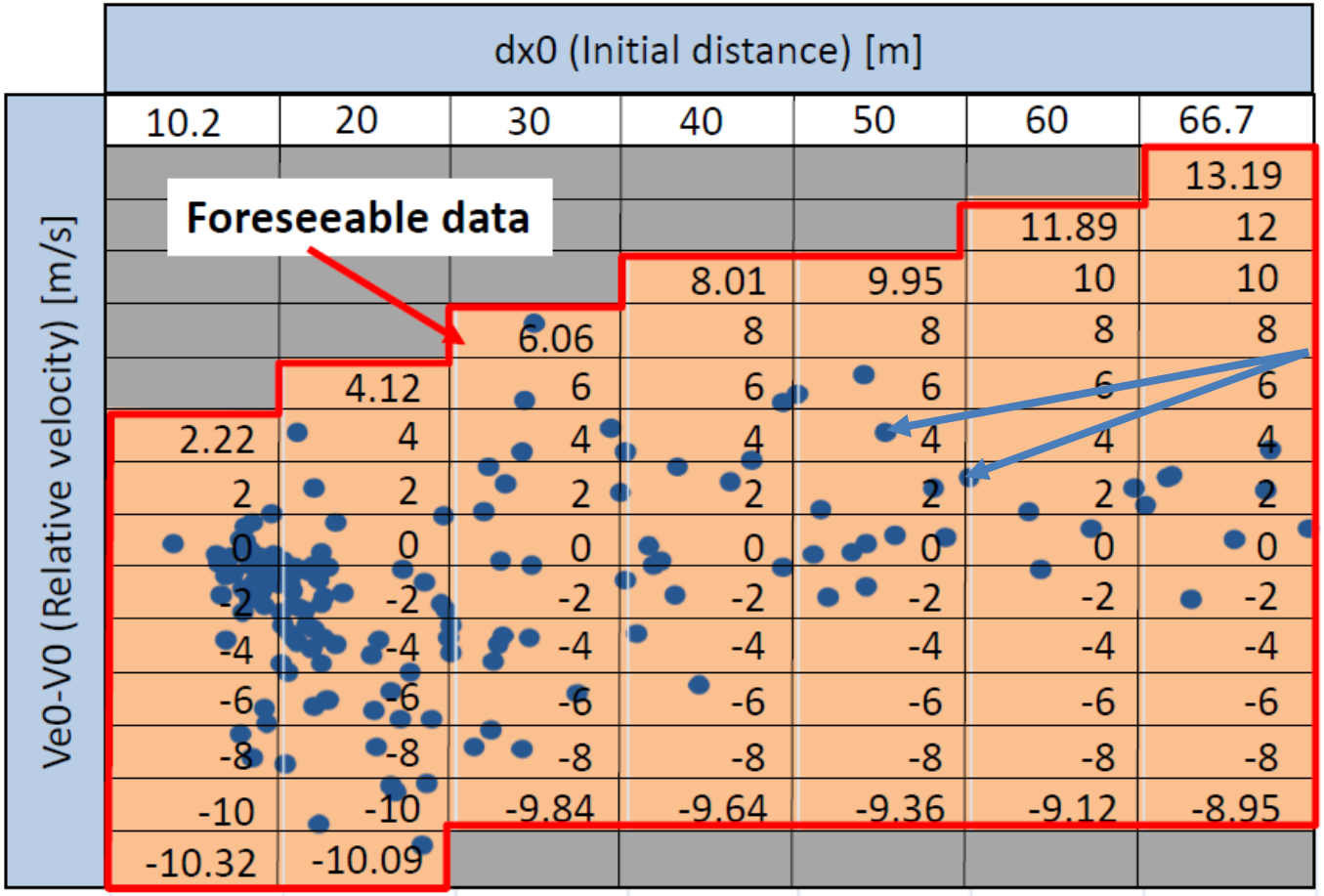
Rationally foreseeable parameters ranges

Precondition data :Ve0=80kph, Vy=1.72m/s



Measured data

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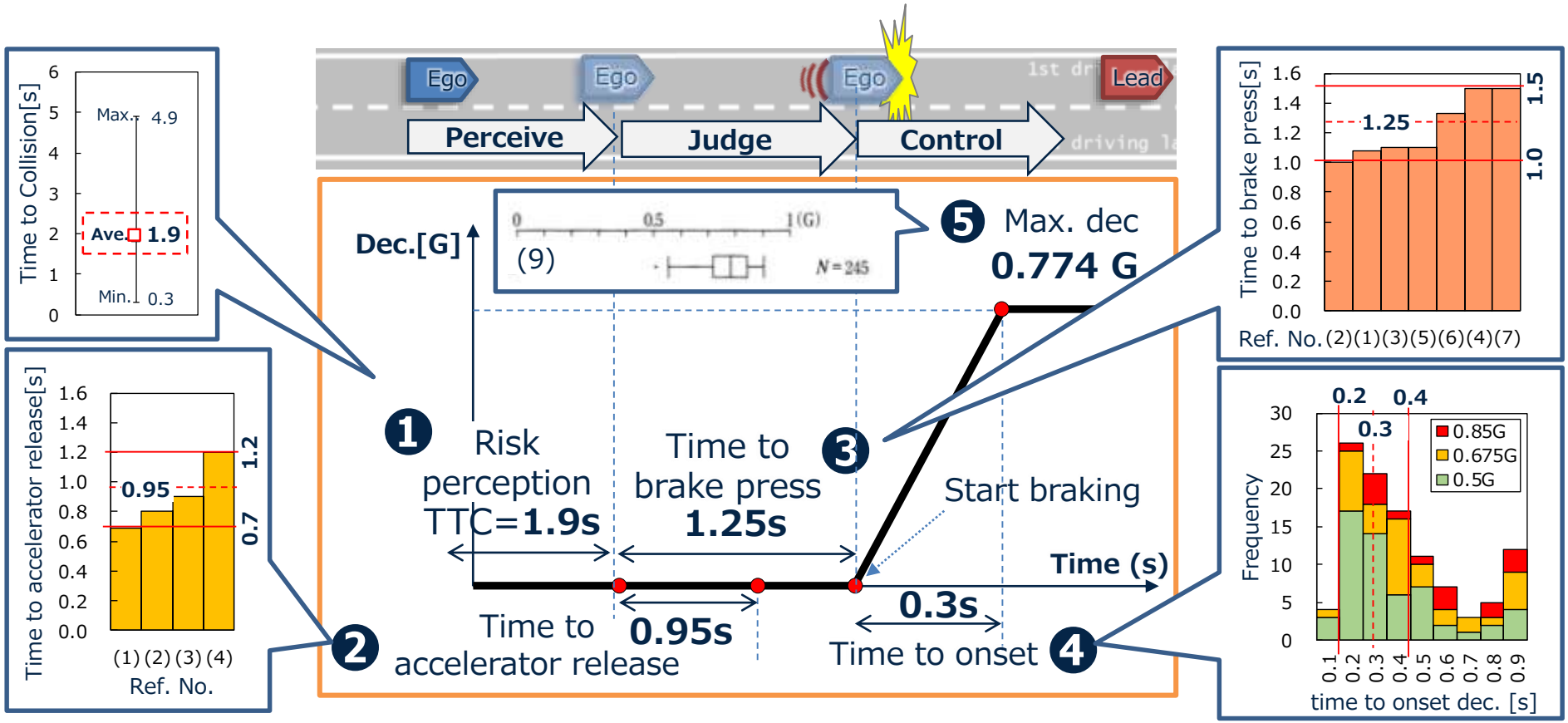
Experienced driver braking model



(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

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Virtual test results

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

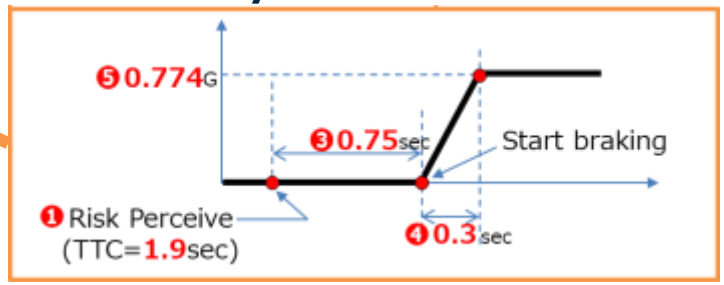
dx0(Initial Distance) [m]

Ve0-V0(Relative Velocity)[m/s]

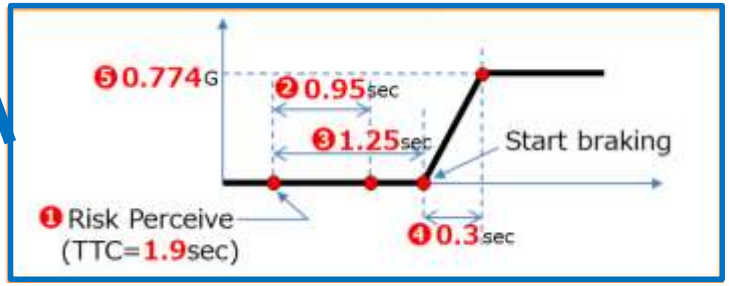
10.2	20	30	40	50	60	66.7
						✘ ✔13.19
					✘ ✔11.89	✘ ✔ 12
			✘ ✔ 8.01	✘ ✔ 9.95	✘ ✔ 10	✘ ✔ 10
		✔ ✔ 6.06	✘ ✔ 8	✘ ✔ 8	✘ ✔ 8	✘ ✔ 8
	✔ ✔ 4.12	✔ ✔ 6	✔ ✔ 6	✔ ✔ 6	✔ ✔ 6	✔ ✔ 6
✘ ✘ 2.22	✔ ✔ 4	✔ ✔ 4	✔ ✔ 4	✔ ✔ 4	✔ ✔ 4	✔ ✔ 4
✘ ✘ 2	✔ ✔ 2	✔ ✔ 2	✔ ✔ 2	✔ ✔ 2	✔ ✔ 2	✔ ✔ 2
✔ ✔ 0	✔ ✔ 0	✔ ✔ 0	✔ ✔ 0	✔ ✔ 0	✔ ✔ 0	✔ ✔ 0
✔ ✔ −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



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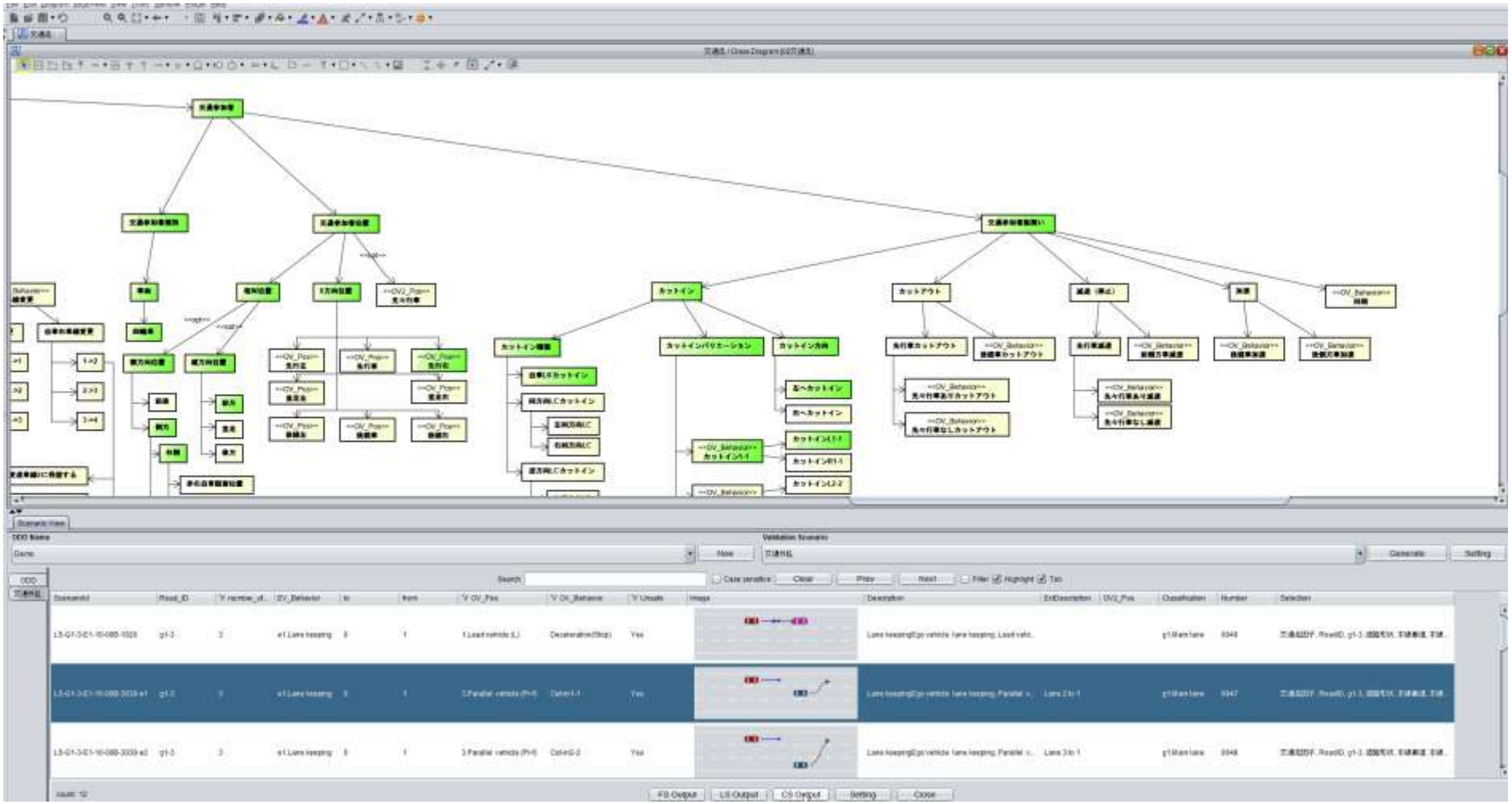
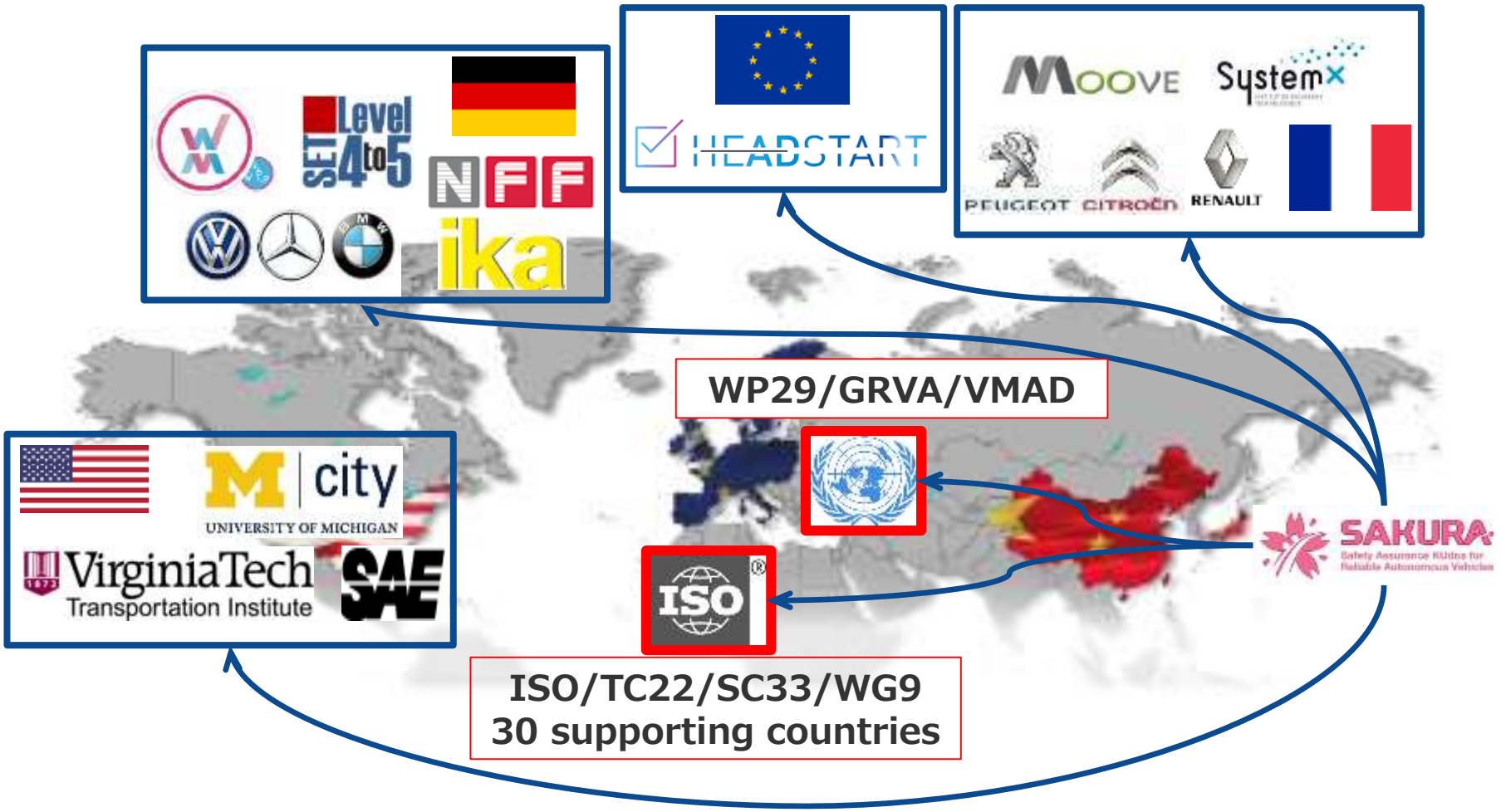
Database preparation



Global strategy



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.