



**SAKURA**

**Safety Assurance KUdos for  
Reliable Autonomous Vehicles**

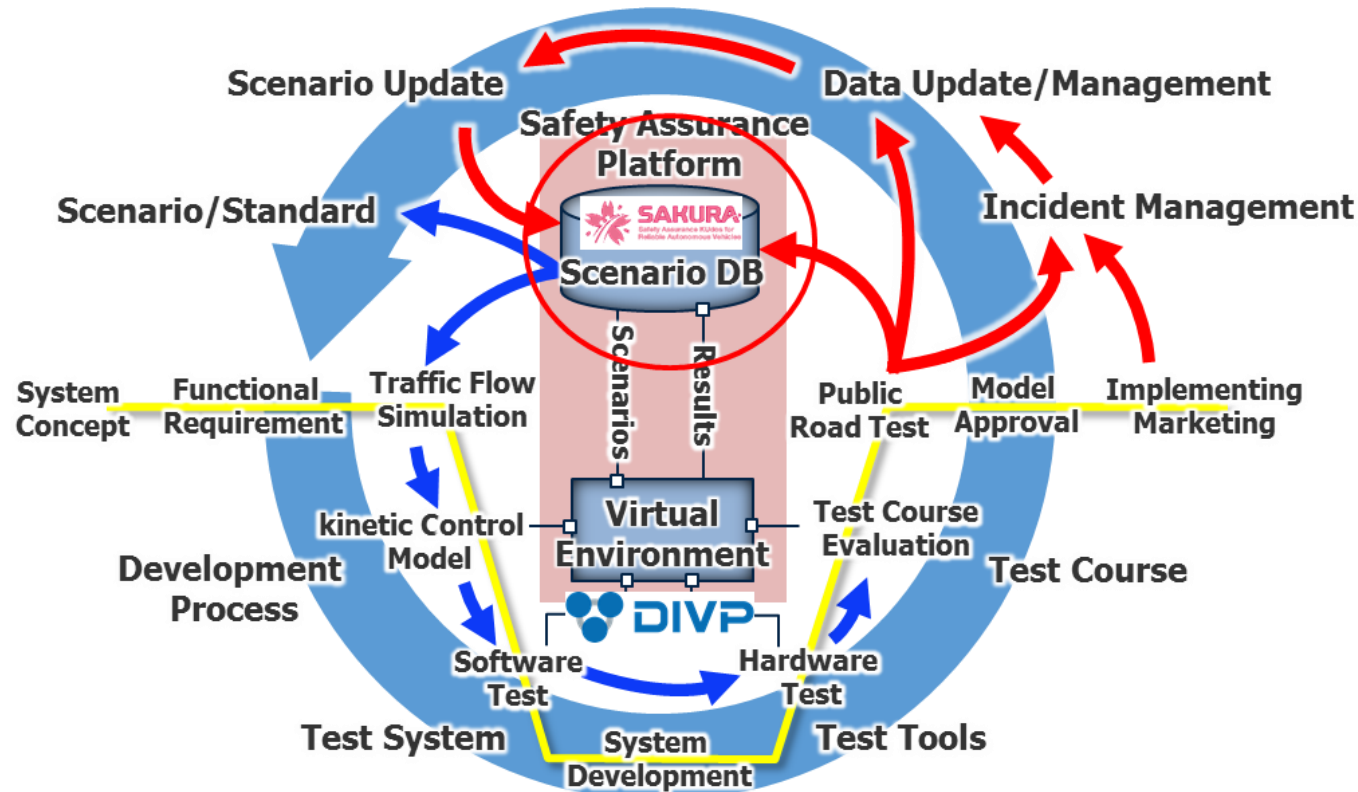
# **Scenario based safety assurance framework and scenario catalog**

**MLIT Japan**

# Overview of Japanese strategy for ADS safety

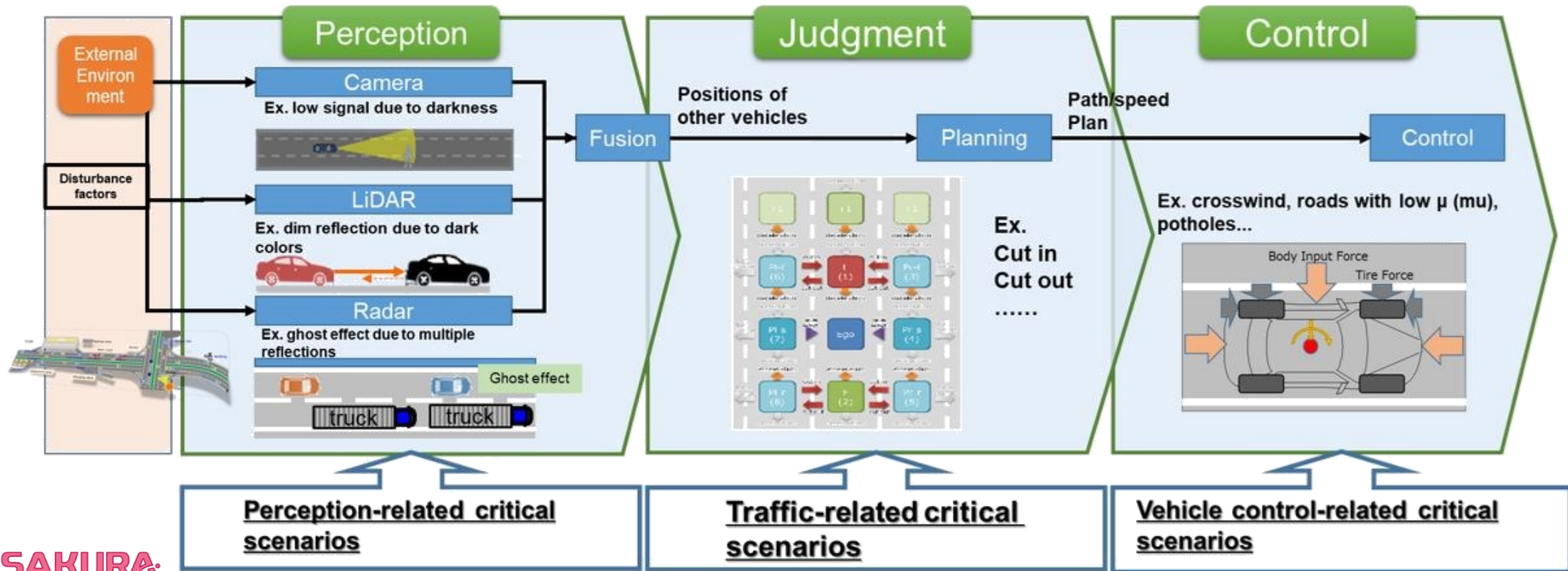
## ◆ Scenario based safety assurance in Japan

- Japan is considering ADS safety assurance framework
- SAKURA project is developing **scenario catalog** and **scenario database**
- DIVP is developing **virtual testing platform** with detailed **perception models**



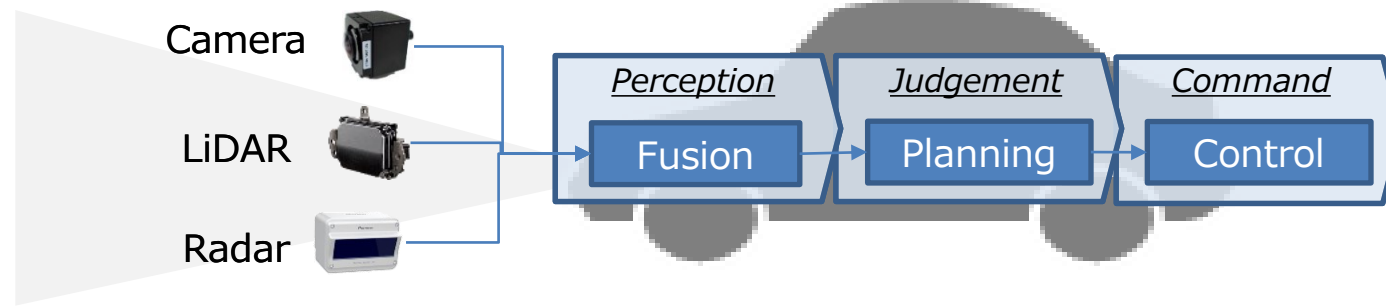
# Concept of safety evaluation framework

- ◆ Divide driving tasks into 3 independent tasks
- ◆ Define critical situations (scenario source) for each task
- ◆ Combination of 3 tasks are defined as “scenario” to be evaluated
- ◆ This framework is reflected in ISO 34502

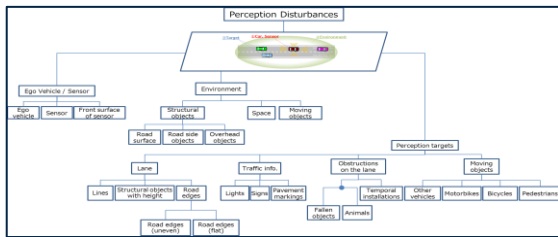


# Perception scenarios

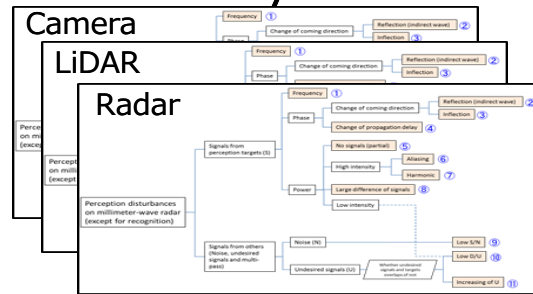
## ◆ Define safety critical scenarios by causal factors and sensor principles



### Environmental factor



### Sensor Physical Principle



### Evaluation scenario

		Physical principles (Perception of signals / sensor orientation)										Physical principles (Recognition)		
		Signals from perception targets (S)							Signals from others					
Ego vehicle / sensor	Environment	Frequency	Phase		Change of propagation delay	No signals (partial)	High intensity			Noise (N)	Undesired signals (U)	Increasing of U	Recognition process	
			Reflection (indirect wave)	Refraction			Aliasing	Harmonic	Large difference of signals					
Ego vehicle	Sensor													
Ego vehicle	Front surface of sensor													
Environment	Structural objects	Road surface												
		Roadside objects												
		Overhead objects												
	Space													
	Moving objects	Structural obstacles												
		Screen												
		Background												
	Lines	Color, Material												
		Shape												
		Dirty / Worn												
Structural objects with height	Color, Material													
	Shape - Large reflection intensity													
	Shape - Small reflection intensity													
Road edges	Color, Material													
	Shape													

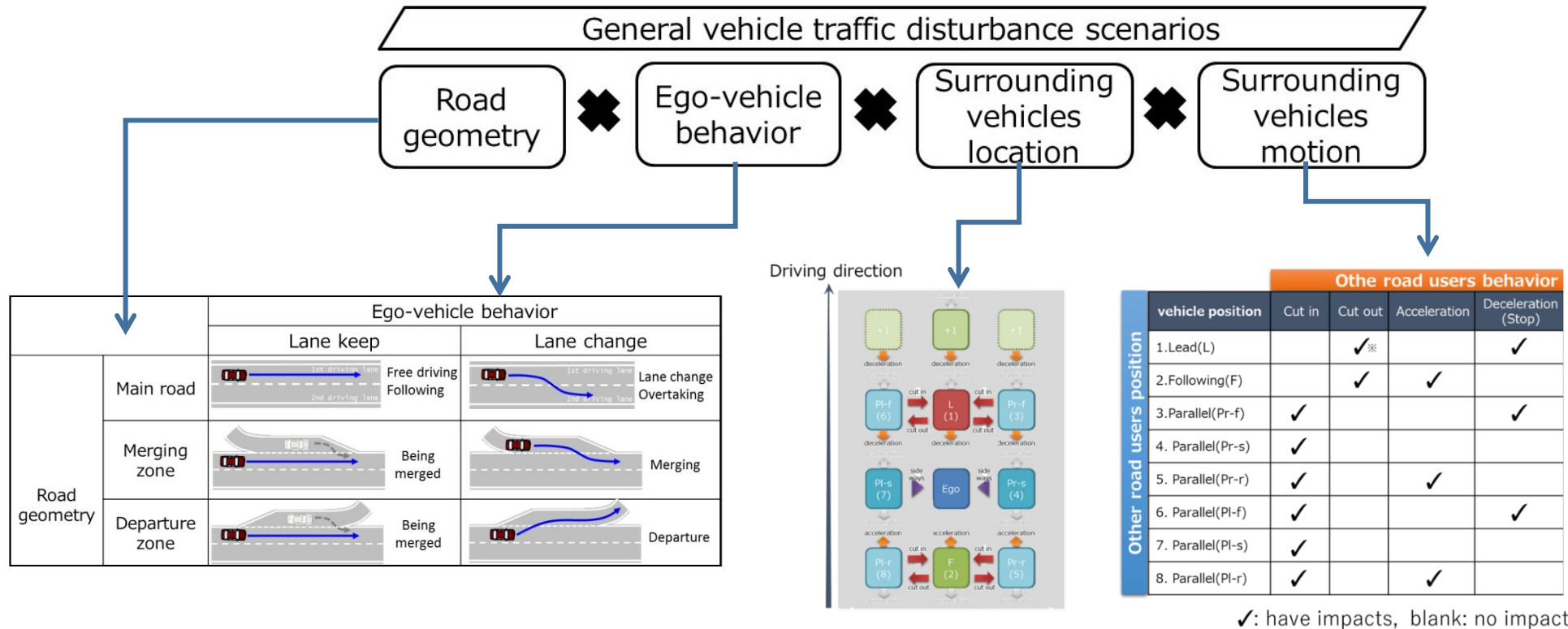
Limited evaluation scenarios based on sensor malfunction principle



# Traffic disturbance scenarios

Traffic scenarios organize and combine physical factors related to safety

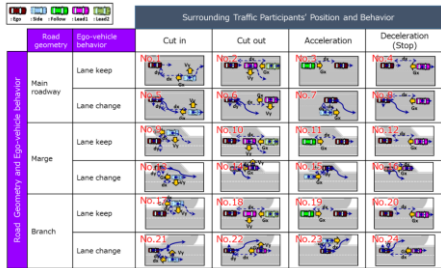
▶ Extract exhaustive and finite scenarios



Vehicle specific traffic-related critical scenario structure schematic

# Traffic disturbance scenarios (Car to Car)

- ◆ Categorize interactions with other traffic participants into finite patterns as Functional Scenario
- ◆ All patterns on the public roads are covered
  - e.g. roundabout is considered as sub-categories of merging or branch



Highway  
24 Scenarios

Road sector and subject-vehicle behaviour		Surrounding traffic participants location and behaviour															
		Subject-vehicle behaviour	Going straight				Lane change / Swerving				Turning						
			Same / Crossed(from R/L) direction		On coming		Same / Crossed(from R/L) direction		On coming		Same / Crossed(from R/L) direction		On coming				
non-intersection	Going straight (Lane keep)	No1	No2	No3	No4	No5	No6	No7	No8	No9	No10	No11	No12	No13	No14	No15	No16
	Lane change	No17	No18	No19	No20	No21	No22	No23	No24	No25	No26	No27	No28	No29	No30	No31	No32
Merge zone	Going straight (Lane keep)	No33	No34	No35	No36	No37	No38	No39	No40	No41	No42	No43	No44	No45	No46	No47	No48
	Lane change	No49	No50	No51	No52	No53	No54	No55	No56	No57	No58	No59	No60	No61	No62	No63	No64
Branch zone	Going straight (Lane keep)	No65	No66	No67	No68	No69	No70	No71	No72	No73	No74	No75	No76	No77	No78	No79	No80
	Lane change	No81	No82	No83	No84	No85	No86	No87	No88	No89	No90	No91	No92	No93	No94	No95	No96
Intersection	Going straight (Lane keep)	No97	No98	No99	No100	No101	No102	No103	No104	No105	No106	No107	No108	No109	No110	No111	No112
	Turning	No113	No114	No115	No116	No117	No118	No119	No120	No121	No122	No123	No124	No125	No126	No127	No128

Urban 58 Scenarios

Add physical factors (turning maneuver, oncoming vehicle, and intersection)

# Traffic disturbance scenarios (Car to VRU)

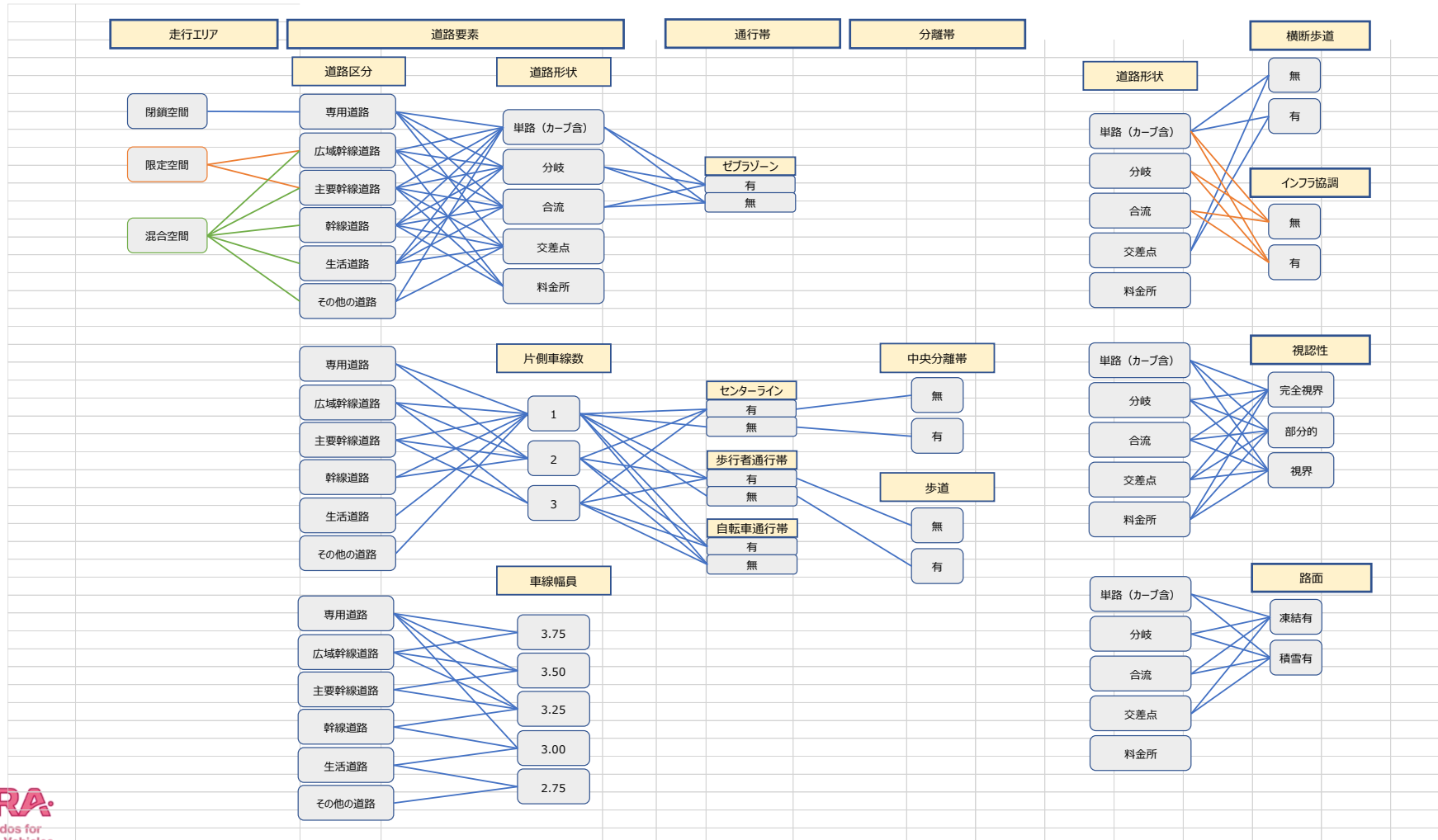
◆ Pedestrian behavior is simplified into 2 patterns

		Pedestrian behavior			
		Walk in driving path	Cross driving path		
Road geometry and Sub. vehicle behavior	Non intersection	Go straight P01		P02	
		Lane change P03		P04	
	Intersection	Go straight P05		P06	
		Turn P07		P08	



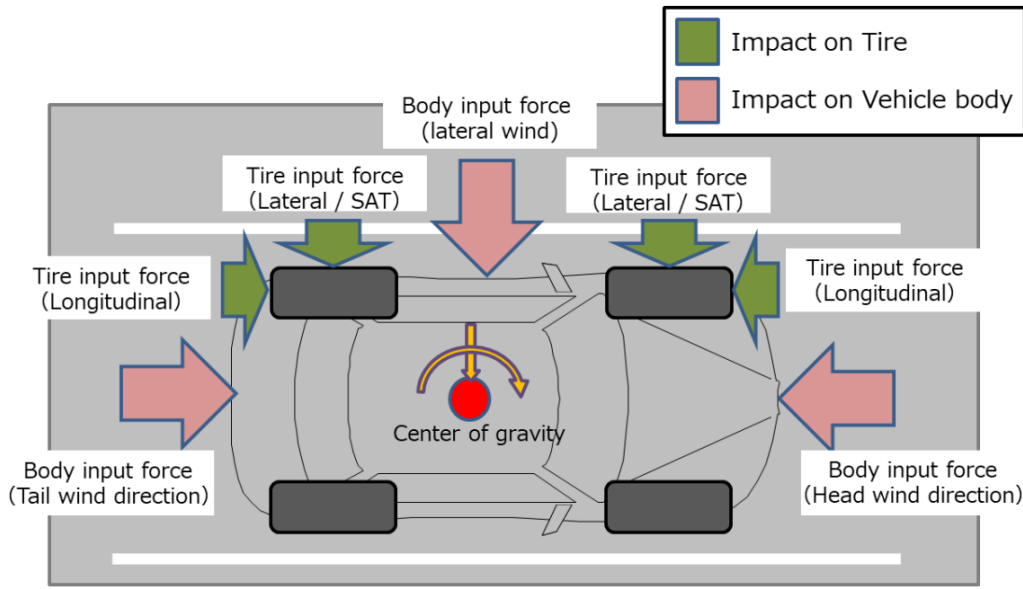
# Structuring entities for detailed scenarios (in progress)

- ◆ Entities listed on ISO 34504 are structured to define detailed Abstract/Logical/Concrete Scenarios from Functional Scenarios

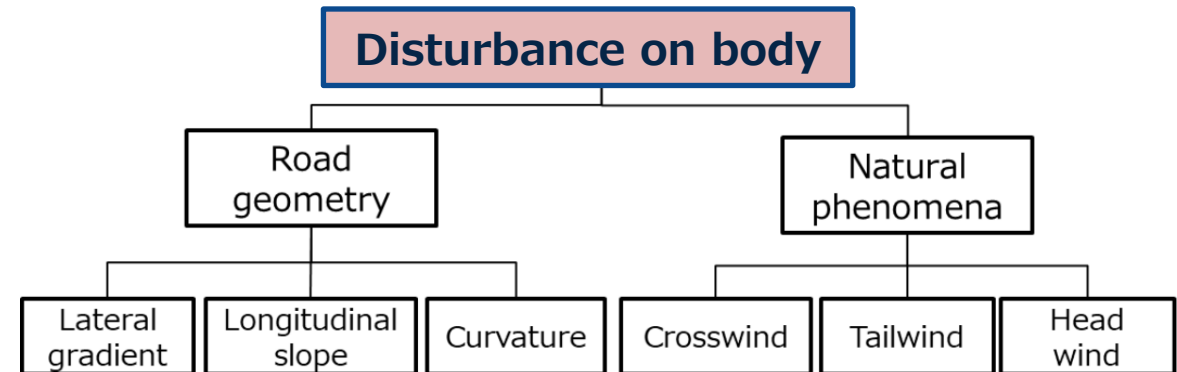
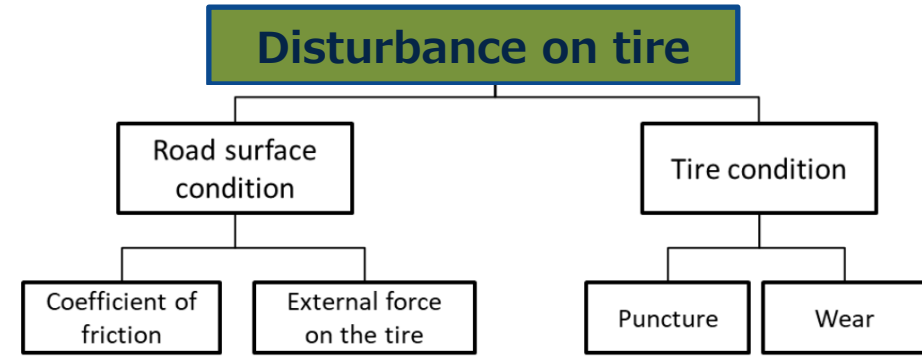


# Vehicle stability disturbance scenario

◆ Scenario is divided into 2 main categories: tire and body



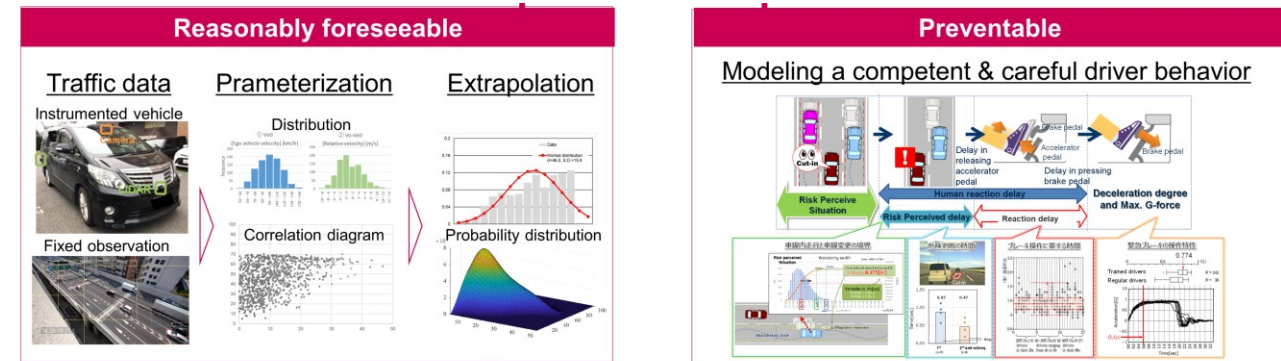
physical principle of vehicle dynamics



# SAKURA database in the context of SA toolchain

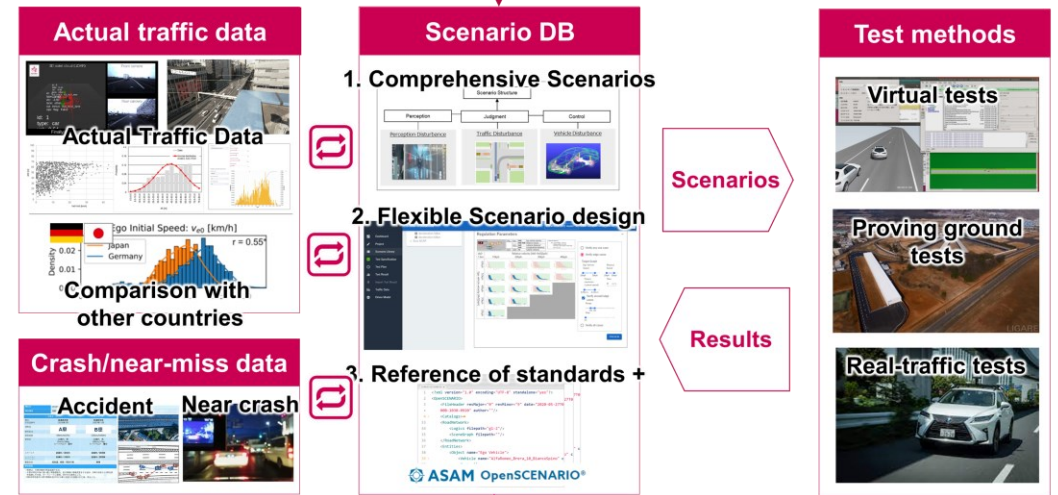
## ◆ Quantify foreseeable and preventable for traffic disturbance scenario

- **Measurement of traffic data**
  - Validate functional scenarios
  - Estimate parameter distribution
- **Modelling C&C driver behavior**
  - Preventable boundary
- **Near crash/Accident scenarios**
  - ※under development



## ◆ Integrate with testing methods

- Provide relevant exposure
- Output concrete scenarios

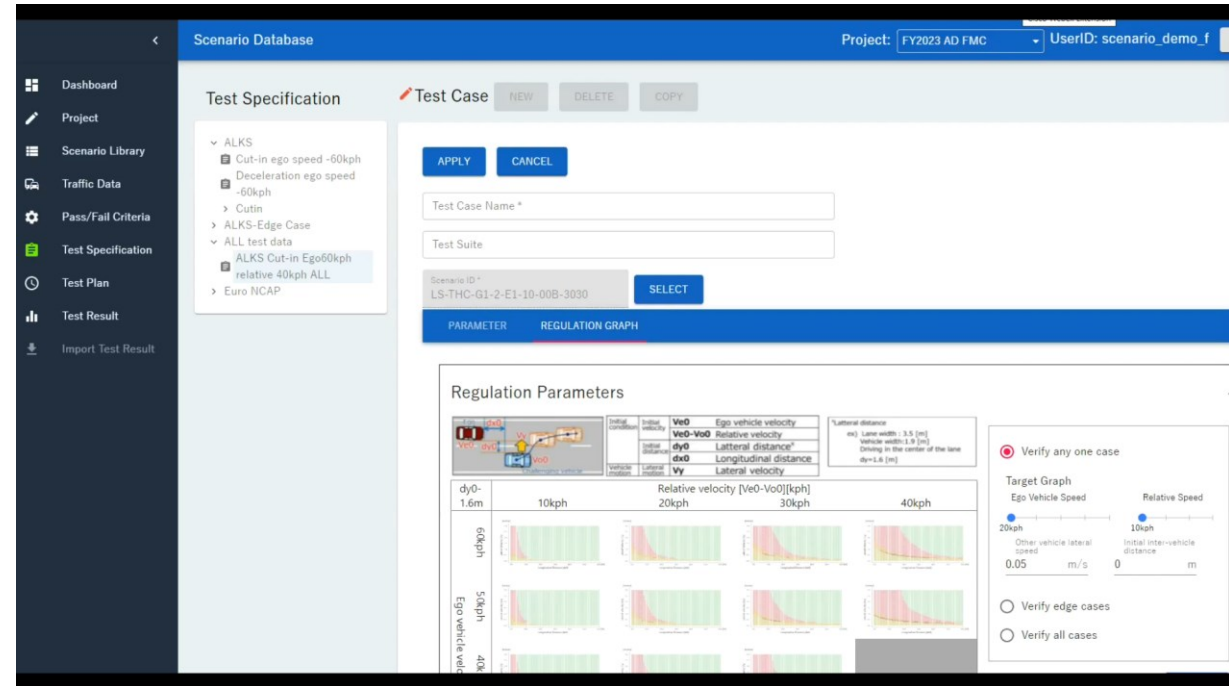


# SAKURA database as practical pipeline

- ◆ Database provides quantitative thresholds for safety assurance
  - Reference for reasonably foreseeable parameter range
  - Pass/Fail Criteria based on C&C driver behavior



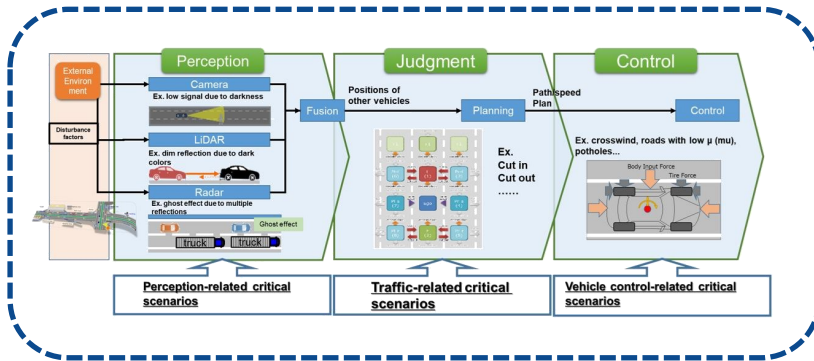
Traffic parameter database



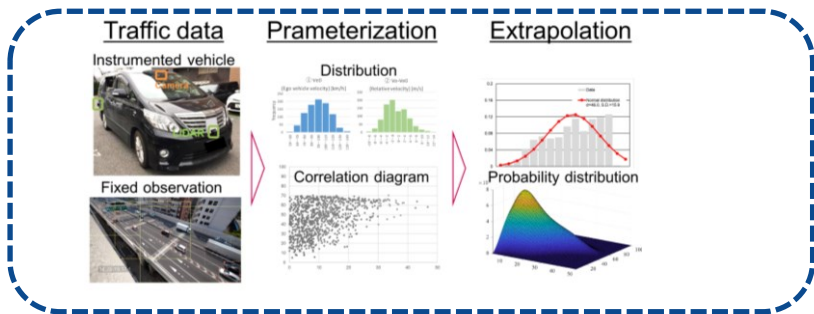
Traffic criteria database

# Overview of SAKURA Framework

Functional Scenario Catalog



Real Traffic Analysis (based on ODD)



C&C Driver Model



Scenario DB

Comprehensive Scenarios

Functional Scenario

Logical Scenario

Reasonably Foreseeable Scenarios

Concrete Scenario (incl. Pass/Fail Criteria)

Pass/Fail Criteria (Preventable boundary)

Test methods



# Summary

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- ◆ **Scenario catalog is being developed to define necessary and sufficient test scenarios**
  - Japan framework is intended to cover **all safety critical scenarios** which ADS may exposed on real traffic
- ◆ **Safety critical scenarios for each driving task are structured**
  - Perception scenarios determine **sensor weakness situation** based on **environmental causal factors** and **sensor detection principles**
  - Traffic disturbance scenarios are defined with **behaviors of traffic participants** and **road geometry** to cover all possible interaction
- ◆ **SAKURA Scenario database is being developed**
  - To bridge the gap between methodology and practical test platform (including virtual simulation) SAKURA database is developed to provide **quantitative threshold of reasonably foreseeable and preventable boundary** of traffic disturbance scenarios