

Results of the simulation studies on reducing  
automobile noise by tightening regulations on  
accelerated driving noise for four-wheeled  
vehicles

The 8th TF-VS  
4th April, 2022  
JAPAN

## ◆ Targets

- ✓ To achieve 100% in the EQSs (Environmental Quality Standards) for Road Traffic Noise
- ✓ To reduce the number of complaints related to vehicle noise

EQS: An administrative goal set as a standard that should be maintained for the protection of human health and the preservation of the living environment, and the standard value is set for each area type and time category.

## ◆ Current status of accelerated driving noise regulation for four-wheeled vehicles in Japan

- The third report of the Future Policy for Motor Vehicle Noise Reduction (July 2015. Central Environment Council) has recommended to introduce the test methods and the limit values of R51-03. -> Phase 1 was introduced in October 2016 and Phase 2 in September 2020.
- On the other hand, the third report stated that the harmonization with the phase 3 limit values of R51-03 and the timing of its introduction will be studied in Japan, taking into account the technical prospects, etc., as well as the status of other regulations (emissions, fuel consumption, safety, etc.), while taking into consideration the study status of UN-ECE/WP29 and other regulations.

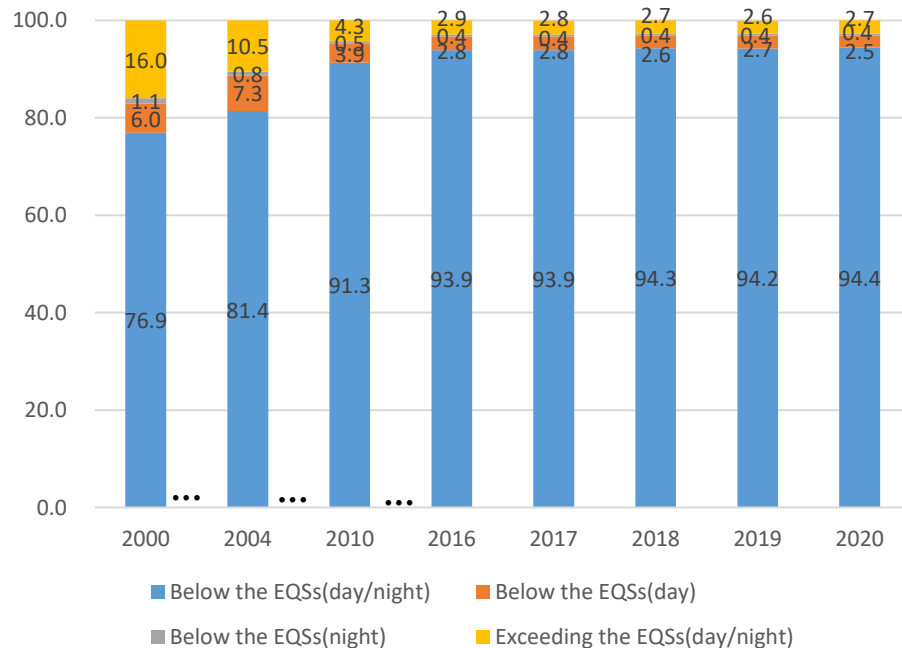
# Current situation of vehicle noise

- ✓ The achievement status of the EQSs of Road Traffic Noise has gradually improved, but has not reached 100% yet.

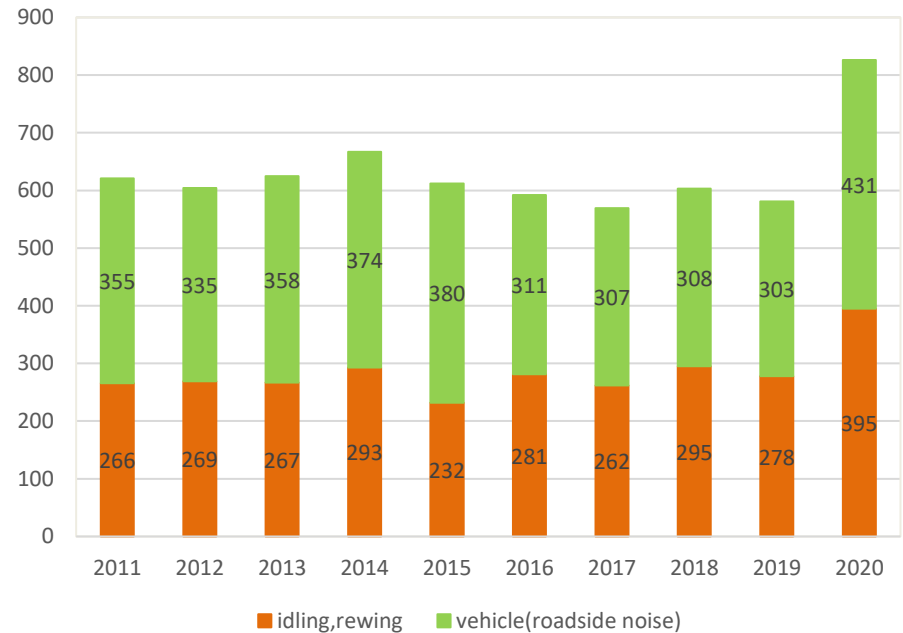
\* EQSs of RTN: The standard value of the space near the road that carries the main traffic is 70 dB or less during the day and 65 dB or less at night. (Evaluation method is  $L_{Aeq}$ )

- ✓ The number of complaints of vehicle noise has increased or decreased depending on the year, but has not been decreasing in recent years.

Achievement status of the EQSs of RTN



Number of complaints related to vehicle noise



- ✓ In terms of R51-03, before introducing phase3, its effect should be verified

<The result of GRB 60th session in 2014>

GRB noted that, following the entry into force of phase 2 for new types of vehicles, EU would undertake a detailed study to review the limits of phase 3 and to correct these values, if deemed to be necessary. Other Contracting Parties were invited to conduct similar studies in the future and to transmit their outcomes to GRB.



Conducted the study to assess the effectiveness of phase3 introduction at the points exceeding EQSs, by using a prediction model

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# Impact prediction of tightening R51-03 noise regulations on road traffic noise

Japan Automobile Research Institute

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# Contents

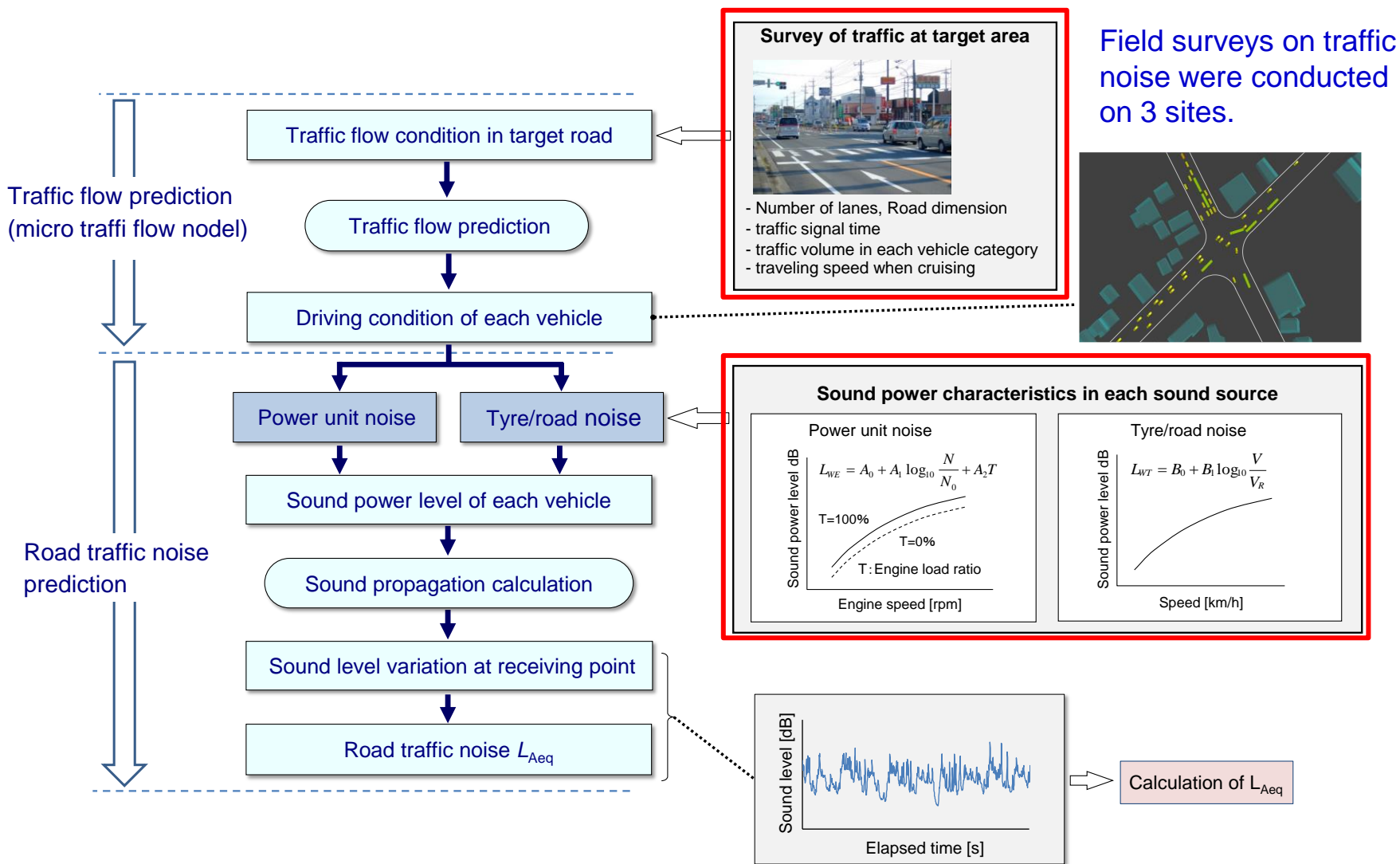
- 1. Method and condition for predictive calculations**
- 2. Field surveys on traffic flow and road traffic noise**
- 3. Result of impact prediction**

# Method and conditions

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- **The original road traffic noise prediction model developed by JARI was applied for the prediction.**
- **Changes in road traffic noise were calculated in case that phase 3 was applied to all vehicles to those conformed to phase 2.**
- **Assumed dense asphalt pavement (maximum chipping size of 13 mm) of average condition.**
- **Based on distributions of measured  $L_{\text{urban}}$  of vehicles conformed to phase 1 and phase 2 provided by JAMA.**

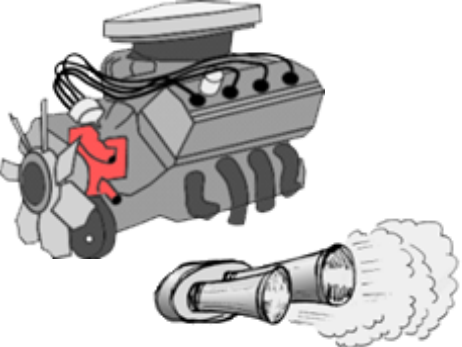
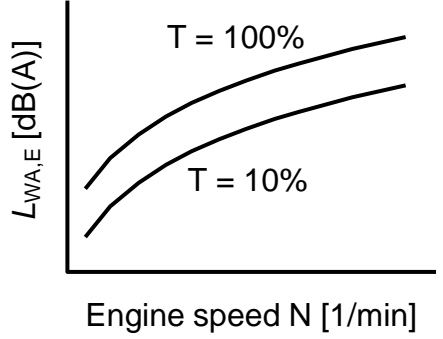
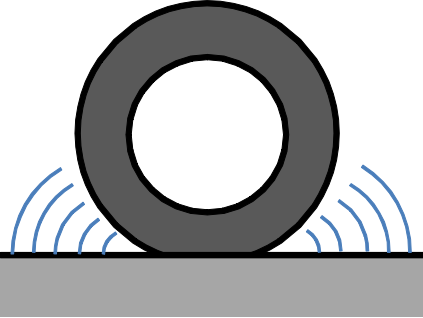
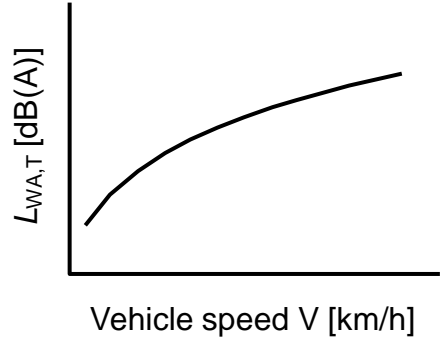
# Road traffic noise prediction model developed by JARI



- Power unit noise and tyre/road noise are treated as individual sound sources.
- Running conditions and generated noise of individual vehicles are taken into consideration.

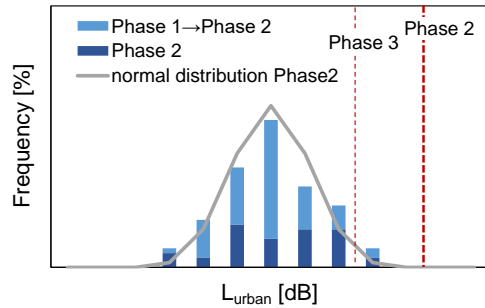


# Expression of sound power level for each sound source

Sound sources	Experimental equations	
<p data-bbox="164 321 483 357">Power unit noise</p> 	$L_{WA,E} = A_0 + A_1 \log_{10} \frac{N}{N_0} + A_2 T$ <p data-bbox="666 464 1130 506"><math>N</math> : Engine speed (rpm)</p> <p data-bbox="666 521 1352 564"><math>N_0</math> : Reference engine speed (1 rpm)</p> <p data-bbox="666 578 1062 621"><math>T</math> : Engine load (%)</p> <p data-bbox="666 635 1255 678"><math>A_0 \sim A_2</math> : Regression coefficients</p>	
<p data-bbox="164 778 473 813">Tyre road noise</p> 	$L_{WA,T} = B_0 + B_1 \log_{10} \frac{V}{V_0}$ <p data-bbox="666 956 1130 999"><math>V</math> : Vehicle speed (km/h)</p> <p data-bbox="666 1013 1352 1056"><math>V_0</math> : Reference vehicle speed (1 km/h)</p> <p data-bbox="666 1071 1217 1113"><math>B_0, B_1</math> : Regression coefficients</p>	

# Setup of sound source characteristics for LDVs

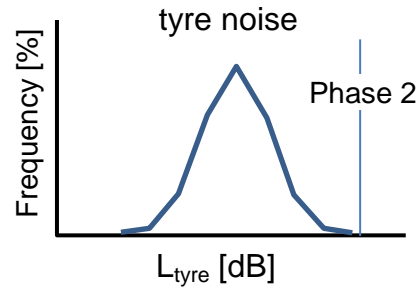
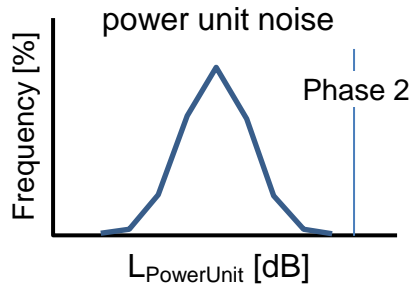
$L_{urban}$  of phase 2 compliant vehicles



Contribution rate of power unit noise and tyre noise in R51-03  $L_{urban}$

M1	50:50 (except "kei")	65:35 ("kei")
N1	60:40 (except "kei")	75:25 ("kei")
N2	90:10	
N3B	90:10 (6 wheels)	
N3C	85:15 (12 wheels)	

Level distribution of each sound source in  $L_{urban}$

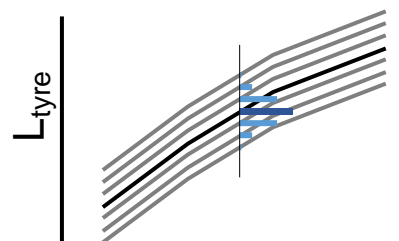
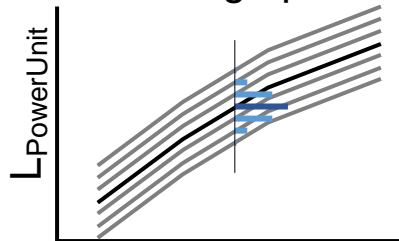


Road surface correction

ISO road surface

DAC surface in average condition

Setting up sound source characteristics



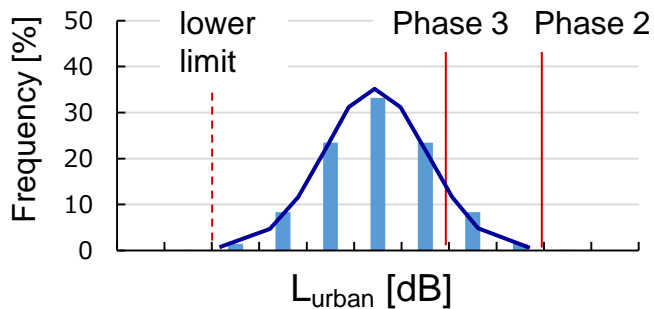
Engine speed N [1/min]

Vehicle speed V [km/h]

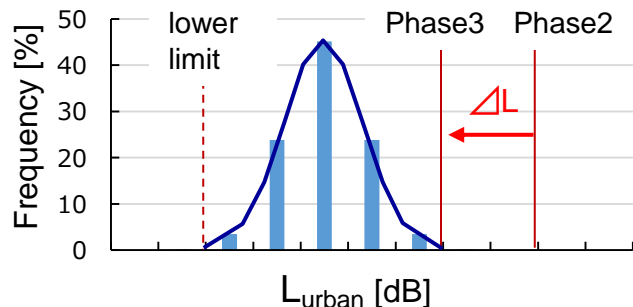
# Changes in frequency distributions of noise sources

## Frequency distribution of $L_{urban}$

Phase 2 (normal distribution)

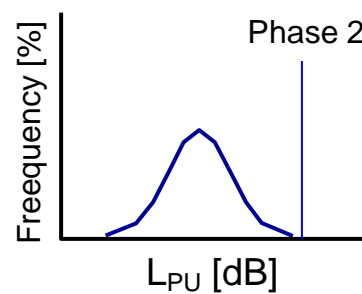


Application of phase 3  
(normal distribution (fixed lower limit) )

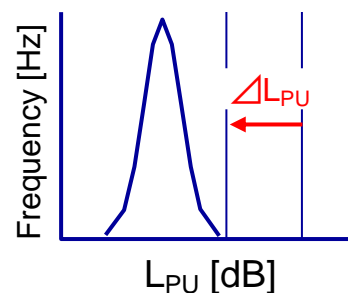


## power unit noise

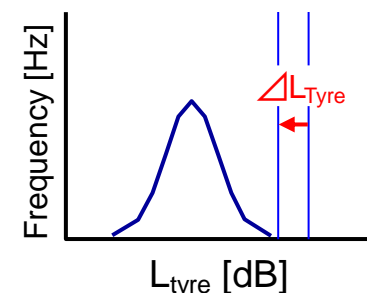
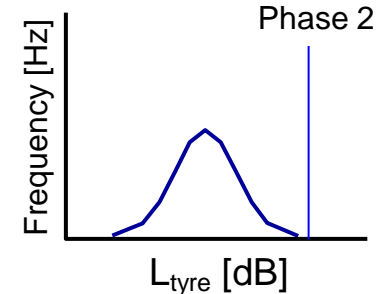
Noise source contribution rate of all vehicles was assumed to be constant in phase 2



Reduction of the upper limit according to the assumed reduction rate



## tyre/road noise



Reduction rate of upper limit  $\Delta L_{PU} : \Delta L_{Tyre}$

LDV (M1,N1) :  $\Delta L_{PU} : \Delta L_{Tyre} = 75 : 25$  and  $50 : 50$

HDV (N2,N3) :  $\Delta L_{PU} : \Delta L_{Tyre} = 100 : 0$

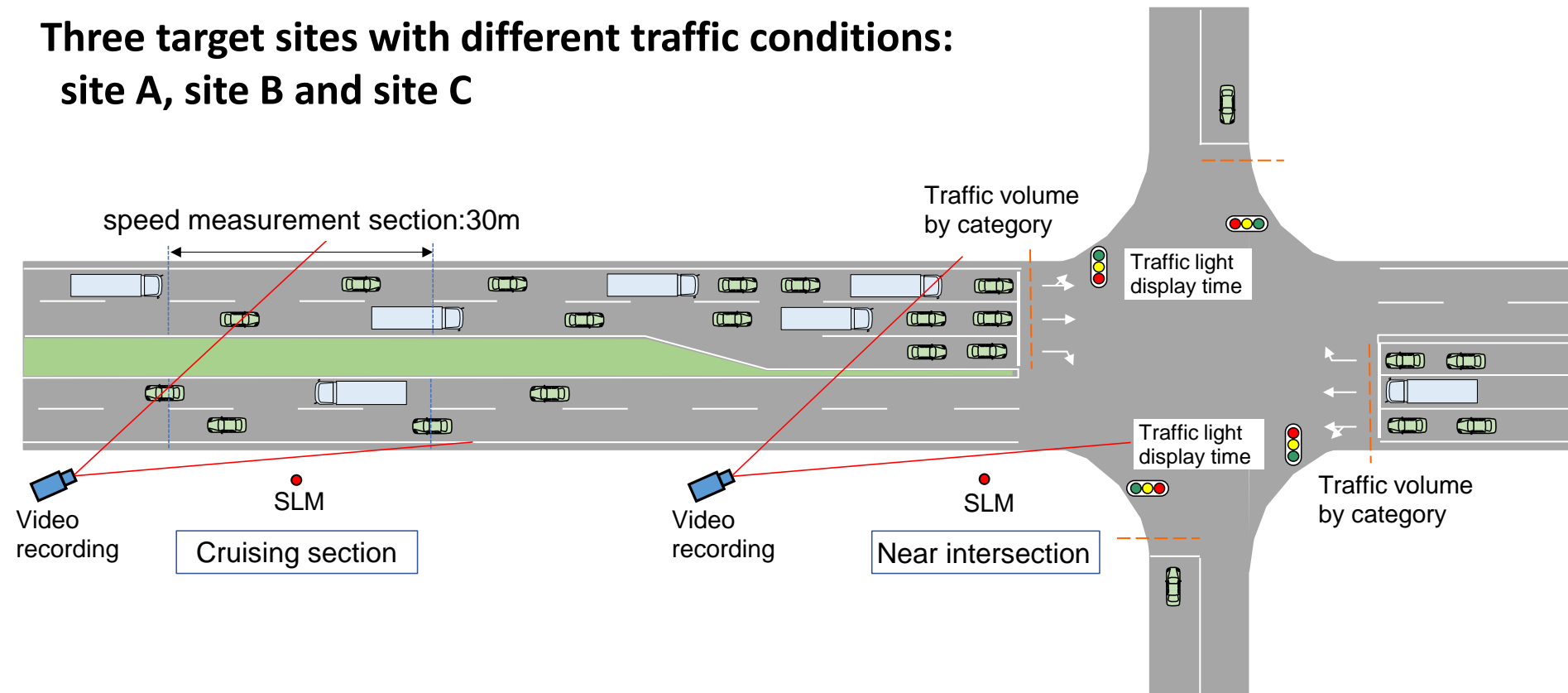
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# Contents

1. Method and condition for predictive calculations
2. Field surveys on traffic flow and road traffic noise
3. Result of impact prediction

# Field survey on traffic flow and noise

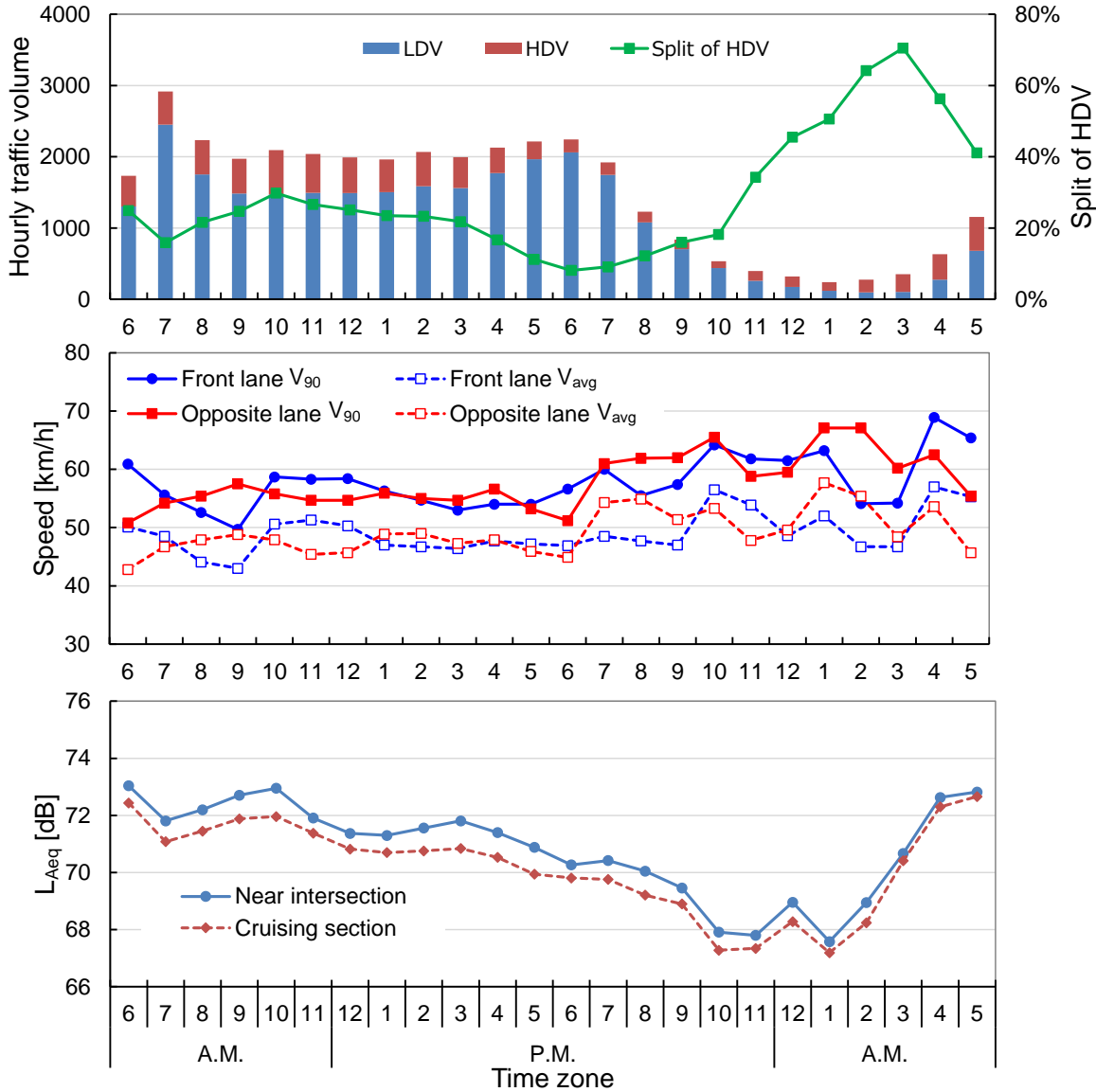
Three target sites with different traffic conditions:  
site A, site B and site C



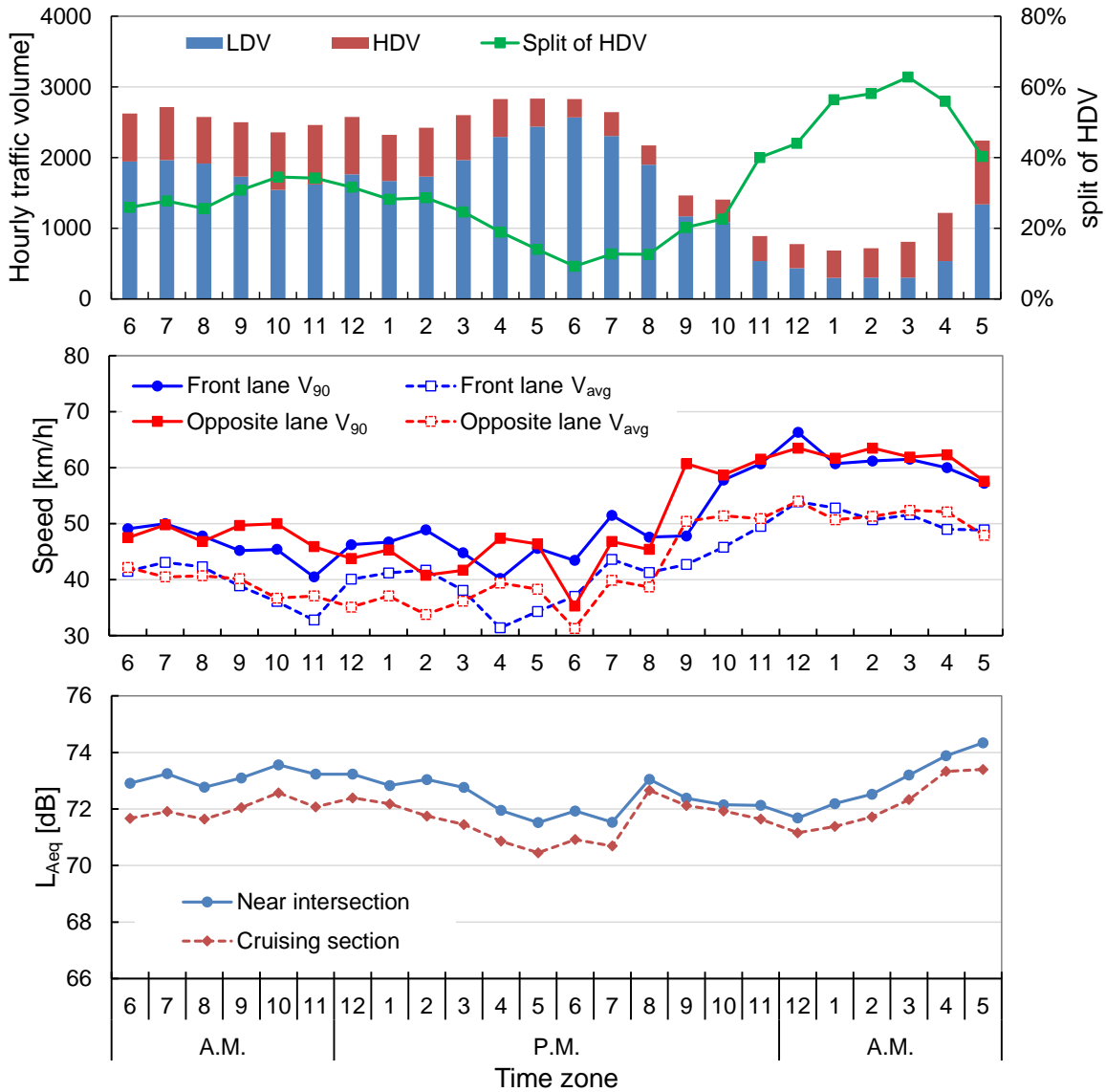
Data input into the prediction model.

- dimension of road: lane width, distance between intersections, etc.
- traffic volume of each vehicle category
- speed in cruising
- traffic light display time

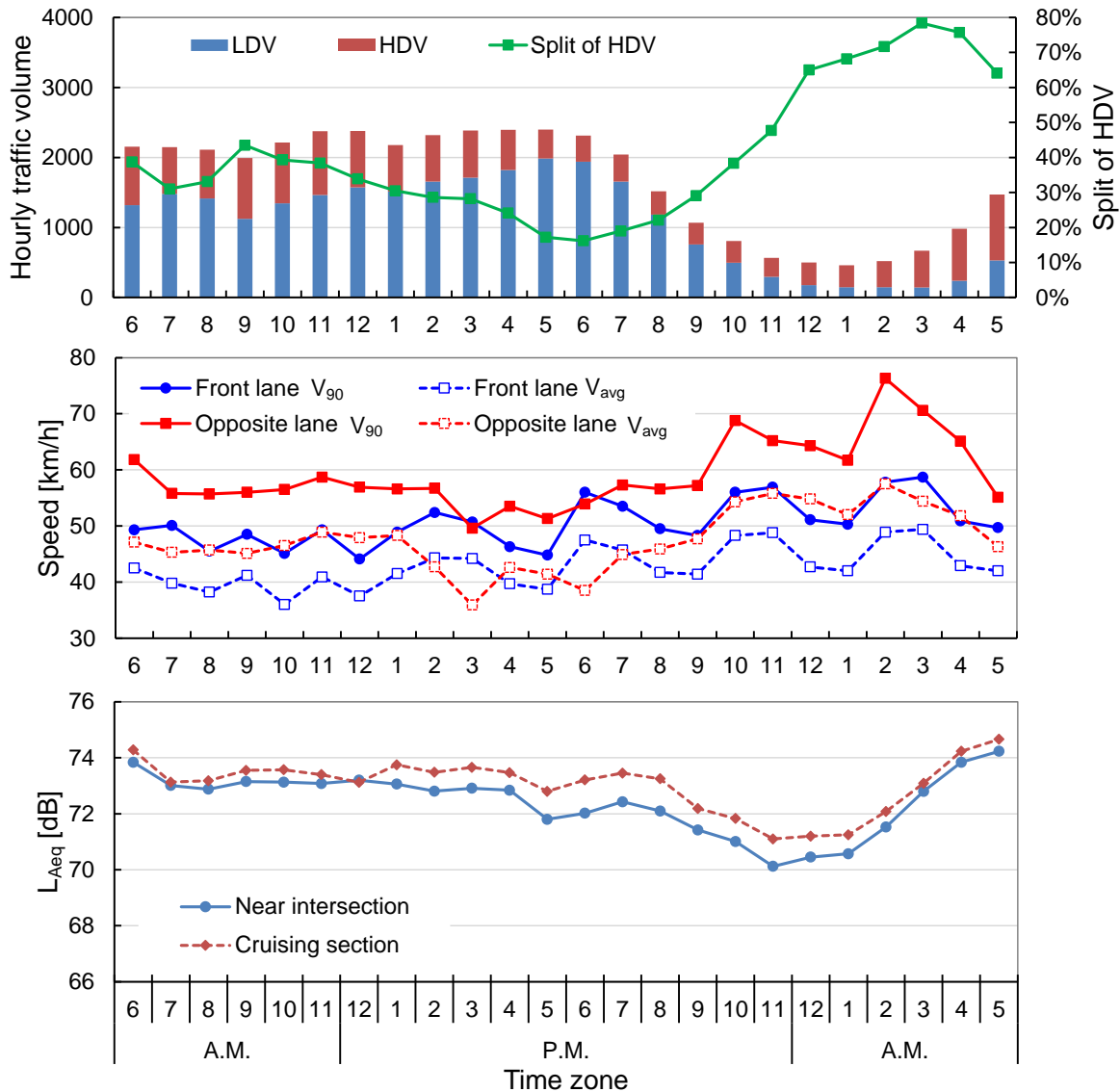
# Result of field survey at site A



# Result of field survey at site B



# Result of field survey at site C





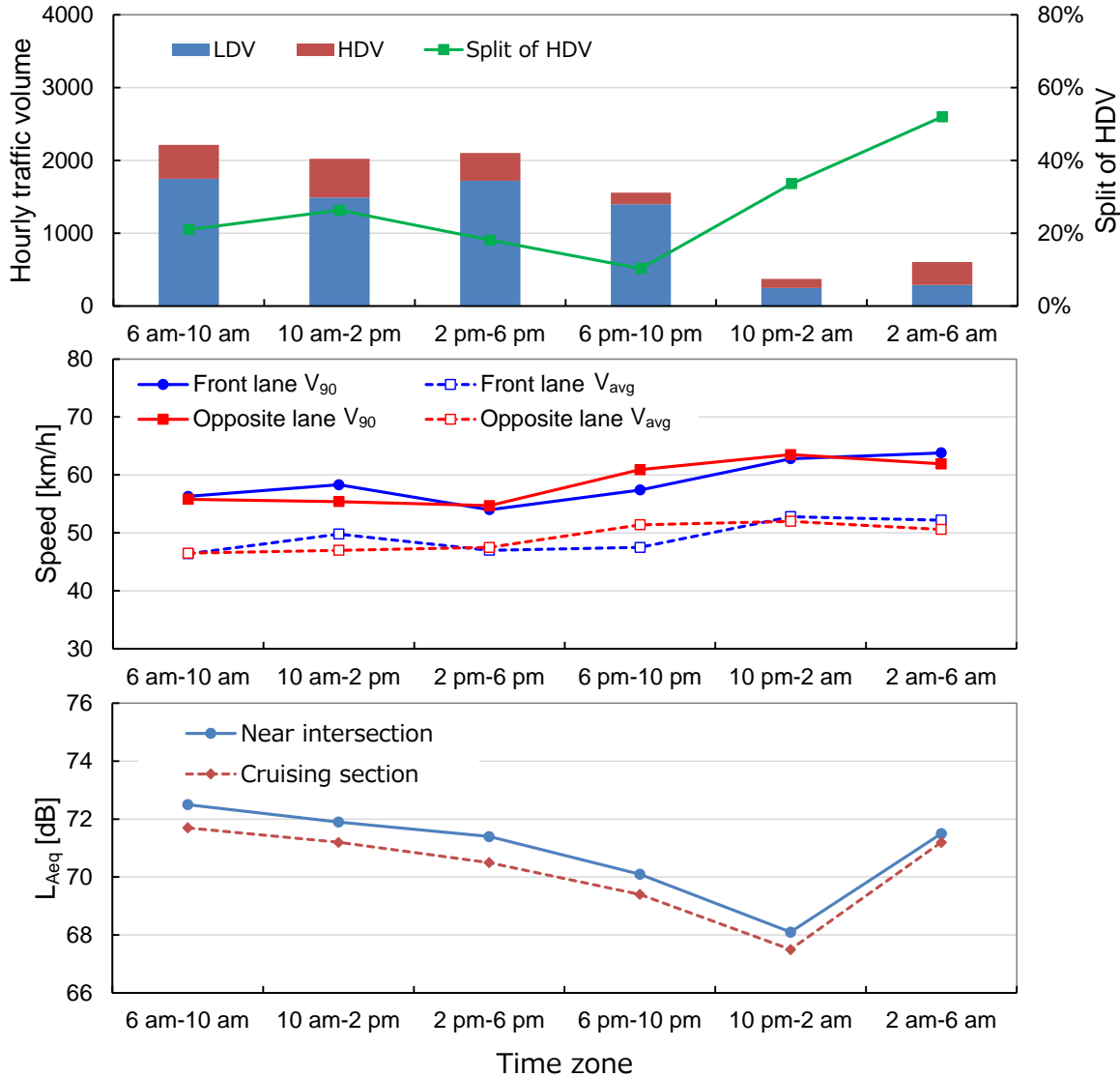
# Time zone division in road traffic noise evaluation

24 hours are divided into 6 time zones (4 hours each). This enables:

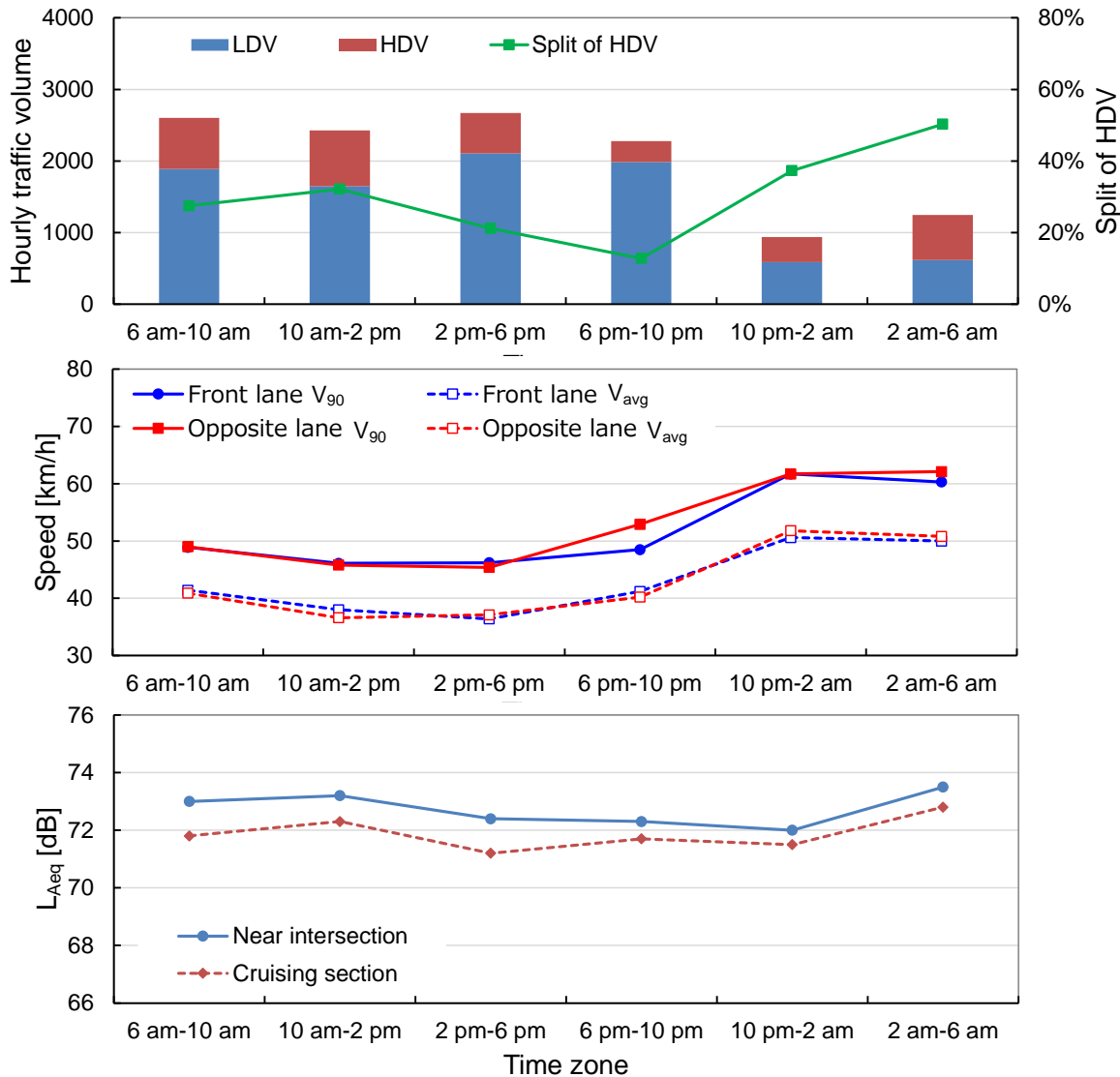
- Field survey data can be used effectively.
- The characteristics of the traffic flow in each time zone can be expressed to some extent.
- Evaluation corresponding to domestic daytime and nighttime  $L_{Aeq}$  and European  $L_{den}$  is possible (1 hour difference in  $L_{den}$ )

	AM						PM											AM					
	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
Adopted time division	6 am-10 am				10 am-2 pm		2 pm-6 pm				6 pm-10 pm				10 pm-2 am			2 am-6 am					
$L_{Aeq}$ in road traffic noise evaluation in Japan							Day									Night							
$L_{den}$ in Environmental Noise Directive							Day						Evening				Night						

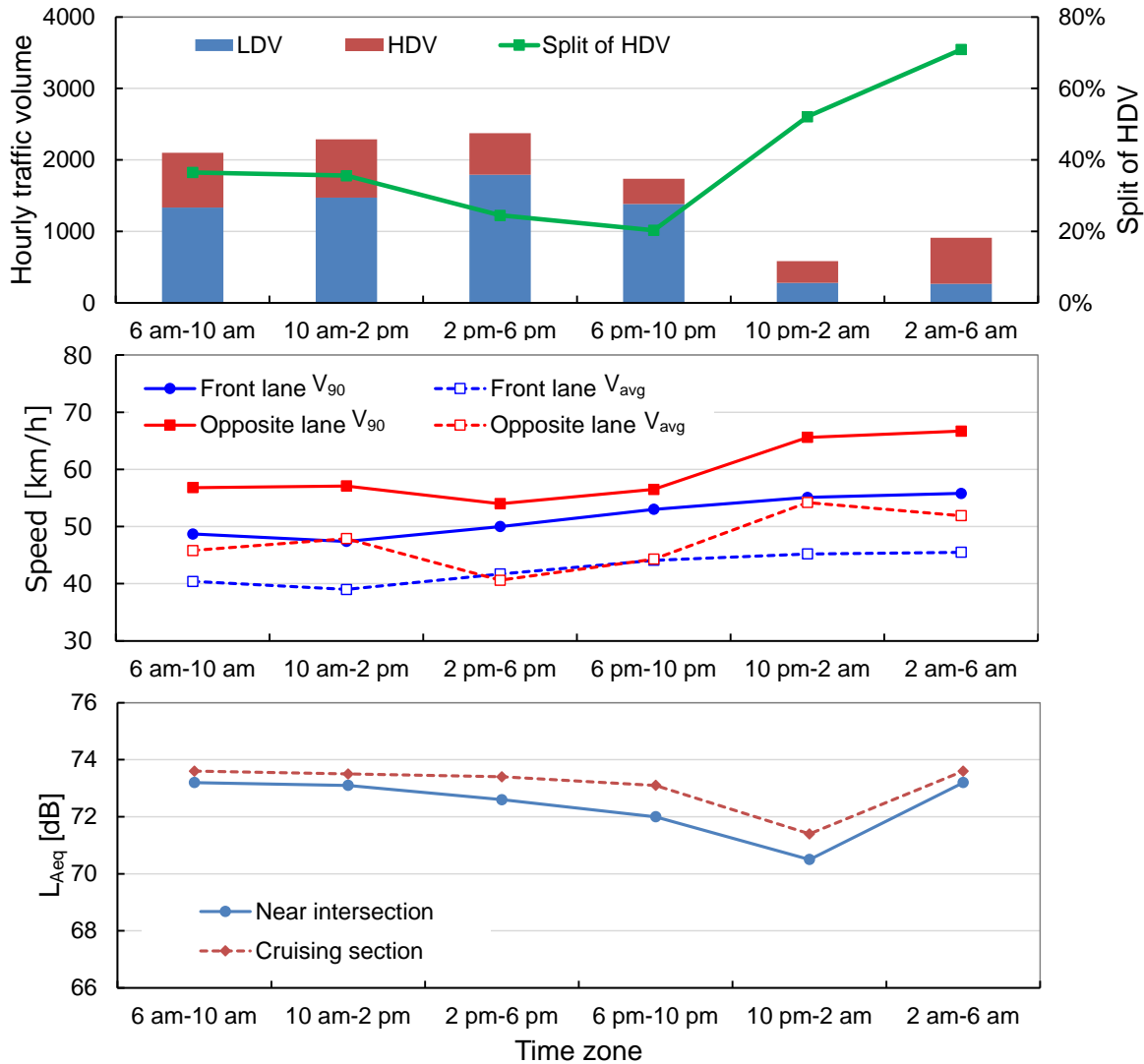
# Traffic volume, speed and $L_{Aeq}$ at site A



# Traffic volume, speed and $L_{Aeq}$ at site B



# Traffic volume, speed and $L_{Aeq}$ at site C



# Summary of field survey result

## Results of field survey

Target survey site		A		B		C	
Time zone		Day	Night	Day	Night	Day	Night
Traffic volume	4-wheeled vehicles	31581	3902	39924	8735	33984	5971
	Motorcycles	571	72	2681	350	613	46
Traffic volume per hour	4-wheeled vehicles	1974	488	2495	1092	2124	747
	Motorcycles	36	9	168	44	38	6
Split of vehicle type	Heavy duty vehicles	19.5%	45.0%	23.6%	44.8%	29.6%	63.6%
	Motorcycles	1.8%	1.8%	6.3%	3.9%	1.8%	0.8%
Speed limit [km/h]		50		60		60	
Measured 90 % ile speed $V_{90}$ [km/h]	front lane	56.0	61.7	46.3	60.7	48.9	53.9
	opposite lane	55.9	62.0	46.5	61.3	55.9	65.9
Measured $L_{Aeq}$ [dB]	near intersection	71.6	70.2	72.7	72.9	72.8	72.1
	cruising section	70.8	69.8	71.8	72.2	73.4	72.6

## Statistics for the applicable section

24 hours traffic volume	31364		52046		45005	
24 hours mixing rate of heavy vehicles	23		28.2		35.3	
Road traffic noise $L_{Aeq}$ [dB]	74	73	73	74	76	75
Environmental standard [dB]	70	65	70	65	70	65

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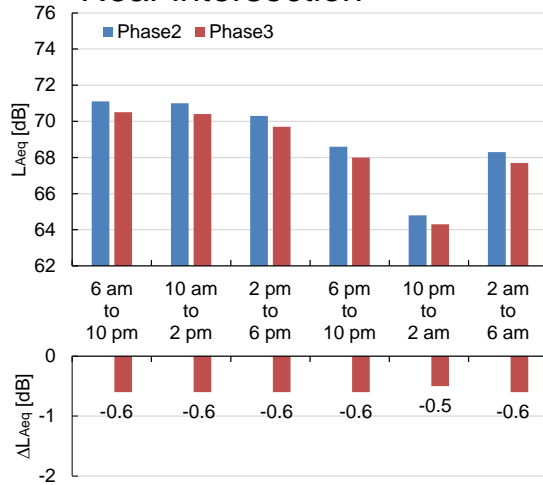
1. Method and condition for predictive calculations
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# Impact prediction of tightening noise regulation

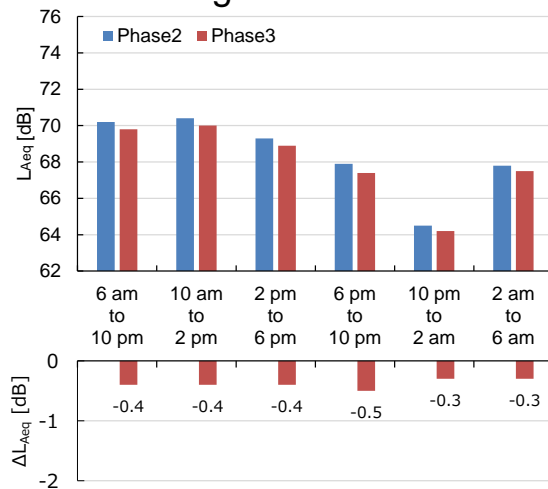
(reduction rate of **75:25** for PU noise and tyre noise for LDV)

## site A

### Near intersection

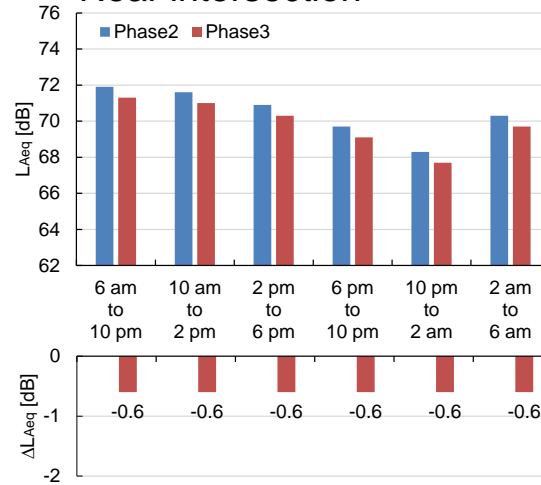


### Cruising section

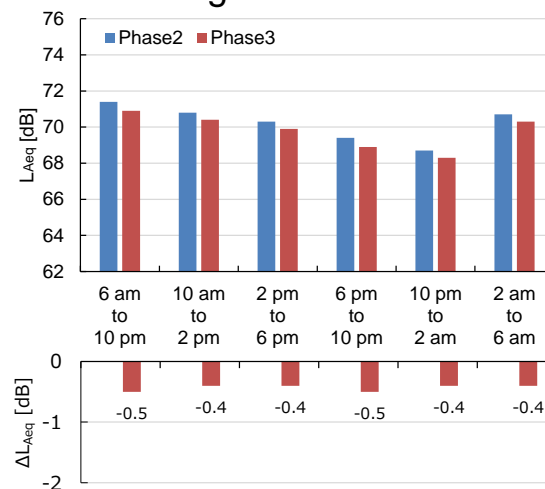


## site B

### Near intersection

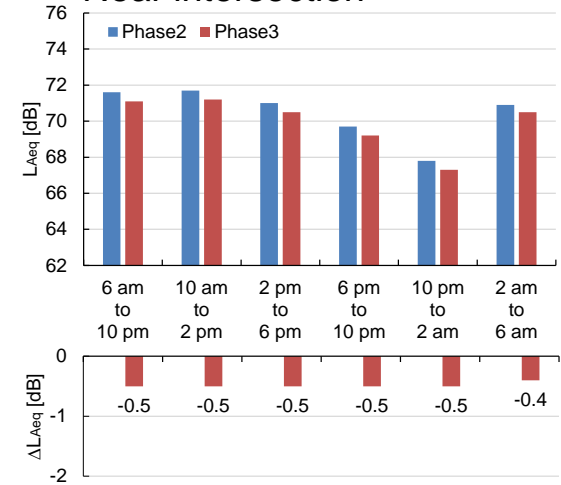


### Cruising section

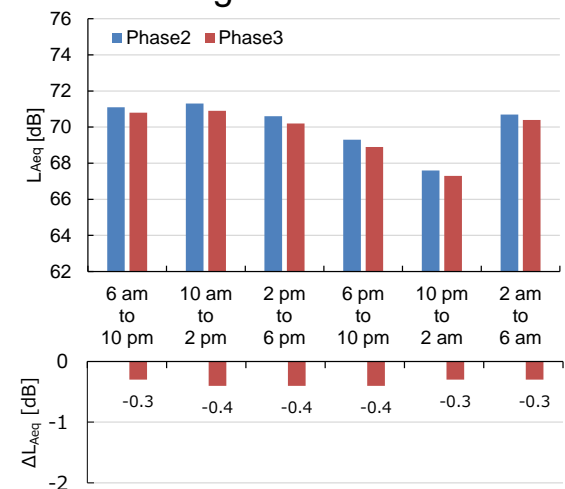


## site C

### Near intersection



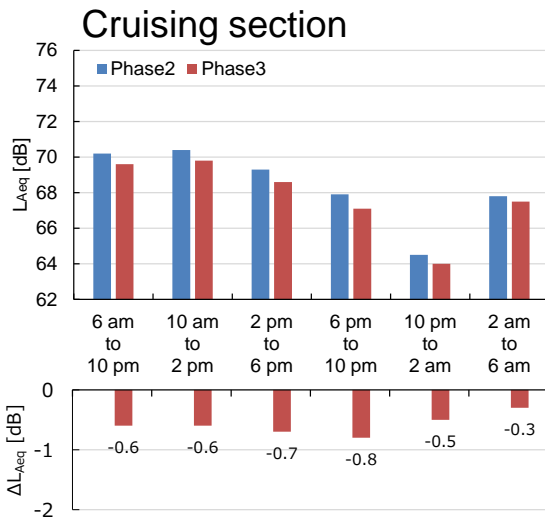
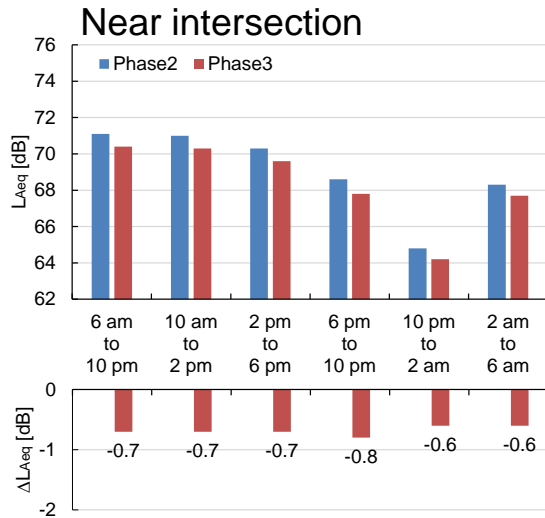
### Cruising section



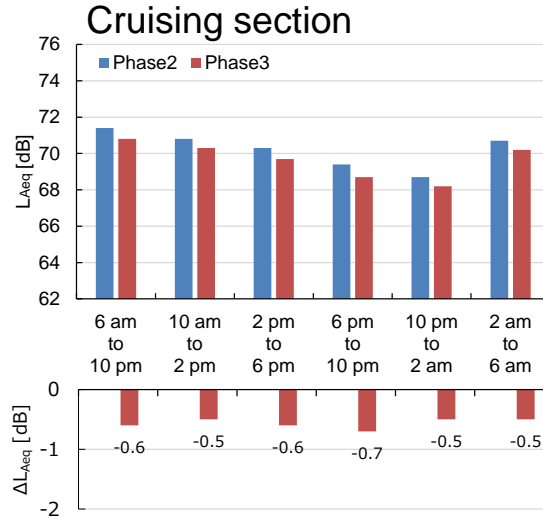
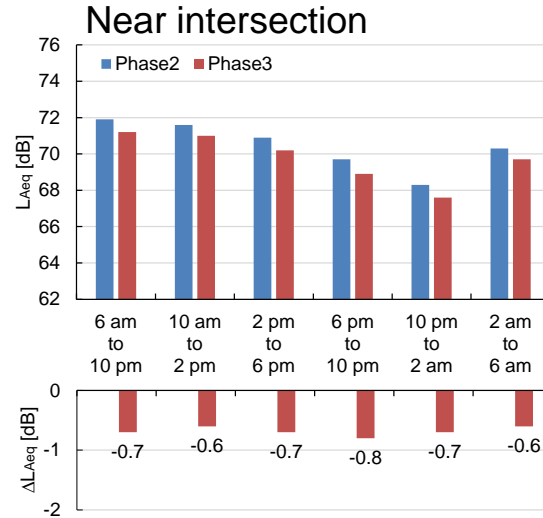
# Impact prediction of tightening noise regulation

(reduction rate of 50:50 for PU noise and tyre noise for LDV)

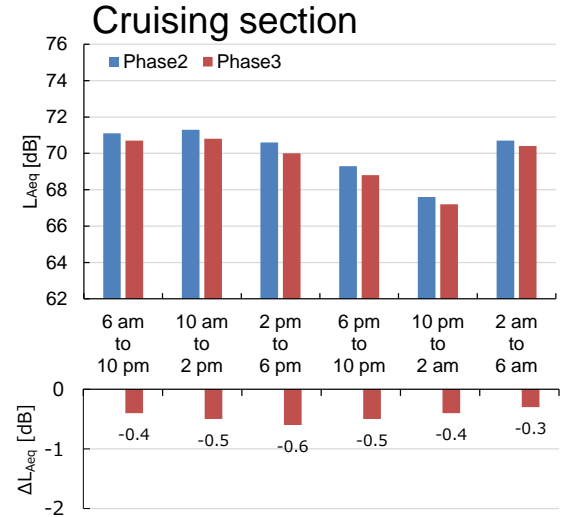
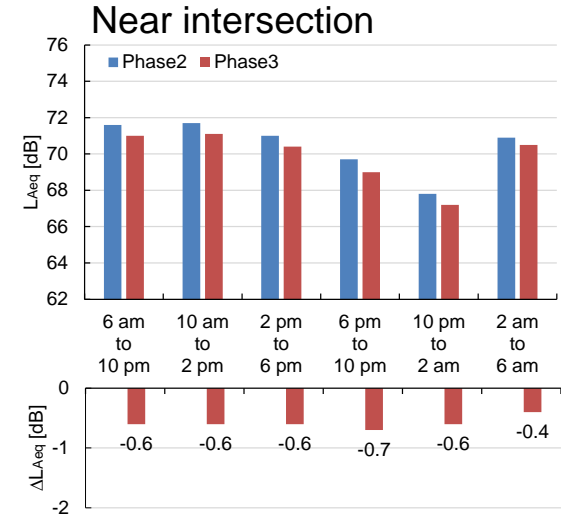
## site A



## site B



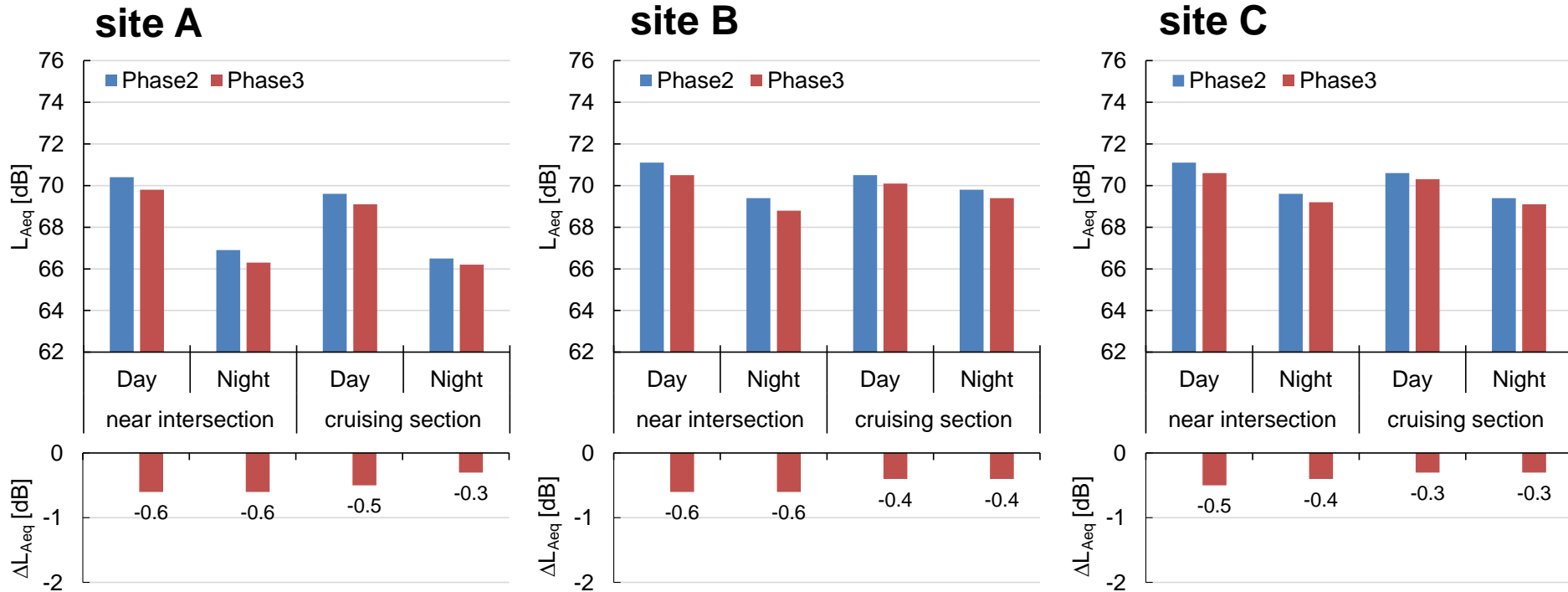
## site C





# Impact prediction of tightening noise regulation

reduction rate of **75:25** for PU noise and tyre noise for LDV



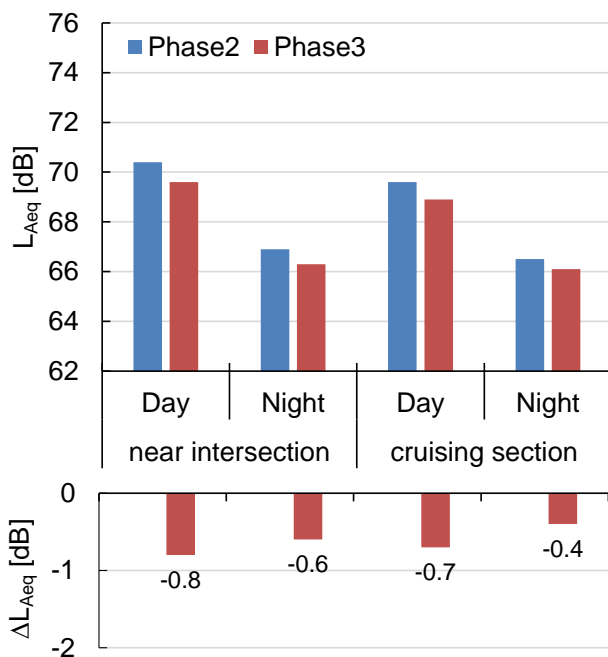
Road traffic noise  $L_{Aeq}$  reduction by applying phase 3

- 0.5 to 0.6 dB in day and 0.4 to 0.6 dB at night near intersection
- 0.3 to 0.5 dB in day and 0.3 to 0.4 dB at night in cruising section

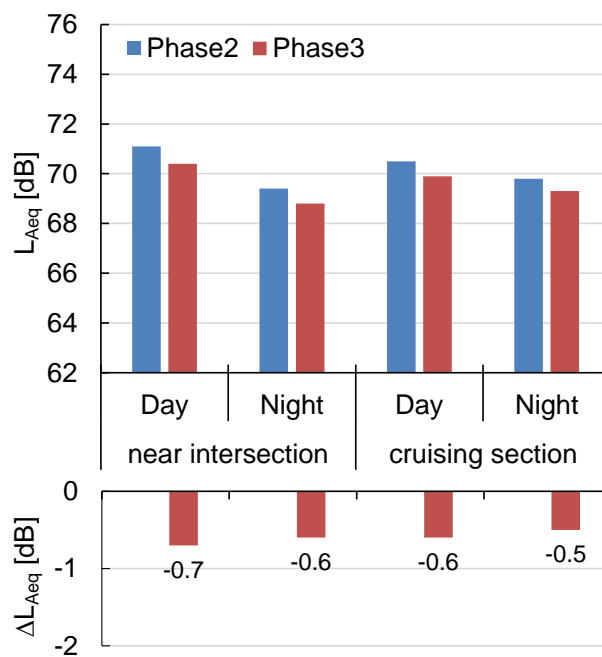
# Impact prediction of tightening noise regulation

reduction rate of **50:50** for PU noise and tyre noise for LDV

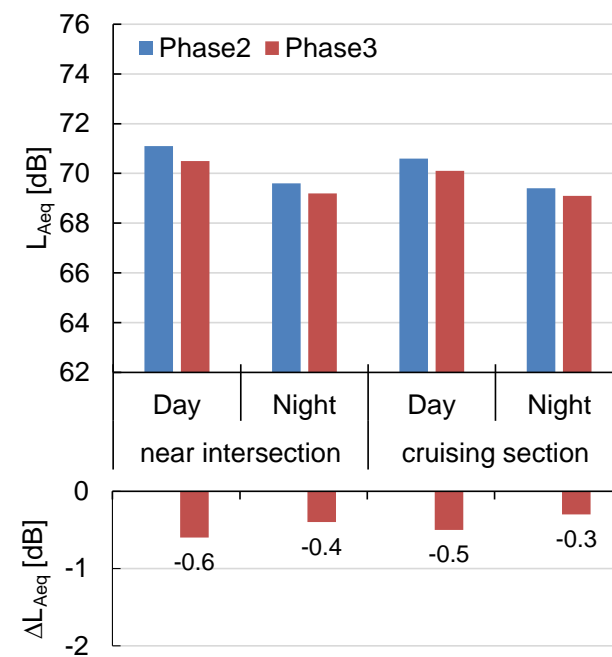
## site A



## site B



## site C



Road traffic noise  $L_{Aeq}$  reduction by applying phase 3

- 0.6 to 0.8 dB in day and 0.4 to 0.6 dB at night near intersection
- 0.5 to 0.7 dB in day and 0.3 to 0.5 dB at night in cruising section

# Summary

The impact on  $L_{Aeq}$  was predicted when the vehicle driving noise regulation was tightened from phase 2 to phase 3. The results obtained based on these setups are as follows.

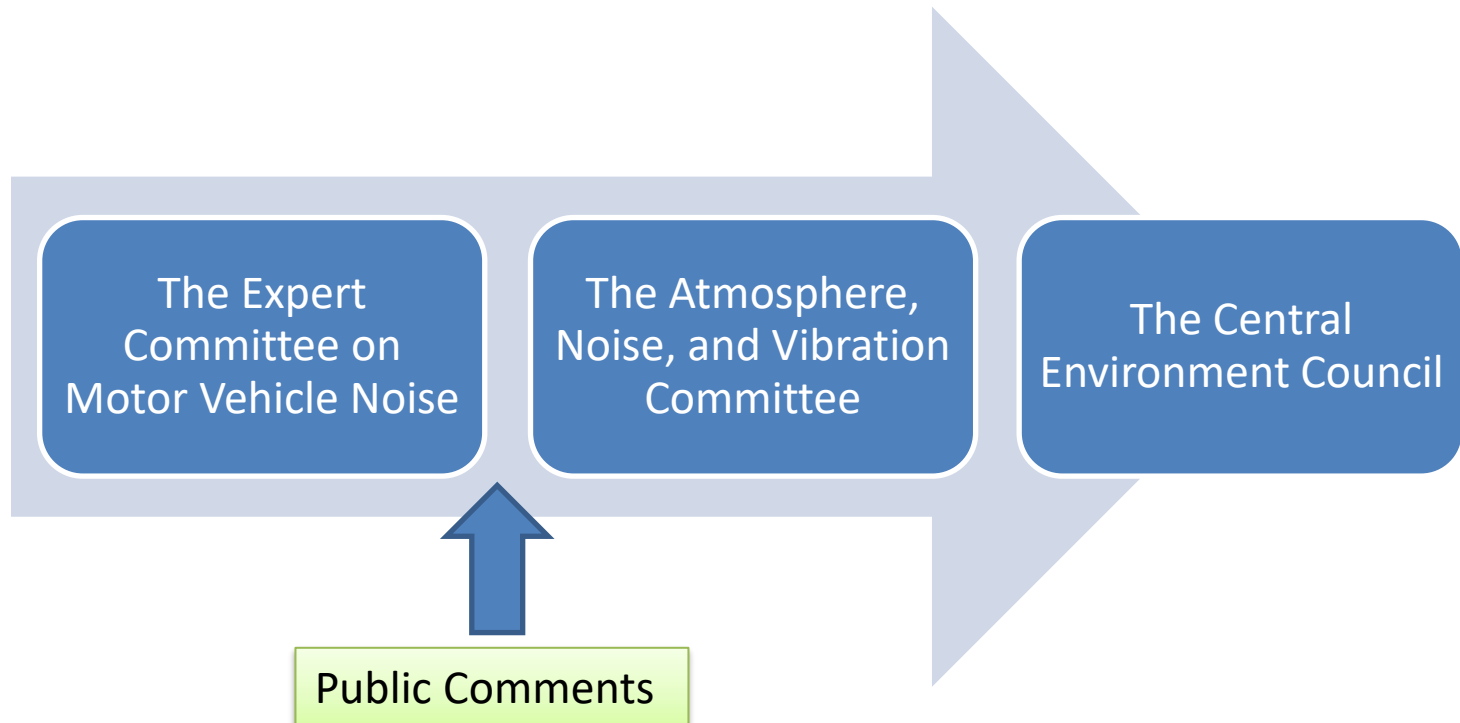
- In case of the reduction rate for each noise source for LDV was set to 75:25, the  $L_{Aeq}$  reduction of applying phase 3 was 0.4 to 0.6 dB near intersections and 0.3 to 0.5 dB in the cruising sections.
- In case of the reduction rate for each noise source for LDV was set to 50:50, the  $L_{Aeq}$  reduction of applying phase 3 was 0.4 to 0.8 dB near intersections and 0.3 to 0.7 dB in the cruising sections.

Reduction of  $L_{Aeq}$  by applying phase 3 in dB

Noise reduction ratio of power unit and tyre for LDV	near intersction		cruising section	
	Day	Night	Day	Night
75:25	0.5-0.6	0.4-0.6	0.3-0.5	0.3-0.4
50:50	0.6-0.8	0.4-0.6	0.5-0.7	0.3-0.5

# Future Schedule

- On March 28<sup>th</sup>, as a result of deliberations by the Expert Committee on Motor Vehicle Noise on the introduction of Phase 3, which has take into consideration the results of the study presented here, it was agreed to introduce Phase 3 because of the noise reduction effect expected from the introduction of Phase 3 limit values.
- For the next step, public comments will be made on the draft version of the forth report of the Future Policy for Motor Vehicle Noise Reduction, and based on the results, the report will be formally reported to the Atmospheric Noise and Vibration Subcommittee for deliberation by the Central Environmental Council.



- ✓ We believe that it must be important to take the technical review in each country, and **assess the effectiveness of new regulation such as beyond phase3 for vehicle noise reduction, before making global agreement on it.**
- ✓ We would like to propose to **highlight importance of such process** by using models and parameters we have discussed at TF-VS, **in its technical report which is going to submit to GRBP.**

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# Appendix

# Result list (1)

Traget site		site A						site B						site C						
Time zone		6AM-10AM	10AM-2PM	2PM-6PM	6PM-10PM	10PM-2AM	2AM-6AM	6AM-10AM	10AM-2PM	2PM-6PM	6PM-10PM	10PM-2AM	2AM-6AM	6AM-10AM	10AM-2PM	2PM-6PM	6PM-10PM	10PM-2AM	2AM-6AM	
Traffic volume per hour	4-wheeled vehicles	2215	2022	2102	1559	372	604	2605	2430	2672	2278	939	1245	2101	2286	2375	1736	584	911	
	Motorcycles	45	27	36	34	10	8	203	116	184	168	44	43	30	34	46	43	8	3	
Split of vehicle type	HDV	21.1	26.3	18.1	10.3	33.6	52	27.5	32.1	21.2	12.8	37.4	50.4	36.5	35.6	24.5	20.3	52.2	70.9	
	Motorcycles	2.0	1.3	1.7	2.2	2.7	1.3	7.8	4.8	6.9	7.4	4.7	3.5	1.4	1.5	1.9	2.5	1.4	0.3	
Measured LAeq [dB]	Near intersection	72.5	71.9	71.4	70.1	68.1	71.5	73	73.2	72.4	72.3	72	73.5	73.2	73.1	72.6	72	70.5	73.2	
	Cruising section	71.7	71.2	70.5	69.4	67.5	71.2	71.8	72.3	71.2	71.7	71.5	72.8	73.6	73.5	73.4	73.1	71.4	73.6	
Predicted LAeq [dB]	Near intersection	Phase2	71.1	71.0	70.3	68.6	64.8	68.3	71.9	71.6	70.9	69.7	68.3	70.3	71.6	71.7	71.0	69.7	67.8	70.9
		Phase3 (75:25)	70.5	70.4	69.7	68.0	64.3	67.7	71.3	71.0	70.3	69.1	67.7	69.7	71.1	71.2	70.5	69.2	67.3	70.5
		Phase3 (50:50)	70.4	70.3	69.6	67.8	64.2	67.7	71.2	71.0	70.2	68.9	67.6	69.7	71.0	71.1	70.4	69.0	67.2	70.5
	Cruising section	Phase2	70.2	70.4	69.3	67.9	64.5	67.8	71.4	70.8	70.3	69.4	68.7	70.7	71.1	71.3	70.6	69.3	67.6	70.7
		Phase3 (75:25)	69.8	70.0	68.9	67.4	64.2	67.5	70.9	70.4	69.9	68.9	68.3	70.3	70.8	70.9	70.2	68.9	67.3	70.4
		Phase3 (50:50)	69.6	69.8	68.6	67.1	64.0	67.5	70.8	70.3	69.7	68.7	68.2	70.2	70.7	70.8	70.0	68.8	67.2	70.4
Predicted LAeq reduction [dB]	Near intersection	Phase3 (75:25)	-0.6	-0.6	-0.6	-0.6	-0.5	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4
		Phase3 (50:50)	-0.7	-0.7	-0.7	-0.8	-0.6	-0.6	-0.7	-0.6	-0.7	-0.8	-0.7	-0.6	-0.6	-0.6	-0.6	-0.7	-0.6	-0.4
	Cruising section	Phase3 (75:25)	-0.4	-0.4	-0.4	-0.5	-0.3	-0.3	-0.5	-0.4	-0.4	-0.5	-0.4	-0.4	-0.3	-0.4	-0.4	-0.4	-0.3	-0.3
		Phase3 (50:50)	-0.6	-0.6	-0.7	-0.8	-0.5	-0.3	-0.6	-0.5	-0.6	-0.7	-0.5	-0.5	-0.4	-0.5	-0.6	-0.5	-0.4	-0.3

# Result list (2)

Traget site		site A		site B		site C		
Time zone		Day	Night	Day	Night	Day	Night	
Traffic volume per hour	4-wheeled vehicles	1975	488	2496	1092	2125	748	
	Motorcycles	36	9	168	44	38	6	
Split of vehicle type	HDV	19.5	45.1	23.6	44.8	29.6	63.6	
	Motorcycles	1.8	1.8	6.7	4	1.8	0.8	
Measured LAeq [dB]	Near intersection	71.6	70.1	72.7	72.8	72.8	72.1	
	Cruising section	70.8	69.7	71.8	72.2	73.4	72.6	
Predicted LAeq [dB]	Near intersection	Phase2	70.4	66.9	71.1	69.4	71.1	69.6
		Phase3 (75:25)	69.8	66.3	70.5	68.8	70.6	69.2
		Phase3 (50:50)	69.6	66.3	70.4	68.8	70.5	69.2
	Cruising section	Phase2	69.6	66.5	70.5	69.8	70.6	69.4
		Phase3 (75:25)	69.1	66.2	70.1	69.4	70.3	69.1
		Phase3 (50:50)	68.9	66.1	69.9	69.3	70.1	69.1
Predicted LAeq reduction [dB]	Near intersection	Phase3 (75:25)	-0.6	-0.6	-0.6	-0.6	-0.5	-0.4
		Phase3 (50:50)	-0.8	-0.6	-0.7	-0.6	-0.6	-0.4
	Cruising section	Phase3 (75:25)	-0.5	-0.3	-0.4	-0.4	-0.3	-0.3
		Phase3 (50:50)	-0.7	-0.4	-0.6	-0.5	-0.5	-0.3