

# SAE/ISO Quiet Car Development

QRTV GTR Informal Group

April 16-18, 2012

ACEA HQ

Brussels, Belgium

# Agenda

- Review of Issues as Identified in December presentation to QRTV
- New Information
- Updated Issue List
- Forecast of SAE / ISO work
- Closing Remarks

# What's been happening since December

- US Notice of Proposed Rulemaking for FMVSS 141 published
- Additional measurement and analysis work contributed to SAE/ISO
- SAE and ISO have prepared revised draft to provide for measurements according to US proposal.

# Issues Identified (Oct. 2012)

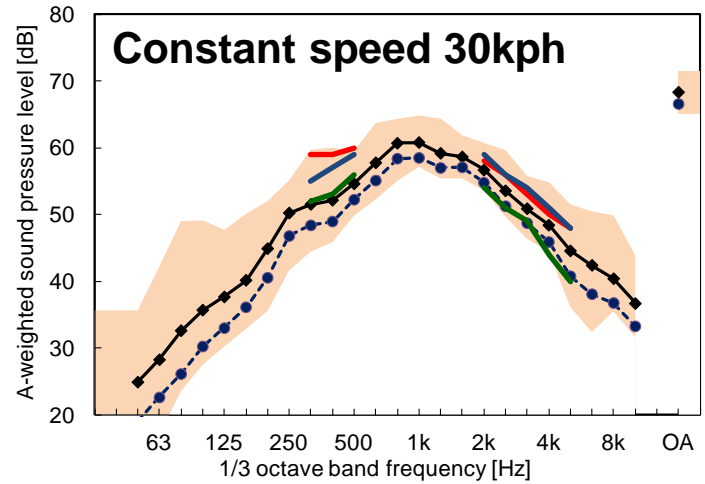
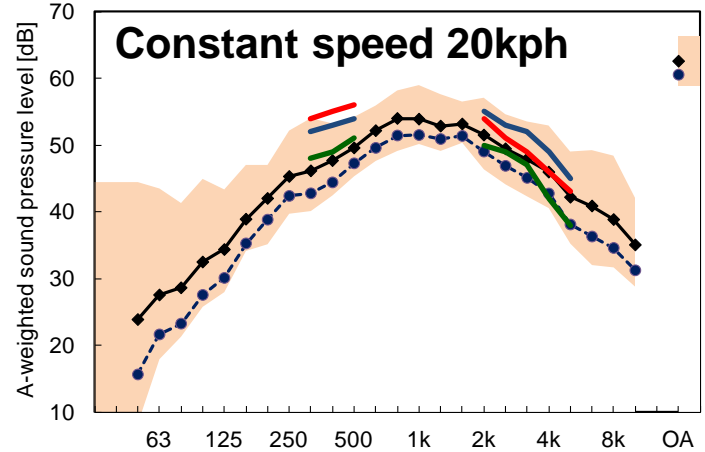
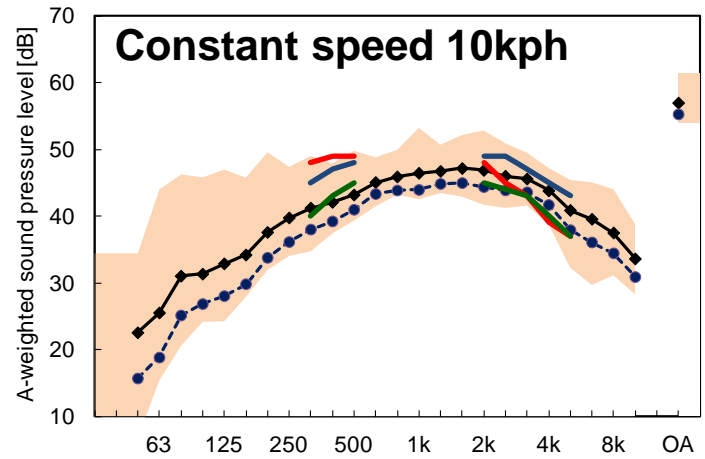
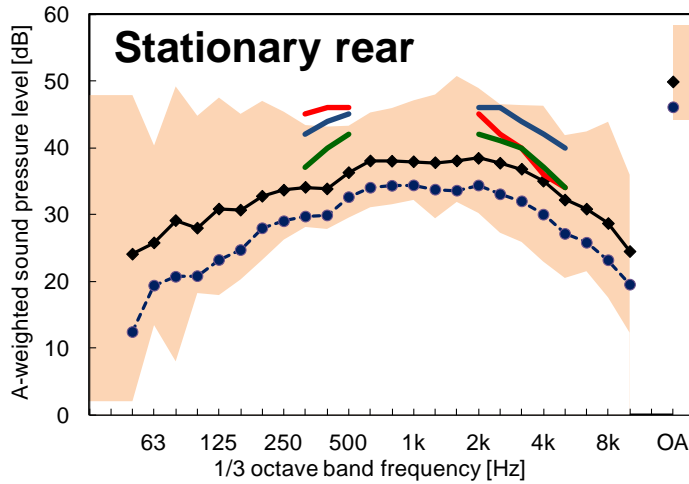
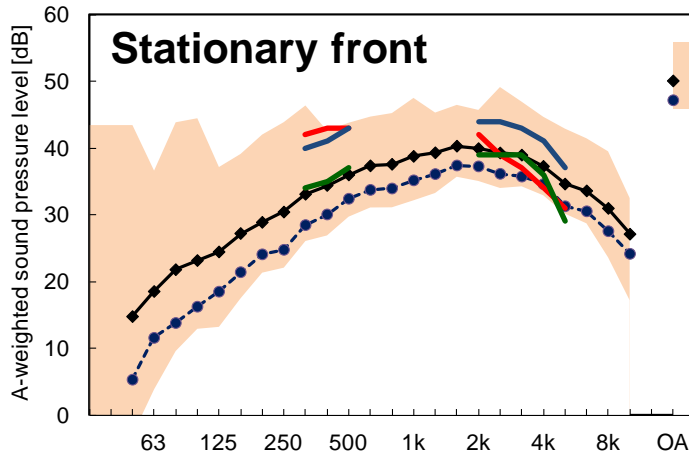
- Measurement and correction for 1/3 octave data.
  - Min, max, L vs. R, Ave., Time slice, windows, filters, averaging.
- Measurement uncertainty – all sources
  - Run to run
  - Day to day
  - Site to site
  - ISO has standard procedures and processes (“GUM”) for evaluation of uncertainty that are required for every published International Standard.
- Use of minimum sound levels in 1/3 octaves for detection and recognition
  - Confirmation with existing IC vehicles
  - Confirmation with Jury evaluations
- Pitch Shift measurement and analysis
  - Ability to measure full vehicle at higher speeds (20, 30 kph)
  - Specification of measurement and analysis methods.
  - Prior knowledge of signals

# New Information















- Additional Vehicles tested according to NHTSA/Volpe research report
  - 97 Vehicles currently in database
- Interior/Exterior Noise data with Volpe sound
- Detection Jury Results
- Comparison of Indoor/Outdoor in 1/3 octave
- Application of Loudness Model
- Pitch shifting – averaging/simulated

## ICE data visual overview

- Gasoline Max-Min
- Gasoline Avg
- Gasoline Avg-Std
- Psychoacoustic (Volpe report)
- ICE Avg (Volpe report)
- ICE Avg-Std (Volpe report)



# OA Sound Level Summary

		Mic.	Stationary	10km/h	20km/h	30km/h
Outdoor Test	Full Vehicle	2m	 	 		
			Depends on background noise level	Depends on background noise level		
Indoor	Vehicle	2m				
					Tire noise on roll can diverge from outdoor result	Tire noise on roll can diverge from outdoor result
	Vehicle(simulate)	2m				



SAE/ISO opinion:  
Technically confirmed



SAE/ISO opinion:  
Technically unclear

















SAE/ISO opinion:  
Technical difficulties



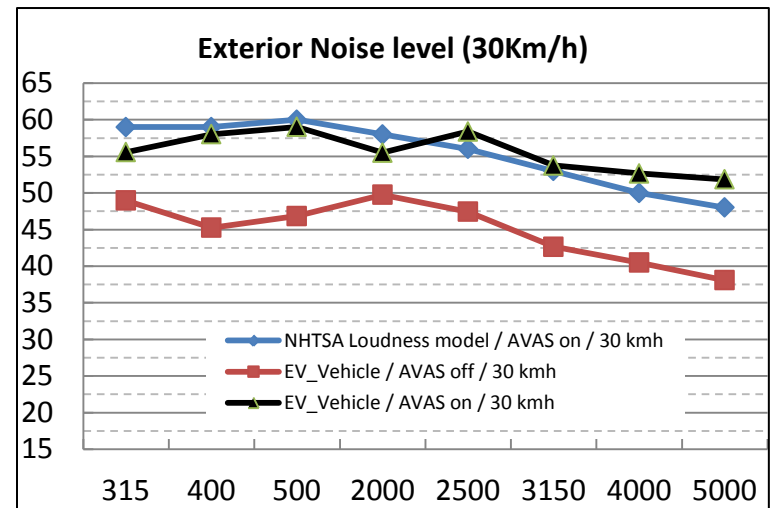
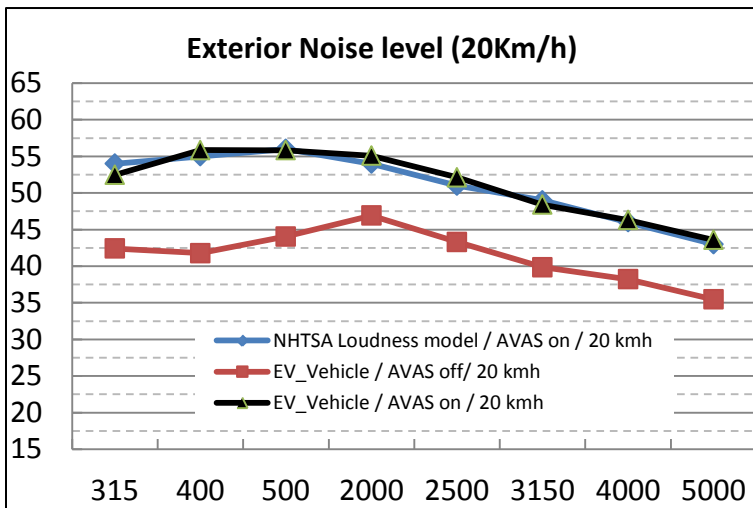
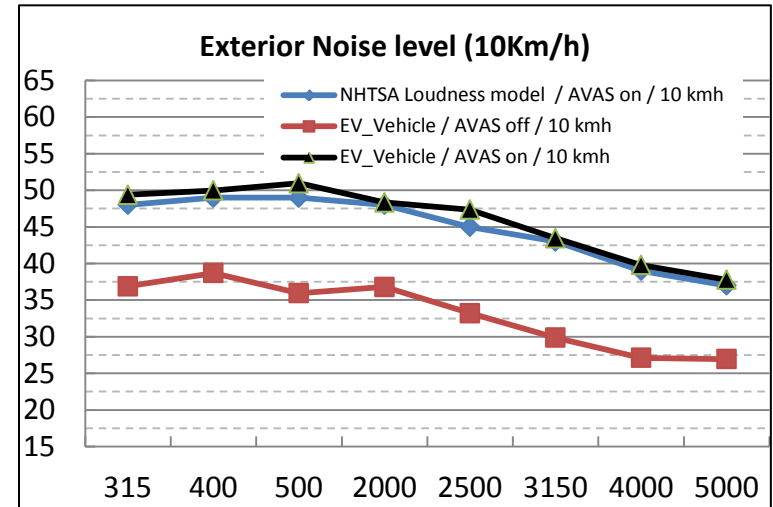
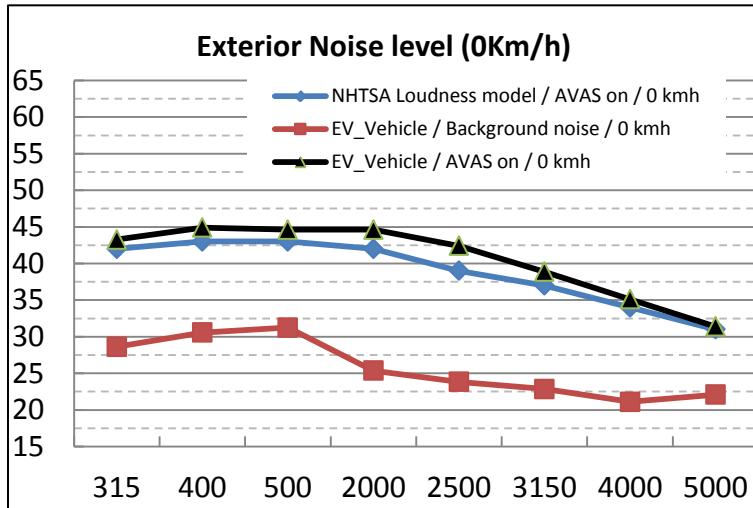
SAE/ISO opinion:  
No current proposal, needs assessment

# 1/3 Octave Sound Level Summary

		Mic.	Stationary	10km/h	20km/h	30km/h
outdoor	Vehicle	2m				
Indoor	Vehicle	2m			 	 
					Issue is accurate measurement of tire noise – 1/3 octaves CAN be measured.	Issue is accurate measurement of tire noise – 1/3 octaves CAN be measured.
	Vehicle(simulate)	2m				
					Issue is accurate measurement of tire noise – 1/3 octaves CAN be measured.	Issue is accurate measurement of tire noise – 1/3 octaves CAN be measured.

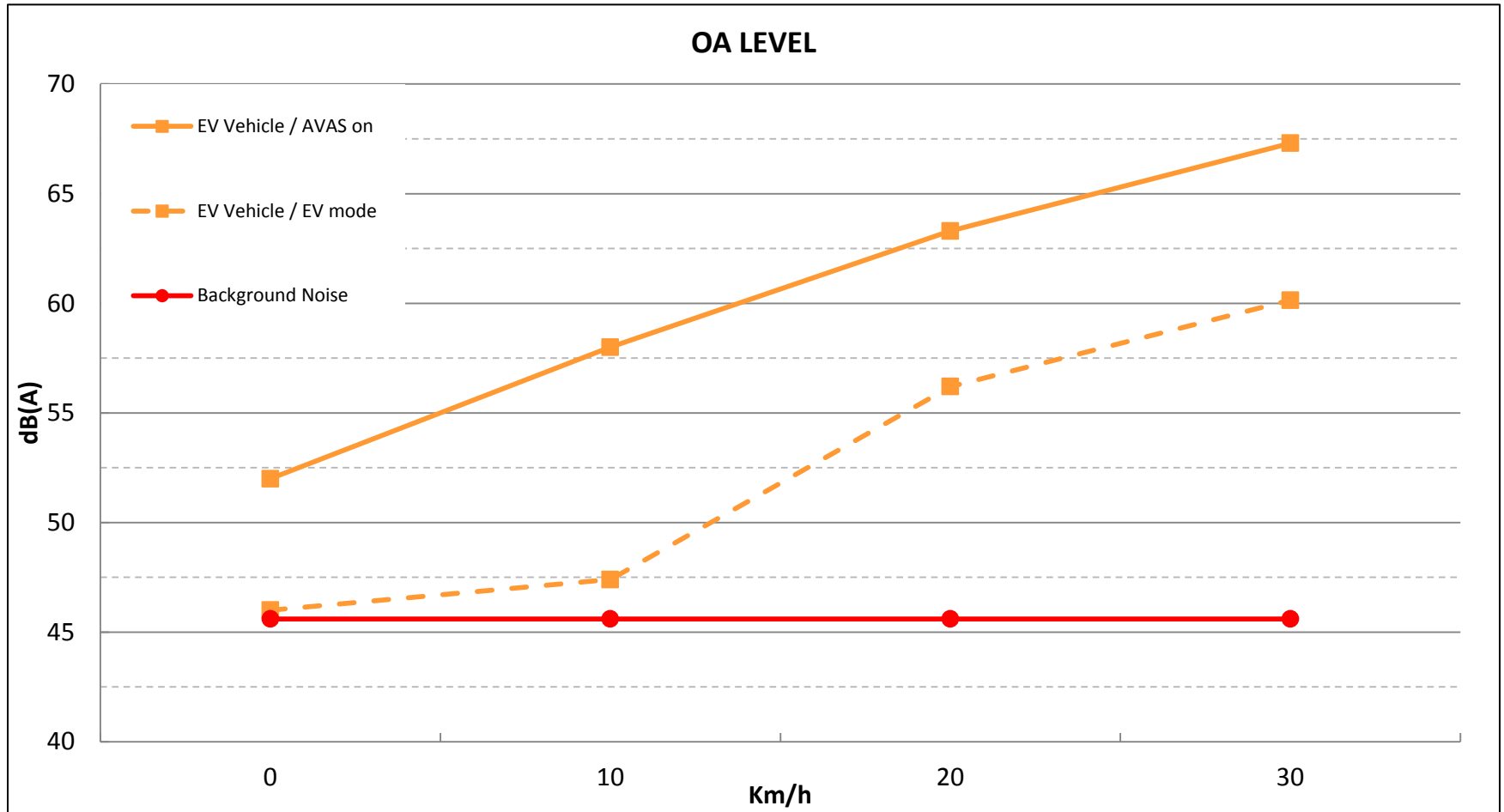


# Step 1: EV Vehicle with NHTSA complaint sound



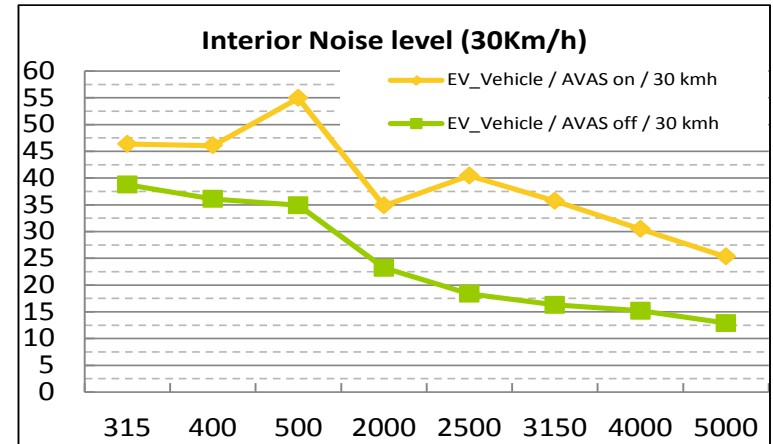
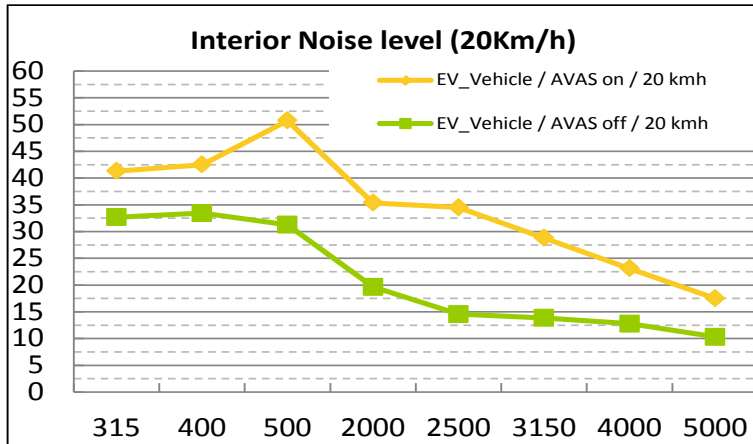
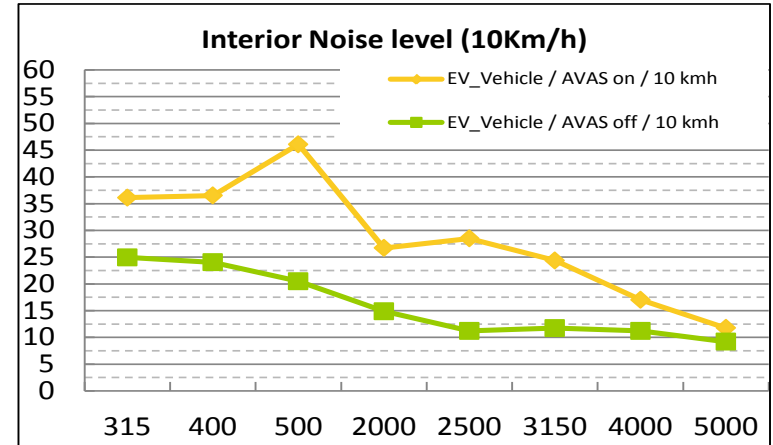
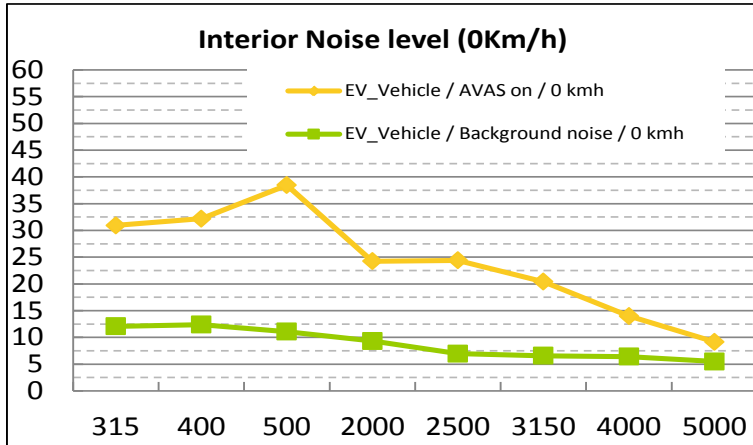
Mean difference between EV mode(AVAS off) and expected level in LOUDNESS model = 10 at 13 dB (A)

# Results - Exterior Noise-Level: OA LEVEL



Hy vehicle AVAS on > ICE for 20km/h & 30km/h  
AVAS on = AVAS off + ~ 7dB

# Result: Interior Noise Level – EV Vehicle

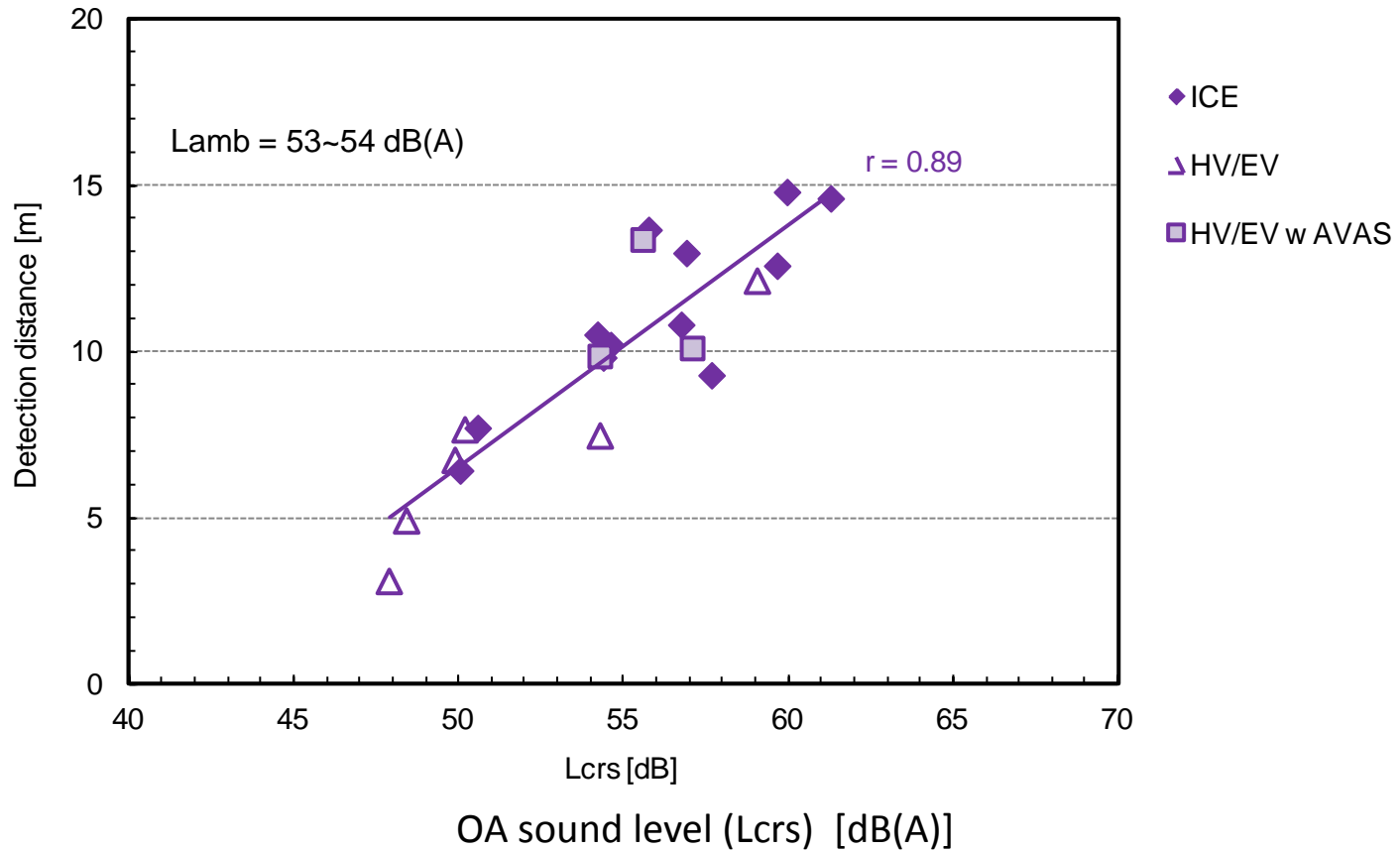


AVAS on = AVAS off + ~ 13dB

Device Clearly Heard by Driver

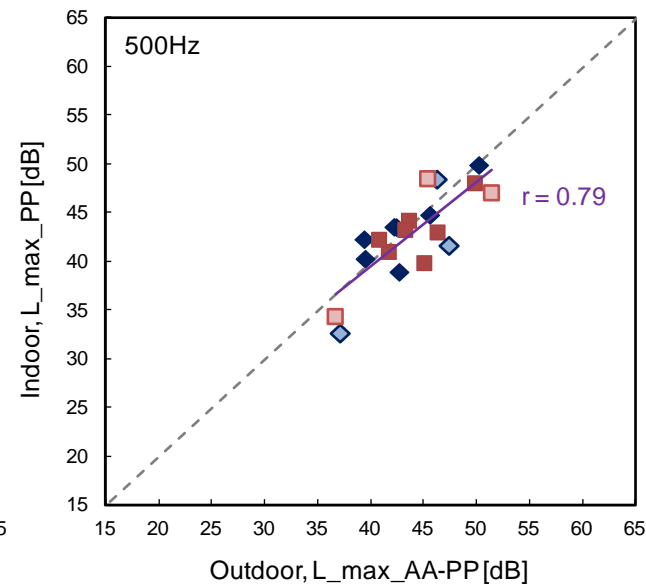
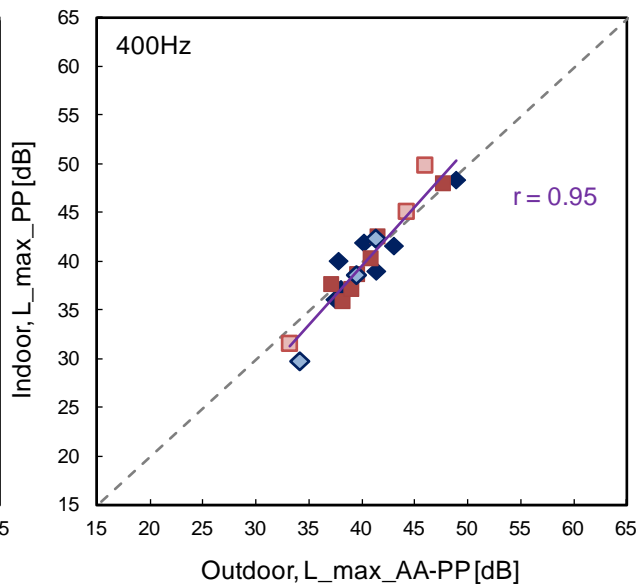
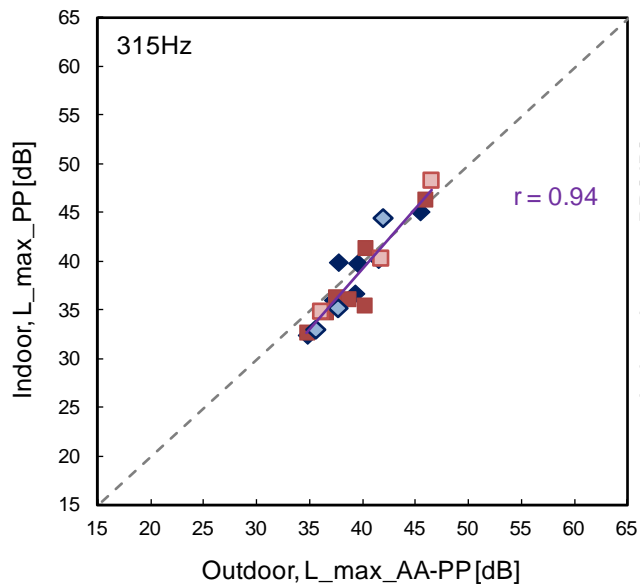
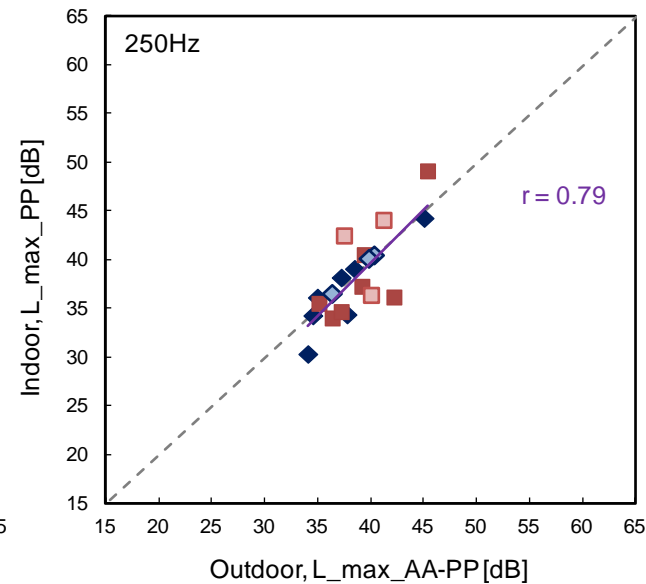
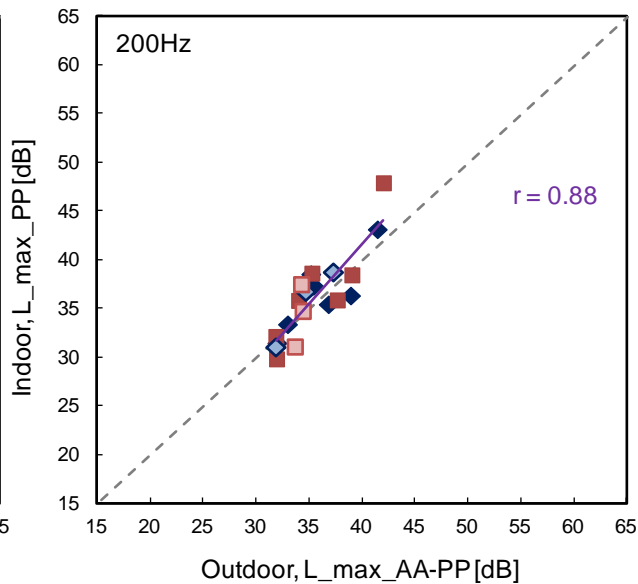
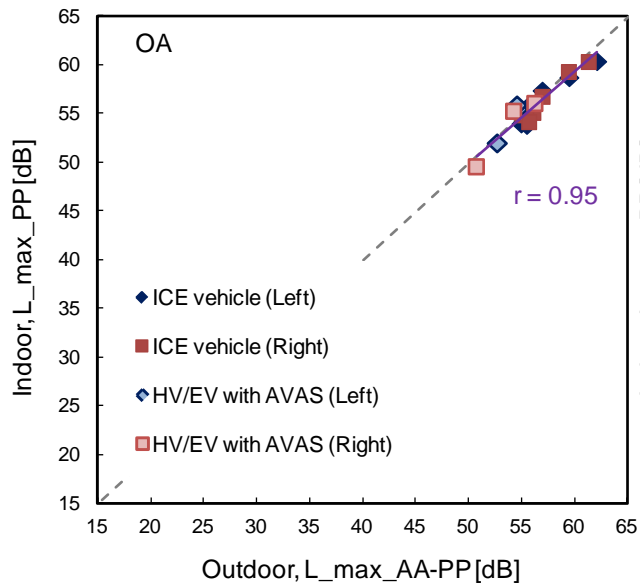
# Detection Jury Results

## "Cruising vehicle sound (Lcrs)" vs "Detection distance"



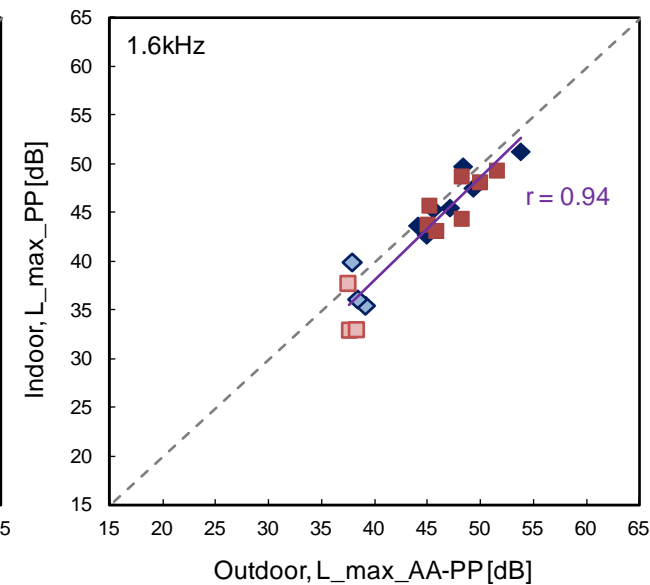
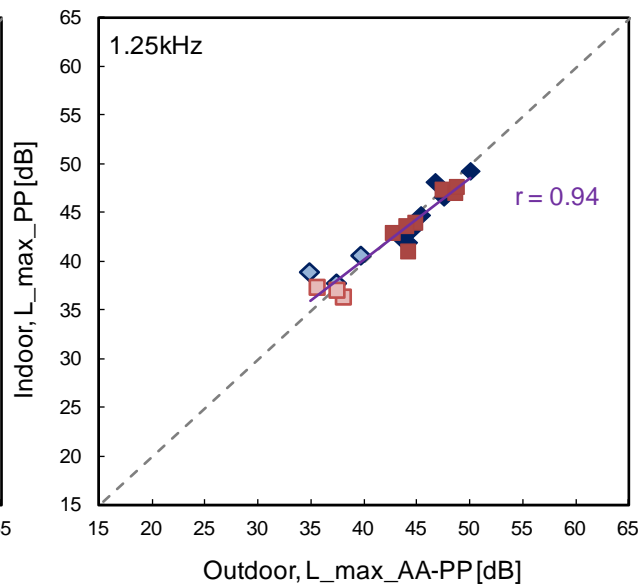
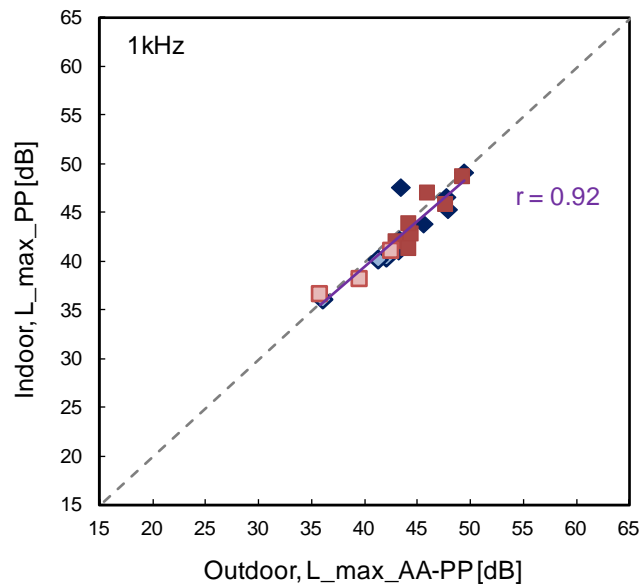
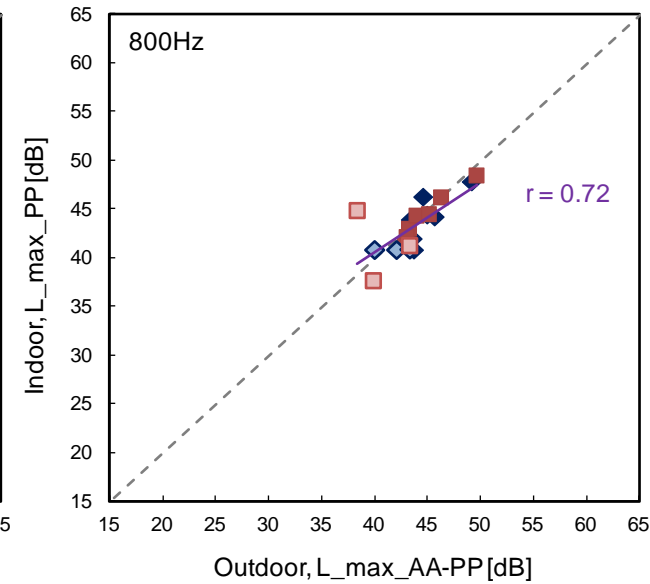
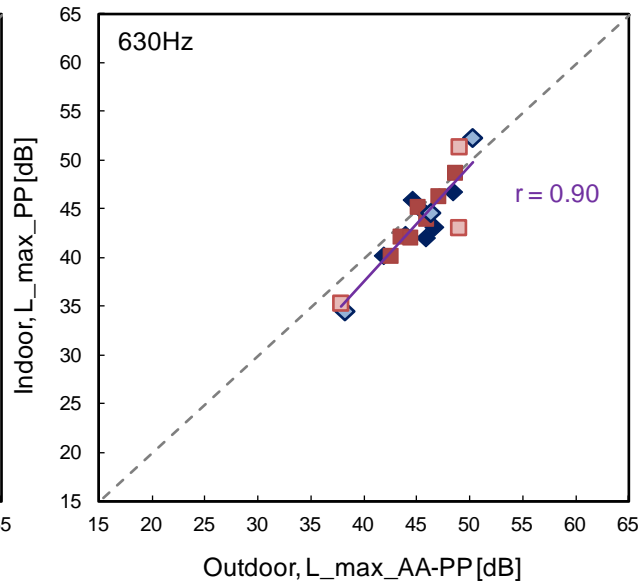
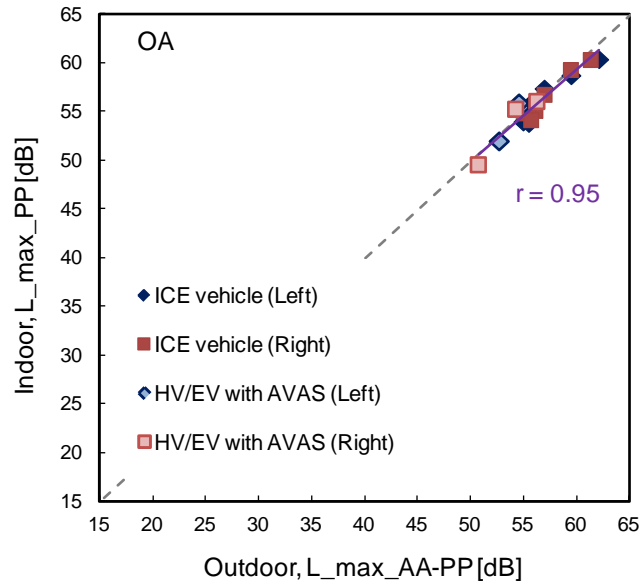
- There is good correlation between Lcrs OA sound level and the detection distance.

# "Outdoor" vs "Indoor" @ 10 km/h

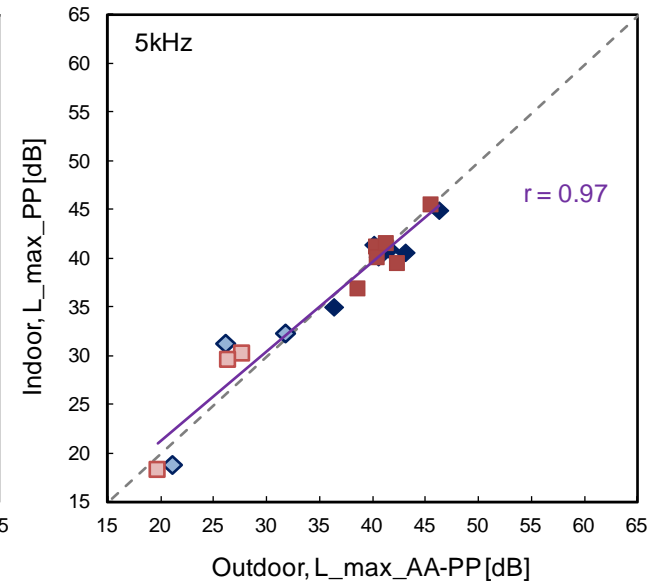
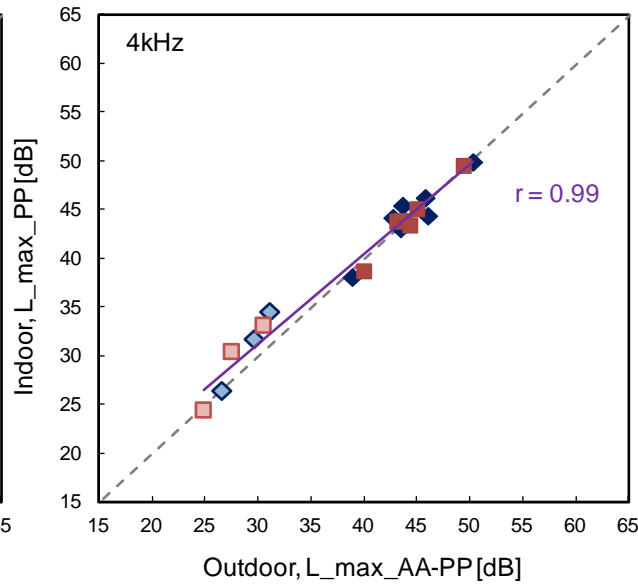
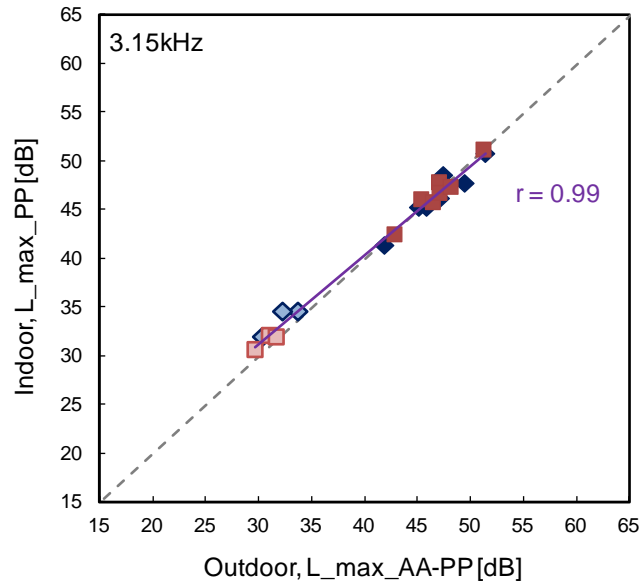
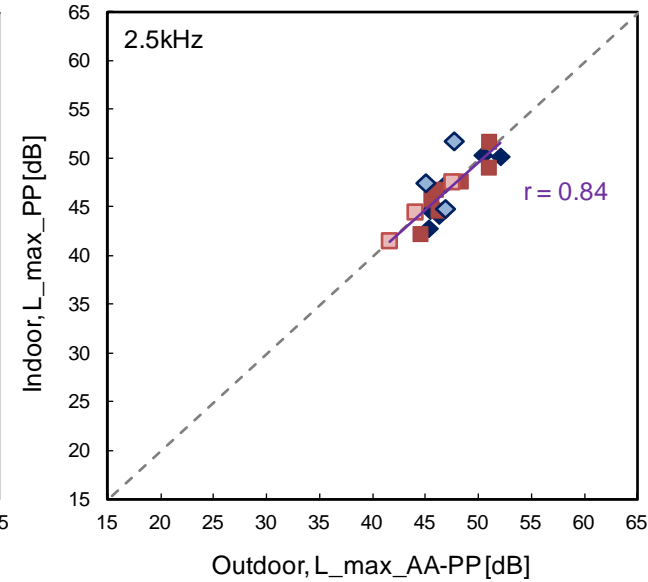
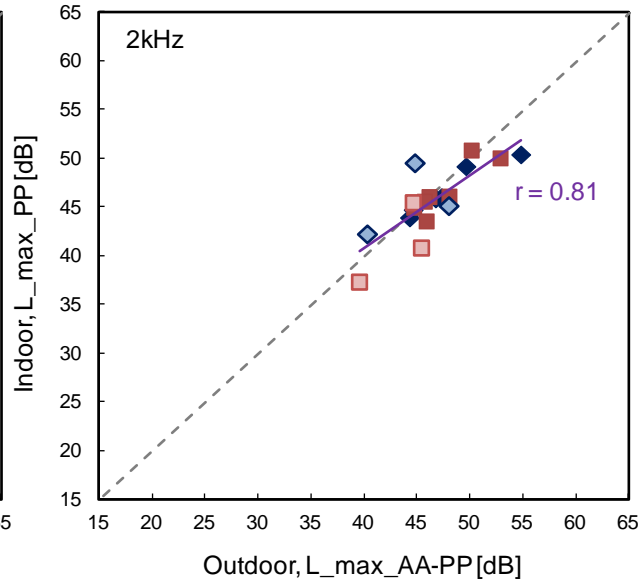
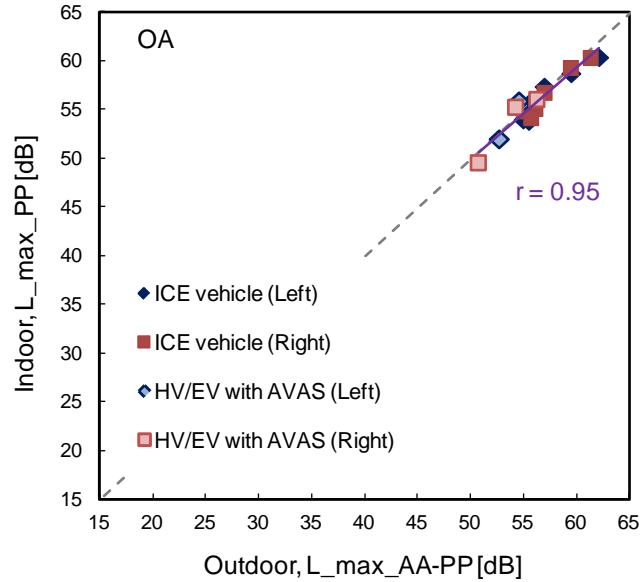


• Outdoor test facility with 25 dB(A) level – Similar to indoor background noise levels

# "Outdoor" vs "Indoor" @10 km/h



# "Outdoor" vs "Indoor" @10 km/h

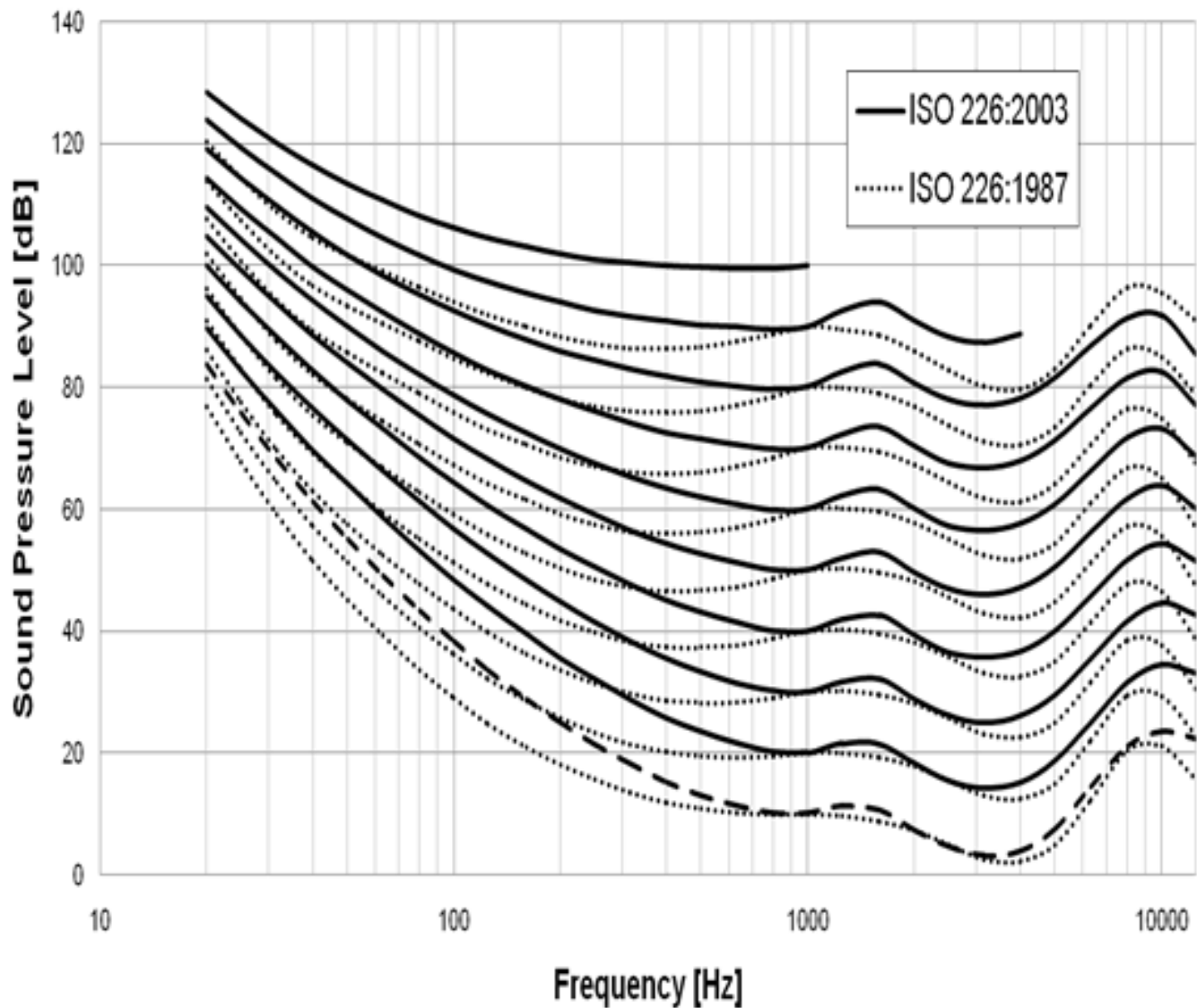


# Application of Loudness Model

- Discussion with Professor Colin Novak, University of Windsor, Project Leader for ISO TC43/WG9 “Loudness”
  - Moore partial loudness model used by VOLPE is older version; not updated for loudness curves according to ISO 226.
  - Impact: In 300-800 Hz band can be up to a 10 dB difference
  - Detection distance: Model was intended for single frequency band analysis. Impact of multiple frequency bands needs further analysis.

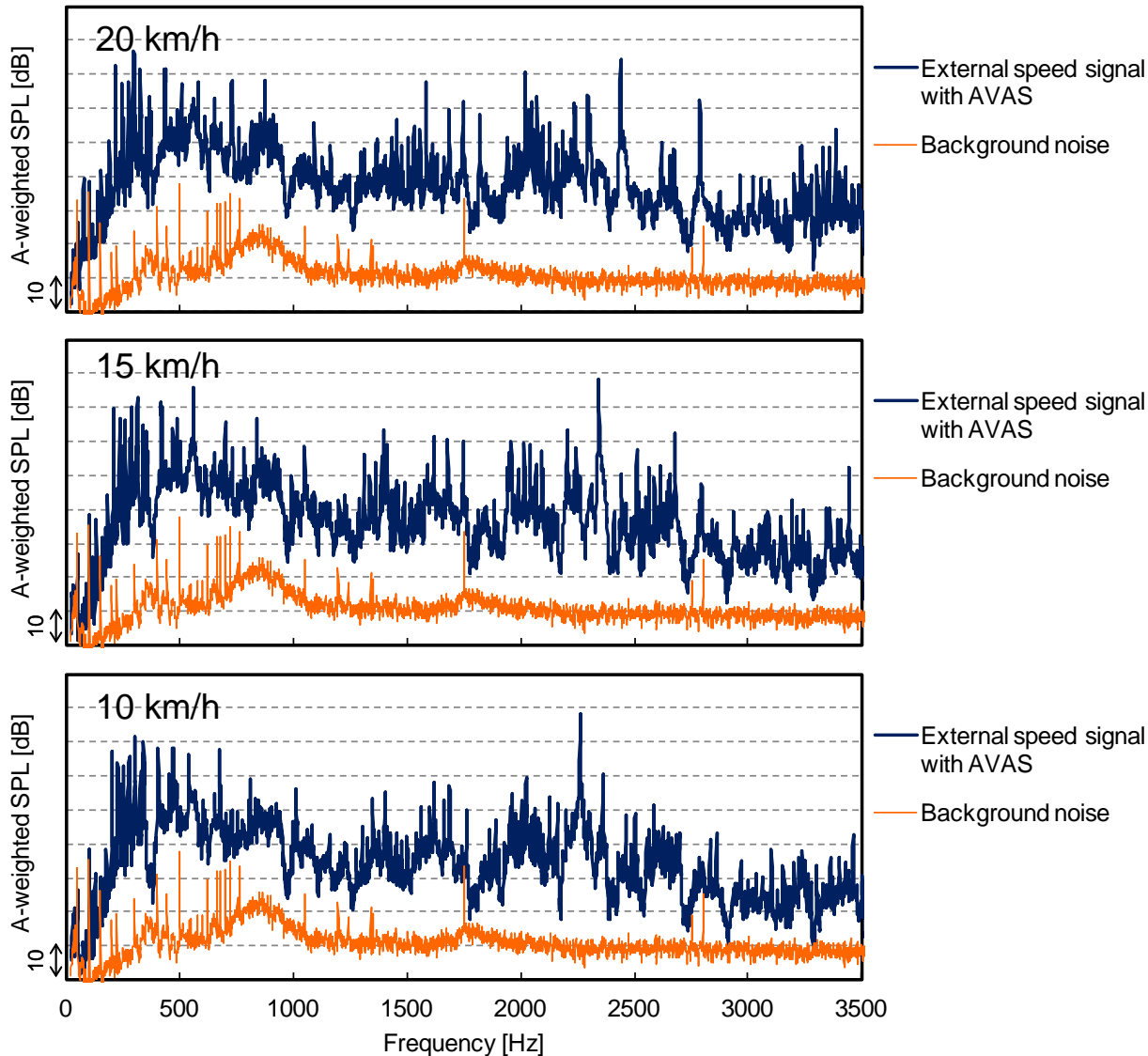


### Equal Loudness Contour Comparison 1987 vs. 2003



# Frequency shift

Simulated Test has Acceptable S/N Ratio (10, 15, 20kph) AVAS On

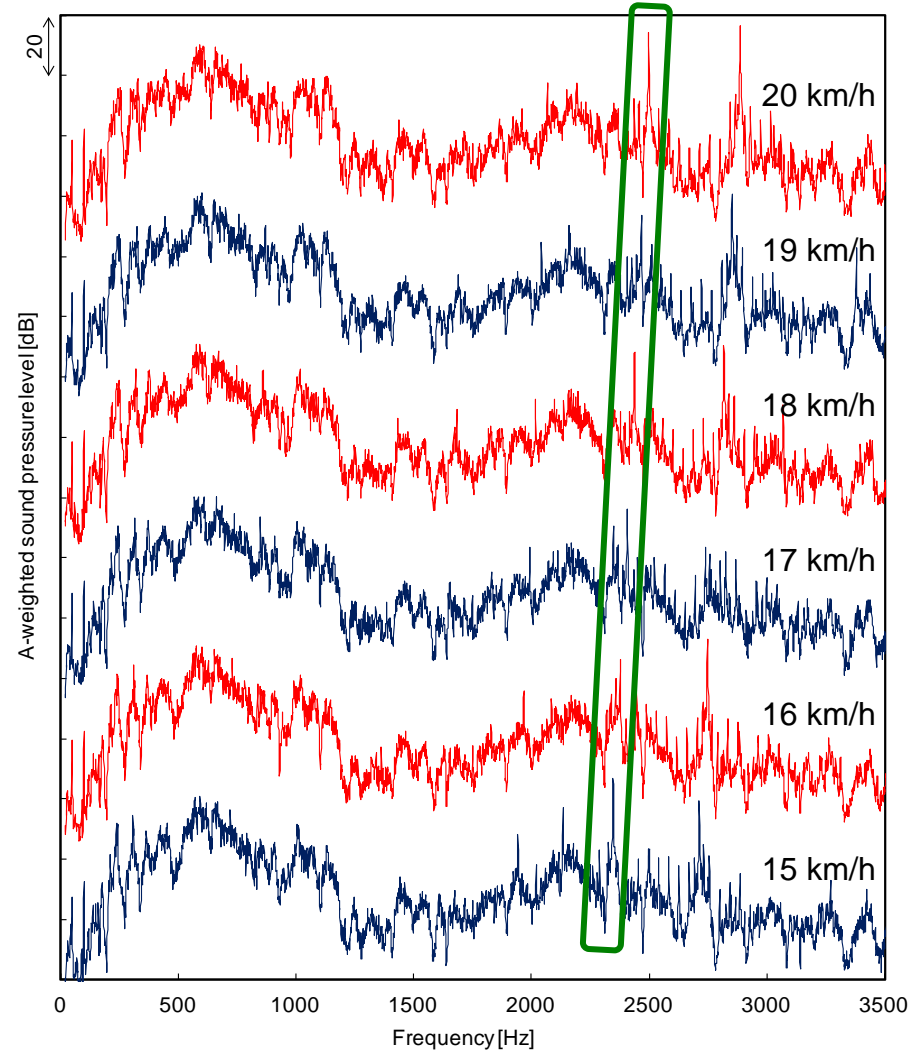
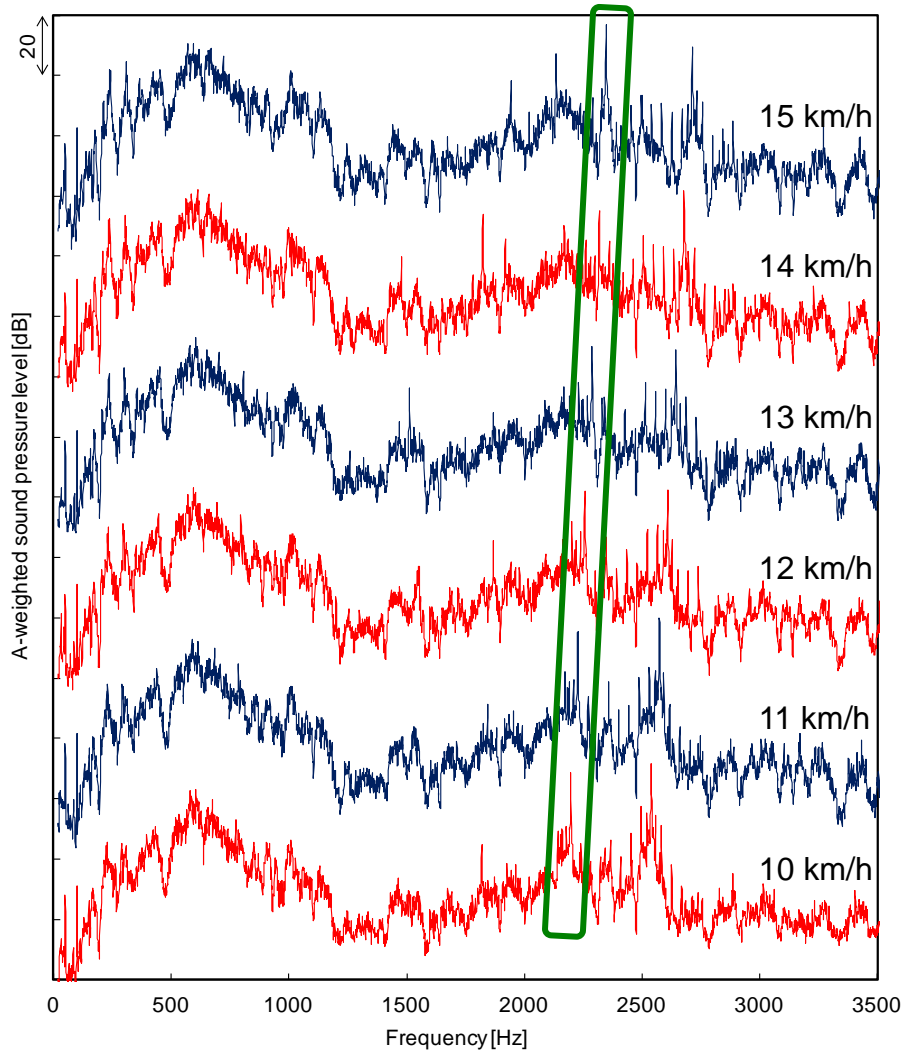


前端左2m,  
高さ1.2m,  
5 sec,  
17回Avg (オーバーラップ75%),  
 $\Delta f=1$  Hz

# Frequency shift

























Simulated Test, step by step results

• 10~20kph, 1kph, AVAS On



Mic:2m, Height1.2m, 5 sec, 17 Avg (overlap 75 %),  $\Delta f=1$  Hz

# Pitch Shift Summary

		Mic.	Stationary	10km/h	20km/h	30km/h
Outdoor Test	Full Vehicle	2m				
		Microphone in proximity to device				
Indoor	Vehicle	2m				
		Proximity				
Indoor and Outdoor	Vehicle(simulate)	2m				
	Component	Proximity				



SAE/ISO opinion:  
Technically confirmed



SAE/ISO opinion:  
Technically unclear



SAE/ISO opinion:  
Technical difficulties



SAE/ISO opinion:  
No current proposal, needs assessment

# Review of Issues from October: Conclusions

- Measurement and correction for 1/3 octave data.
  - Precise specifications for 1/3 octave analysis to be introduced into SAE/ISO standards suitable for accurate, repeatable, and reproducible results.
  - Correction not possible due to fluctuation. [See measurement uncertainty]
- Measurement uncertainty – Issues currently identified, to be completed
  - Environmental fluctuation (greater outdoors)
  - Driver variation (vehicle speed, centerline accuracy) [No issue indoors]
  - Test article variation (Vehicle condition, tires, temperature, stones on track)
  - Test equipment (Calibration, software, etc.)
  - Indoor uncertainty less than outdoors
- Use of minimum sound levels in 1/3 octaves for detection and recognition
  - Moore model review: Suggest further investigation and confirmation that latest reference curves are used.
  - Jury evaluations confirms good detectability of vehicles with sounds not fulfilling proposed specifications.
- Pitch Shift measurement and analysis
  - Precise specifications for pitch shift analysis to be introduced into SAE/ISO standards.
  - Alternative testing methods and analysis will remain under investigation to eliminate need for prior knowledge of signals.

# Forecast

- **Can see viable technical approach for measurement and analysis.**
- SAE and ISO documents updated in short term to reflect editorial, clarification, and corrections noted in ISO/CD ballot comments.
  - Time Schedule: 3-4 months for republished SAE J2889-1
- Inclusion of updated 1/3 octave measurement procedure and developed commencing motion procedure will take further time.
  - Time Schedule: 9-12 Months for implementation into SAE and ISO.
  - Alternative pitch shift measurements need conceptual development and validation

# Additional Remarks

- Choice of bands and levels to better match required detectability without negative interior noise impact to customers.
- Development of test alternatives for full vehicle outdoor measurements.
- Pitch shifting reviewed to allow “Gear Shift” effect for improved detectability.
- **Guidance on direction can reduce development time.**

# Thank You

- Questions?