WP2: Identification of noise emission levels for electric and hybrid-electric vehicles

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Presentation Outline

1. WP2 Objectives
2. Detailed Description of Individual Tasks
3. Next Immediate Steps - Deliverables

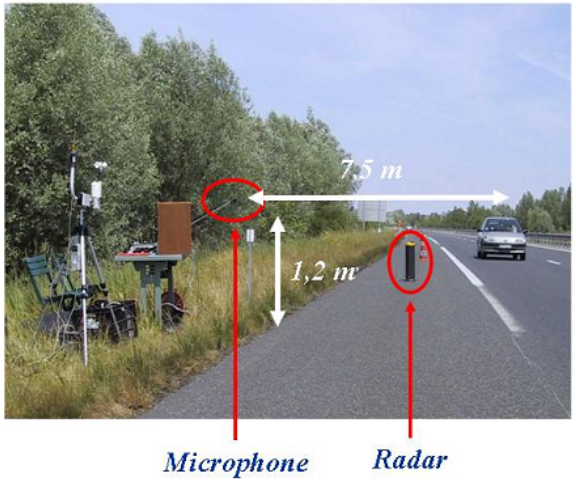
WP2 Objectives

- Identify the sound power emissions (propulsion noise and rolling noise) for EVs/HEVs under controlled operating conditions
- Include the effects of added alert sounds on electric vehicles (*removed from the project*)
- Derive new source description terms for EVs/HEVs for use within the CNOSSOS-EU noise model
- Address the perception of EV/HEV noise characteristics (including impacts of added alert sounds) under real-world operation

Detailed description of individual Tasks

Task 2.1	Review of currently available methods and results
Task 2.2	Sound power emission of the electric/hybrid vehicles under test track conditions
Task 2.3	~~*Impact of alert sounds on electric vehicle emission*~~
Task 2.4	Noise emission from electric vehicles in real-world operation

Task 2.1: Review of currently available methods and results



- **State-of-the-art on the evaluation of vehicle noise**
  - LV, Vans, medium trucks, buses
  - Suburban and urban conditions
- **Application to electric and hybrid-electric vehicles**
  - Same vehicle types and traffic configurations ?

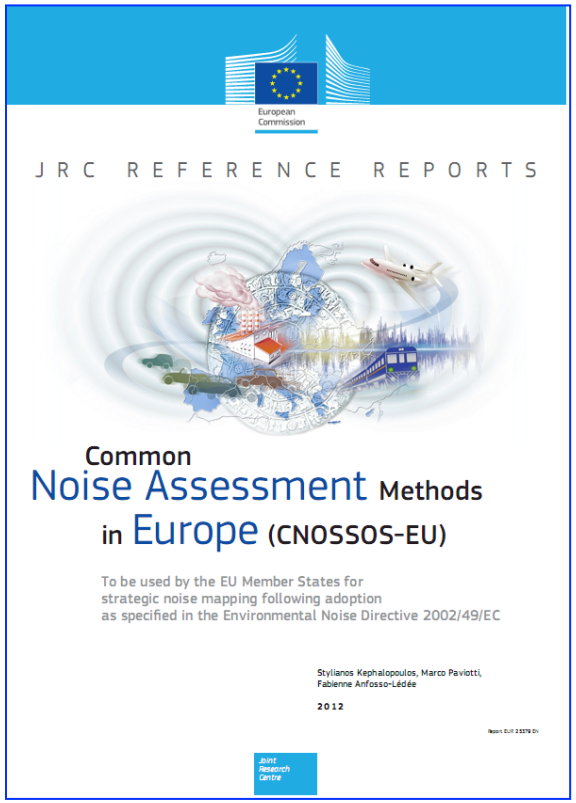
Task 2.2: Sound power emission under test track conditions

- **Pass-by methods**
  - CPB: motor on and off to identify the real impacts of powertrain and tyres ?
  - ISO 362 (effect of acceleration) ?
  - Which vehicle categories ?

- **Array techniques**
  - Well-adapted for medium and large vehicles.
  - What about small vehicles (spatial resolution) ?

Task 2.2: Sound power emission under test track conditions (Continued)

- **CNOSSOS-EU compatible techniques**
  - For EV : Rolling noise only ?
  - For Hybrid : Part between rolling and powertrain noise ? Influence of hybrid technology ?
  - How to take into account special EV tyres and pavement effects (in connection with WP3) ?
  - Driver behaviour ?



Task 2.4: Noise emission from electric vehicles in real-world operation

- **Complete evaluation of noise emission of electric vehicle**
  - Passing-by tests
  - Binaural registration for auralisation

- **How are they perceived by road users ?**

IFSTTAR contribution

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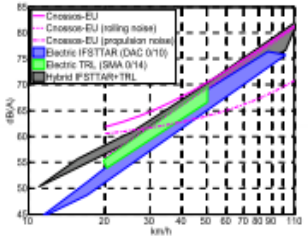
Summary of work and results for vehicle category 1

- Assessment of the noise emission of EVs and HEVs
  - Practical tests
  - Collection of data already available by partners (TRL + IFSTTAR)

- Comparison with CNOSSOS-EU
  - Electric vehicles:
    - Propulsion noise: determination of constant correction terms in each octave band
    - Rolling noise: no correction, pending results from WP3
  - Hybrid vehicles: no correction required



Summary of work and results for vehicle category 1

- How have the correction terms been determined?
  - ➢ Collection of ICE vehicles measured on IFSTTAR test site
    - ⇨ Mean ICE vehicle in each octave band (ICE propulsion noise + rolling noise)
  - ➢ Collection of vehicles in electric propulsion mode on the same site
    - ⇨ Mean EV in each octave band (EV propulsion noise + rolling noise)
  - ⇨ Correction term = EV propulsion noise – ICE propulsion noise

Octave i	*63 Hz*	125 Hz	250 Hz	500 Hz
$\Delta L_{WP,VE,i}$	*-5.0 dB*	-1.7 dB	-4.2 dB	-15 dB
Octave i	**1000 Hz**	**2000 Hz**	**4000 Hz**	
$\Delta L_{WP,VE,i}$	-15 dB	-15 dB	-13.8 dB	

Remark: the correction coefficients have been arbitrarily limited to -15 dB(A).

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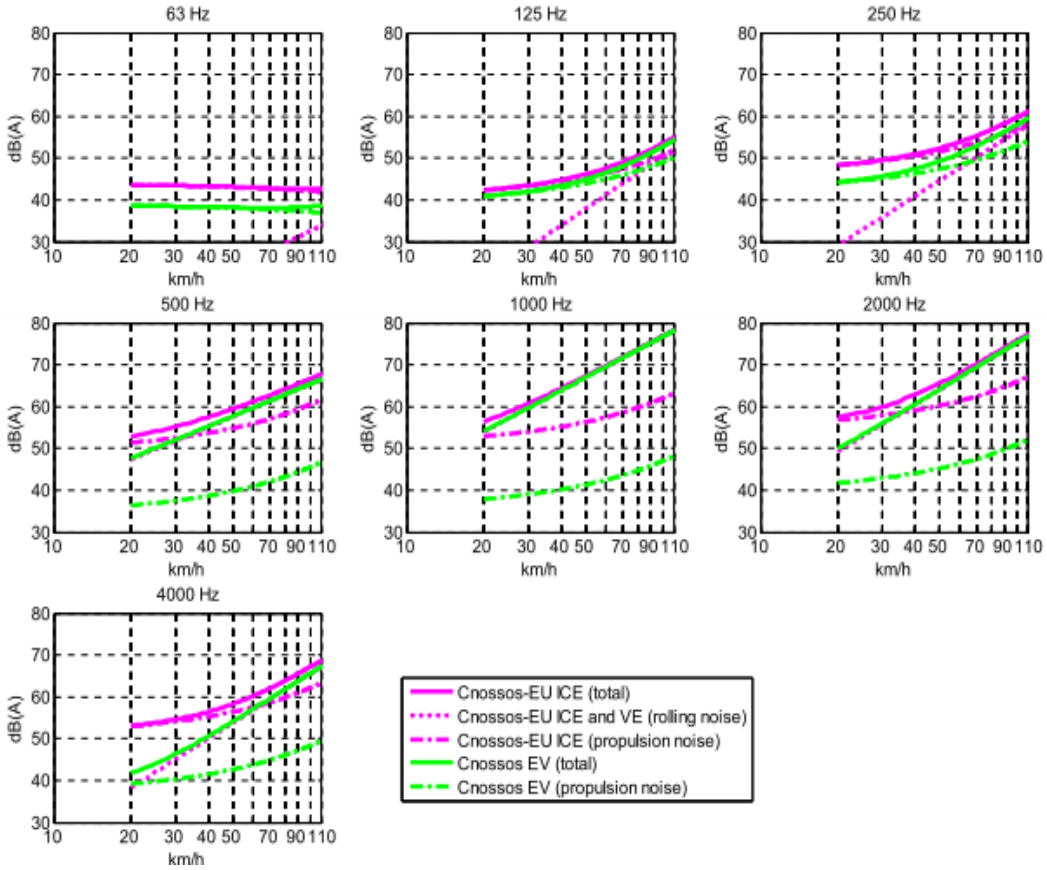
Summary of work and results for vehicle category 1

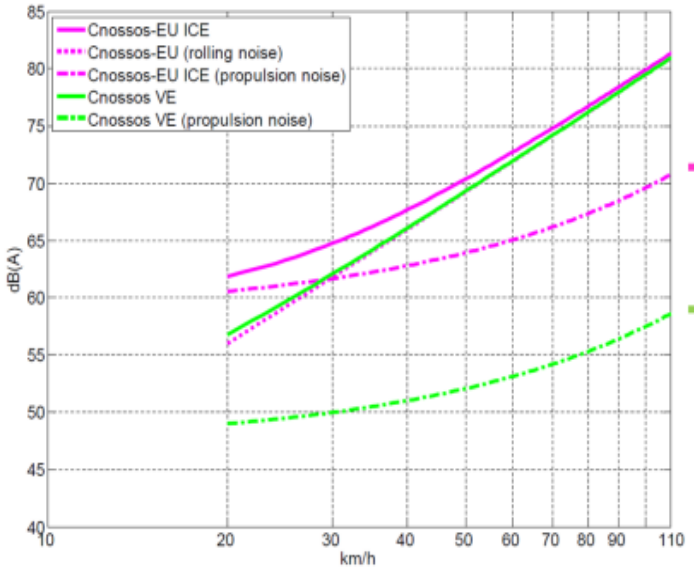
- CNOSSOS-EU and proposal for EVs (in octave bands)



Summary of work and results for vehicle category 1

- Impact on global noise levels, as a function of speed

Speed (km/h)	20	30	40	50	70	90	110
Propulsion noise $L_{EV} - L_{ICE}$ (dB(A))	-11,6	-11,7	-11,8	-11,9	-12,0	-12,1	-12,1
Total noise $L_{EV} - L_{ICE}$ (dB(A))	-5,1	-2,7	-1,6	-1,0	-0,6	-0,5	-0,4



→ *Propulsion noise for ICE vehicles (CNOSSOS-EU)*

→ *Propulsion noise for EVs (FOREVER)*

Analysis of vehicles from category 2

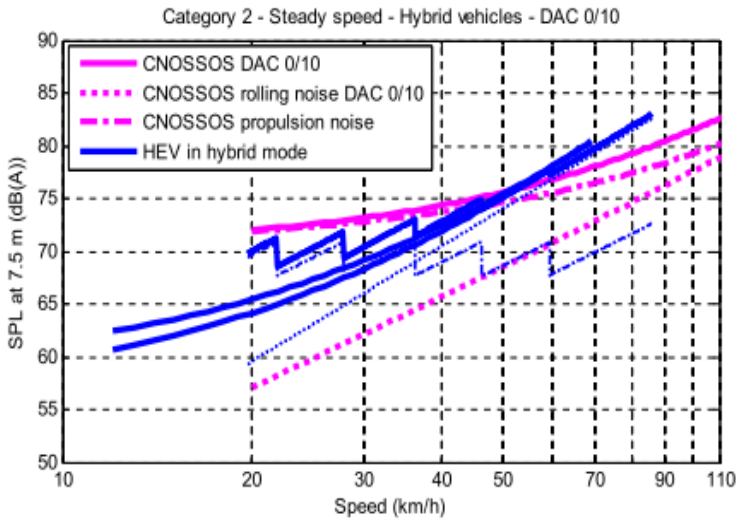
- Category 2 = vehicles with 2 axles (twin tyres on rear axle) and GVW > 3.5 t
- Only few vehicles available

EC vehicle category	CNOSSOS vehicle category	Powertrain mode	Road surface	Measurement		Speed				Dataset	
				CPB	array	stab	accel	decel	Brak-ing	Global SPL	Third-octave SPL
N3	2	Parallel Hybrid	DAC 0/10	✓	✓	✓	✓		✓	✓	✓
N3	2	Electric	DAC 0/10	✓	✓	✓	✓		✓	✓	✓
M3	2	Series Hybrid	DAC 0/10	✓	✓	✓	✓		✓	✓	✓
M3	2	Electric	DAC 0/10	✓	✓	✓	✓		✓	✓	✓
N2	2	Electric	DAC 0/10	✓	✓	✓	✓	✓		✓	✓

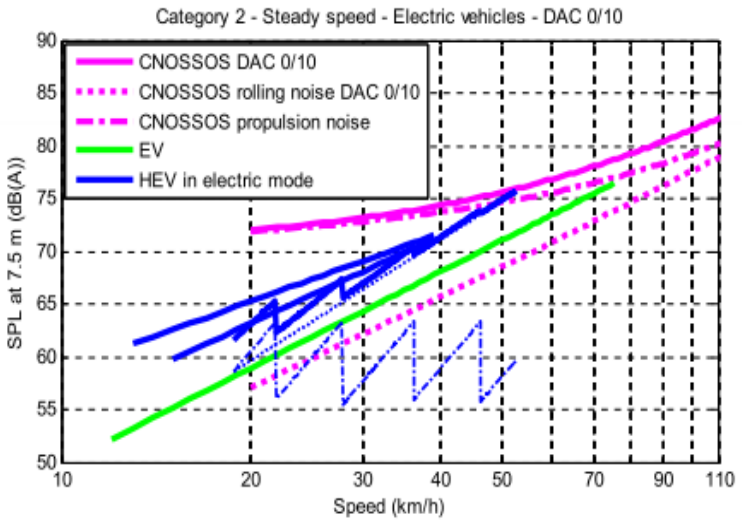
Assessment of HEV and EV noise

- Vehicles from Cat. 2 at steady speed

Vehicles in hybrid mode



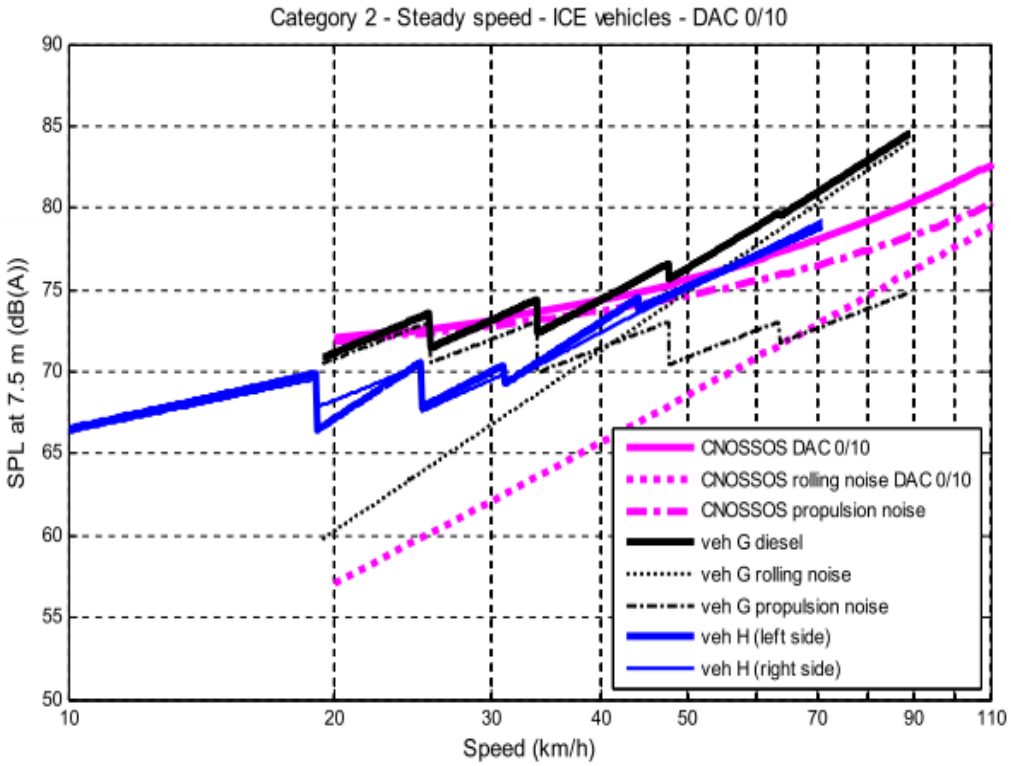
Vehicles in electric mode



⇨ Need for considering CNOSSOS-EU for ICE vehicles in category 2

3.1. Comparison of CNOSSOS-EU with ICE vehicles on IFSTTAR site

- CNOSSOS corrected for DAC 0/10 (rolling noise)

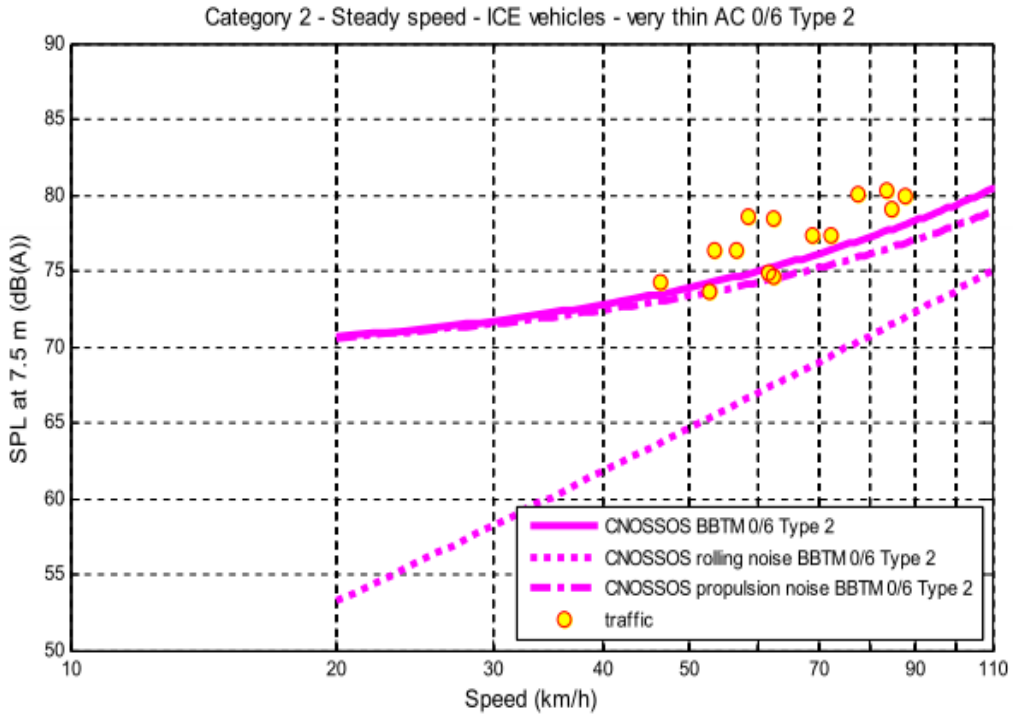


CNOSSOS seems to :

- **underestimate rolling noise**
- **overestimate propulsion noise**

3.2. Comparison of CNOSSOS-EU with traffic vehicles

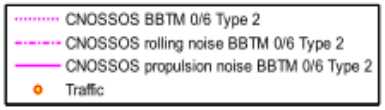
- CNOSSOS corrected for BBTM 0/6 Type 2 (rolling noise + propulsion noise)

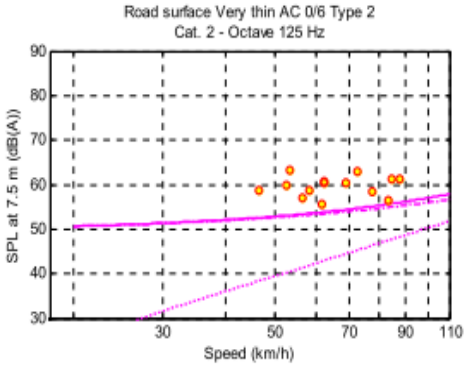


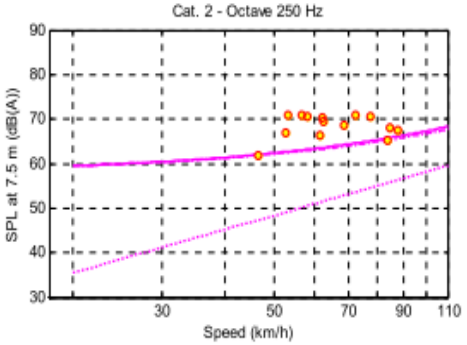
CNOSSOS tends to :

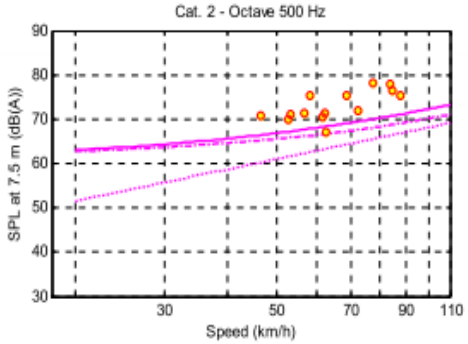
- **underestimate the measures**

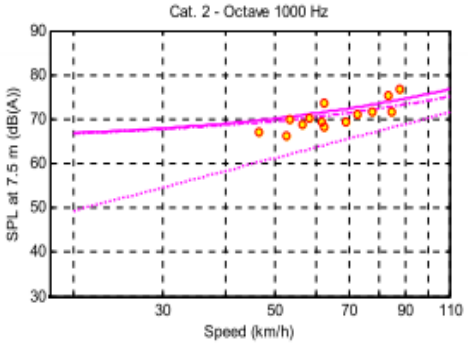
3.2. Comparison of CNOSSOS-EU with traffic vehicles

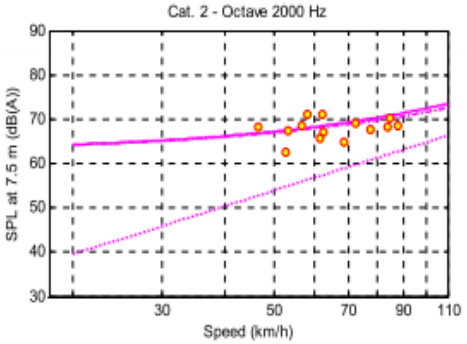


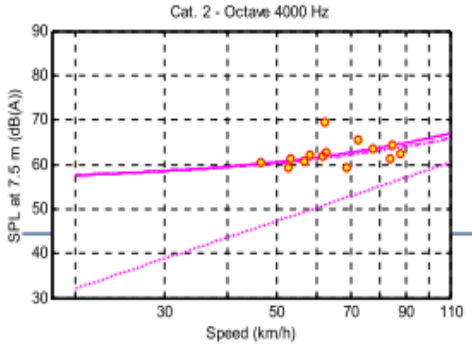






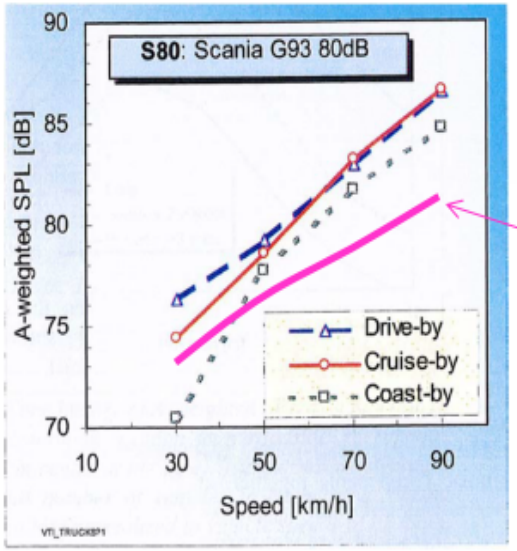






- CNOSSOS underestimates the measures up to 500 Hz
- Estimates are correct from 1000 to 4000 Hz

3.3. Comparison with data from the litterature



[book Sandberg, ISO surface ?]

CNOSSOS

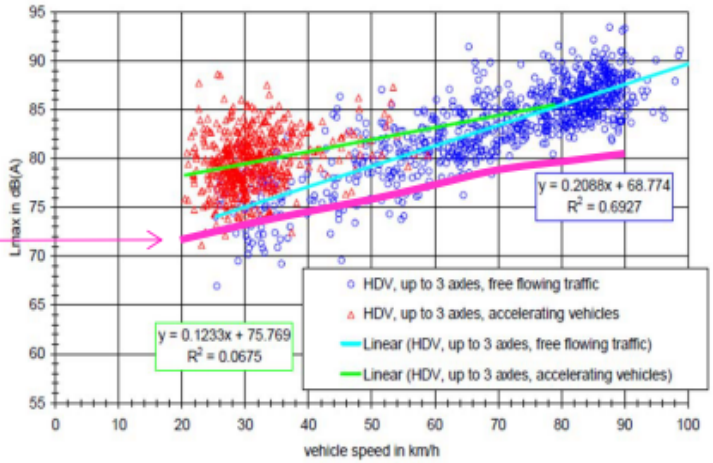


Figure 12: Lmax values for heavy duty vehicles with up to 3 axles versus vehicle speed on asphalt concrete 0/11 or stone mastic asphalt 0/11 for free flowing traffic and accelerating vehicles.

[Steven 2005, DAC 0/11 and SMA 0/11]

Conclusions for category 2

- Several difficulties occur:
  - Our measurement with ICE vehicles **do not coincide** correctly with CNOSSOS-EU model (rolling noise and propulsion noise).
  - There is a **low amount** of test electric and hybrid vehicles available.
  - The category includes a very **wide range** of vehicle types.

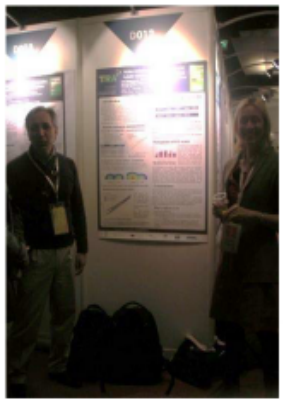
⇨**No noise emission conclusion may be drawn on EV and HEV in this vehicle category.**

⇨It could be worth confronting CNOSSOS-EU with other ICE measurements.

- ➢Should the propulsion noise model be quieter?
- ➢Should the rolling noise model be louder?
  - ⇨*Reduction of the crossing speed value?*

Dissemination

- Congress TRA2014 (14-17 April 2014, Paris, France)



- French congress CFA2014 (22-25 April 2014, Poitiers)

- Forum Acusticum (7-12 September 2014, Krakow, Poland)

Thank you for your attention

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