SC4Life conference will take place on the 5th December in the room #3

11:30 – 13:00 SESSION 1: Cities and Territory

Session Chair: Paulo Pereira

Keynote Speech

The LIFE E-VIA project

Electric Vehicle noise control by assessment and optimisation of tyre/road interaction

(LIFE18 ENV/IT/000201)

http://life-evia.eu http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=7210

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SC4Life SmartCity360° THE GATEWAY TO INNOVATION UM CITIES University of Minho

PARTNERS AND WEBSITES

- Partners:
  - COMUNE DI FIRENZE
  - IPOOL(iPOOL S.r.l.), Italy
  - UNIRC (Universita' Mediterranea di Reggio Calabria), Italy
  - CRD(Continental Reifen Deutschland GmbH), Germany
  - VIENROSE(Vie en.ro.se Ingegneria srl), Italy
  - IFSTTAR(Institut français des sciences et technologies des transports, de l'aménagement et des réseaux), France
- Websites:
  - http://life-evia.eu
  - http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=7210

OBJECTIVES

- The project **objectives** are (hereafter BEV/PHEV cars are generally referred to as electric vehicles, EV):
- To reduce noise for roads inside very populated urban areas through the implementation of a mitigation measure aimed at **optimizing road surfaces and tyres of EVs**. Two road surfaces, at least 5 different EV types, one reference ICE Vehicle (ICEV) and at least 3 types of tyres per vehicle type (including tyres specifically designed for EVs) will be tested
- To estimate the mitigation efficiency and potential of tyres, pavements and traffic (traffic spectrum, speeds, handling conditions) at a higher and comprehensive level: a Life Cycle Analysis (LCA) and a Life Cycle Cost Analysis (LCCA) will be performed to demonstrate the individual and synergistic efficiency of pavement surfaces, tyres and vehicles (including the comparison between internal combustion vehicles, mixed traffic, and EV traffic)
- To contribute to EU legislation effective implementation (EU Directives 2002/49/EC and 2015/996/EC), providing rolling noise coefficients within the Common Noise Assessment Method (CNOSSOS-EU), specifically tuned for EVs which are actually in need of data for practitioners, agencies, and departments aiming at developing future scenarios
- To contribute to national and Italian regional policies, issuing guidelines about use and application of the methodology output of the project, which will be adopted, through the Regional Env. Agency (ARPAT), supporting the project, by Tuscany Region, strongly interested in noise issues (partner of LIFE NEREIDE and Leopoldo project, and issued a law about control of road pavements with CPX method). Calabria Region and Città of Reggio Calabria also expressed their interest
- To raise people's awareness of noise pollution and health effects explaining the opportunities provided by EVs through specific dissemination and promotional events, also investigating people perception regarding noise in terms of soundscape methodology and involving them in noise data acquisition
- To demonstrate and promote sustainable road transport mobility (electric), reducing noise emission by 5 dB(A) at receivers roadside and achieving also CO_2 emissions reduction (21%), based on the Italian context (LPG, CNG, Hybrid, EV, petrol cars, diesel cars) and the concerned literature
- To encourage low-noise surfaces implementation in further EU and extra-EU scenarios, demonstrating durability and sustainability, through in-depth LCA&LCCA

OBJECTIVES IN PRACTICE..

Objectives	
2 pavement solutions	P
5 different EV types	EV
One reference ICE vehicle	ICE
3*6=18 types of tyres	T
LCA and LCCA (synergistic efficiency of pavement surfaces, tyres and vehicles)	
Providing rolling noise coefficients within the Common Noise assessment Method (CNOSSOS-EU)	
Contributing to national and Italian regional policies	
raise people's awareness of noise pollution and health effects	
Reducing noise emission by 5 dB(A) at receivers roadside and achieving also CO_2 emissions reduction (21%),	
low-noise surfaces: implementing in further EU and extra-EU scenarios, and demonstrating durability and sustainability, through in-depth LCA&LCCA	

OBJECTIVES IN PRACTICE..

Experiments

2 pavement solutions

5 different EV types

One reference ICE vehicle

3*6=18 types of tyres

Analyses

LCA and LCCA

CNOSSOS-EU coefficients

Results

low-noise, durable, and sustainable surfaces.

National and Italian regional policies.

Raise people's awareness

In practice

Reducing noise emission by 5 dB(A).

CO2 emissions reduction (21%).

PAVEMENT SOLUTIONS?

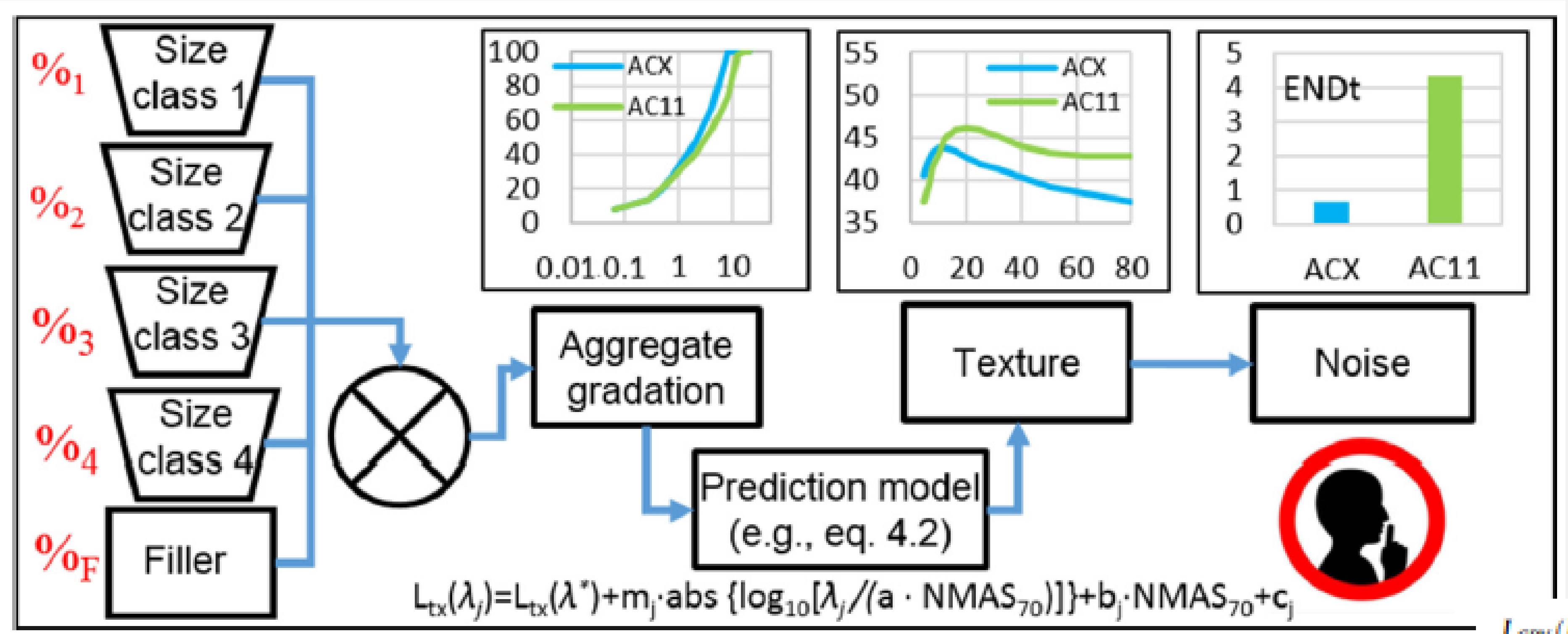
Reference	Type of solutions	Thickness (mm)	Maximum aggregate size or NMAS (mm)	Texture (mm) or/and air void content (%)	Noise reduction (dB)
(Praticò et al., 2013)	PERS	30	2mm (rubber) 8 mm (aggregate)	30-35%	5-15 (vs. DAV)
	RAC (O)	30	12 (as OGFC)	14-20%	6
	RAC(G)	30-50	12 (as DGFC)	4%	
	SMA 0/16	30-50	16 mm	4%	-1 ~ -2
	SMA 0/11	30-50	11	4%	0
	SMA 0/8	30-50	8	4%	1
	SMA (general)	30-50	5-16 mm	0.5-1.5 mm (4%)	-2 ~ -1
	DAC 0/11 or DAC 0/8	30	8/11	0.8 mm (4%)	0
	PAC 0/8	45	16	25%	3
	PAC 0/11	45	11	25%	4
	PAC 0/8	45	8 mm	25%	5
	TPA	25 (top)+ 45 (bottom)	8 (top) 16 (bottom)	20% (top) 25% (bottom)	4-6 (vs. DAC)
	Thin layers	5- 8 mm	5 – 8 mm	5 -15%	3-7
	Bardon	25 – 35 – 50 mm c.a.	14	SH=2mm	3 (vs. HRA)
	Masterflex	(15-50 mm)	6-10-14	2 mm	5-6 (vs. DAC)
	Novachip	(12 – 25 mm)	6 mm; 9 mm; 12mm; (1/4 – 3/8 – 1/2)	Texture similar to PAC	1 (VS. PCC/DAC)
	MASTERpave	(20 mm – 50 mm -75 mm)	6 – 14 – 20 mm	1.5-2	4
	UL-M	20 – 50 mm	6 mm – 10 mm – 14mm	1.5 mm	5-7 (vs. DAC)
	MicroFlex		6 mm	AV=13%	3.9-4.9 (vs, DAC)
	Colsoft	20-30 mm	6 mm – 10 mm	2 mm	3~5 (vs. DAC)
	Rugosoft	20-50 mm	Unknown	Unknown	5~7 (vs. DAC)
	Nanosoft	25-40 mm	4 mm	Unknown	9
	MICROVIA	10-30 mm	6 mm	0.8 mm	Unknown
	Rollpave	30 mm	6 mm	Unknown	4.3
	Nobelpave	NA			
	Surface dressing	3~20 mm	3~20 mm		+2~-3 dB
	Porous cement concrete	80	9.5 mm	20-25%	4~8
	Portland cement concrete - general			4%-25%	-2~8

PAVEMENT SOLUTIONS?

Reference	Type of solutions	Thickness (mm)	Maximum aggregate size or NMAS (mm)	Texture (mm) or/and air void content (%)	Acoustic indicator used	Noise reduction (dB)	Noise increase (dB/year)
(Donavan and Janello, 2018)	ARFC	25 mm	9.5 mm	20-21%	CPX/OBSI	/	0.5 dB/Year
(Anderson et al., 2013; Pierce et al., 2009)	OGFC-AR	19 mm	9.51 mm		OBSI	4.3 (vs. HMA)	2.1
	OGFC-SBS	19 mm	9.51 mm		OBSI	3.4 (vs. HMA)	1.45
	HMA	30 mm	12.5 mm		OBSI	/	1.03
(Bendtsen et al., 2010, 2009; Illingworth &Rodkin, 2002)	OGAC	25 mm	9.5 mm	/	/	/	0.11-0.19
(Bendtsen et al., 2010, 2009; Rochat et al., 2010)	DGAC	30 mm	12.5 mm	9%	SPB	/	0.24*-0.29**
	OGAC	30 mm	12.5 mm	15%	SPB	1.7 (vs. DGAC)	0.20*-0.12**
	OGAC	75 mm	12.5 mm	12%	SPB	3.3 (vs. DGAC)	0.10*-0.31**
	RAC-O	30 mm	12.5 mm	12%	SPB	2.3 (vs. DGAC)	0.40*-0.36**
	BWC	30 mm	12.5 mm	7%	SPB	0.9 (vs. DGAC)	/
(Bendtsen and Nielsen, 2008)	DGAC11	33 mm	11	2.8	SPB/CPX	/	0.72*-0.8**
	UTLAC	22 mm	8	14.4	SPB/CPX	2.2 (vs. DGAC11)	1.06*-0.35**
	OGAC	28 mm	8	15.3	SPB/CPX	2.9 (vs. DGAC11)	0.8*-0.09**
	SMA8	29 mm	8	12.4	SPB/CPX	0.4 (vs. DGAC11)	0.5*-0.21**
	SMA6+	26 mm	6+5/8	[illegible]	SPB/CPX	1.6 (vs. DGAC11)	0.93*-0.63**
	SMA8+	33 mm	8+8/11	[illegible]	SPB/CPX	2.5 (vs. DGAC11)	1.32*-0.67**

NOTE. **ARFC**= Asphalt Rubber Friction Course; **OGFC-AR**= OGFC+Asphalt Rubber; **OGFC-SBS**=OGFC+styrene-butadiene-styrene; **HMA**= Hot Mix Asphalt; **OGAC**= Open Graded Asphalt Concrete; **DGAC**= Dense Graded Asphalt Concrete; **RAC-O**=Rubber Asphalt Concrete-Open; **BWC**= Bonded Wearing Course; **UTLAC**= Ultra Thin Layer Asphalt Concrete; **SMA**= Stone Mastic Asphalt; **CPX**= Close Proximity Method; **OBSI**= On Board Sound Intensity Method; **SPB**= Statistical Pass-by Method.
*passenger car; ** multi-axle vehicle

PAVEMENT SOLUTIONS?



Praticò and Briante, 2020.

Del Pizzo et al, 2020.

$$L_{CPX}(HF)=a_{hf}L_{SG,tx}(8\text{mm})+b_{hf}$$

where:

$L_{CPX}(HF)$ is noise level at high frequency,
$L_{SG,tx,8}$ is the SG texture level at 8 mm,
a_{hf} and b_{hf} are the regression parameters

and:

$$L_{CPX}(LF)=a_{lf}L_{SG,tx}(80\text{ mm})+b_{lf}$$

EV: Renault FLuence Z.E.

EV *VS.* ICE …(?!)

ICEV: Renault Megane Grandtour

- Czuka et al., 2016: On the basis of current knowledge, it turns out that rolling noise from light electric vehicles does not differ from conventional vehicles.
- Mocanua et al, 2016:
  - EV… **different sizes, masses, weight distribution** and acoustic properties of these types of vehicles,…
  - EV.. are acoustically similar to combustion-based cars at velocities above 30 km/h, but they are significantly less audible at velocities below 30 km/h, therefore an increased risk exists, especially for visually impaired and blind Pedestrians
- EV have **high power-to-weight ratios or rather high torques** that remain relatively constant even at low speeds. Does this potential increase in acceleration performance indeed lead to **higher than normal (with respect to c-cars) accelerations**?
- EV can recuperate kinetic energy from deceleration phases and load the accumulator, thereby improving energy-efficiency. Does recuperation lead to higher than normal (with respect to c-cars) decelerations or cause **abrupt braking**?
- Does the different weight distribution and centre of gravity of e-cars have an effect on the **dynamic behaviour of the car**?

EV *VS.* ICE …(?!)

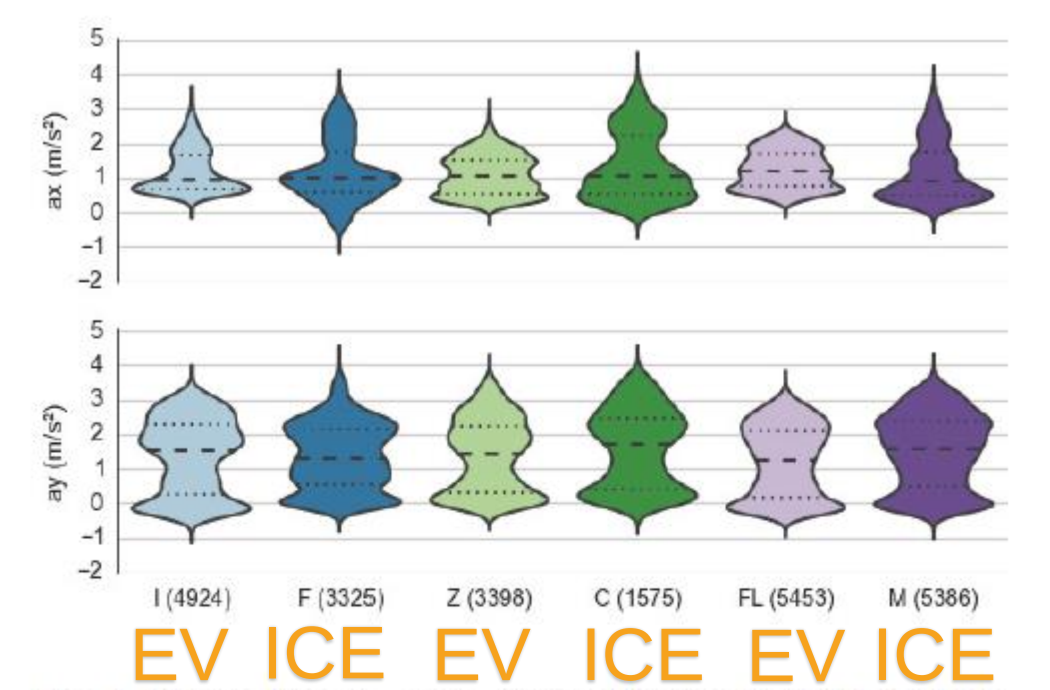


Fig. 1. Violin plots of a_x and a_y for acceleration from 0 to 40 km/h.

- Ax: longitudinal
- Ay: lateral acceleration
- 1) Renault **FL**uence Z.E. - Renault **M**egane Grandtour,
- 2) Renault **Z**oe - Renault Captur and
- 3) Mitsubishi **i**-MiEV - **F**iat 500.

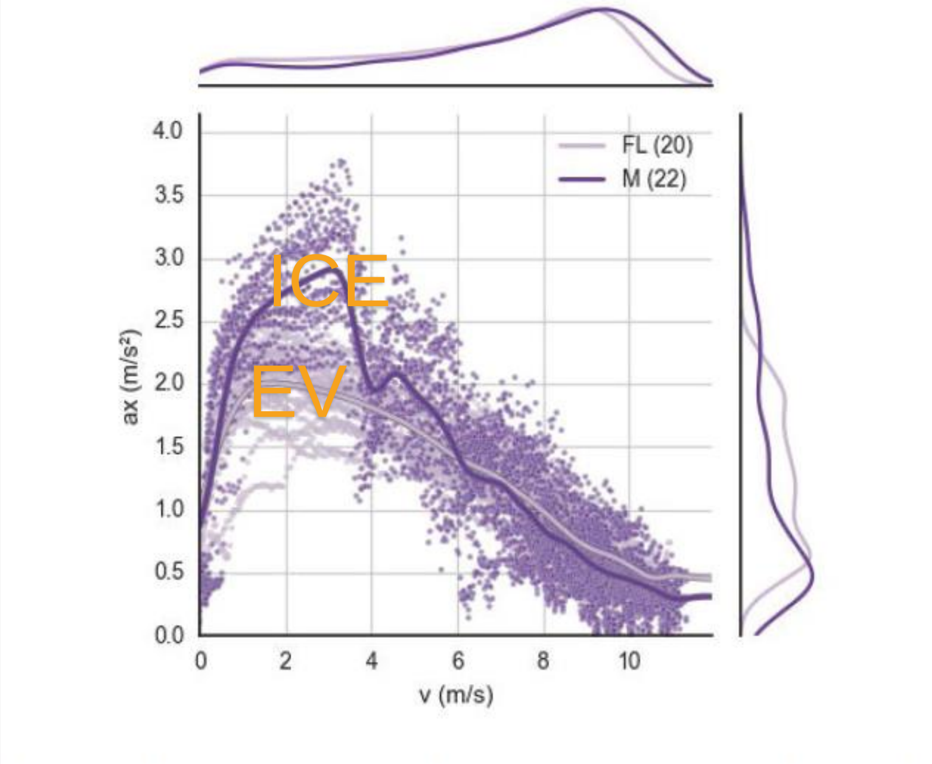
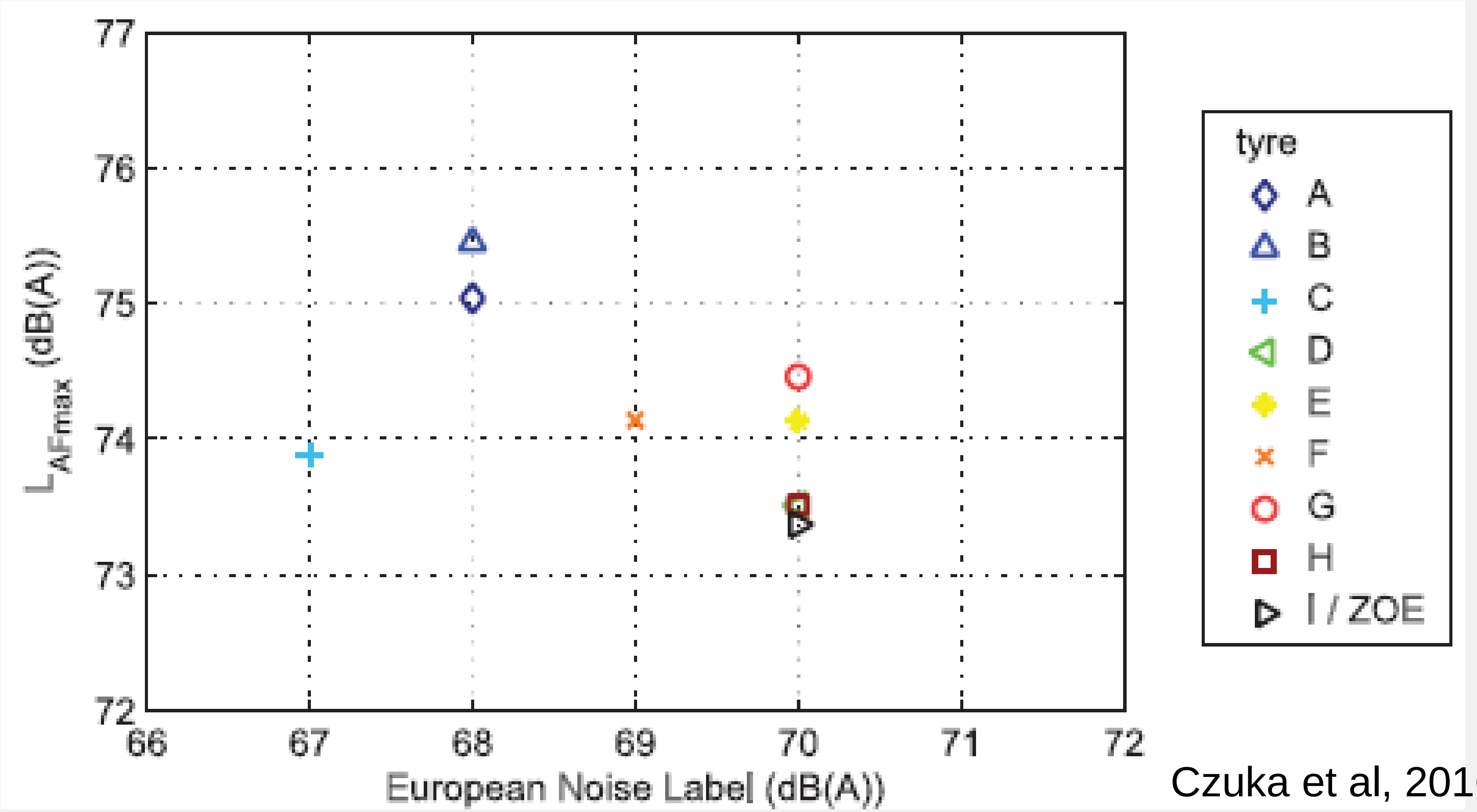


Fig. 2. Joint plot of a_x versus v for acceleration from 0 to 40 km/h, vehicle pair: FL-M.

Mocanua et al, 2016

TYRE SOLUTIONS?



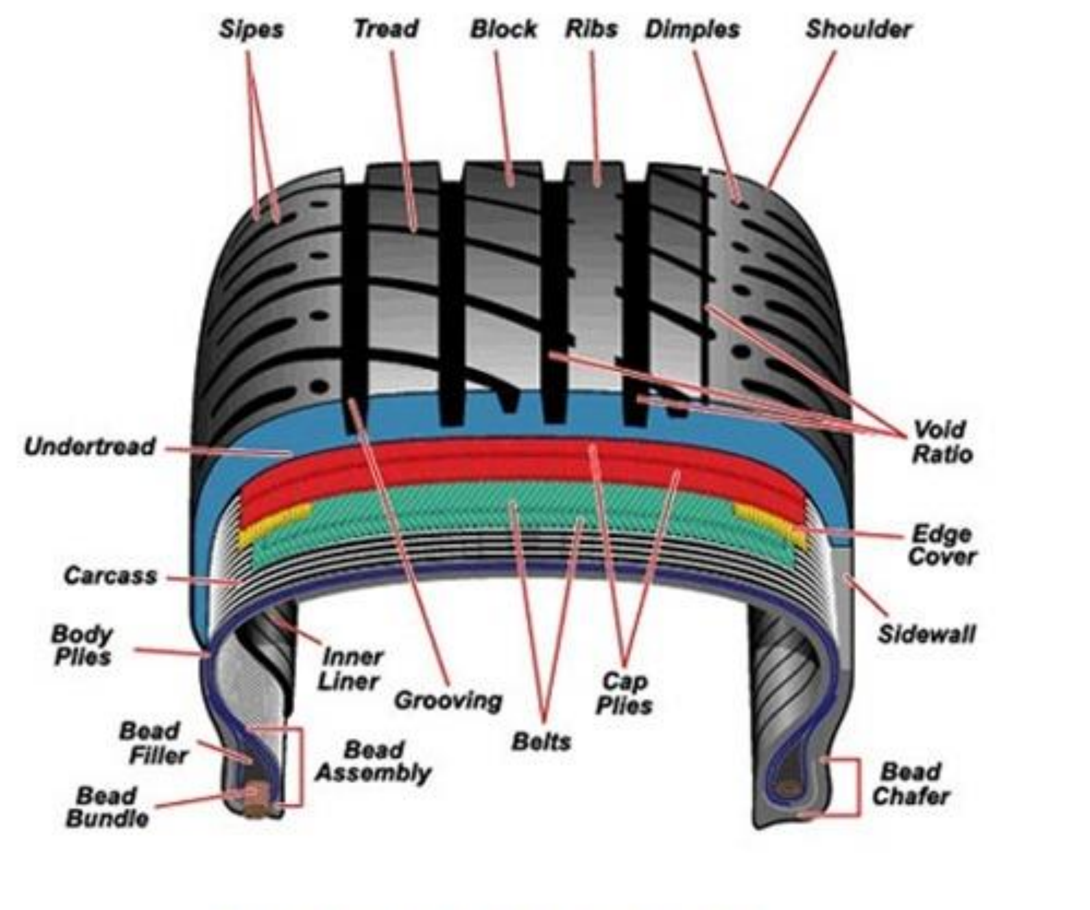
Czuka et al, 2016

Table 1. Set of tyres selected for the measurements. The EU label is in the format "Rolling Resistance/Wet Grip/Noise Emission".

Abbreviation	Brand	Model	Dimensions	EU Label
A	Dunlop	Sport BluResponse	205/55 R16 91H	B/A/68
B	Goodyear	Efficient Grip	205/55 R16 91H	C/C/68
C	Kumho	Ecowing ES 01 KH27	205/55 R16 91V	B/B/67
D	Pirelli	Cinturato P1 Verde	205/55 R16 91H	B/B/70
E	Toyo	NANOENERGY 2	205/55 R16 91V	A/C/70
F	Bridgestone	Ecopia EP150	205/55 R16 91H	B/B/69
G	Michelin	ENERGY SAVER	205/55 R16 91W	B/A/70
H	Hankook	Kinergy Eco K425	205/55 R16 91H	B/B/70
I	Michelin	ENERGY E-V	195/55 R16 91Q	A/A/70

- Noise levels measured at 80 km/h on AC11 compared with the EU noise labels, for the 8 tyre types fitted to the Fluence Z.E. and 1 tyre fitted to the ZOE (black).
- **EU labels do not properly render the tyre ranking given by the noise measurement on the AC11 surface (?)**.

TYRE SOLUTIONS?



STRUCTURE OF A TYRE

http://www.mapeng.net/news/mechanical_English_article/2015/7/mapeng_15722145195363.html

- Tread pattern (sipes, ribs)?
- Shoulders?
- Carcass?
- Sidewalls?
- Geometry?

Noise?, Friction?

Rolling resistance?

Holistic approach?

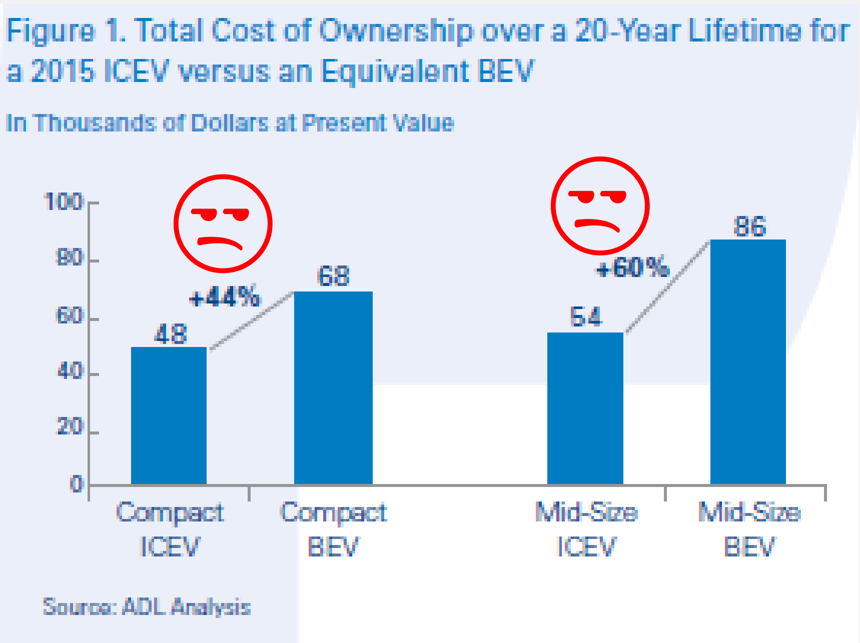
LCA AND LCCA?

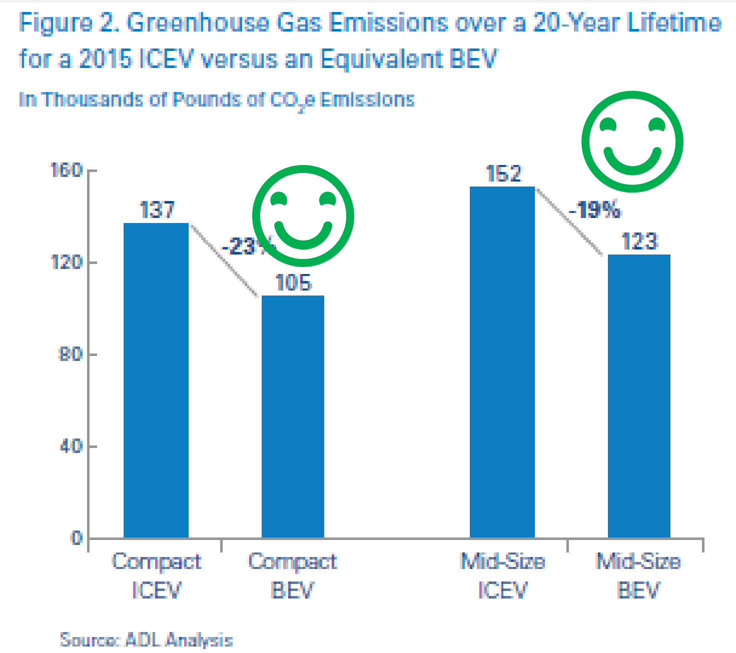
Impact assessment methods and indicators

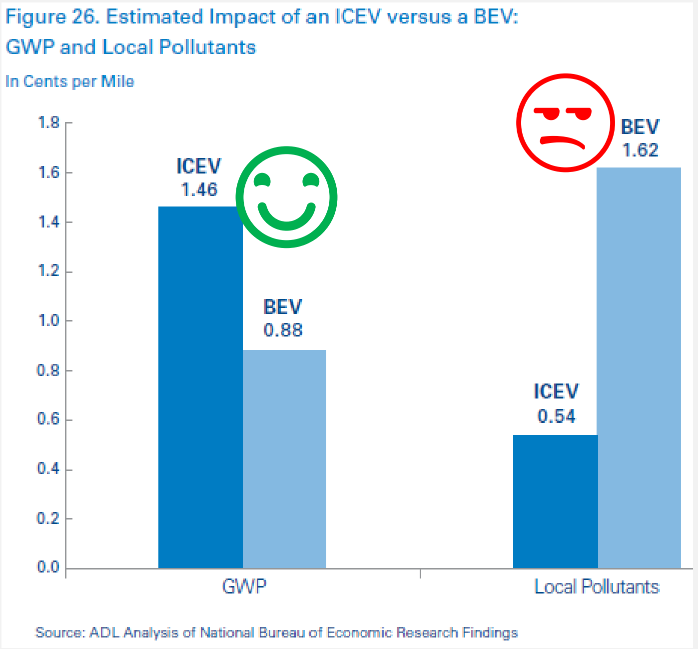
- GER (MJprimary):GER is calculated as the total primary energy demand of the whole life cycle.
- GER: Global Energy Requirement (MJprimary);
- GWP: GlobalWarming Potential (GWP, kg CO_2eq);
- AP: Acidification Potential (AP, kg SO_2eq);
- NP: Eutrophication Potential (NP, kg PO_4eq^{3-})
- POCP: Photochemical Oxidation Potential (POCP, kg C_2H_4eq).
- Noise
- Costs..

LCA AND LCC

BUT...







Brennan and Barder

CNOSSOS METHOD

$$L_{W',eq,line,i,m} = L_{W,i,m} + 10 \times \lg\left(\frac{Q_m}{1000 \times v_m}\right)$$

$$L_p = L_W - \left|10 \cdot \log\left(\frac{Q}{4\pi \cdot r^2}\right)\right|$$

$$L_{W,i,m}(v_m) = 10 \times \lg\left(10^{L_{WR,i,m}(v_m)/10} + 10^{L_{WP,i,m}(v_m)/10}\right)$$

$$L_{WR,i,m} = A_{R,i,m} + B_{R,i,m} \times \lg\left(\frac{v_m}{v_{ref}}\right) + \Delta L_{WR,i,m}(v_m)$$

$$L_{WP,i,m} = A_{P,i,m} + B_{P,i,m} \times \frac{(v_m - v_{ref})}{v_{ref}} + \Delta L_{WP,i,m}(v_m)$$

Sound power (W) emission	
Flow, average speed, and i-th vehicle contribution	
I-th Rolling (R) noise	i-th Propulsion (P) noise
Vehicle category (5 categories)	
Speed	
Road surface	
Driving conditions (acc)	Driving cond.(acc, grad)
Tyres and temperature	
Age of pavement (?)	

$$\Delta L_{WR,i,m}(v_m) = \Delta L_{WR,road,i,m}(v_m) + \Delta L_{studded\ tyres,i,m=1}(v_m) + \Delta L_{WR,acc,i,m} + \Delta L_{W,temp}(\tau)$$

$$\Delta L_{WP,i,m}(v_m) = \Delta L_{WP,road,i,m}(v_m) + \Delta L_{WP,acc,i,m} + \Delta L_{WP,grad,i,m}(v_m)$$

WHERE ARE WE GOING NOW?

Museo Nazionale della Magna Grecia- Reggio Calabria-Italy

MAIN PARAMETERS OF THE PROJECT AND GANTT CHART

Action		2019				2020				2021				2022				2023				2024			
Action numbe	Name of the action	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
A. Preparatory actions (if needed)																									
A.1	Electric vehicles and their noise emission			■	■	■																			
A.2	Quiet pavement technologies and their performance over time			■	■	■																			
A.3	Tyre role in the new context of EV and ICEV			■	■	■																			
B. Implementation actions (obligatory)																									
B.1	Tracks design				■	■	■	■	■	■															
B.2	Tyre-pavement coupling study and prototype implementation			■	■	■	■	■	■	■	■	■													
B.3	Pilot area: Implementation. Replication and tranferability						■	■	■	■	■	■	■	■	■	■	■	■							
B.4	Track efficiency tests in the pilot area							■	■	■	■	■	■	■	■	■									
B.5	Soundscape analysis			■	■	■	■	■	■	■	■	■	■	■											
B.6	Evaluation of EV noise emissions							■	■	■	■	■	■	■	■	■									
B.7	Holistic performances of tyres			■	■	■	■	■	■	■	■	■	■	■	■	■	■								
C. Monitoring of the impact of the project actions (obligatory)																									
C.1	Monitoring of the impact of the project actions			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
C.2	Life cycle analysis (LCA) and life cycle costing (LCC)			■	■	■	■	■	■	■	■	■	■	■	■	■	■								
D. Public awareness and dissemination of results (obligatory)																									
D.1	Information and awareness raising activities			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
D.2	Technical dissemination activities to stakeholders			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
E. Project management (obligatory)																									
E.1	Coordination, Monitoring and Project management			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
E.2	After LIFE Plan																■	■							

A2: August 26th, 2019+9months=May,25th, 2020?

Project: August 26th, 2019+45months=May,25th, 2023?

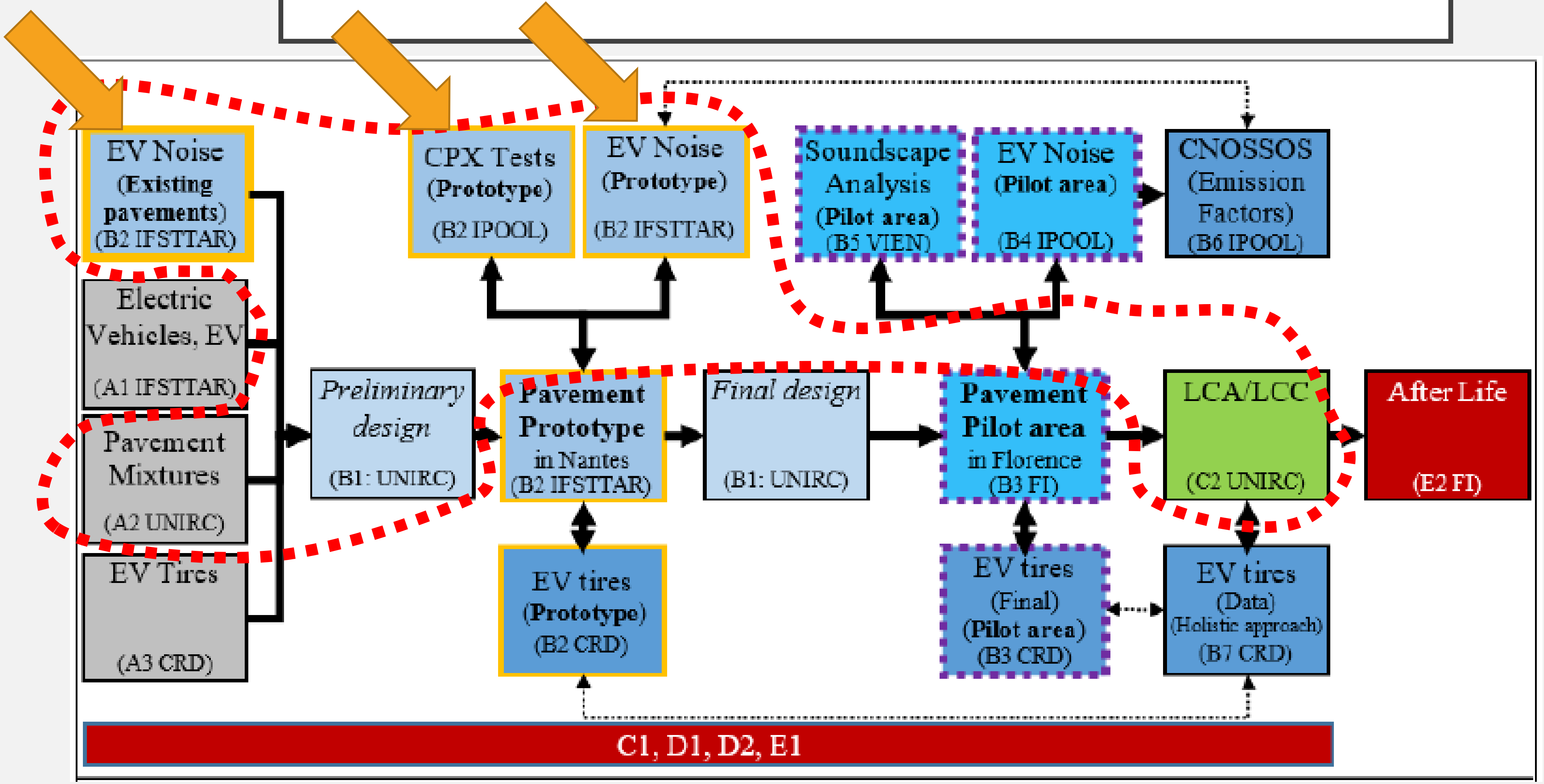
BENEFICIARY RESPONSIBLE FOR IMPLEMENTATION AND INTERACTIONS

- **Project:**
  - **UNIRC (IFSTTAR, IPOOL)**:
  - UNIRC gathers and structures available references in the pursuit of the following actions (mainly B1 and C2).
  - IFSTTAR and IPOOL provide advice, support and references **for tyre-pavement interaction (IFSTTAR)** and noise-related issues (IPOOL).
- Actually: Being B2 prodromal to B1 and being this latter studied also in A2, A2 interacts with B2, too

ACTIONS CONNECTED-CONTINUED

- **B2➔B1: Tracks design**. B1 aims at selecting mixtures (volumetrics, materials, and surface texture), for the tracks to be constructed in France and Italy, in order to minimize noise from EV, taking into account the synergy with actions B2. [UNIRC]. B1. Milestone deadline: 31/01/2021?. Report deadline: 31/03/2020? : 31/03/2021?.
- **C2: Life cycle analysis (LCA) and life cycle costing (LCC).** These analyses will evaluate track efficiency from a comprehensive point of view, including soundscape components (B5), thus achieving obj.6 of demonstrating the durability and effectiveness through LCA/LCC. [UNIRC]. C2 Report: deadline: 02/2023 (28/02/2023)?

FLOWCHART



EV Noise (Existing pavements) (B2 IFSTTAR)
CPX Tests (Prototype) (B2 IPOOL)
EV Noise (Prototype) (B2 IFSTTAR)
Soundscape Analysis (Pilot area) (B5 VIEN)
EV Noise (Pilot area) (B4 IPOOL)
CNOSSOS (Emission Factors) (B6 IPOOL)
Electric Vehicles, EV (A1 IFSTTAR)
Pavement Mixtures (A2 UNIRC)
EV Tires (A3 CRD)
Preliminary design (B1: UNIRC)
Pavement Prototype in Nantes (B2 IFSTTAR)
Final design (B1: UNIRC)
Pavement Pilot area in Florence (B3 FI)
LCA/LCC (C2 UNIRC)
After Life (E2 FI)
EV tires (Prototype) (B2 CRD)
EV tires (Final) (Pilot area) (B3 CRD)
EV tires (Data) (Holistic approach) (B7 CRD)
C1, D1, D2, E1

ACTION A2 - QUIET PAVEMENT TECHNOLOGIES AND THEIR PERFORMANCE OVER TIME-REPORT CONTENTS

1. Main parameters of the project and of A2
2. Solutions in the literature (including CR-based ones)
3. Analysis solution-by-solution (Acoustic performance and durability (including preliminary tests); Non-acoustic performance and durability; Corresponding mixture composition; Corresponding agency and user costs)
4. Comparative analyses
5. Raw materials and processes involved and their impact on environmental indicators
6. Research and industrial areas and elements to enhance the formula/processes
7. Their compatibility and perspectives when analysed in terms of 2015/996/EC directive, CNOSSOS-EU mod
8. Their compatibility and perspectives when compared to the transition from the actual spectrum of traffic to a new scenario in which EVs will be an outstanding percentage
9. B2: lesson learned to date and how they impact track design
10. Other emerged issues and perspectives
11. How this report compares to the as-design report stated in the proposal
12. Conclusions (scientific and practical bases to design the tracks)
13. References

(SOME!) REFERENCES

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Università degli Studi
Mediterranea
di Reggio Calabria

LIFE PROJECT E-VIA UNIVERSITY MEDITERRANEA OF REGGIO CALABRIA OPENINGS FOR POST-DOCS IN THE FIELD OF PAVEMENT-TYRE INTERACTION!

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Thank you for the attention!!!