GC.SST.2011.7-2. Specific safety issues of electric vehicles

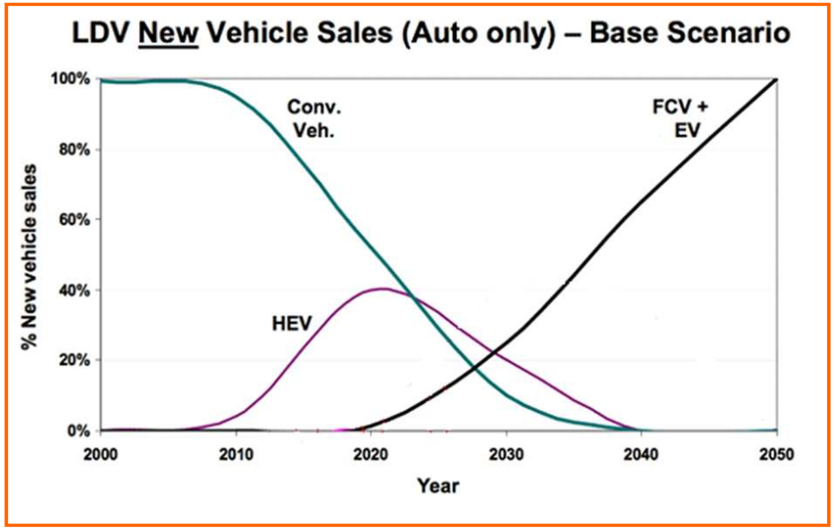
Electric Vehicle Alert for Detection and Emergency Response (eVADER)

An EARPA Project Initiative for FP7

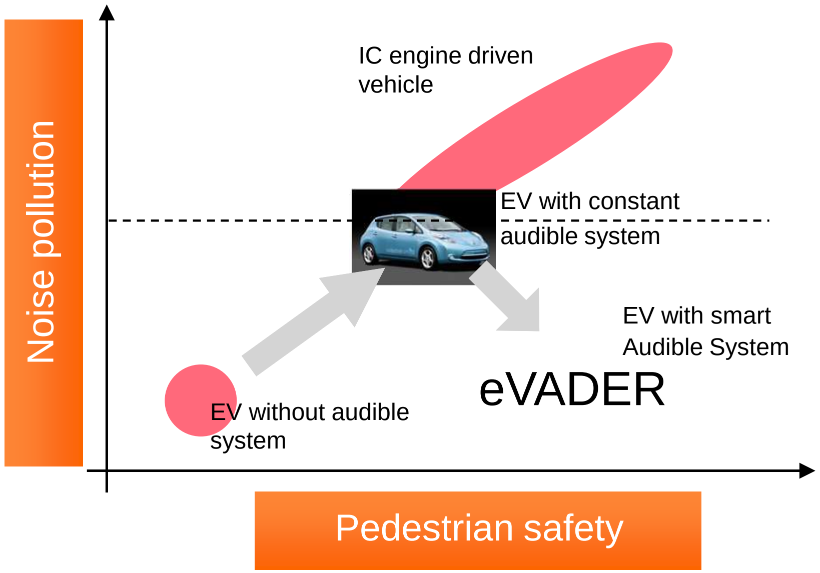
CONTENT

- Background
- Objectives & Innovations
- Partners
- Structure and Timing

Background: Current European research situation



A significant growing in the EV sales is expected



The objectives of the eVADER projects are to improve the pedestrian safety without to increase of noise pollution for the next EV generation

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•Project Objectives

•Investigate the Interior and Exterior Sound Scape of Electric vehicles for safe operation, considering Driver's feedback, feasible pedestrian reactions, driver and pedestrian warning systems and Pedestrian Safety.

- **To get a comprehensive knowledge of the sound criteria for interior and exterior noise of EV with special emphasis on driver's feedback and pedestrian safety**

- **To achieve a high level of pedestrian safety in terms of the additional risk associated to the low exterior noise of EV**

- **Integration of Intelligent Vehicle Safety Systems (IVSS) data with warning signals for close-to accident pedestrian safety.**

- **The knowledge gained to be used for future applications on real traffic conditions**

•Project Innovations

•The eVADER consortium wants to provide all users (children, elderly, blind,…) a positive and concrete answer to highly reduce the safety risk that electrical and silent vehicles might cause for pedestrians

- **Project developed thinking in user's needs**
- **Project based on jury tests results and IVSS testing**
- **Search of optimal warning signal**
- **Optimisation of warning signal performance v.s. acoustic landscape**
- **Integration between IVSS, environment information and acoustic warning signal**

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PARTNERS – Consortium as a whole

- **Current partners**

• IDIADA • LMS International • AIT • TNO	R&D Centers
• INSA-Lyon • Technical University of Darmstadt	Universities
• RENAULT • NISSAN NTCE • PSA	OEM's
• CONTINENTAL • MERIDIAM AUDIO	Tier-1's
• European Blind Union	End users

PARTNERS: Interaction partners – WP – Consortium as a whole

Beneficiary Number	Partner	Country	Expertise	Tasks – Role in eVADER
1 (coordinator)	IDIADA AUTOMOTIVE TECHNOLOGY SA	SPAIN	Validation and Testing of Vehicles and Vehicle Components	Coordination and management Global Validation and Testing
2	TUD	GERMANY	NVH and psycho-acoustics	Design and construction of acoustic warning devices. Application of in-vehicle intelligent systems with warning actuators
3	LMS-INTERNATIONAL	BELGIUM	Development and construction of NVH hardware and software	Dissemination
4	ÖSTERREICHISCHES FORSCHUNGS- UND PRÜFZENTRUM ARSENAL GES.M.B.H.	AUSTRIA	NVH, road safety, road traffic noise, tyre/road noise	Algorithms and strategy definition for in-vehicle intelligent systems data and warning systems integration in FEV
5	TNO	THE NETHERLANDS	Validation and Testing of Vehicles and Vehicle Components	Warning signal generators
6	INSA-LYON	FRANCE	Technical University	Psycho-acoustic and sound radiation phenomena
7	NISSAN-NTCE	ENGLAND	Vehicle manufacturer	Vehicle implementation
8	RENAULT	FRANCE	Vehicle manufacturer	Concept definition and system requirements
9	PSA	FRANCE	Vehicle manufacturer	Concept definition and system requirements
10	CONTINENTAL	FRANCE	Supplier, Tier1	System feasibility, Driving Assist System
11	EUROPEAN BLIND UNION	FRANCE	Networking national members blind organisations	Coordination, management and dissemination (End user)

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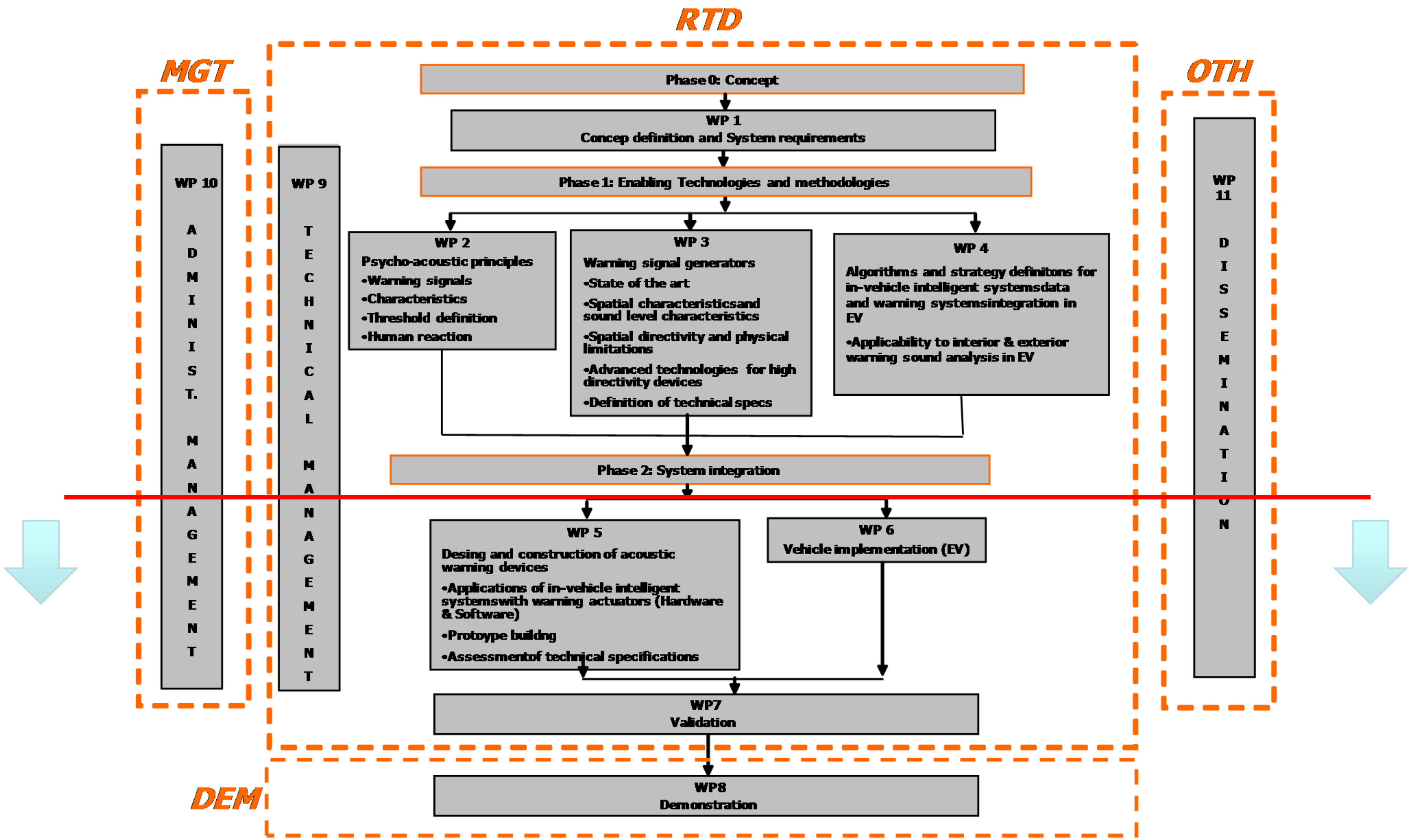
Project structure

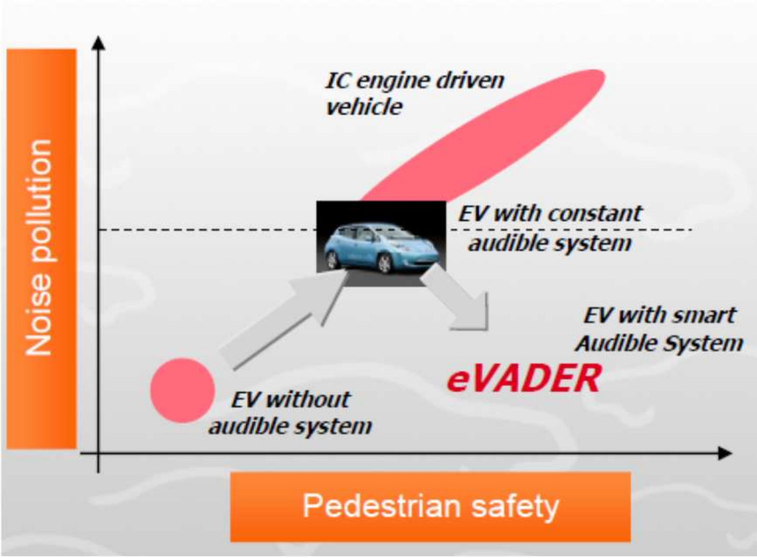


Work package 1

Concept definition and system requirements

16/04/2013

Main purpose and objectives



Define the scope of the study for the all project

Task Overview :

Task 1.1: Definition of layout and experimental setup [M1-M2]
- At risk situations
- Noise environnement in cities
- Scenarii and proving grounds

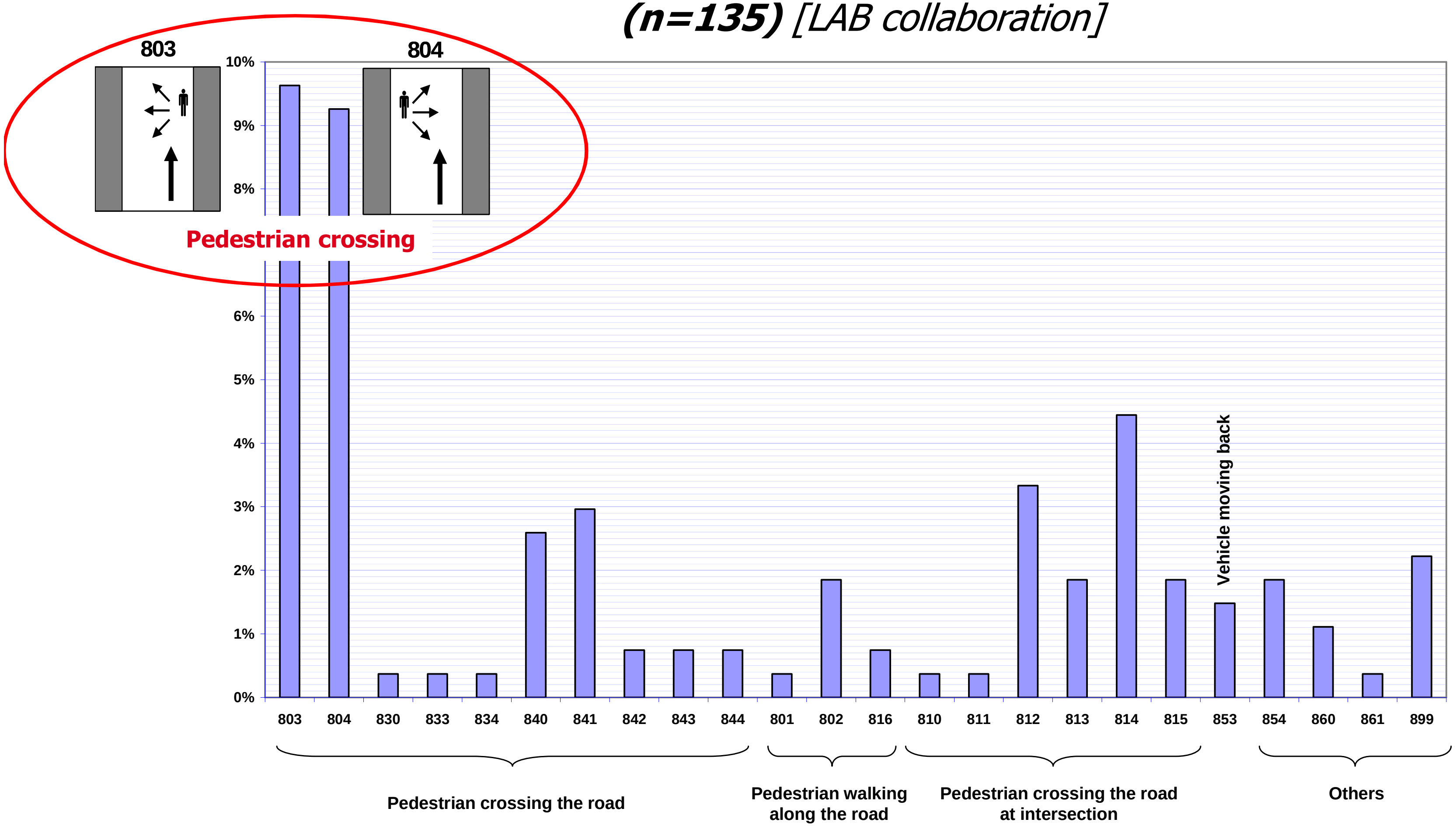
Task 1.2: Safety management between the driver/vehicle and the pedestrian [M1-M3]

Task 1.3: Specification for in vehicle implementation [M2-M5]

Task 1.4 Characterization of the natural noise of E and ICE vehicle [M4-M6]

At-risk situations (T1.1)

Distribution of pedestrian accidents following the pre-accidental manoeuver (n=135) *[LAB collaboration]*



At-risk situations (T1.1)

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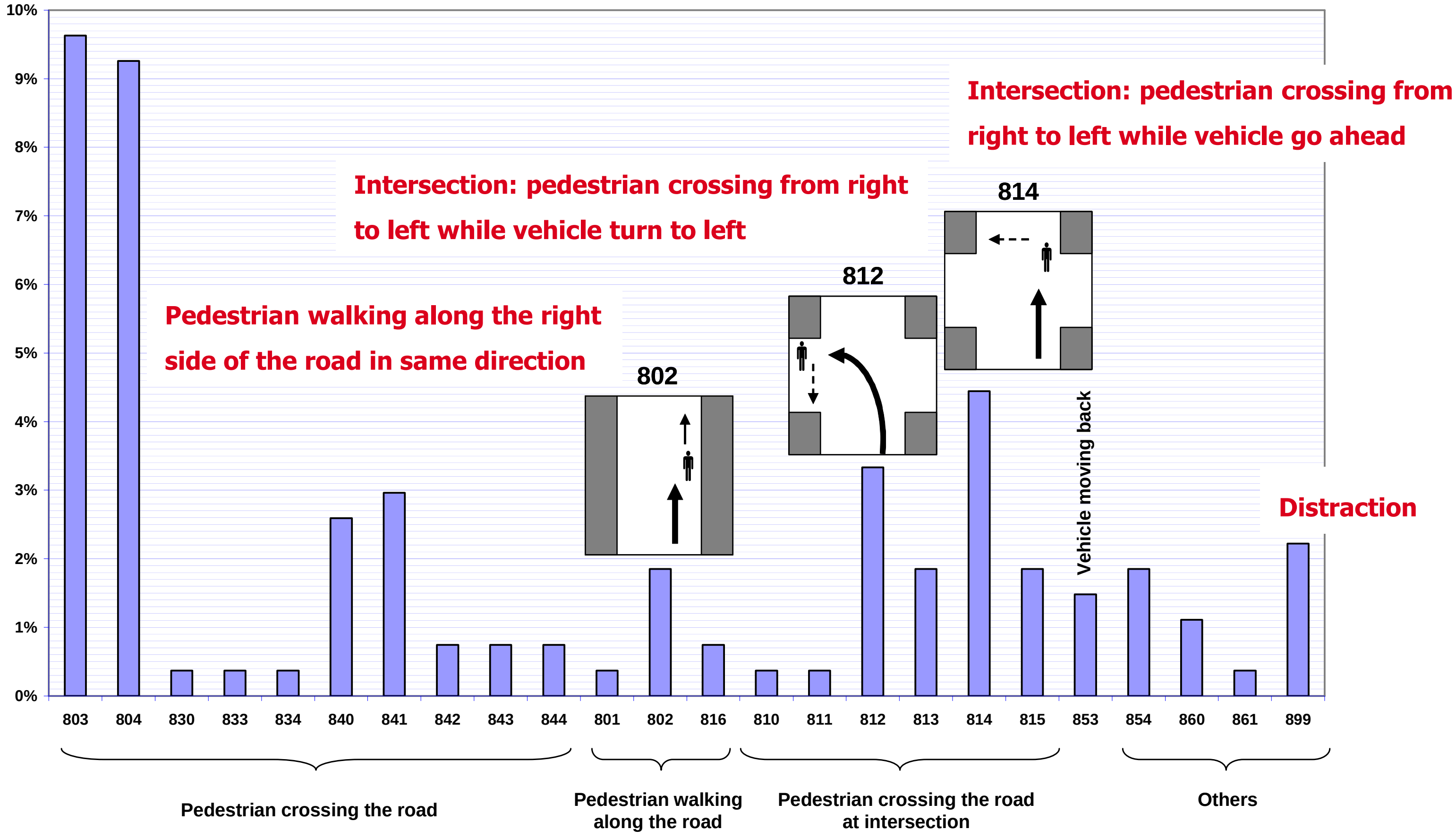


Questionnaire disseminated among the EBU network:

To collect general information on VI persons' pedestrian practices, on at-risk situations and on the dangers posed by electric vehicles in a urban environment
35 short questions, 5 parts for the 13/04/2012

1. General information
2. Selection of crossing locations
    21. Identifying the crossing point
    22. Decide when to start crossing
    23. When crossing the street
3. Potential hazards
4. Improving the audibility of electric vehicles
5. Real experience

Database of noise environment (T1.1)

5 partners:
IDIADA (Barcelona), TUD (Darmstadt), AIT (Vienna), PSA (Bièvres, Jouy),
Renault (Paris)
+ Nissan (United-States, with microphones)

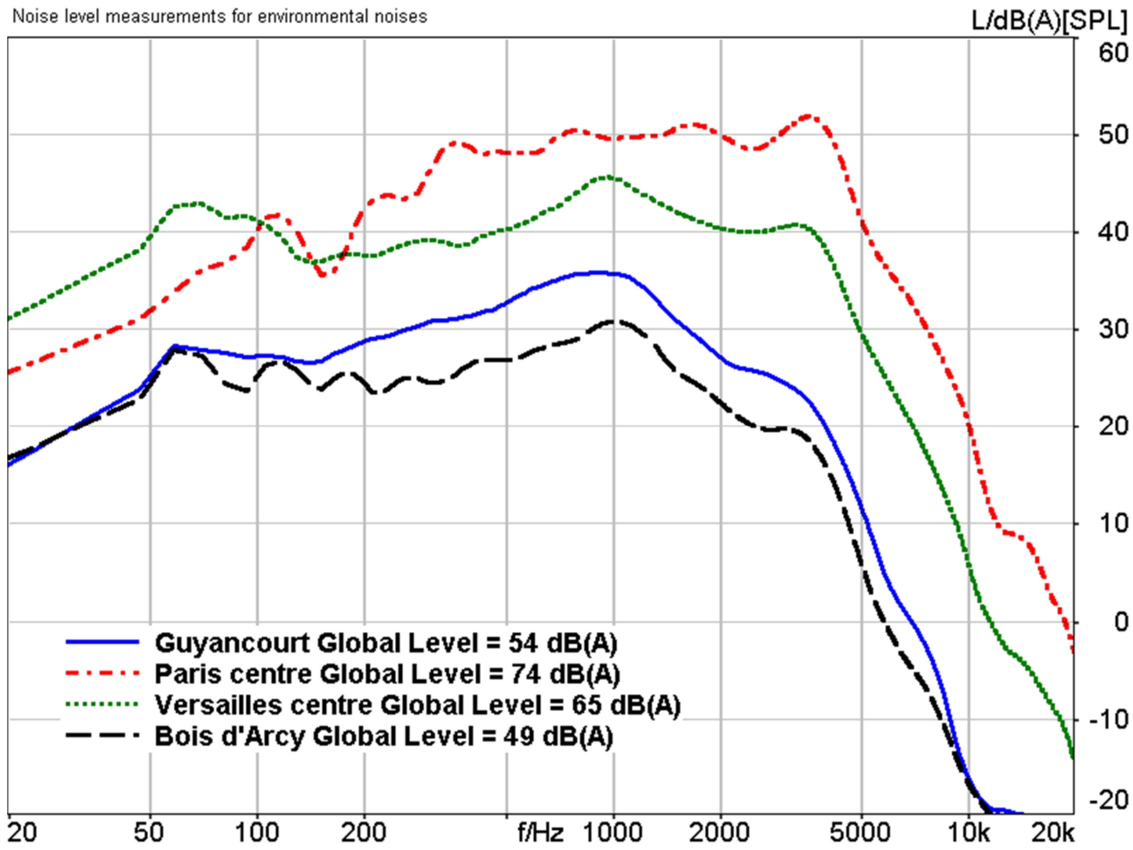
1 protocol:
Acquisition with a binaural head;
Distance to the road, on the pavement: 1 m
Linear equalization filter
Sampling frequency: 48 kHz, 24 bits
Meteorological conditions: sky: clear, wind: negligible => sunny :o)

2 sites:
Low traffic volume: 40-50 dB(A)
Moderate traffic volume: 60-70 dB(A)

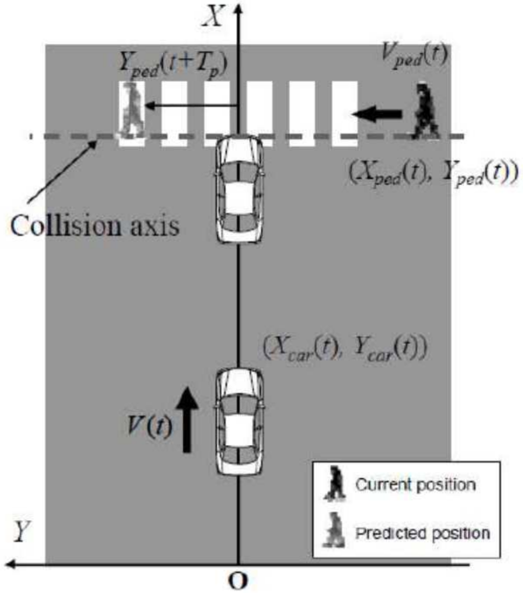
Database of noise environment (T1.1)

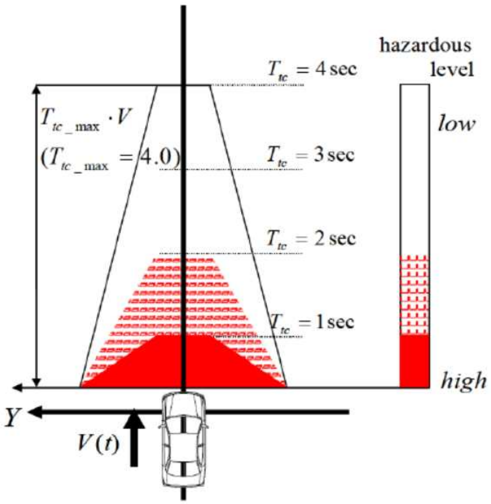
Database of noise environment (T1.1)

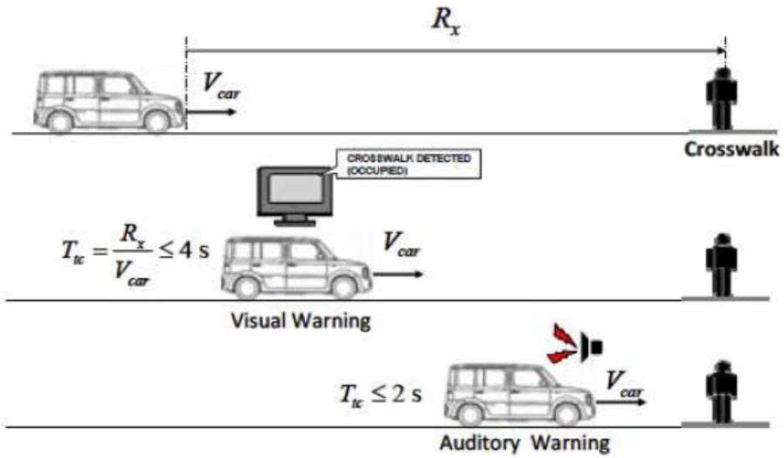
Expected variability between different locations: around 25 dB(A)



Safety management (T1.2)







Risk estimation and proposition of management by the system

Specifications for WP3 and WP4 (T1.3)

*Presence of **a switch** to deactivate (temporally) the system and **a device for indicating** the pause state (a luminous indicator for example)*

*The system will need to **be diagnosed** and have to include different operating process relative to the different life situation*
*- The sound has to **provide information** to the vulnerable road users.*
*Connection to one of the **car's network** (some of those network are already full)*

*Level of emission at the maximum of the directional lobe: around **90 dB(A) at 1m***
*Acoustic bandwidth: its frequency range will start between **300 / 400 Hz***
*The system has to be **waterproof** (IP67), resistant to gritting and other **external aggressions , vibrations…***
Tension of use, temperature, life time, etc.

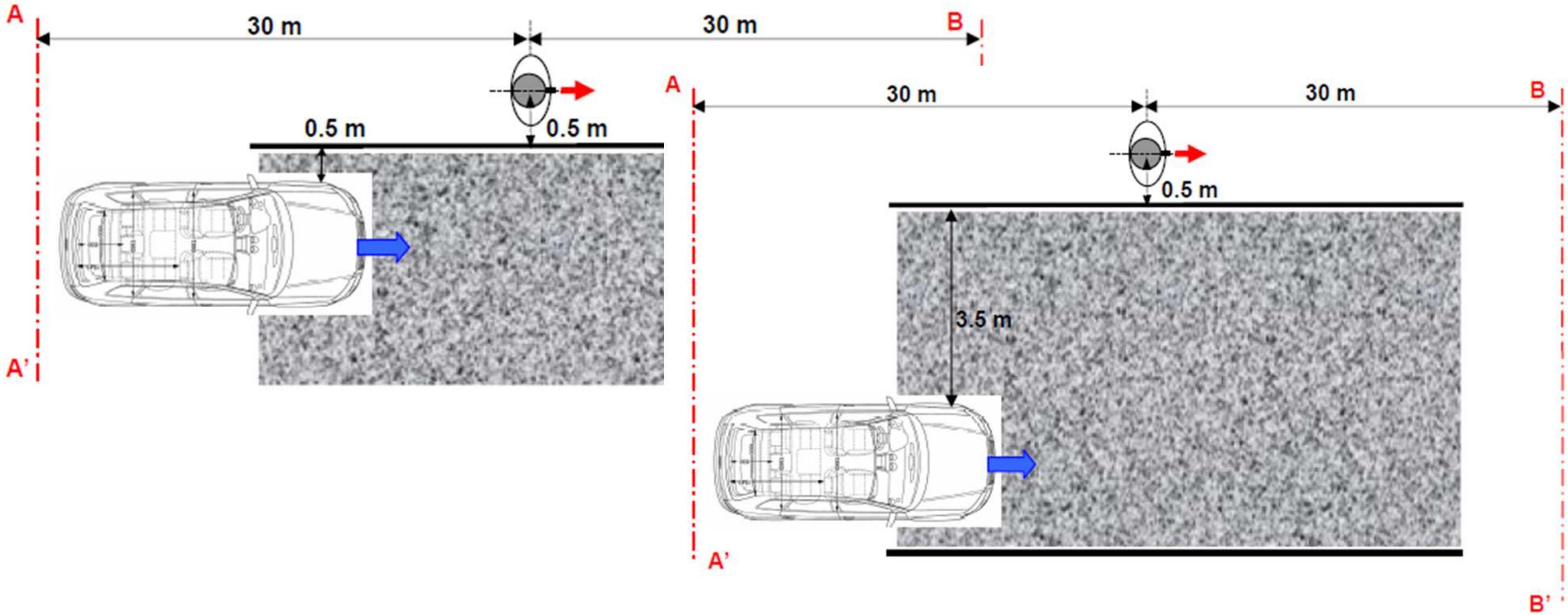
***Adaptable** according to the situation (for example: day/night, dry /wet ground,….)*
Scenario with ADAS and without ADAS

Noise measurement of common vehicles (T1.4)

1 protocol
3 speeds: 10, 20, 30 km/h
8 scenarii

SCENARII 5 & 6: *Walking along & backing vehicle (near, away)*

JASIC (2009)

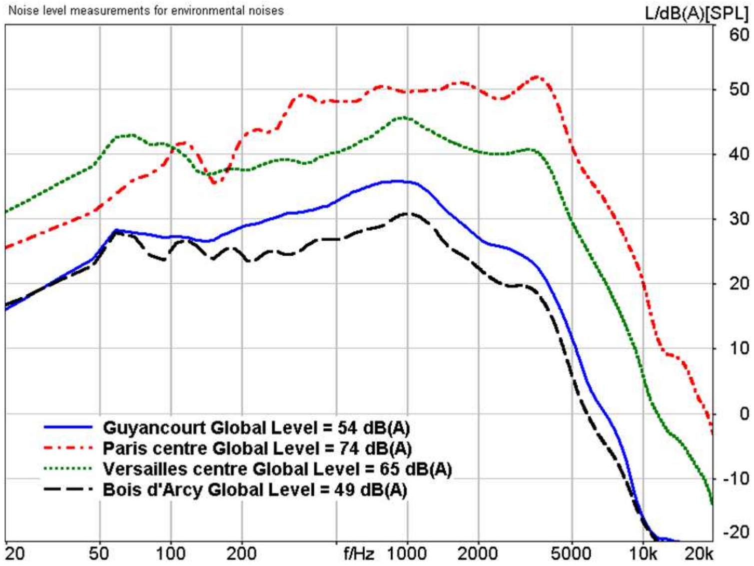


Noise measurement of common vehicles (T1.4)

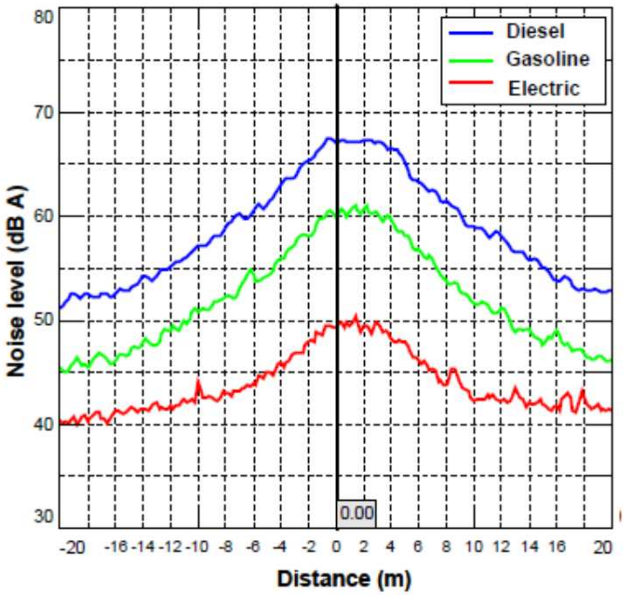
Noise measurement in IDIADA

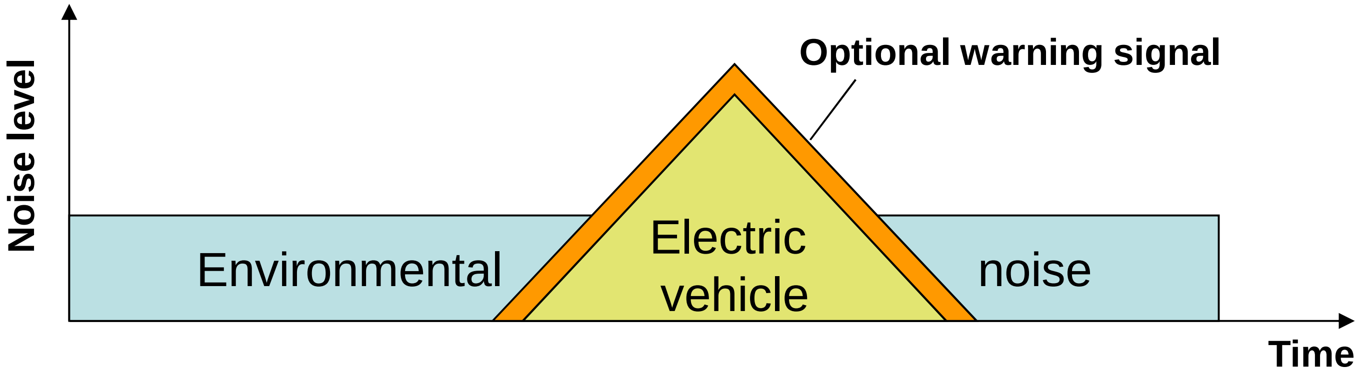
Synthesis stimuli

Background noises in city



Vehicle approaching at 10 km/h on ISO proving ground





Deliverable and Milestone status

Del n°	Title	Planned	Delivered
D1.1	Database of noise environment	December 2011	January 2012
D1.2	List of vehicles under study and mandatory	December 2011	February 2012
D1.3	Test condition definition, measurement and judgment protocol	December 2011	January 2012
D1.4	Safety management between driver, car and pedestrian	February 2012	Marsh 2012
D1.5	Specification for in vehicle implementation	December 2011	January 2012
D1.6	Noise measurement of common vehicle	December 2011	Marsh 2012
D1.7	Synthesis report	Marsh 2012	May 2012

Work package 2

Sound meaning- Psychoacoustic aspects

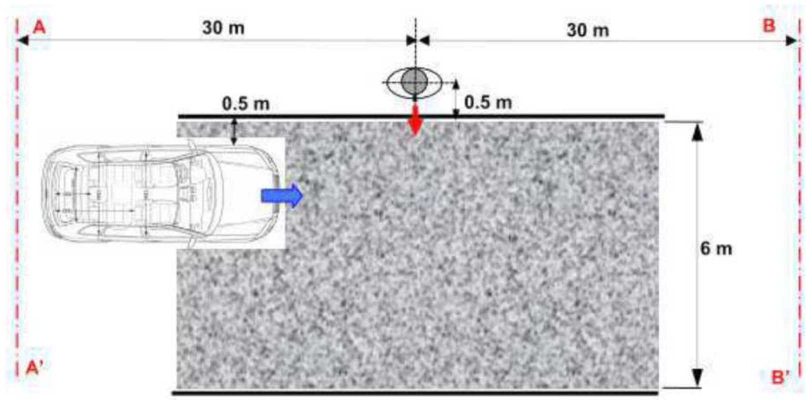
Experiment 1 : detectability

Goal :

- Evaluate the influence of 3 timbre parameters upon the detectability of a warning sound
- Parameters :
  - frequency bandwidth
  - frequency modulation
  - temporal fluctuation

Procedure :

- Simulation of a passing-by car (20 km/h), with a background noise.
- Subject's task : detect the car as soon as possible, and its direction (left / right).



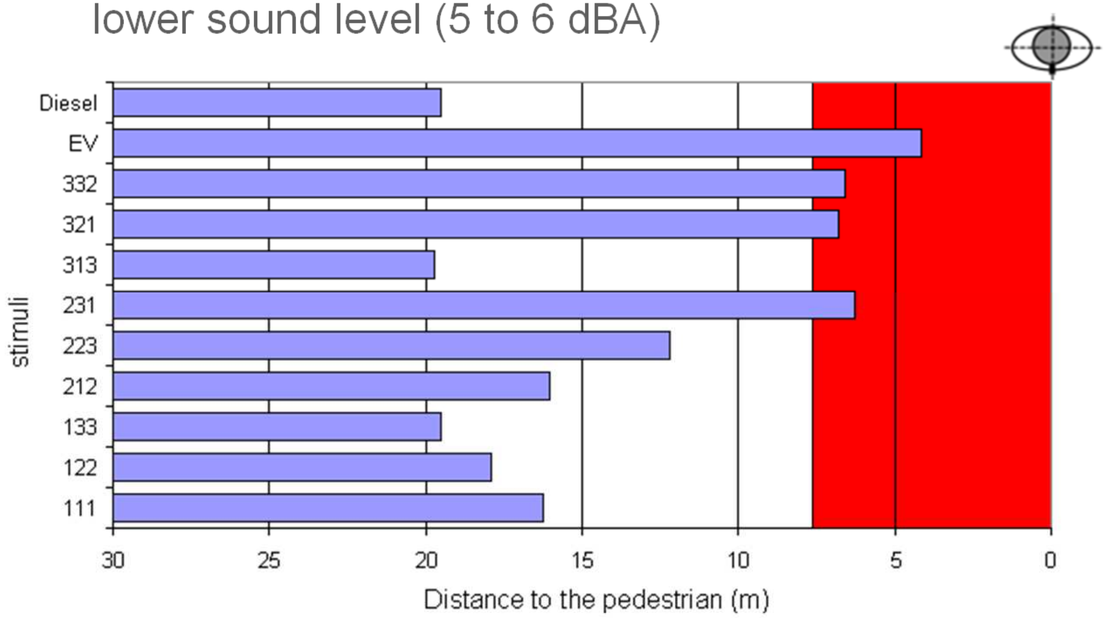
Participants :

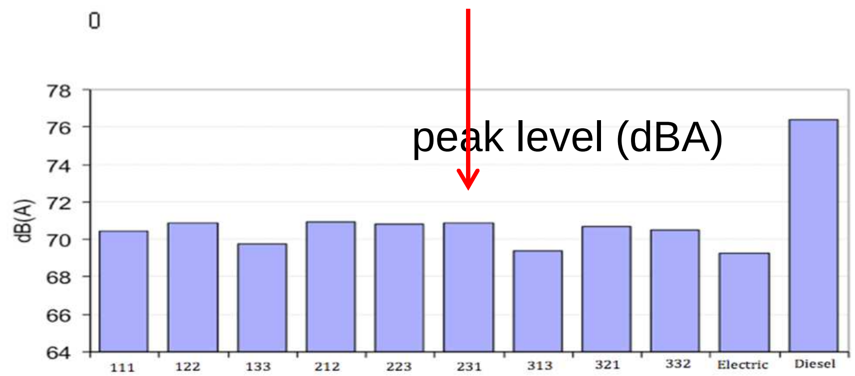
- 153 participants (100 sighted, 53 VI)

Experiment 1 : detectability

Results :

- Some warning sounds make the EV as easily detected than a diesel car, for a much lower sound level (5 to 6 dBA)





Experiment 1 : detectability

Guidelines :

- The frequency band should be limited, in the medium frequency range (300 – 900 Hz in this experiment) : higher detectability for a given overall level;
- localisation is not a great issue, as people just need to roughly estimate the direction of the sound.
- temporal fluctuations enhance detectability.

Experiment 1 : detectability

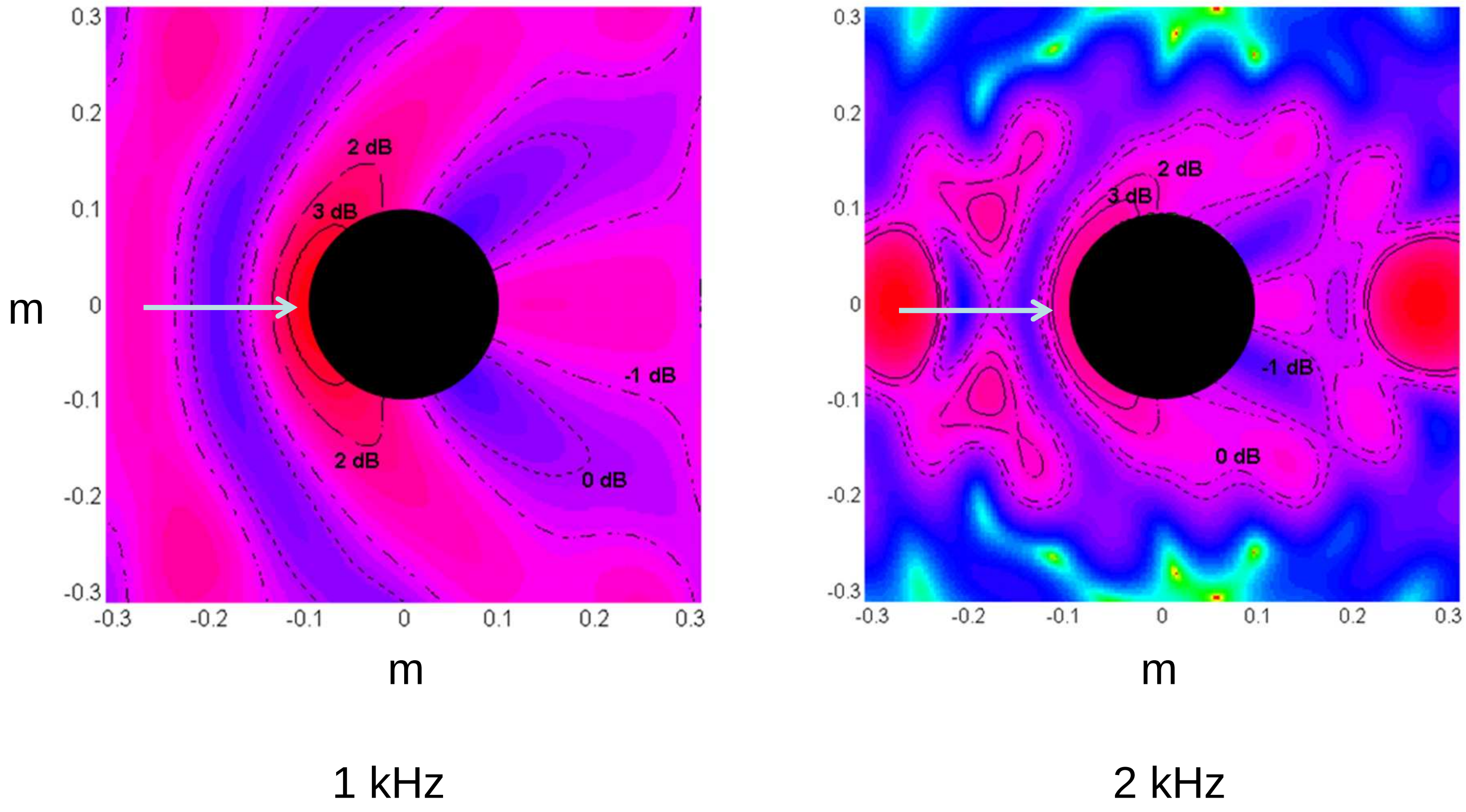
Experiment factors

- Speed :
  - 20 km/, 30 km/h
- Pitch :
  - 300 Hz (exp. 1), 225 Hz, 375 Hz.
- Modulation frequency :
  - 25% lower, as in exp. 1, 25% faster.

Stimulus Code	Pitch f0	Amplitude Moduation
#11	225 Hz	25% slower
#12	225 Hz	original speed
#13	225 Hz	25% faster
#21	300 Hz	25% slower
#22	300 Hz	original speed
#23	300 Hz	25% faster
#31	375 Hz	25% slower
#32	375 Hz	original speed
#33	375 Hz	25% faster

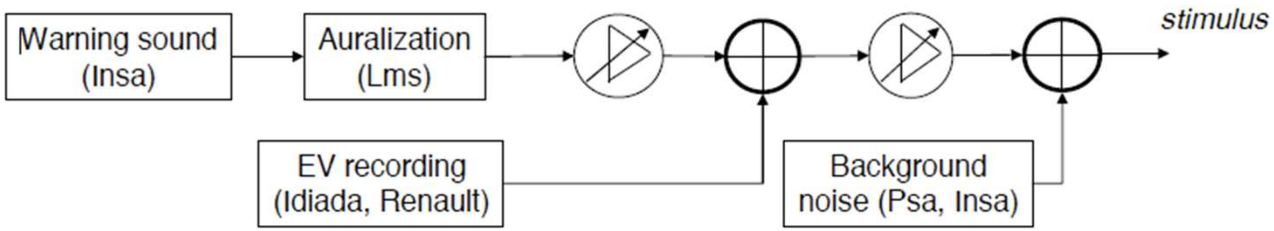
: speed (20/30)

Experiment 1 : detectability
Diffraction patterns around pedestrian's head



Experiment 1 : detectability

Sound synthesis



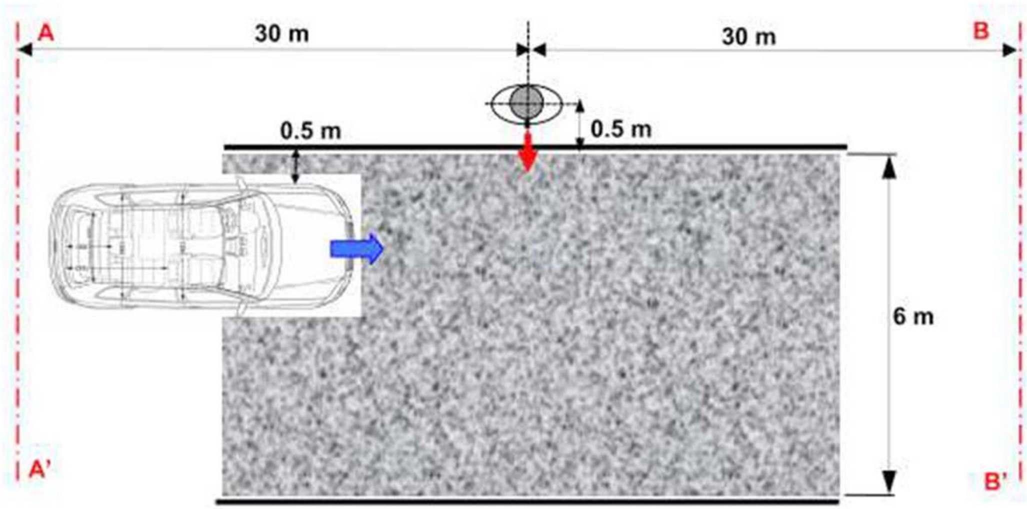
- Background noise : no rain, 64 dB(A).
- 20 stimuli (for each speed : 9 EVs, Diesel car).
- 4 repetitions (from left or right).

Experiment 1 : detectability

Question

- Information about the speed of the car can be given by :
  – change of the pitch;
  – change of the amplitude modulation frequency.

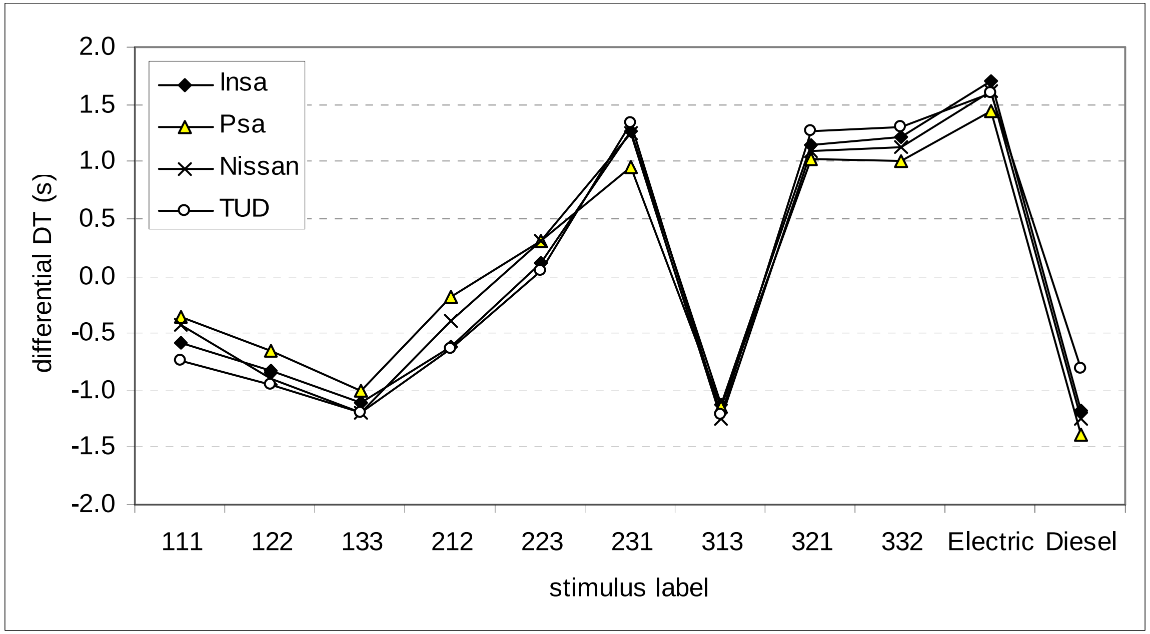
- Scenario : "waiting to cross"

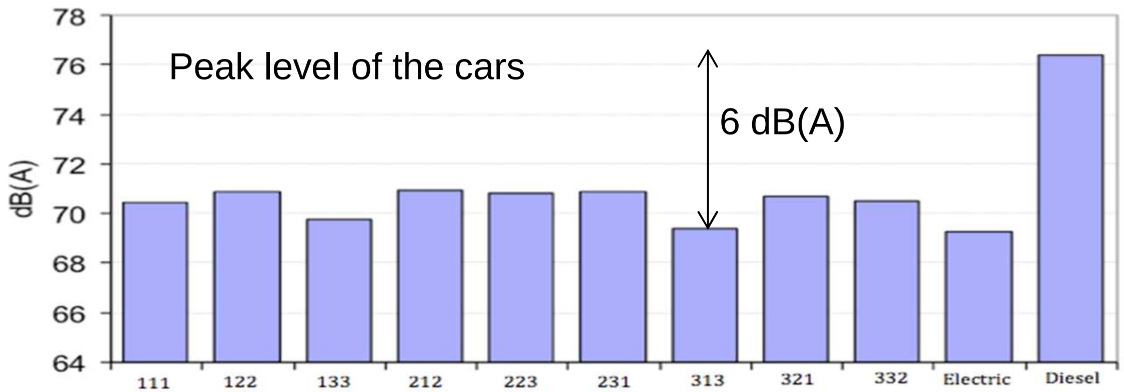


Main achievements: Detectability
Efficiency of carefully design warning sounds

- Sounds 133 and 313 makes the EV as easily detectable than the Diesel car.

- But the sound level is much lower !





Some comments on detection

- NHTSA requirements (*preferred alternative 2*) :
  – Minimum sound level in one-third octave bands 315, 400, 500, 2000, 2500, 3150, 4000 and 5000 Hz;
  – 1% shift in pitch frequency per km/h.
- European parliament resolution
  – The sound should be easily indicative of vehicle behaviour and should sound similar to the sound of a vehicle of the same category equipped with an internal combustion engine;
  – The sound level may not exceed the approximate sound level of a similar vehicle of the same category equipped with an internal combustion engine.
- Our recommendations :
  – Energy focused in a small frequency range;
  – Temporal non-stationarity.

Experiment 2 : Sound meaning

Goal :

- Is it possible to give some information about the speed and the distance of the car through some timbre parameters ?

Procedure :

- Modification of pitch (300 Hz +/- 15 Hz) and of the speed of the temporal fluctuations.
- Sounds added to a passing by EV (20 and 30 km/h).
- Subject's task : indicate when crossing the road would no longer be safe;

Participants :

- 118 (63 sighted, 55 VI)

Experiment 2 : Sound meaning

Results :

- no effect of timbre parameters on the estimation of speed or distance of the car.
- Speed evaluation is related to the perception of loudness increase.

Experiment 3 : Unpleasantness

- Goal : evaluate the influence of using such warning sounds on annoyance.
- Experiment :
  - simulation of a traffic flow (20 and 30 km/h) with a given proportion of EVs (0%, 25%, 50%, 75% and 100%).
  - simulation of a typical window attenuation.
  - sequence duration : 1 *mn* (40 cars).
  - annoyance evaluation (monadic scale).

Experiment 3 : Unpleasantness

Goal :

- Evaluate the unpleasantness of warning sounds used in the previous experiments

Procedure :

- Presentation of each sound added to a passing-by car (20 km/h), no background noise.
- Subject's task : evaluate the unpleasantness of the sound (continuous scale).

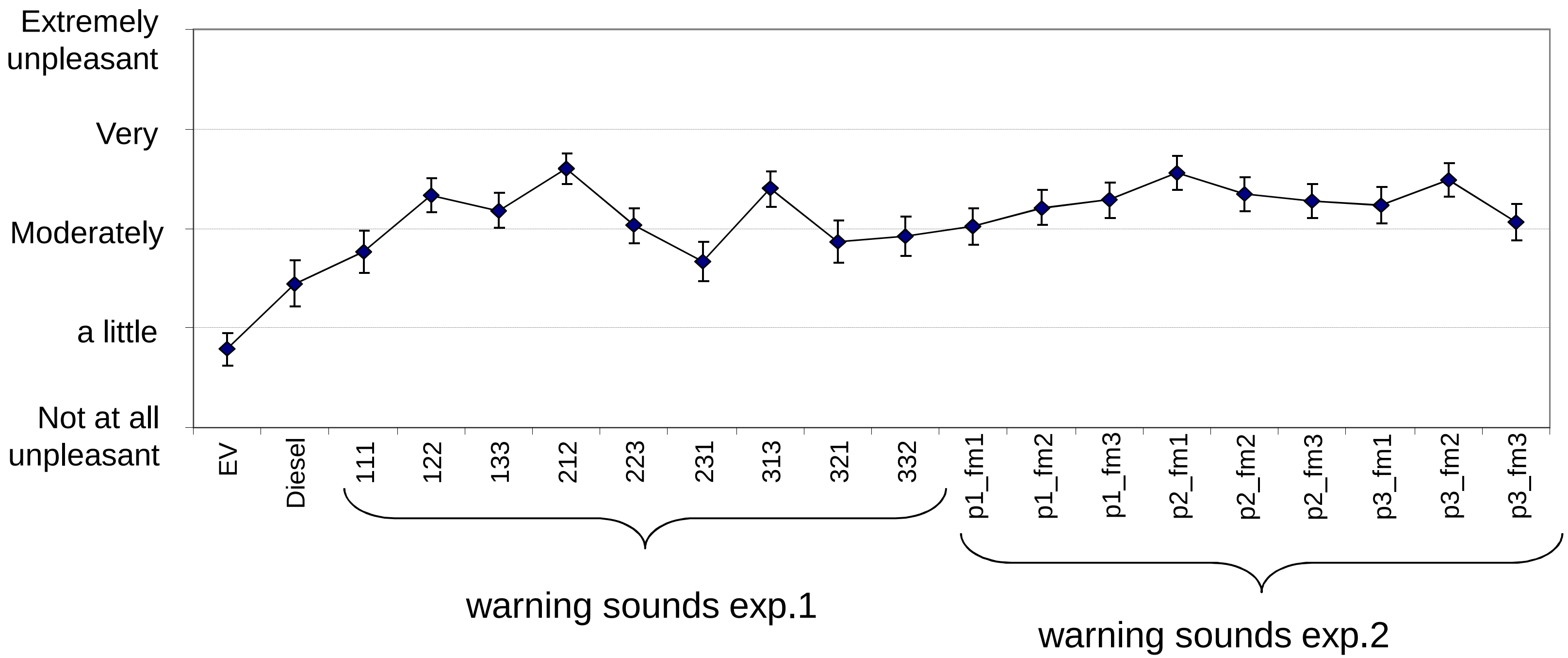
Participants :

- 118 (63 sighted, 55 VI)

Experiment 3 : Unpleasantness

Goal :

- As very often for emergency signals, detectability and unpleasantness are positively correlated.
- Sound 111 (3 harmonics, no temporal; no frequency fluctuation) seems to offer a good compromise.



Work package 3

Warning signal generation

WP3 Warning Signal Generators

Objectives

- To investigate the physical principles and technical possibilities for the design and construction of (a) warning signal generator(s) that are available to realise the requirements and objectives formulated by Work Packages 1 and 2.

- Activities in WP3 focus on the assessment of selected key features of acoustic warning generators based on simplified geometries, simulated beamforming techniques, and partial experimental validation of components and simulation models with the objective to pinpoint expected performance limitations and critical implementation issues.

- To rank the different concepts and implementations with respect to the conformity with the requirements.

Main results

- Requirements for the warning signal generator were provided
- Two types of moving coil transducers were selected: a loudspeaker and an inertial mass shaker
- Different beam forming algorithms have been compared resulting in the selection of the sound power minimization beamformer
- The geometry of the array was determined on the basis of a simplified source geometry
- Validation of the beamforming simulations based on transfer functions from WP5
- Feasibility study of inertial mass shakers applied to a Nissan Leaf front bumper
- Sensitivity study of beamforming behaviour for temperature variations
- Prediction of sound pressure levels for two different loudspeaker types
- Real-time implementation and validation of simulation results

TNO innovation for life

Objective/specifications

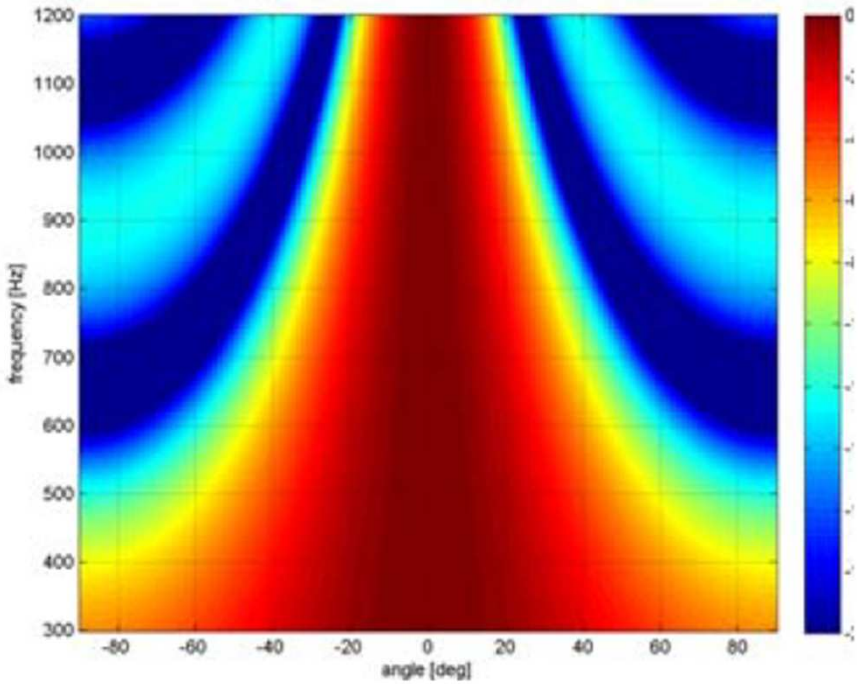
eVADER

- The array consists of a maximum of 6 acoustic sources;
- The frequency range is 300 Hz to 1.2 kHz, which is based on the three 'best' prototype sounds made available by INSA on 31-1-2013
- Directivity is required in the horizontal direction
- No directivity in the vertical direction required
- The steering direction of the beam is between -60 degrees and +60 degrees
- Directivity is required in a single beaming direction; multiple beams at the same time are not required
- The angular tracking speed is 300°/s

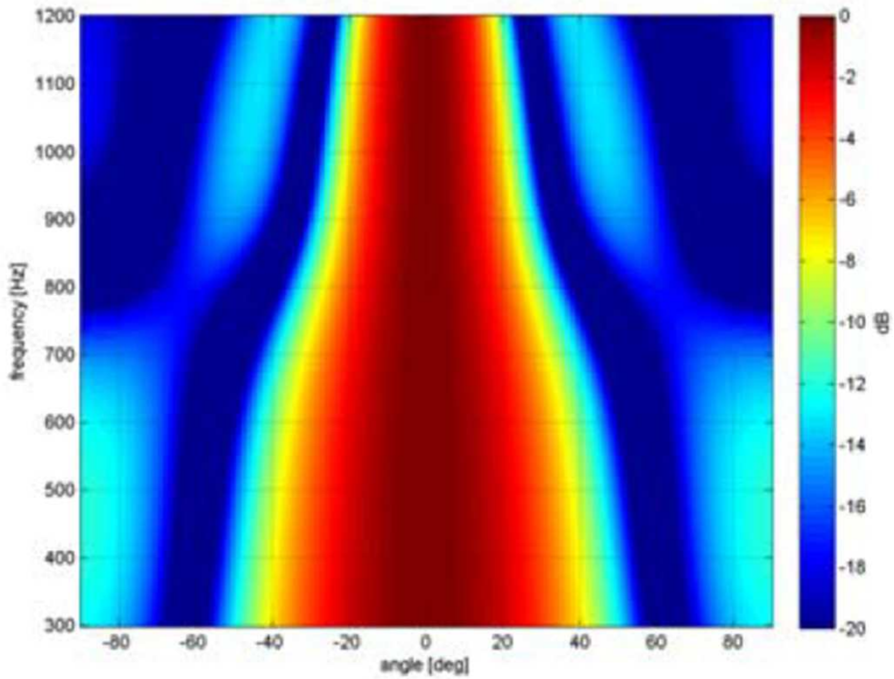
Beam shape comparison

Influence of the algorithm

Delay and sum



Sound power minimisation



Uniform array geometry in both cases

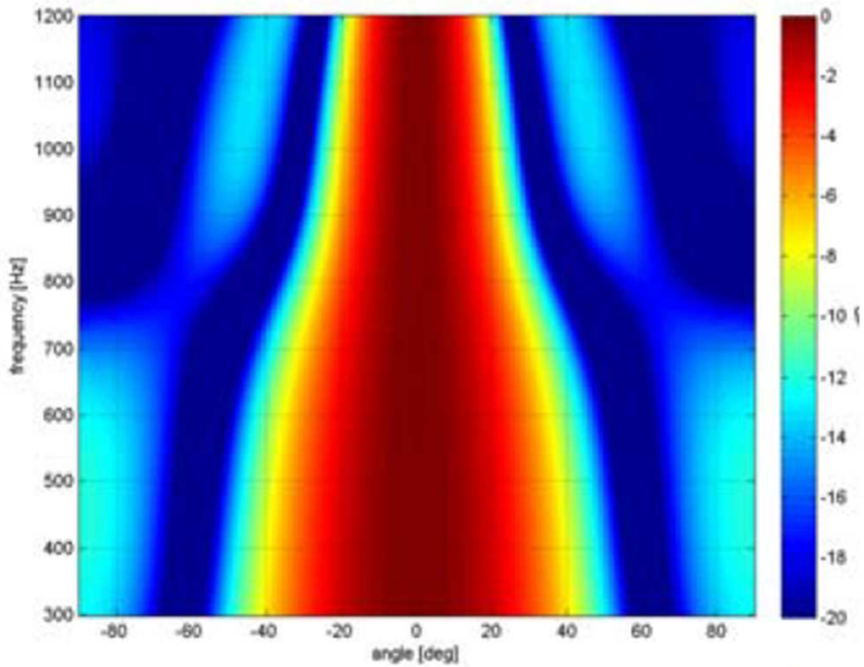
Beam shape comparison

Influence of the array geometry

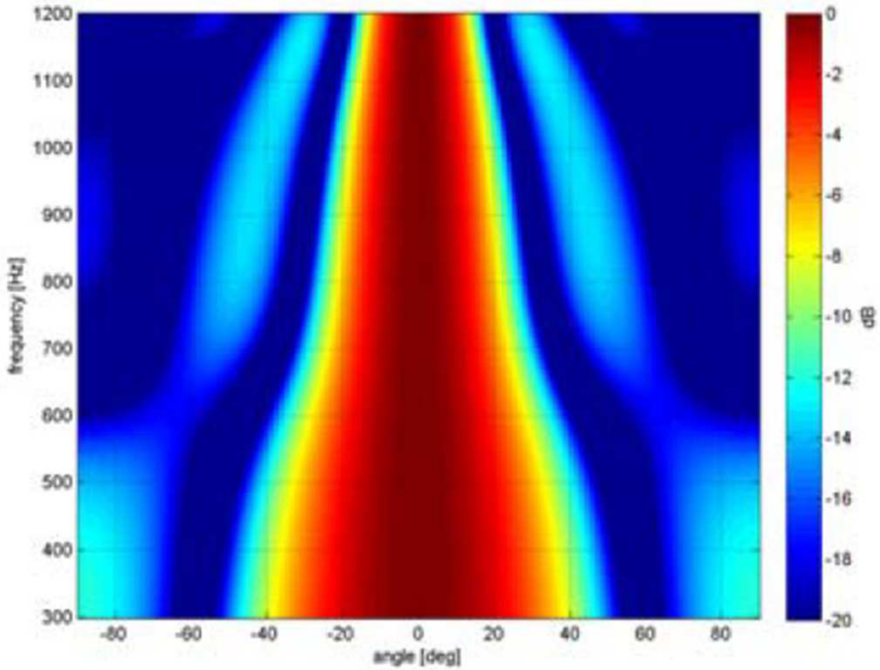
- Uniform array: : -0.2860 -0.1716 -0.0572 0.0572 0.1716 0.2860 m → width: 0.572 m.

- Nonuniform array: : -0.3718 -0.2002 -0.0572 0.0572 0.2002 0.3718 m → width: 0.7436 m.

Uniform



Non-Uniform



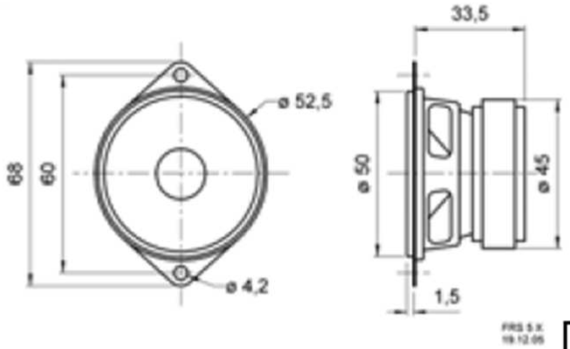
sound power minimisation algorithm in both cases

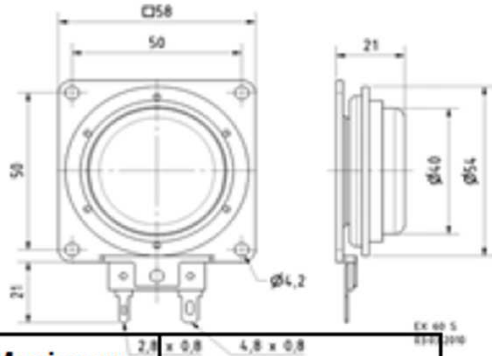
Transducer characterization

Karl Janssens, LMS

Moving coil loudspeaker

Intertial mass shaker





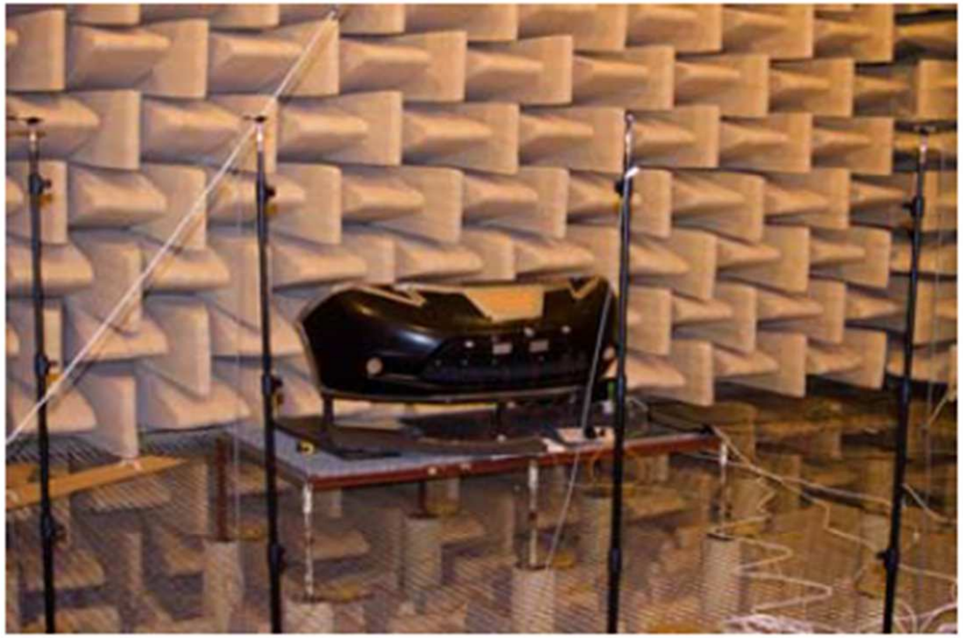
Maximum power	8 W
Nominal impedance Z	8 Ohm
Voice coil diameter	14 mm
Net weight	0,14 kg
Connections	4,8 x 0,8 mm (+) 2,8 x 0,8 mm (−)

Maximum power	25 W
Nominal impedance Z	8 Ohm
Voice coil diameter	32,5 mm
Net weight	0,12 kg
Connections	4,8 x 0,8 mm (+) 2,8 x 0,8 mm (−)
Temperature range	−25 ... 70 °C

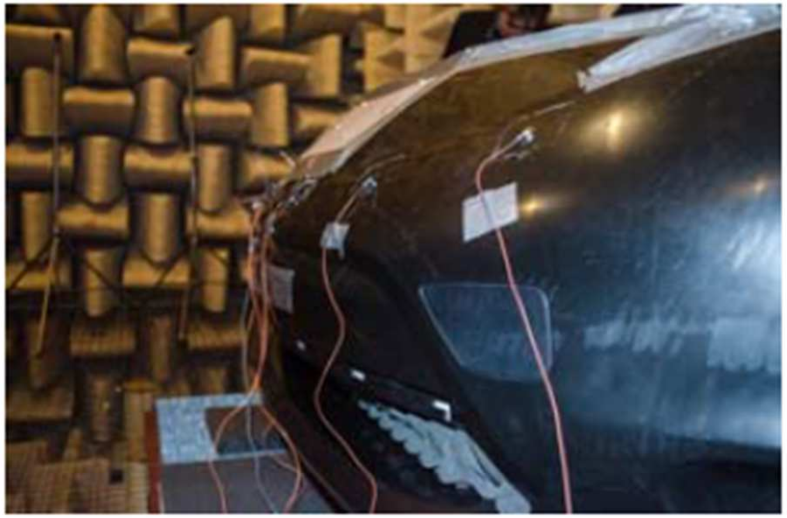
Inertial mass shaker feasibility

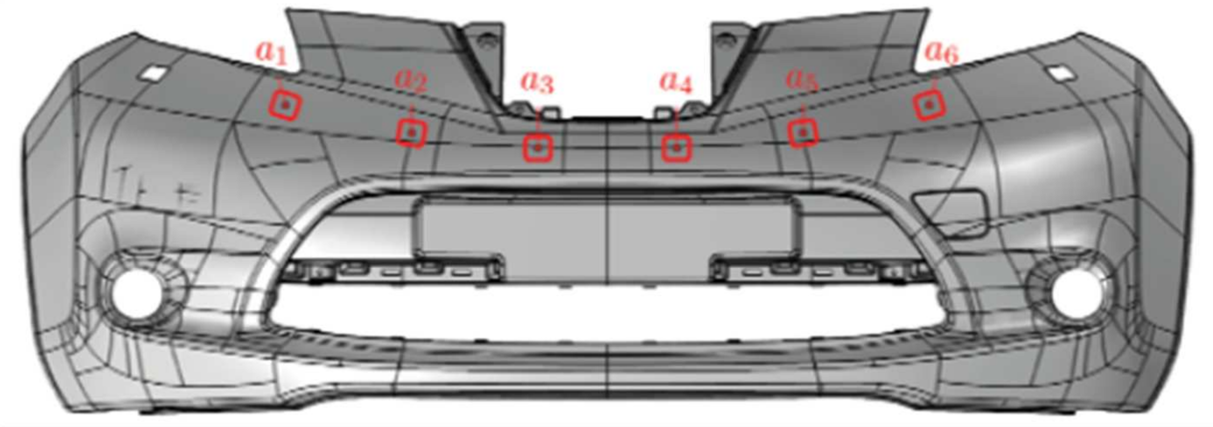
Erwin Jansen, TNO

- Transfer function from actuator current to pressure
- Impedance measurements on the front bumper
- Transfer functions from actuator current to bumper acceleration



Inertial mass shaker feasibility





Specifications

- The array consists of 6 acoustic sources
- The horizontal positions of the sources are -0.3718 -0.2002 -0.0572 0.0572 0.2002 0.3718 m
- The frequency range is 300 Hz to 1.2 kHz
- The acoustic sources are moving coil loudspeakers with a nominal halfspace reference efficiency ≥ 86 dB SPL @ 1W, 1m, a peak effective volume displacement ≥ 0.125(cm)^3, and an electrical input power ≥ 8W
- The steering direction of the beam is between -60 degrees and +60 degrees
- Directivity is required in a single beaming direction; multiple beams at the same time are not required
- The angular tracking speed is 300°/s
- Transfer functions are obtained prior to operation by a separate system
- Real-time implementation will be based on a SHARC DSP (SHARC compiled software library will be made available by TNO to help real-time implementation in WP5, provided as is)

Work package 4

Algorithms and Strategy Definitions for Acoustic Warning Devices

Main purpose and objectives

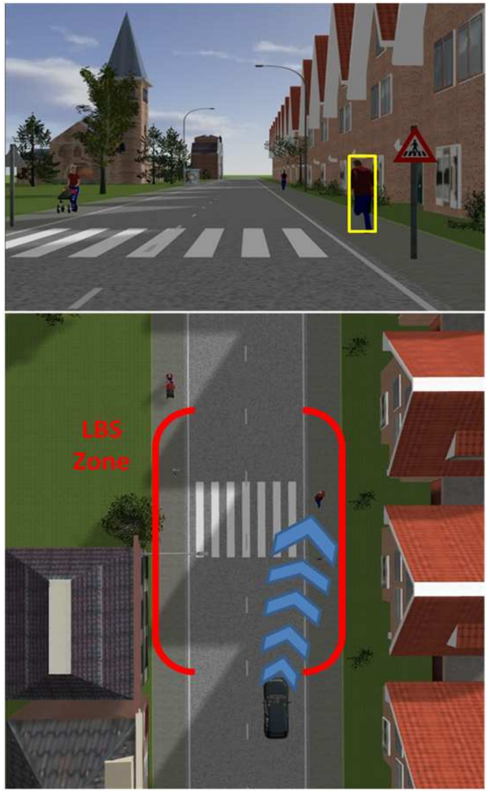
Tasks Overview:

Task 4.1: State of the Art about interior and exterior warning systems and Environmental perception systems. [M5-M7]
-> **Finished**

Task 4.2: Strategies and Algorithms for exterior warning [M6-M10]
-> On-Going

Task 4.3: Strategies and Algorithms for Interior warning [M10-M13]
-> **On-Going**

Task 4.4 Development of an environmental perception system [M14-M20]
-> Beginning



Main achievements

Tasks	Main achievements	Comments
WP4.1	State of the art: Strategies for interior warning Strategies for exterior warning for EV and HEV D4.1	The state of the art presents both existing and commercial devices and systems as well as on-going technological development
WP4.2	Algorithms for generating exterior warning are currently in development.	The algorithms will be made available as software modules and will be described in D4.4.
WP4.3	Use case definition HMI concept for interior and exterior warning D4.3 Algorithms for generating warnings for passengers are under development	The UC definition and detailed strategies for HMI are presented in deliverable 4.3
WP4.4	First requirements for environmental perception devices Architecture definition	On course

Use case definition and HMI concept overview

<table>
<tr><th>Car speed</th><th>Pedestrian</th><th></th><th>Hot spots (0= low risk; 1=high risk)</th><th>Date & time (0= low risk; 1=high risk)</th><th>Use Case</th><th>Supposed Risk</th><th>External warning</th><th>Interior warning</th></tr>
<tr><td>over 35Kmh</td><td>--</td><td>--</td><td>--</td><td>--</td><td>UC0</td><td></td><td>No sound</td><td>no</td></tr>
<tr><td rowspan="12">under 35Kmh, no speeding</td><td rowspan="5">NO Pedestrian sensor</td><td rowspan="4">Location Based System (LBS) OK</td><td>0</td><td>0</td><td>UC1</td><td>Low</td><td>Full forward, low warning sound</td><td>no</td></tr>
<tr><td>0</td><td>1</td><td rowspan="2">UC2</td><td rowspan="2">Medium</td><td rowspan="2">Full forward, medium warning sound</td><td rowspan="2">no</td></tr>
<tr><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>UC3+</td><td rowspan="2">High</td><td rowspan="2">Full forward, high warning sound</td><td>icon</td></tr>
<tr><td>NO LBS or speeding</td><td>--</td><td>--</td><td>UC3</td><td>no</td></tr>
<tr><td rowspan="5">Pedestrian sensor OK, NO Pedestrian detected</td><td rowspan="4">Location Based System (LBS) OK</td><td>0</td><td>0</td><td rowspan="3">UC4</td><td rowspan="3">Low</td><td rowspan="3">Full forward, low warning sound (no sound in future)</td><td rowspan="3">no</td></tr>
<tr><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td rowspan="2">UC5</td><td rowspan="2">Medium</td><td rowspan="2">Full forward, medium warning sound (no sound in future)</td><td rowspan="2">no</td></tr>
<tr><td>NO LBS</td><td colspan="2">--</td></tr>
<tr><td rowspan="2">Pedestrian detected</td><td>Low conflict Probability</td><td colspan="2" rowspan="2">--</td><td>UC6</td><td>Medium</td><td>Directional if possible Medium warning sound</td><td>icon</td></tr>
<tr><td>High conflict probability</td><td>UC7</td><td>Highest</td><td>Directional if possible Highest warning sound</td><td>icon + Sound, directive if possible</td></tr>
</table>

Workpackage 4.3

- Why not 0 false positives?

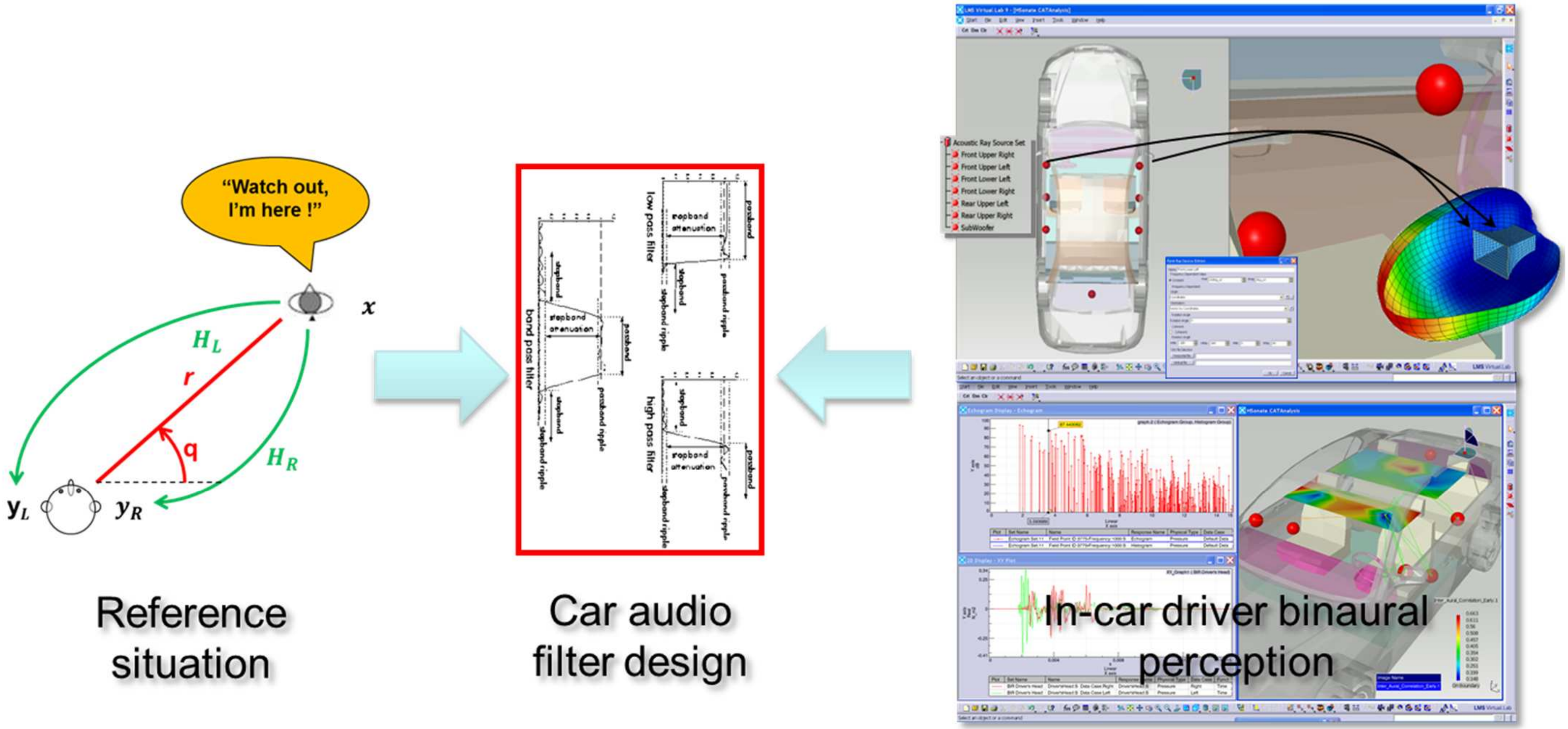
- Because sometimes there are structures that look very similar to pedestrians although they are something completely different…

- Why not 100% classification rate?

- Because sometimes it is very hard to recognize pedestrians in a camera image…

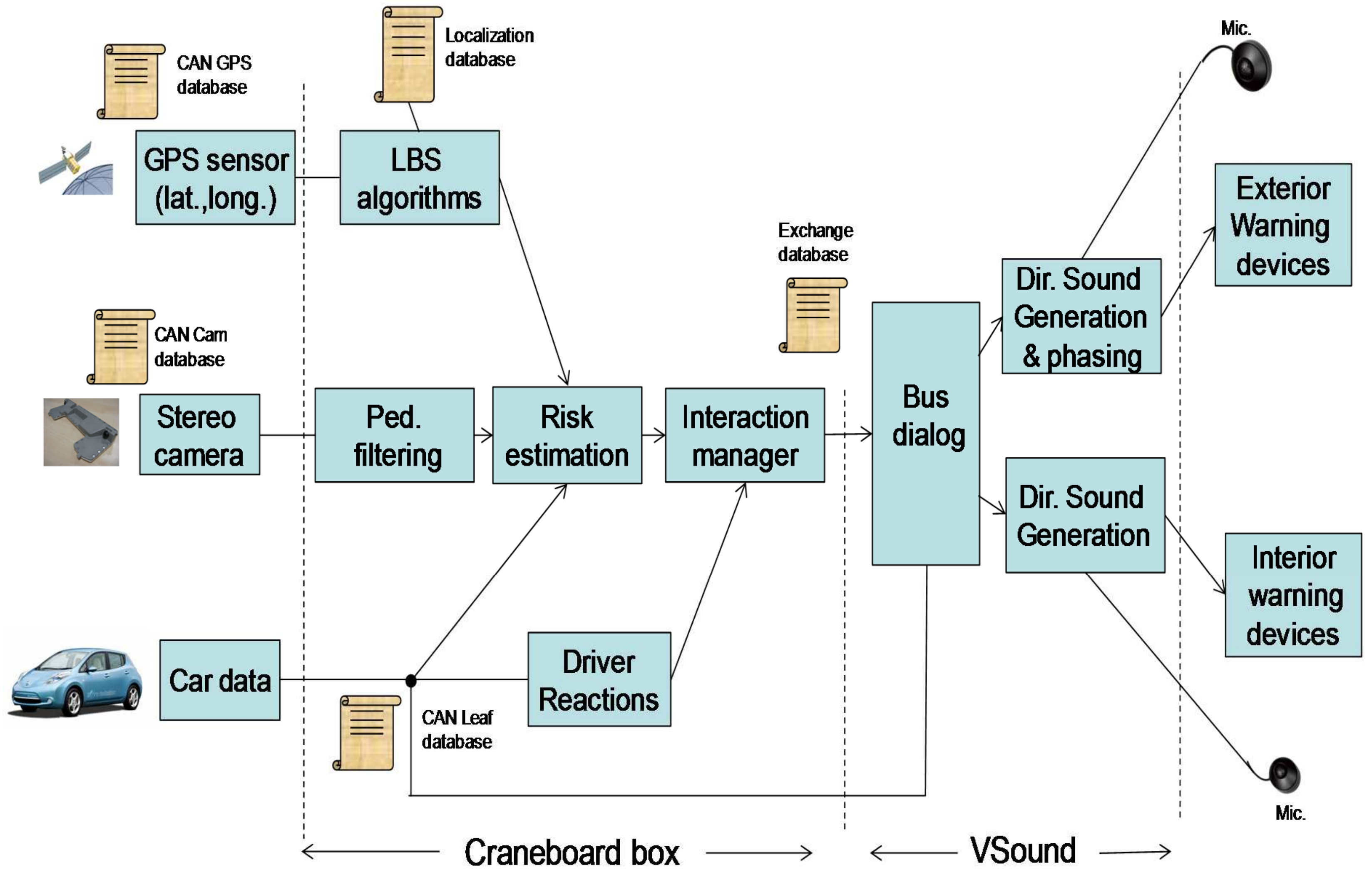
Workpackage 4.3

Interior warning system design



Proposed simulation-based acoustic warning system design

EVADER SW overview



Deliverable and Milestone status

Del n°	Title	Planned	Delivered
D4.1	State of The Art report	May 2012	June 2012
D4.2	Concepts and algorithms for environmental perception	October 2012	delayed July 2013 (mistake in the initial planning: the deliverable was planed to be delivered before the tasks begun!)
D4.3	HMI Concept	Jan 2013	March 2013
D4.4	Algorithms and test results for exterior and interior warning	July 2013	Deliverable planned for M22 (July 2013)

Work Package 5

Design and construction of acoustic warning devices

Objectives

Main purpose:

build a prototype of an in-vehicle warning device and design the appropriate software

Tasks:

- 5.1: Definition of system requirements
- 5.2: Modelling of the sound source and the sound radiation
- 5.3a/b: System Design (5.3a Hardware / 5.3b Software)
- 5.4: Construction of a prototype
- 5.5: Test of the prototype
- 5.6: Assessment of technical specs

5.1: Definition of system requirements

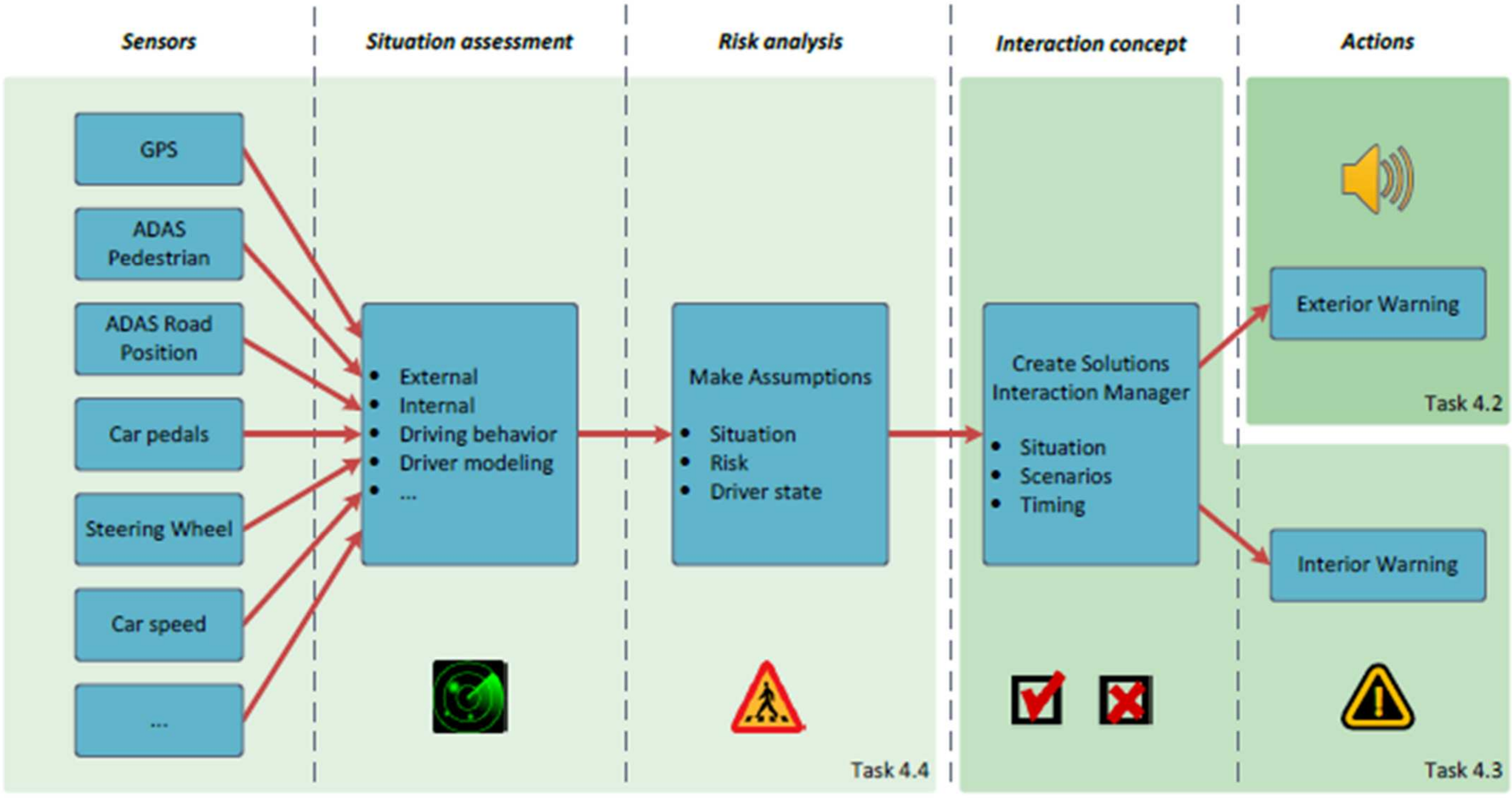
Description of system architecture

- Inputs / outputs
- Hardware
  - Sensors: stereoscopic camera, GPS, microphone…
  - Actuators: external loudspeaker array, internal loudspeakers…

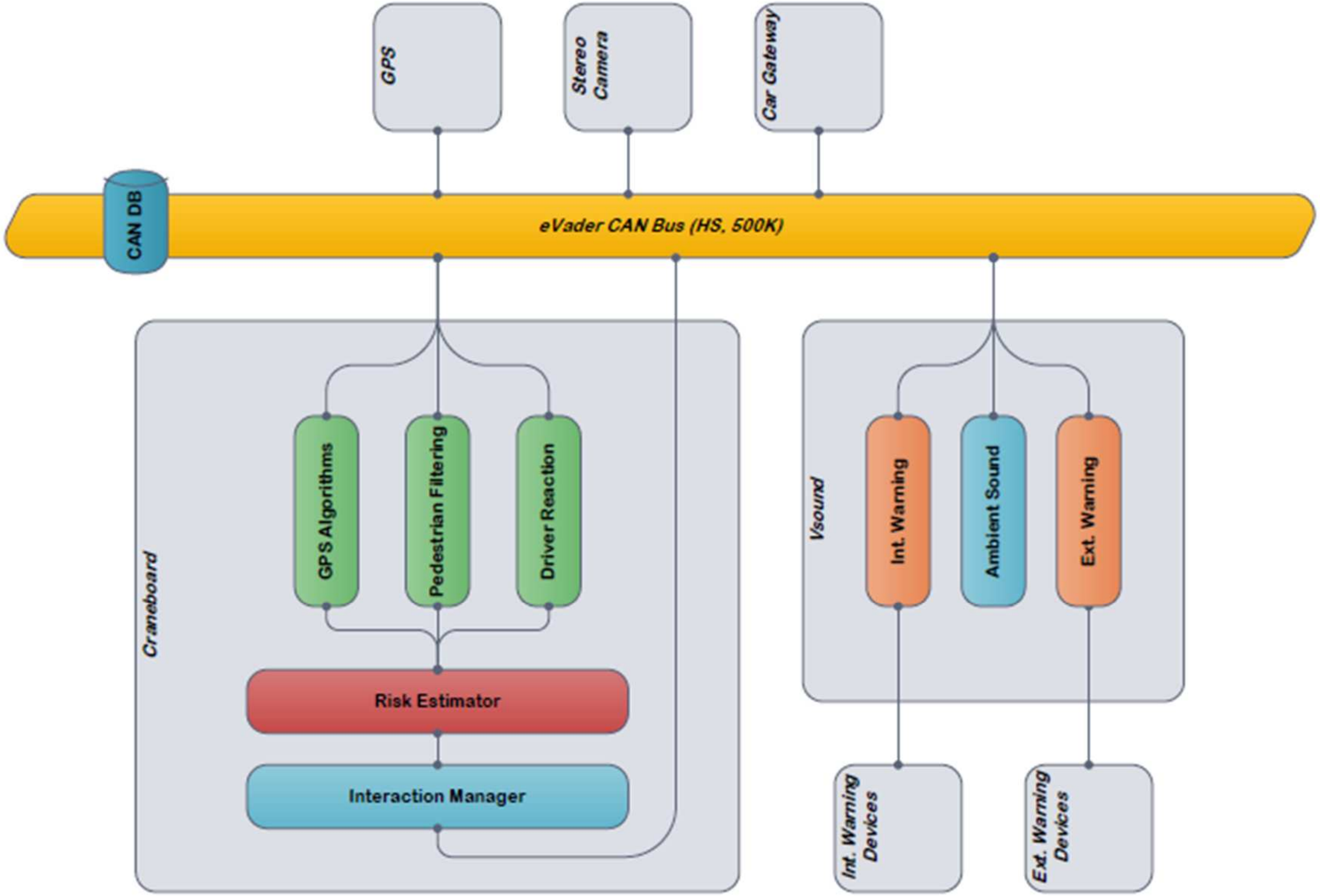
Sound source specifications

- Acoustical specifications
- Electrical specifications
- Mechanical specifications

System architecture



SW / HW architecture



Sound source specifications

Acoustical specifications

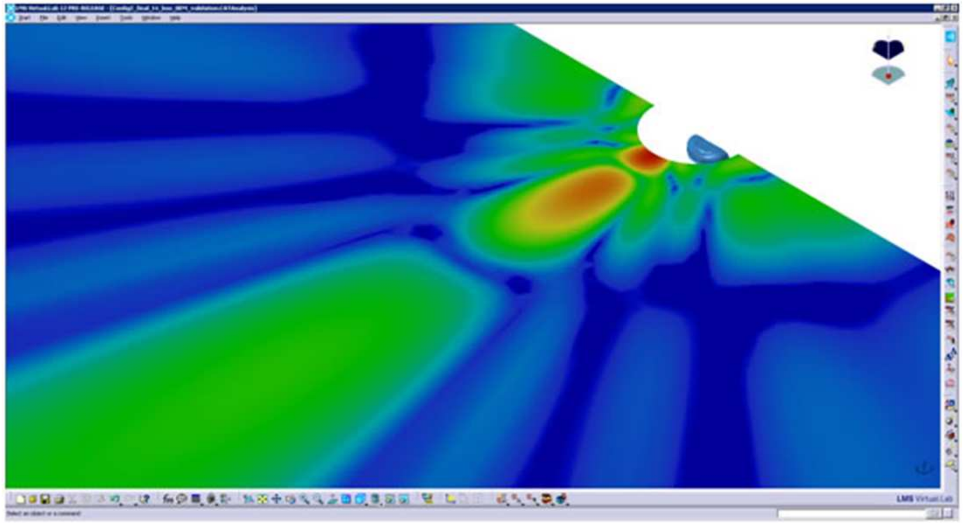
- Frequency range: 300 Hz – 1.2 kHz
- Max. 76 dB SPL at 1 m (max. 90 dB SPL in main lobe)
- Only horizontal directionality: -60° to +60°
- single beam
- Tracking speed: 300°/s
- Switch time to new beam: 30 ms

Mechanical specifications

- Resistance to shock / water: IP 67
- Temperature up to 90°C
- Vibrations up to 5 *g*
- Automative fluids

Electrical specifications

- Resistant to voltages up to 18 V



Deliverable update

Deliverable N°	Deliverable Title	Planned	Delivered
D5.1	Definition of system requirements	Dec. 2012	Mar. 2013
D5.2	Model of sound source and sound radiation	Feb. 2013	Apr. 2013
D5.3	Prototype acoustic warning device	Jun. 2013	Sept. 2013 (seems mistaken for D5.5)
D5.4	Prototype of the EP sensing system including sensing and HMI	Aug. 2013	Aug. 2013? (depends on D4.2)
D5.5	Prototype of the warning generator	Aug. 2013	Jun. 2013
D5.6	Validation of the warning device / measurements	Nov. 2013	Dec. 2013

Task 5.2 Modelling of the sound source

Synergies between tasks 3.4 and 5.2

- Task 3.4

Simulation study of different array geometries and sizes

- ► Real-time implementation
- ► Assessment of the performance
- ► Sensitivity analysis
- ► Robustness assessment

- Task 5.2

Simulation study of sound radiation of the integrated warning device

- ► Warning device location
- ► Specific vehicle characteristics
- ► Driving scenarios
- ► Acoustic environment

Synergies between tasks 3.4 and 5.2

- Task 3.4

Simulation study of different array geometries and sizes

- Task 5.2

Simulation study of sound radiation of the integrated warning device

► Real-time implementation

► *Assessment of the performance*

► *Sensitivity analysis*

► *Robustness assessment*

► Warning device location

► *Specific vehicle characteristics*

► *Driving scenarios*

► *Acoustic environment*

Close link

Task 5.2 Modelling of the sound source

Synergies between tasks 3.4 and 5.2

Specifications:
#transducers (6), location warning system (bumper)

↓

Initial beam forming assessment
Based on simplified models — T3.4

↓

Sound radiation assessment of the installed warning device
Limited number of candidate configurations — T5.2

↓

Beam forming assessment
Based on obtained transfer functions — T3.4

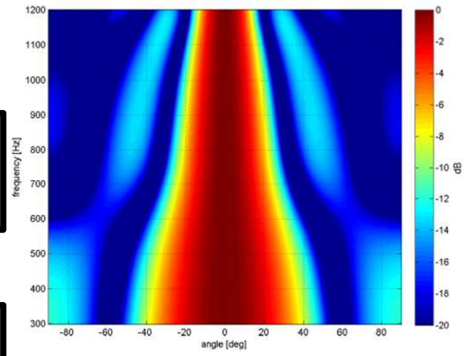
↓

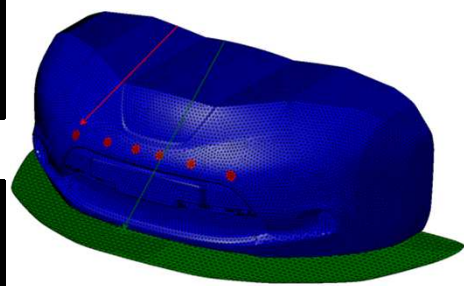
Performance verification
Based on obtained control coefficients — T5.2

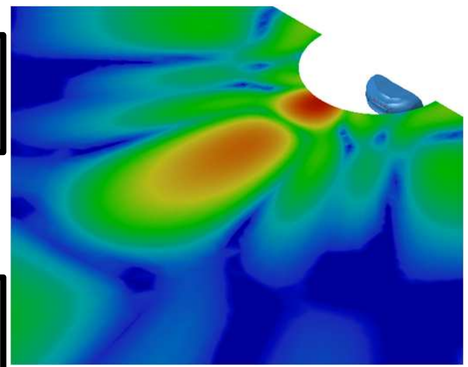
↓

Expected performance and critical implementation issues — D3.2, D5.2

Sensitivity: temperature, environment,….



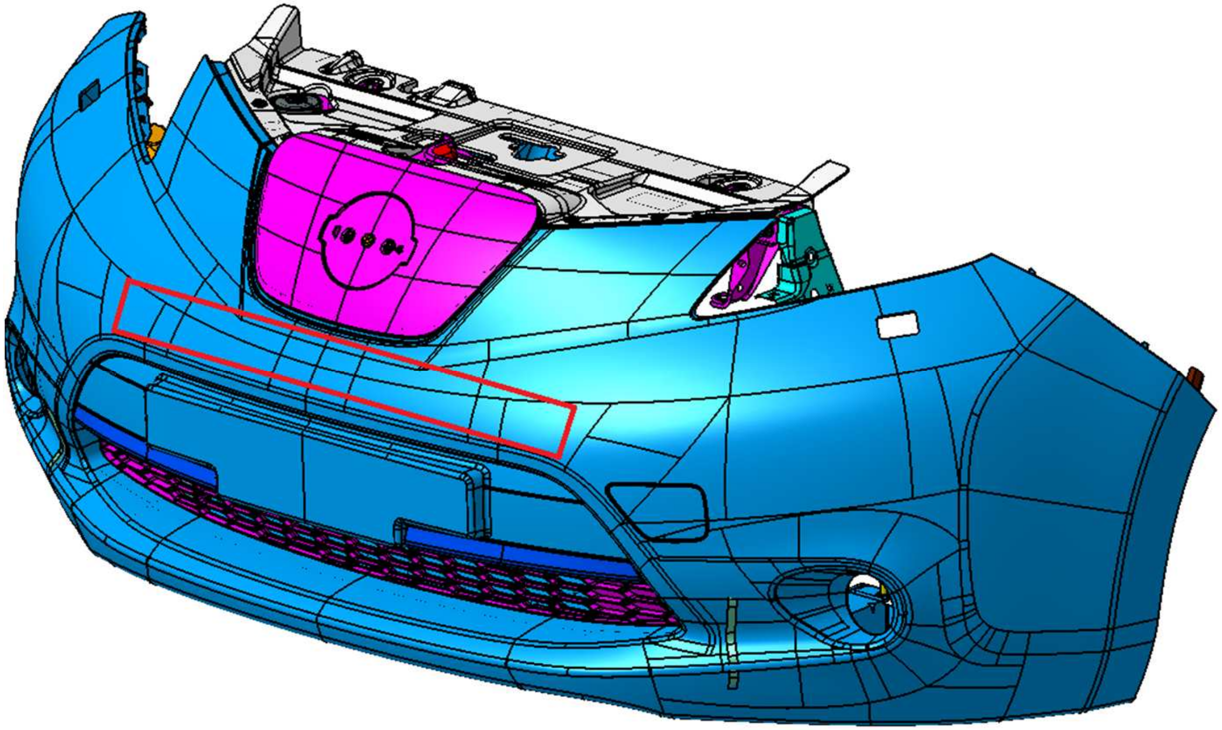




Task 5.2 Modelling of the sound source

Sound radiation assessment of the installed warning device

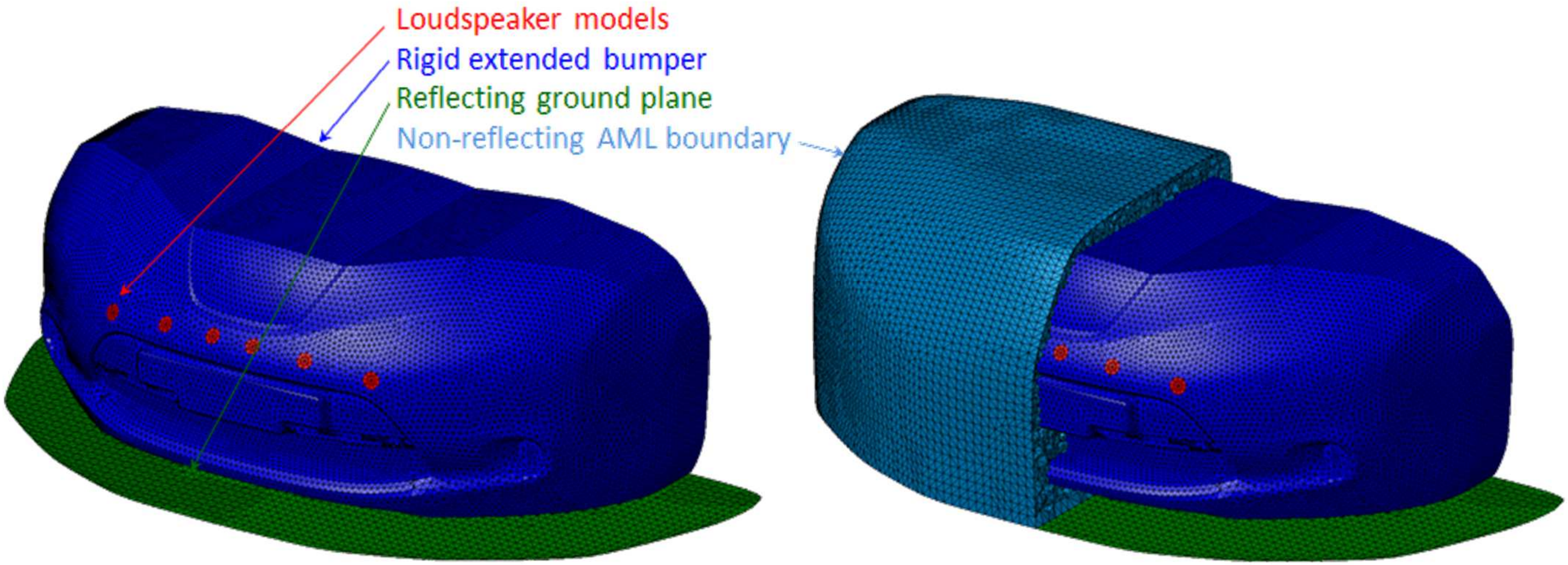
- Base input for building up the numerical model: Nissan bumper CAD model



- To eliminate the impact of edge reflections of the isolated bumper the CAD model was extended

Task 5.2 Modelling of the sound source

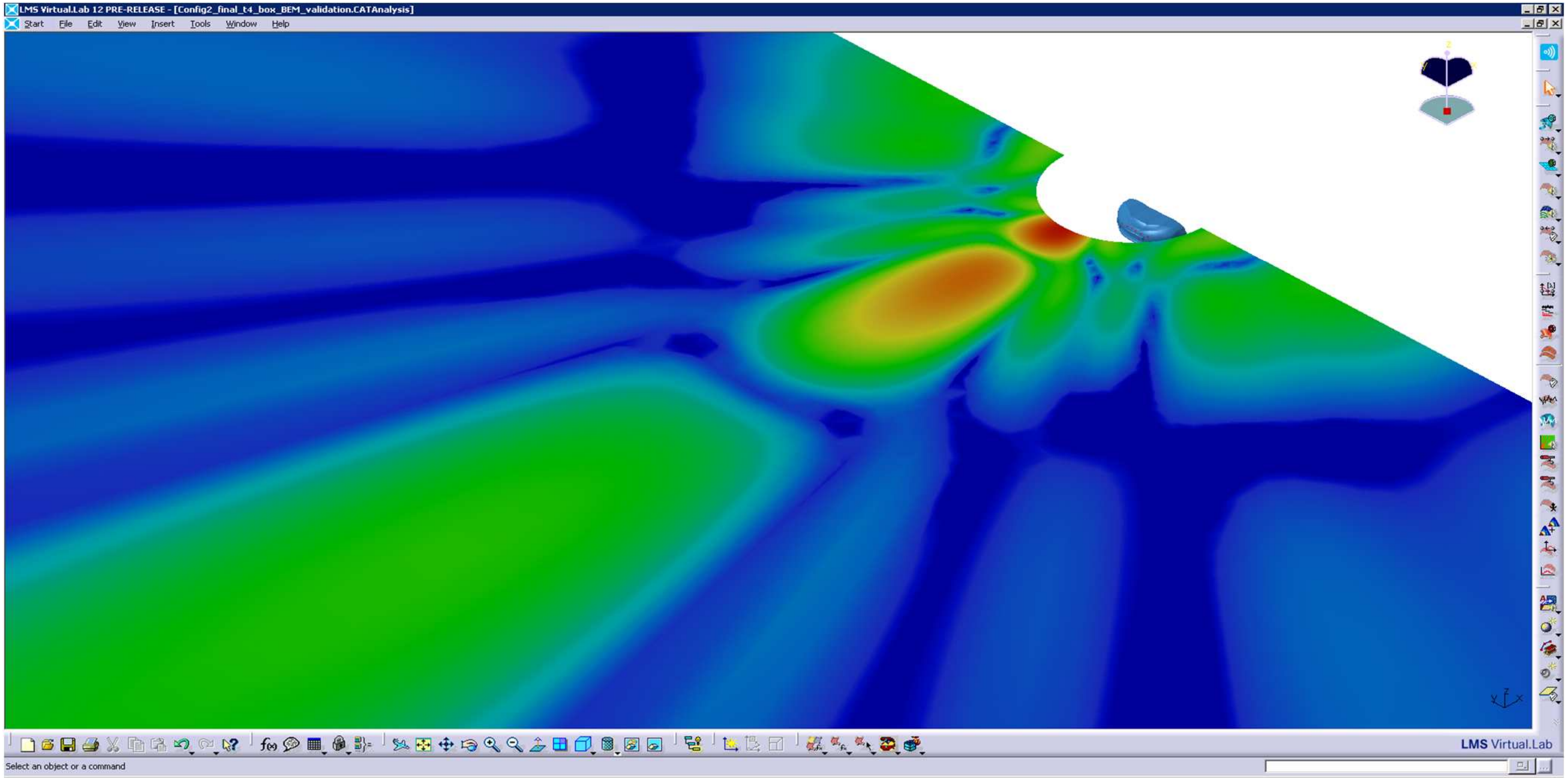
Sound radiation assessment of the installed warning device



Baseline Finite Element model for non-uniform transducer spacing (modelled as baffled pistons with an area equal to the effective area of the speakers)

Task 5.2 Modelling of the sound source

Performance verification



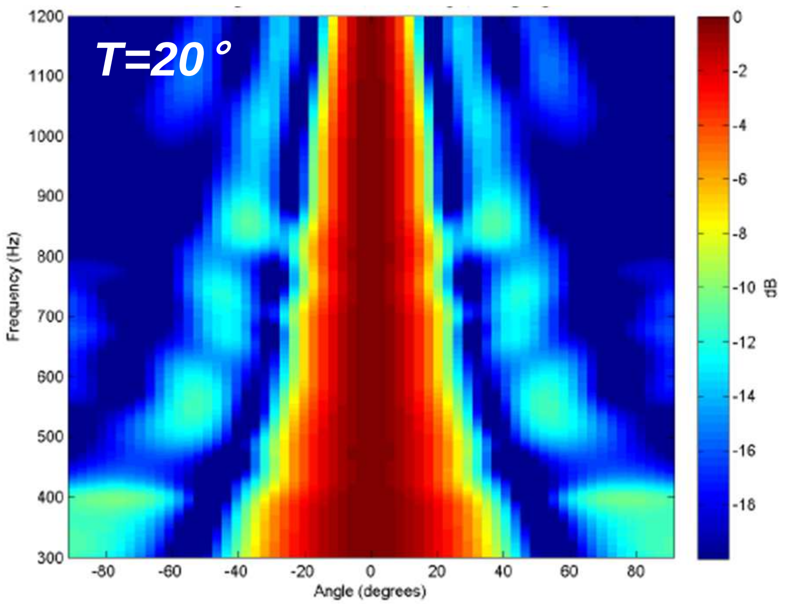
Using the control parameters identified in WP3, the spatial distribution of the acoustic pressure was reconstructed

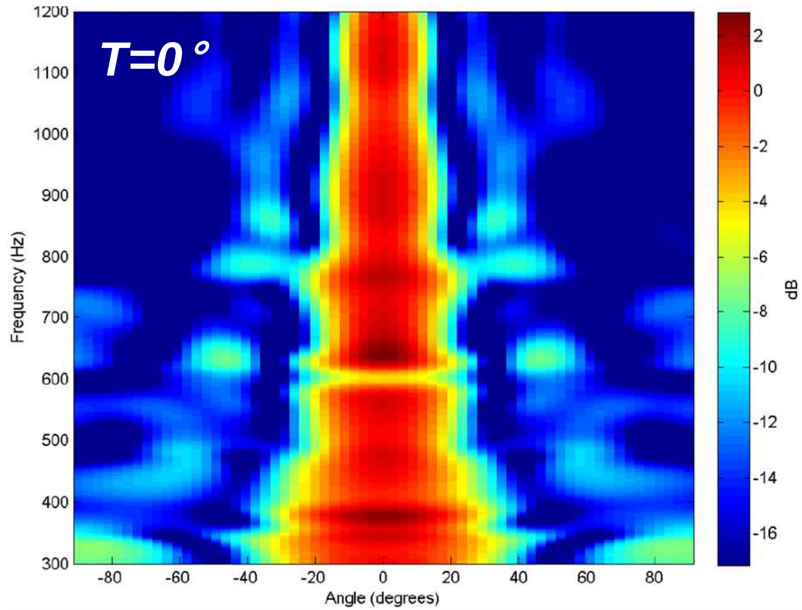
Task 5.2 Modelling of the sound source

Sensitivity study

- To verify the robustness of the warning generator's performance, a sensitivity study to quantify the impact of the most critical changes in the acoustic environment in which the signal generator needs to operate was performed:
  - Changes in the environmental temperature and relative humidity
  - Impact of the road surface impedance
  - the influence of nearby scattering objects such as e.g. parked vehicles

- Changes in the environmental temperature and relative humidity
  - Change the properties of the ambient acoustic fluid
  - Impact of temperature is higher than that of humidity
  - The baseline model can be reused for this study

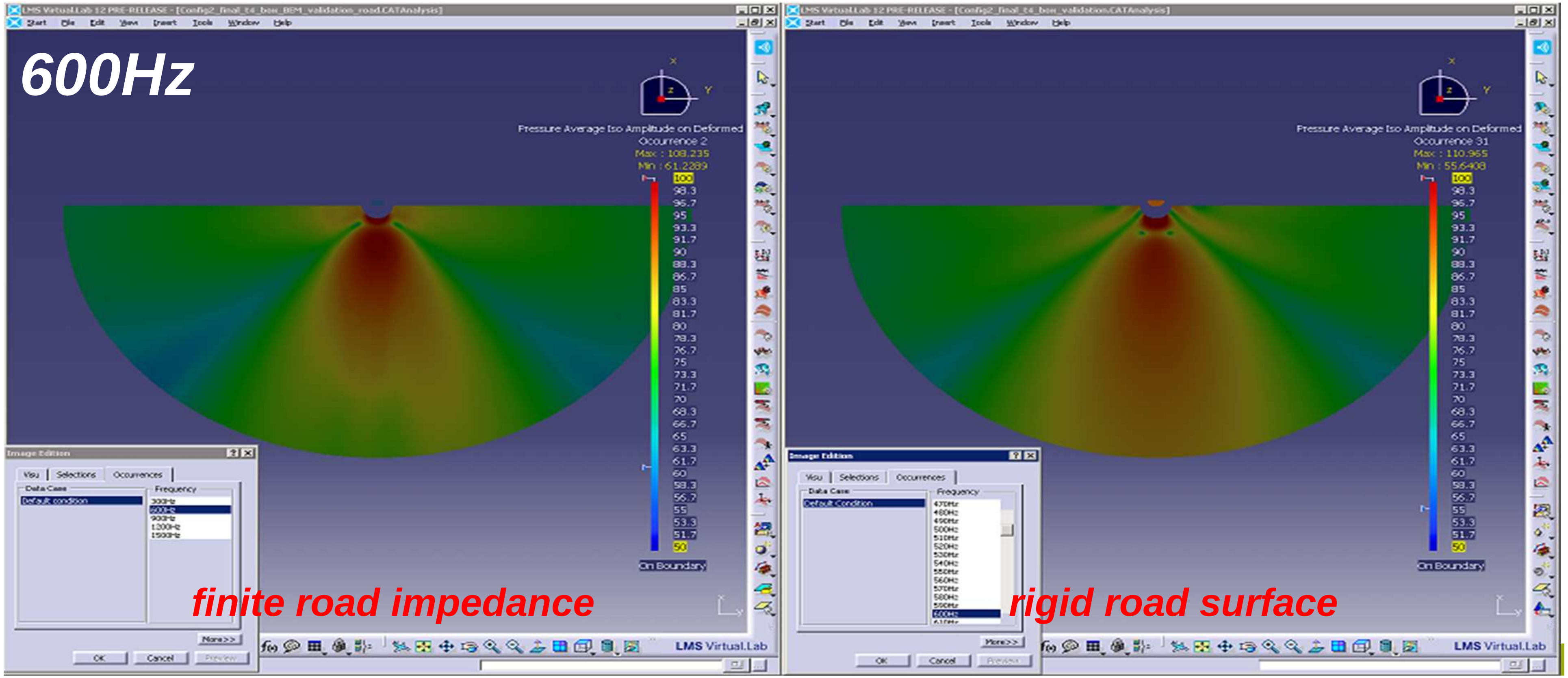




Task 5.2 Modelling of the sound source

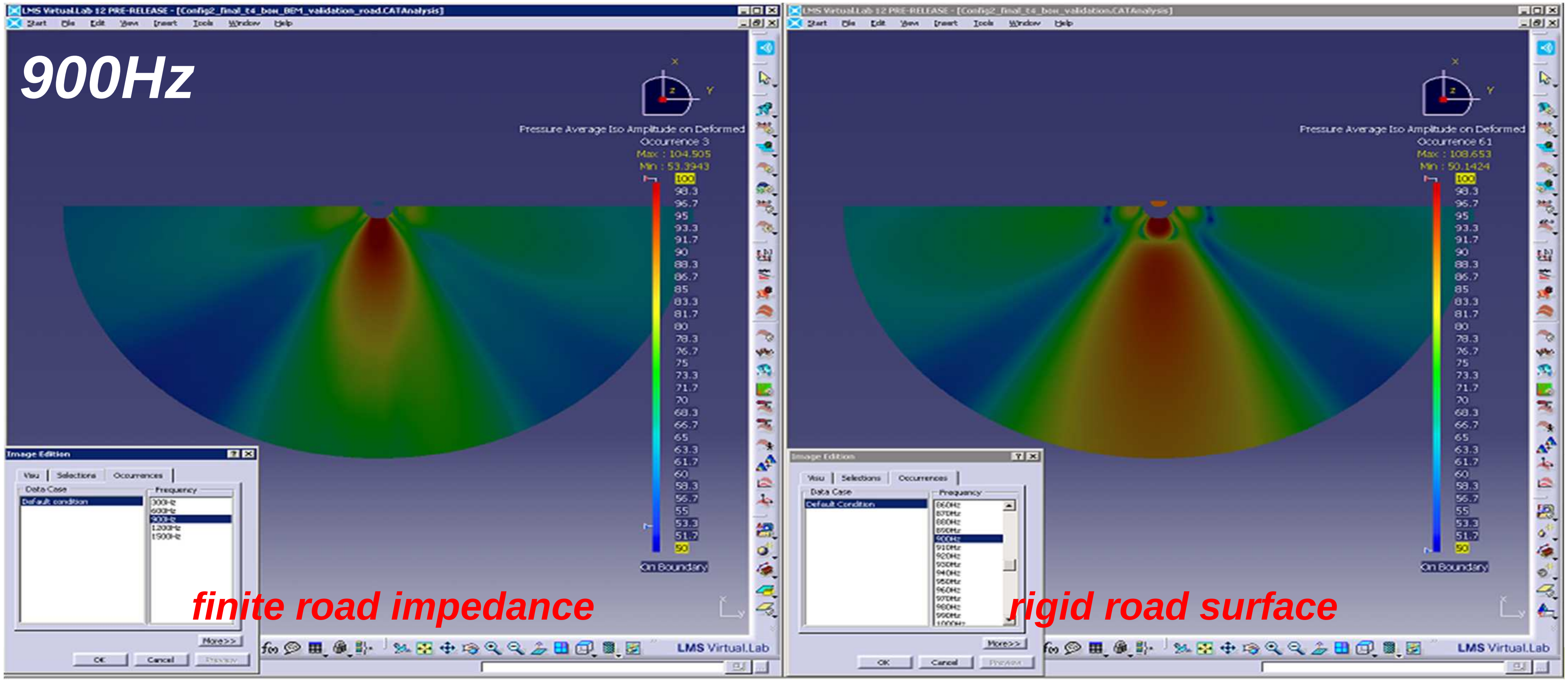
Sensitivity study

- Impact of the road surface impedance
  - The presence of a straight stretch of road does not significantly impact the overall beam forming



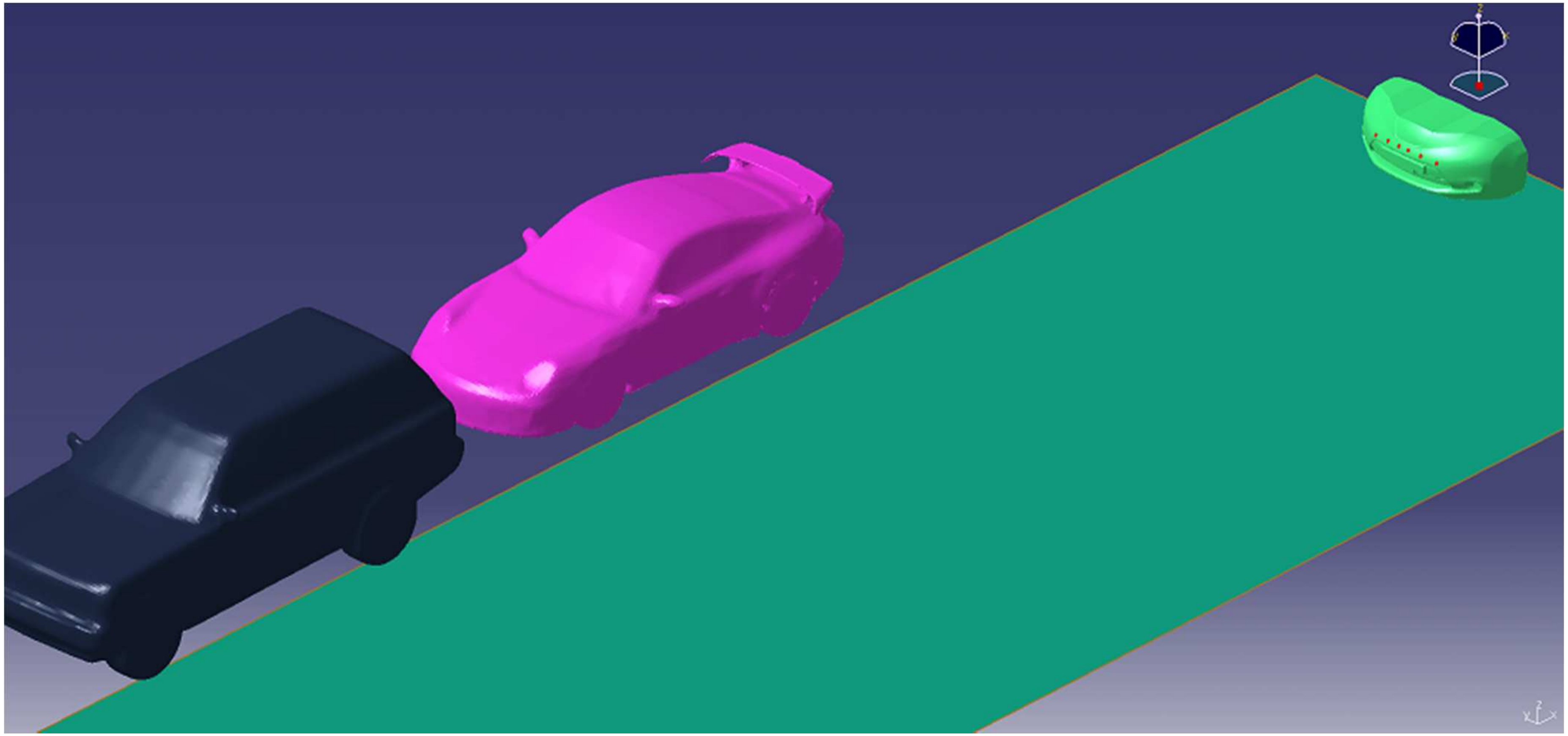
Sensitivity study

- Impact of the road surface impedance
  - The presence of a straight stretch of road does not significantly impact the overall beam forming



Sensitivity study

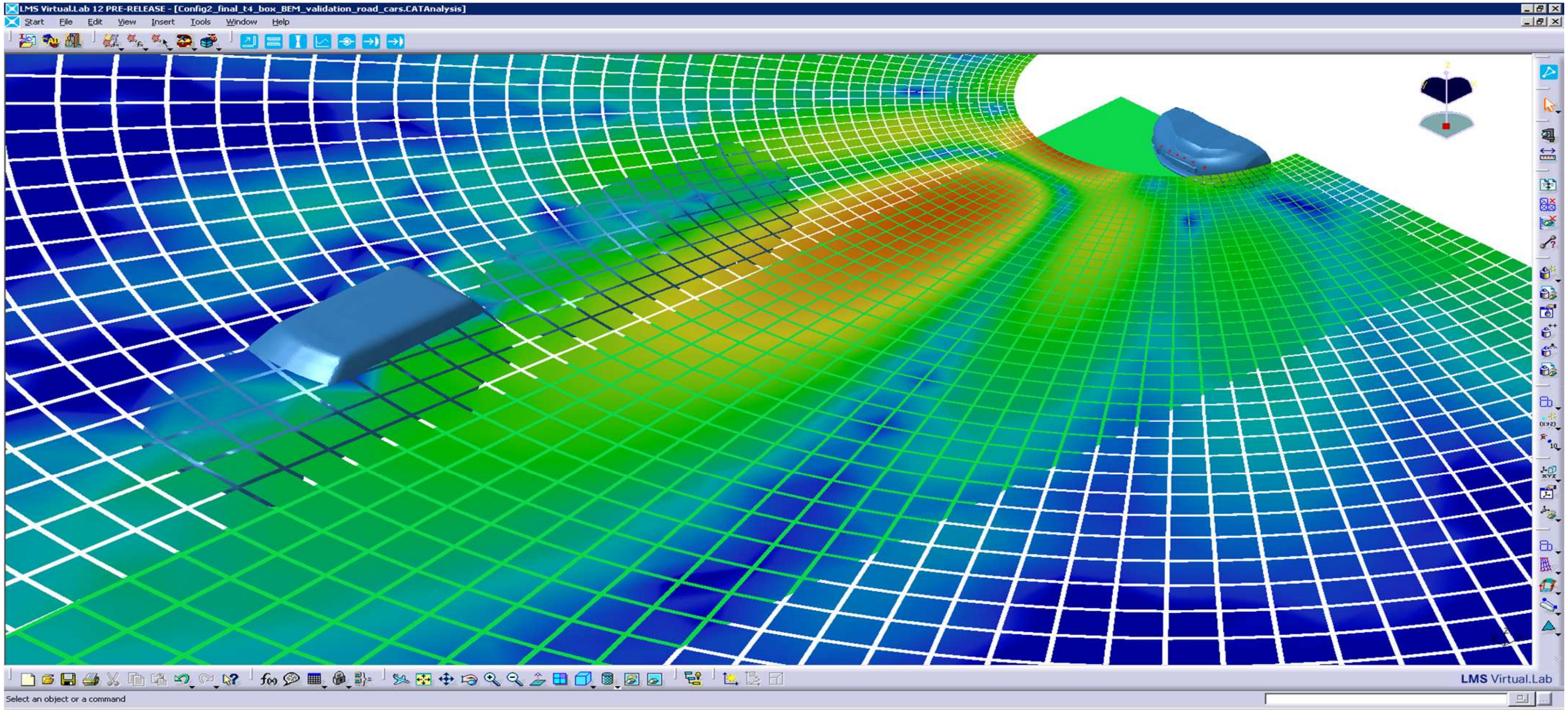
- the influence of nearby scattering objects such as e.g. parked vehicles



Task 5.2 Modelling of the sound source

Sensitivity study

- the influence of nearby scattering objects such as e.g. parked vehicles

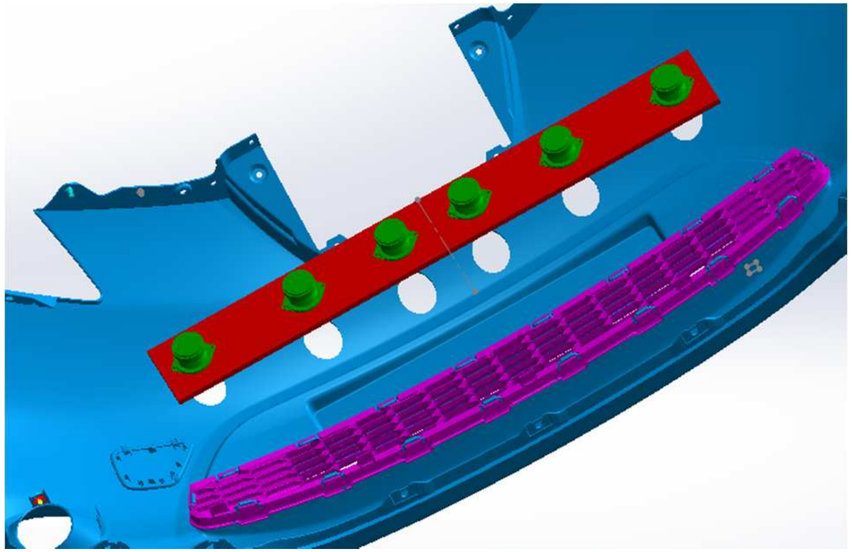


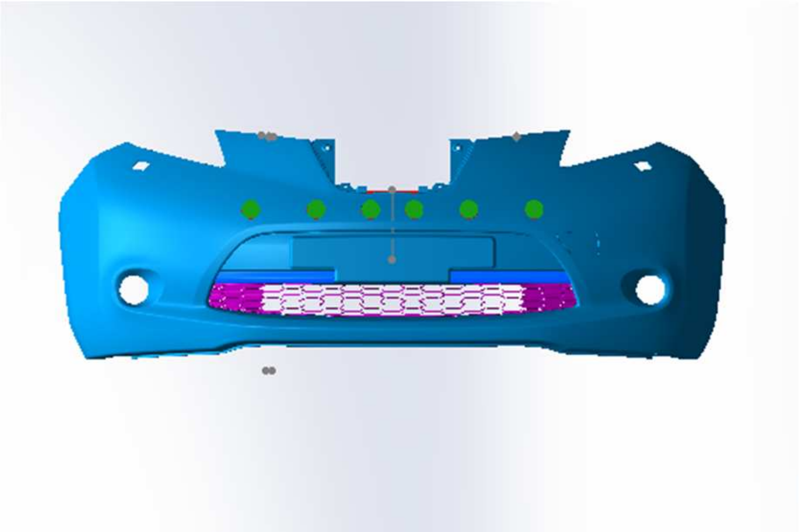
5.3: Hardware design

Mechanical design of the sound source

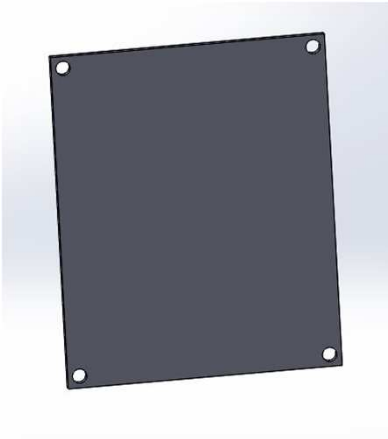
- Loudspeakers designed
- Positioned on bumper

- Issues:
  - Protection against shock / water projections
  - Cabling of loudspeakers through internal car components



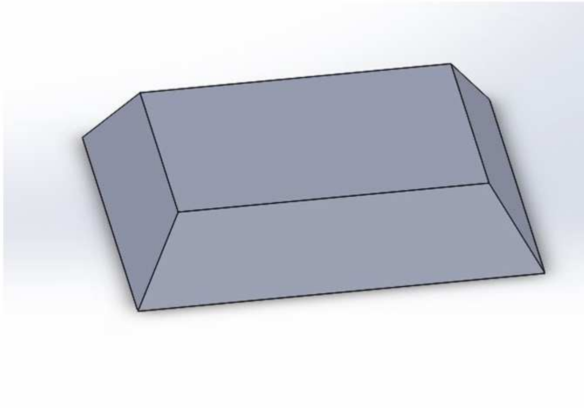


Mechanical design of components

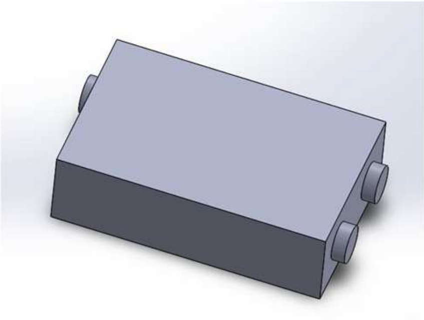


Craneboard

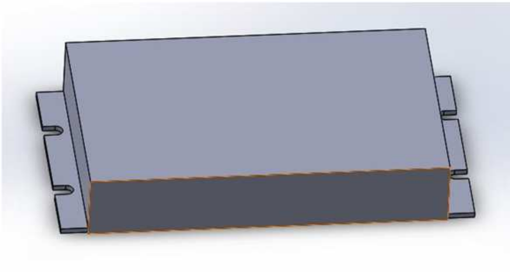
Norsonic outdoor microphone



TRadio



GPS to CAN



Peak CAN

Conti stereoscopic camera?

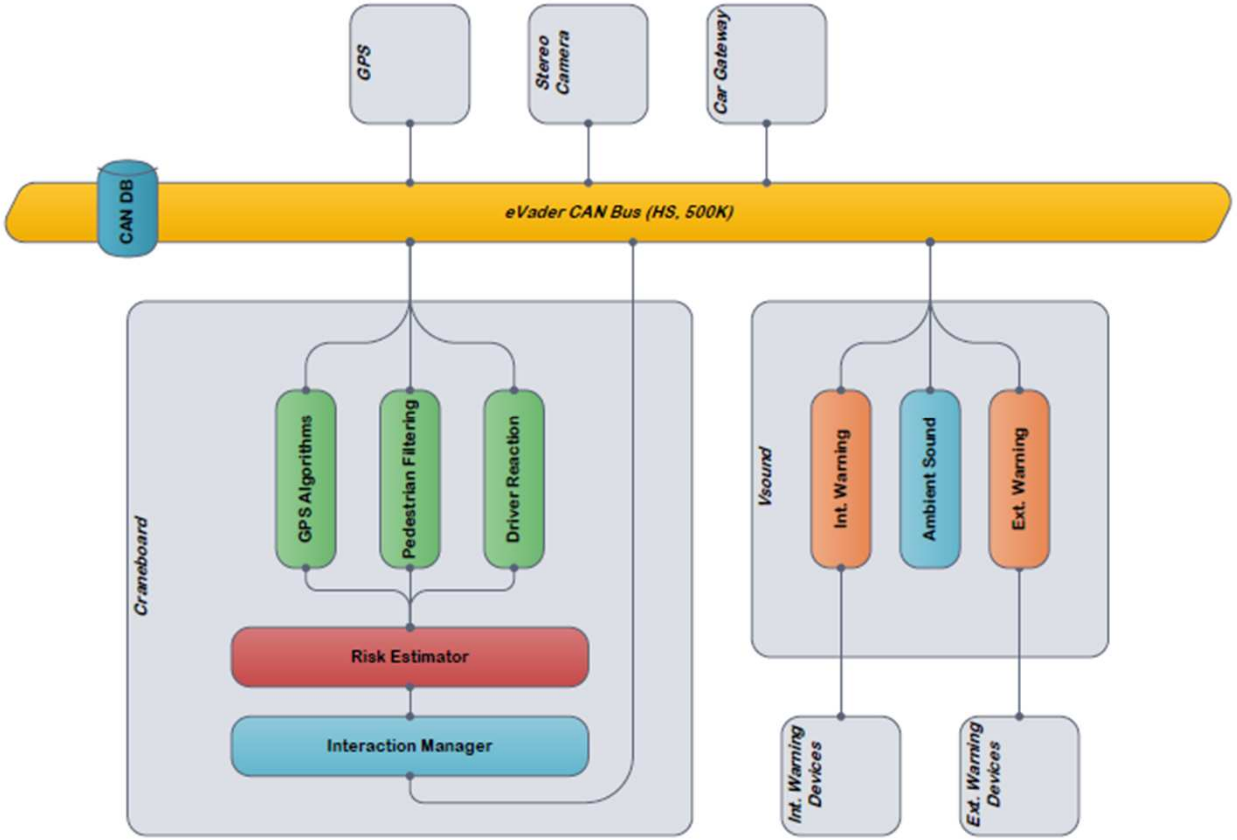
5.3: Hardware design

Next steps:

- Get drawings of stereoscopic camera
- Positioning of components on car prototype
  - sensors:
    - GPS
    - Microphone
    - Stereoscopic camera
  - Electronic components:
    - CAN components (PEAK + bus)
    - Craneboard, TRadio, Vsound,… + cables
    - Loudspeakers amplifiers
- Possible issue with microphone: protect against wind + moisture
  - Outdoor microphone: B&K 4198 or Norsonic Nor1210
  - Placement on the car to minimize influence of rain + wind
  - Ready solution from OEMs?

5.3: Software design

System architecture designed (WP4)



Deliverable update

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D5.5	Prototype of the warning generator	Aug. 2013	Jun. 2013
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Work Package 6

Implementation of eVADER systems into EV Vehicle (Nissan LEAF)

WP6: Objectives & Tasks

Objectives:

- Integration of the eVADER developed algorithms, sounds and hardware into Nissan LEAF vehicle.
- Evaluation of the performance and suitability of the eVADER system as a viable pedestrian alert solution for quiet vehicles
- Creation and evaluation of sounds in-line with the findings of WP2 (good detectability) which may also provide Brand Image cues and satisfy customer acceptance and environmental requirements

WP6: Objectives & Tasks

Task Overview:

- Task 6.1 [M23 – M28]
  - Specify hardware requirements for system integration
  - Determine transducer installation requirements
  - Determine vehicle electrical systems integration requirements
  - Software performance integration with vehicle systems
  - Installation of complete system into test vehicle
  - Verify no adverse effects on normal vehicle systems operation

- Task 6.2 [M27 – M30]
  - System testing in controlled environment to evaluate performance

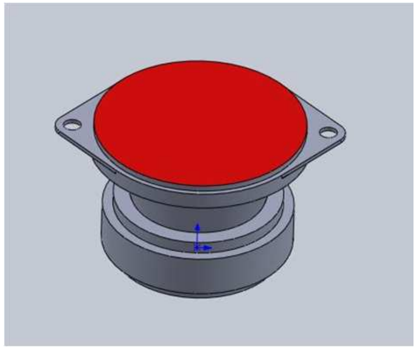
- Task 6.3 [M30 – M34]
  - Implement recommended alert sound from WP2 for initial demonstrations
  - Develop additional sounds following the guidelines of WP2 which also incorporate Brand Image cues and satisfy customer acceptance and environmental impact requirements.

Loudspeaker

Loudspeaker specifications:

- Visaton FRS 5 X - 8 Ohm
- Diaphragm diameter: 5 cm

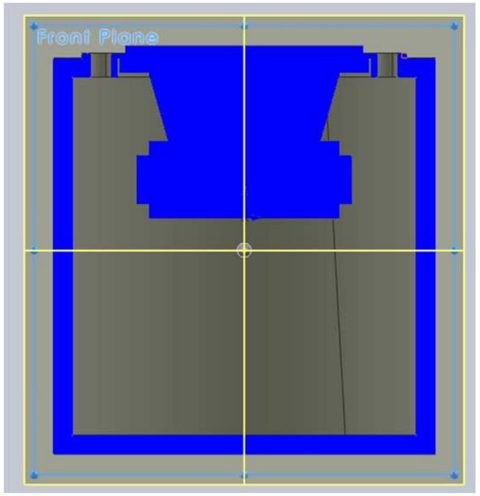
Rated power	5W
Frequency response	120-20000 Hz
Resonance frequency	190 Hz

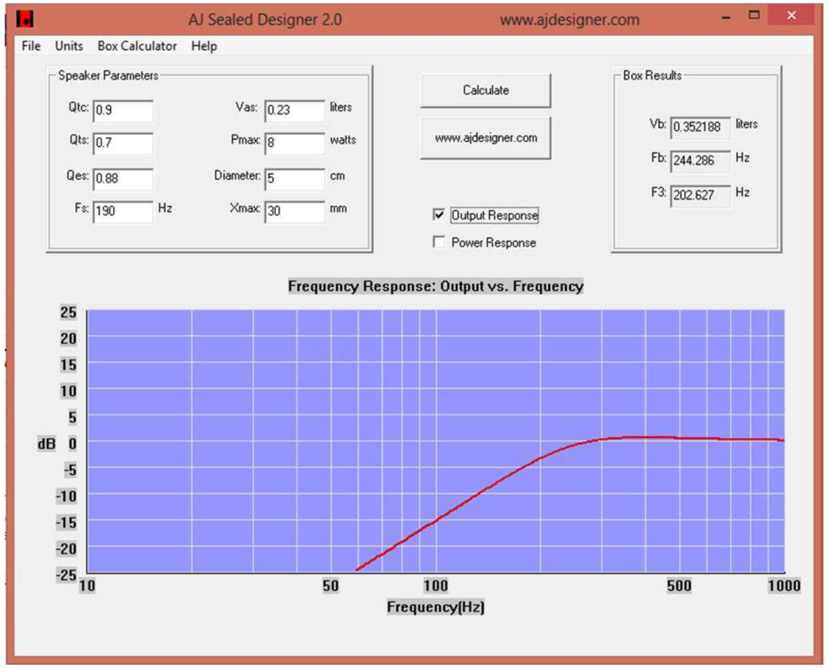


Amplifier specifications:

Operating voltage	6 - 18 Vdc
Output power	2 x 10 Watt
Frequency range	40 - 16,000 Hz
Loudspeaker impedance	2 - 8 Ω
Sensitivity	80mV

Loudspeaker enclosure





Dimensions:

- Length: 85 mm
- Diameter: 80 mm
- Originally a test enclosure for the speaker, can be modified if dimensions not suitable in car

Loudspeaker protection

Protection against stone, rain...:

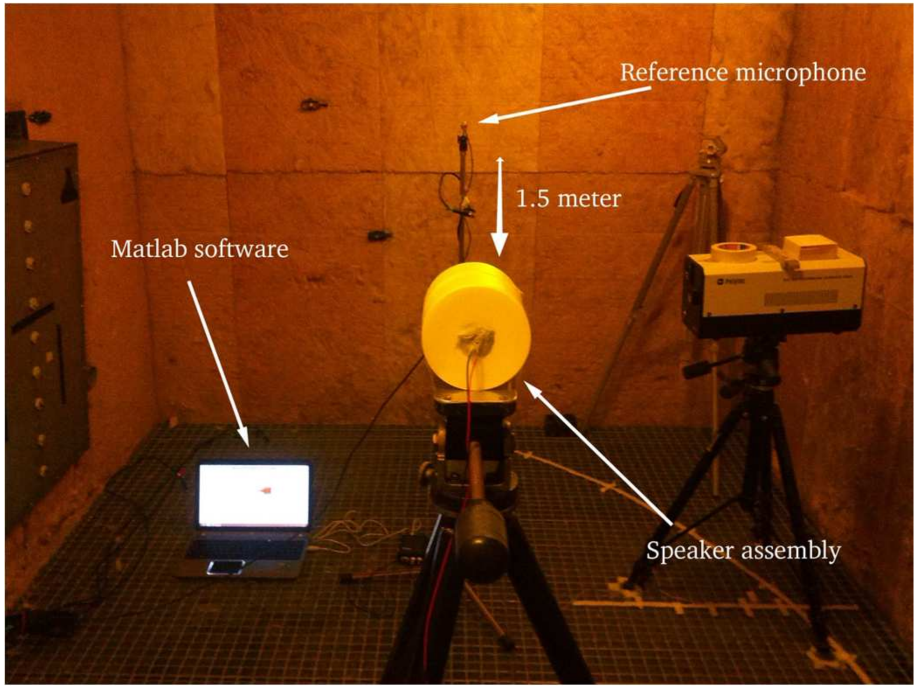
- Grid (mechanical impact protection): inner diameter: 59 mm (speaker diameter: 50 mm)

- GAW 113 from GORE TEX protection rating IP 65 (IP 67 not possible in this size, but also not necessary) should have been produced, still not delivered

Loudspeaker test

Test condition:

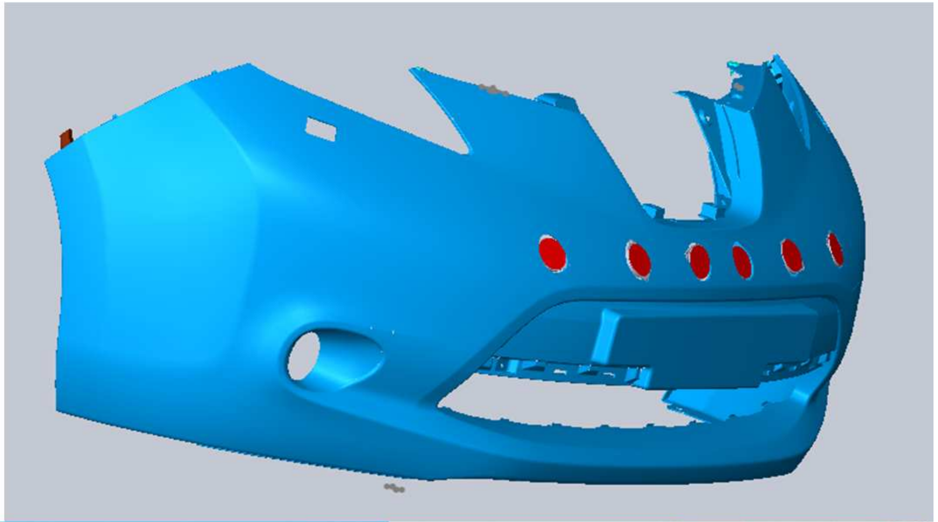
- Same input signal (noise) for all loudspeakers
- Measurement with microphone 46AE from GRAS



Array construction

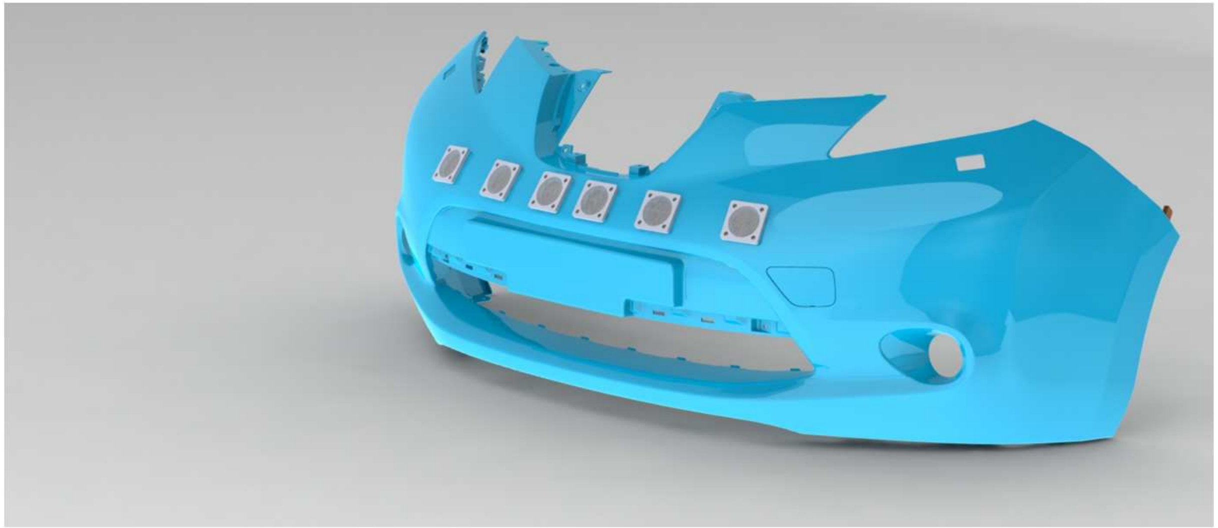
Array design

- Based on results of T5.2 (LMS) and WP3 (TNO)



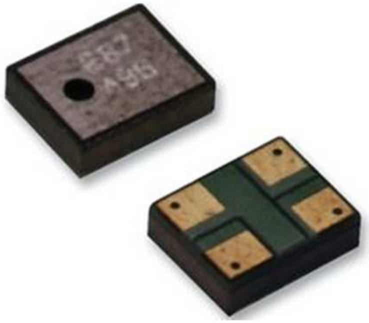
- Loudspeaker without / with protection grid

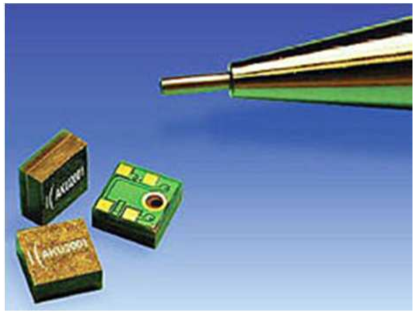
Array construction



- Drilling of holes + speaker mounting planned next 2 weeks

Microphone array design





Objective

- Measure street sound level
- Single microphone subject to influence of noise (wind, transient sounds...)
  → use of multiple microphones positioned around the car

Chosen microphone

Knowles Sisonic microphone (MEMS):

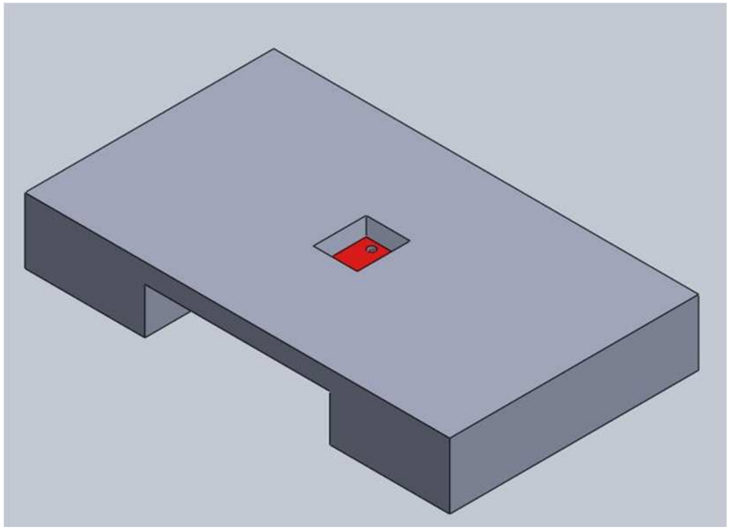
- Cheap (useful for array)
- Robust, insensitive to variation of environmental condition
- Insensitive to mechanical vibrations

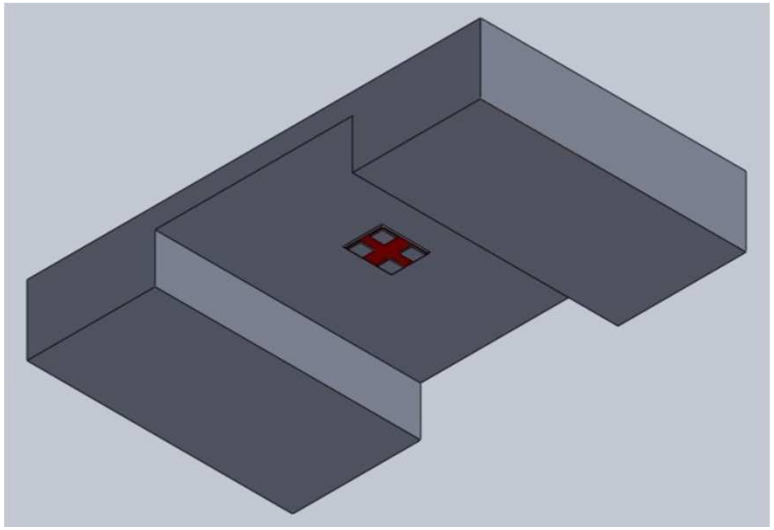
Position

- Bumper not optimal due to deplacement wind
  → must be investigated

Microphone holder

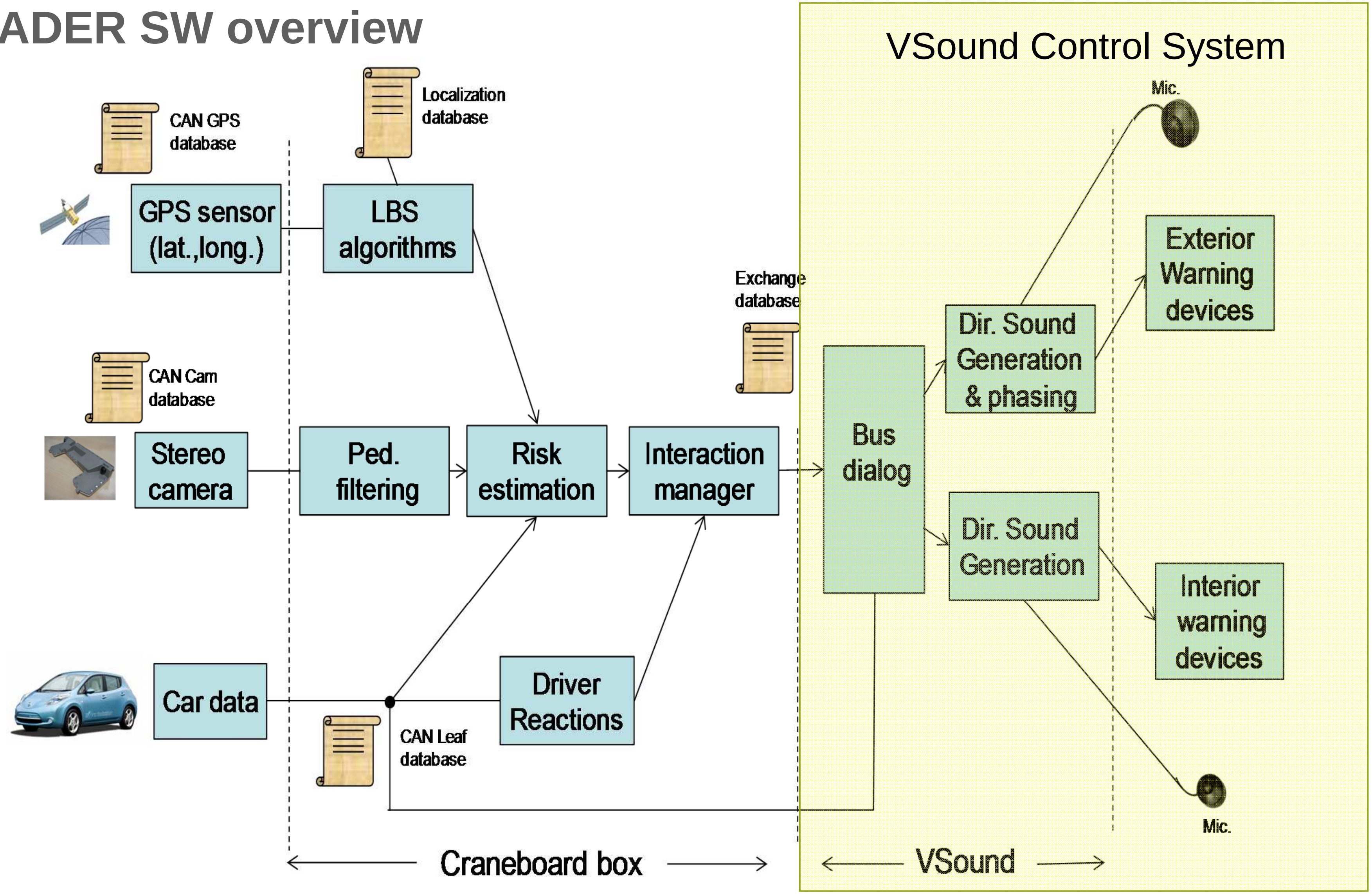
- Objective: test of the properties of GAW 113
- Sensitivity change of mic after mounting the protection



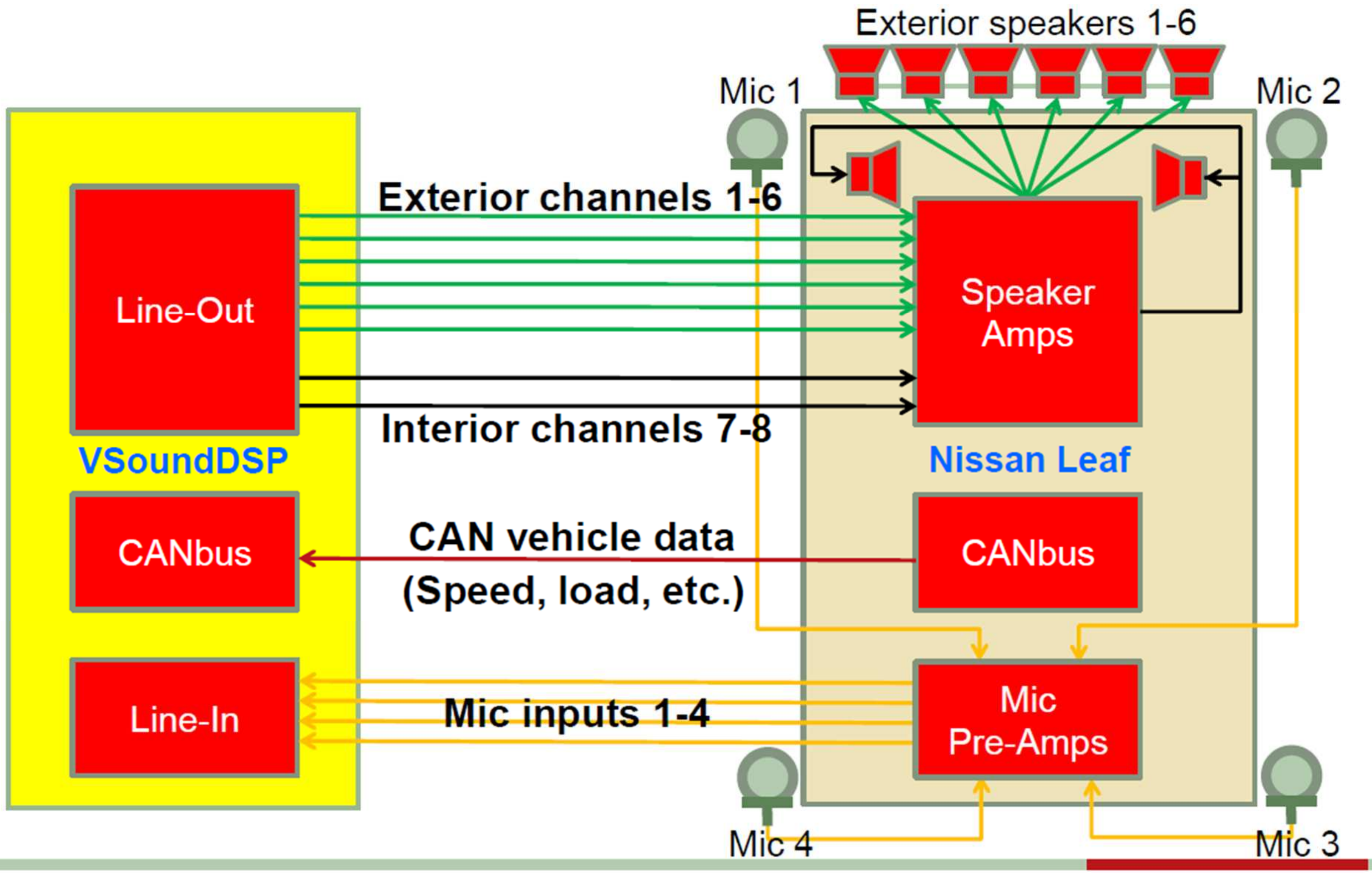


Extract from WP4

EVADER SW overview



VSound Controller Integration Overview



Deliverables

Deliverable	Deliverable Description	Delivery date
D6.1	Software & Hardware specifications	24
D6.2	Strategy of system integration into the vehicle	27
D6.3	Prototype system hardware & software installed on vehicle for evaluation & demonstration	31
D6.4	Report on results of evaluation tests	33
D6.5	Example sounds meeting WP2 requirements incorporating 'Brand Identity' features (Nissan, Renault & PSA examples)	34

Work package 11

Dissemination

WP 11 Main purpose and objectives

- Ensure project impact: society, science, technology
  - To contribute to EV vehicle safety
  - To reach the market: transform results into solutions
  - Contribute to state-of-the art in related scientific community
  - Support market access by improved/new services, testing and simulation tools

  - **Comply with & Impact evolving Regulations**
  - **Impact public discussion & awareness**

WP 11.1 Dissemination events

8 papers at major events and conferences

- IQPC Automotive NVH, 23-24/1/2012, Wiesbaden (D)
- Acoustics 2012, 23-27/4/2012, Nantes (F) [*2 papers*]
- Inter-Noise 2012, 19-22/8/2012, New-York (USA)
- FISITA 2012 World Automotive Congress, 27-30/11/2012, Beijing (CN)
- AIA-DAGA 2013 Conf. on Acoustics, 18-21/3/2013, Merano (I) [*3 papers*]

Several new papers scheduled

- IQPC Noise Optimisation EV/HEV, 25-27/9/2013, Frankfurt (D)
- TRA 2014, Transport Research Arena 2014, 14-17/4/2014, Paris (F)
- FISITA 2014, World Automotive Congress, 2-6/6/2014, Maastricht (NL)

Internal mailing and newsletter EBU

WP 11.1 Dissemination events

Public workshops: 2 workshops committed in the DoW

- Month 24 (IDIADA)
- Month 36 (IDIADA)

- EVS 27 Barcelona, 17-20 Nov -> IDIADA
- Coupled to an LMS Event in Munich in October -> LMS
- Coupled to other autumn project workshops (GRESIMO, COST…) -> LMS

WP 11.2 Website structure and update

http://www.evader-project.eu/