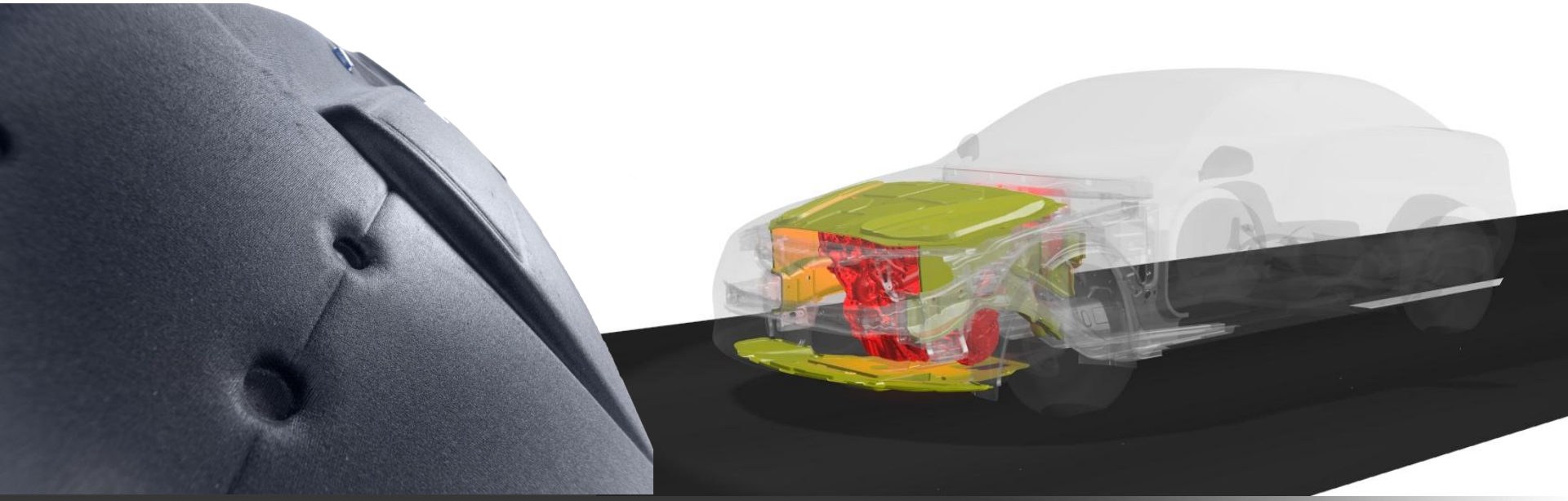


# Engine encapsulation

## A synergic approach to exterior noise and $CO_2$ emissions reduction

Brussels, 18th December 2012
Maurizio Mantovani - Autoneum

# Agenda

1. **Who is Autoneum**

2. Benefits of encapsulation in view of current and future $CO_2$ emission and exterior noise regulations

3. Concepts and materials for engine encapsulation

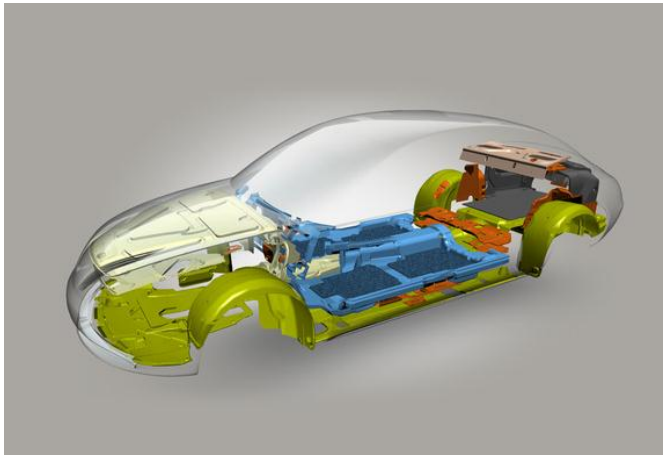
4. Conclusion

# Who is Autoneum?

Autoneum is the global technology leader in **acoustic and thermal management solutions for motor vehicles**.

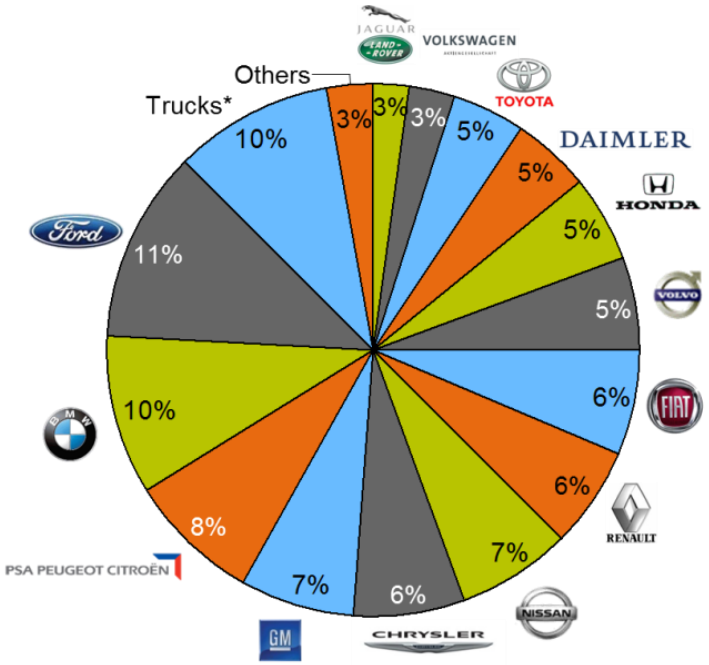
Competitive strenghts:

- Leading provider of integrated solutions for Acoustic and Thermal Management
- Product leadership through technology and innovation
- Long-standing relationships with diversified, broad and balanced customer base
- Global footprint
- Operational excellence to maintain efficient cost structure



# Autoneum at a glance
## Key figures

| Autoneum Group – stock-listed and independent since May 2011 | |
|---|---|
| 26 | Countries across the globe (incl. Joint Ventures and Licencees) |
| 48 | Manufacturing locations |
| 7 | Development Centers |
| 1 | Central Research & Technology Center (at headquarters) |
| 9,400 | Employees |
| 1,722 | Mio. Swiss francs Sales in 2011 |



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1. Who is Autoneum
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# Main Factors Influencing Engine Encapsulation

## Regulation

- $CO_2$ reduction / NEDC / C.A.F.E.
- Exterior noise reduction

## Final-user perspective

- Real fuel-consumption
- Acoustic/Thermal comfort
- Reduction of engine wear

## Technical requirements

- Thermal safety
- Weight balance
- Engine bay architecture

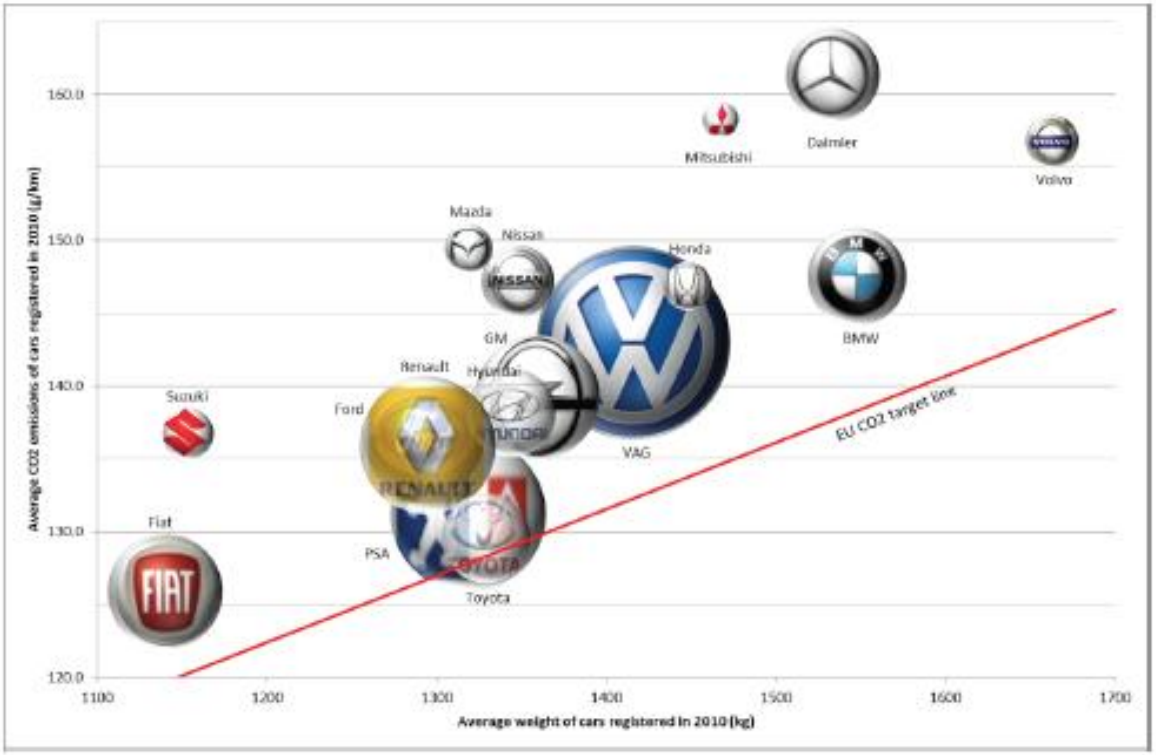
# European Regulation 443/2009 on $CO_2$

- From 2012 OEM's that do not fulfill their fleet target will pay a **penalty** per vehicle per excess gram $CO_2$ according to following rules:
  - 1st gram = € 5.-
  - 2nd gram = € 15.-
  - 3rd gram = € 25.-
  - Above 4 grams = € 95 .-

- Only part of the fleet considered until 2015
  - 65% in 2012
  - 75% in 2013
  - 80% in 2014
  - 100% from 2015 onwards
- From **2019** 100% of the fleet charged with **€ 95** per excess gram $CO_2$/km

# European Regulation 443/2009 on $CO_2$

- Regulation applies for passenger cars (category M1*)
- Each vehicle has a specific $CO_2$-target based on its mass: 1372 kg = 130 g/km
  this values are used for calculating the fleet target, that will be used for the tax




Specific vehicle $CO_2$ - emission target

=

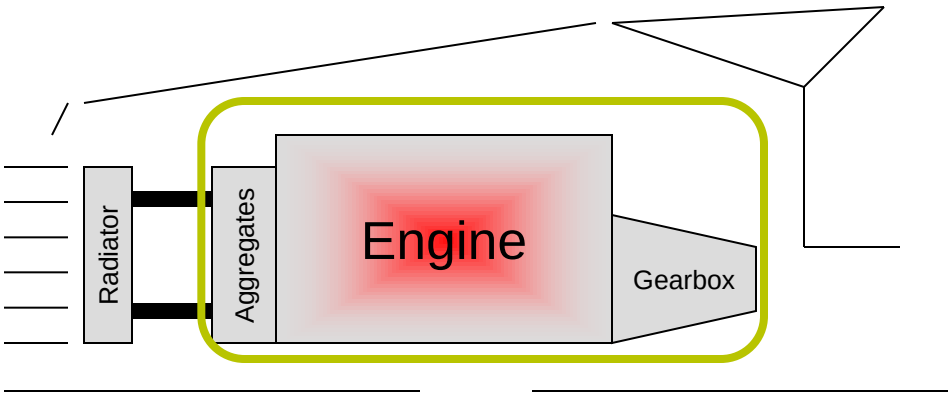
$130 + a \bullet (M - M_0)$

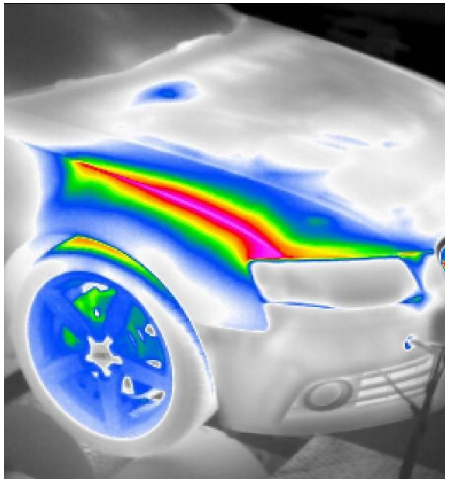
a = 0.0457
$M_0$ = 1372 kg
M = vehicle mass

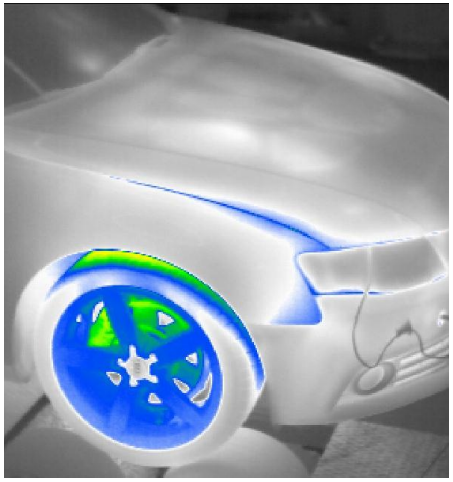
*) Vehicles used for the carriage of passengers and comprising no more than 8 seats in addition to the driver's seat

Source: www.transportenvironment.org

# Encapsulation for $CO_2$ emissions reduction



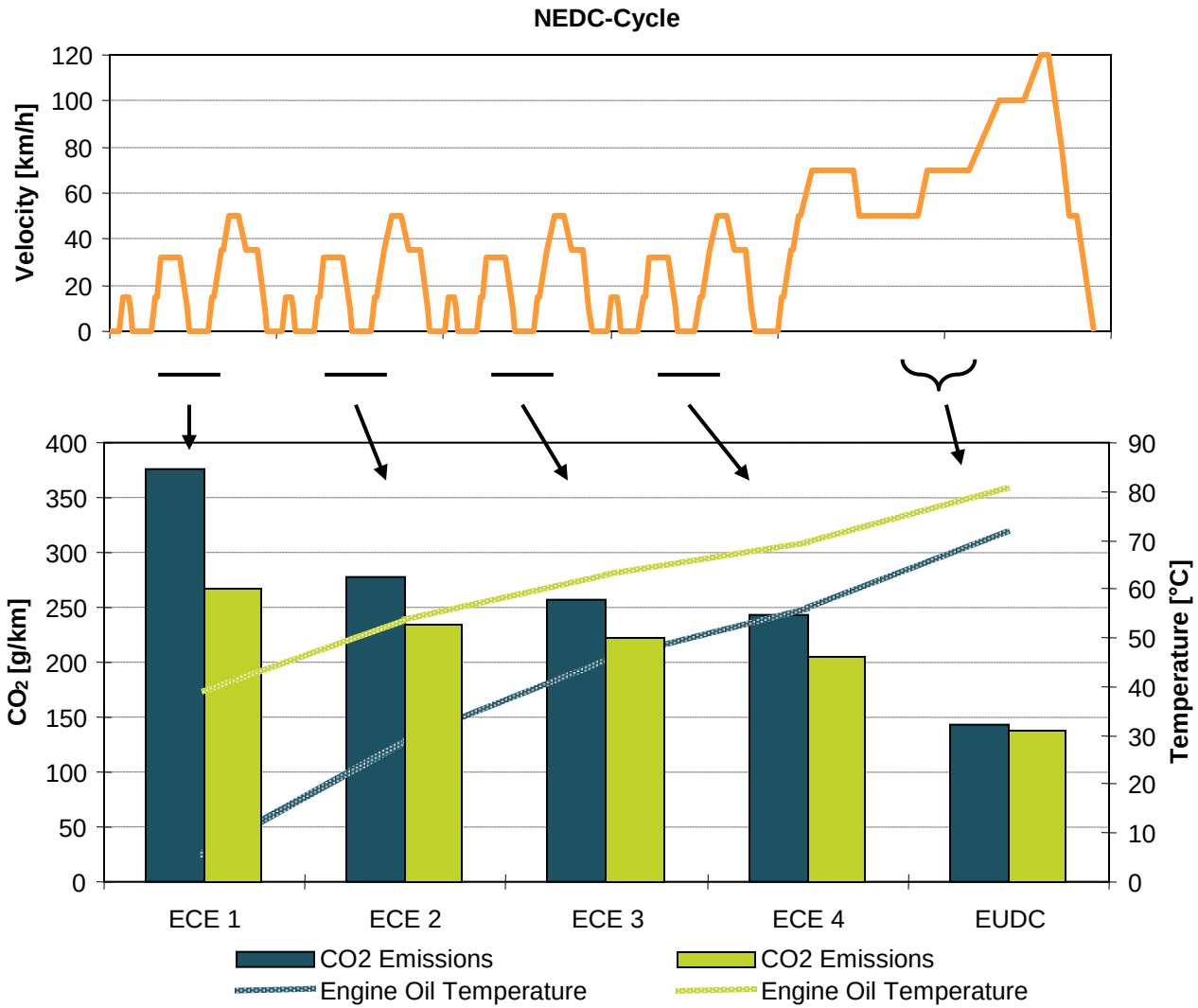


The engine is not fully efficient until it has warmed up to operating temperature

Lubricants/fluids perform best at operating temperature and keep engine friction to a minimum

Engine encapsulation mainly allows cold start from higher temperature

# Encapsulation for $CO_2$ emissions reduction




## C-segment diesel car

Ambient temperature: -7°C

Engine oil initial temp.: -7°C

Ambient temperature: -7°C

Engine oil initial temp.: 31°C

$CO_2$ emission reduction during ECE 1: -29%

Overall $CO_2$ reduction: -13%

# New European Regulation 725/2011

REGULATION (EU) No: 725/2011 of 25 July 2011

**Certification of innovative technologies** whose impact on $CO_2$ emissions in NEDC cannot be evaluated.

**5.9. Engine starting temperature**

The starting temperature of the engine influences the $CO_2$ emissions. A higher engine temperature reduces friction losses of the lubricant and moving parts. A percentage reduction factor of $CO_2$ emissions in relation to a temperature increase of the engine (temperature of coolant) can be given. This value refers to the NEDC including a cold start.

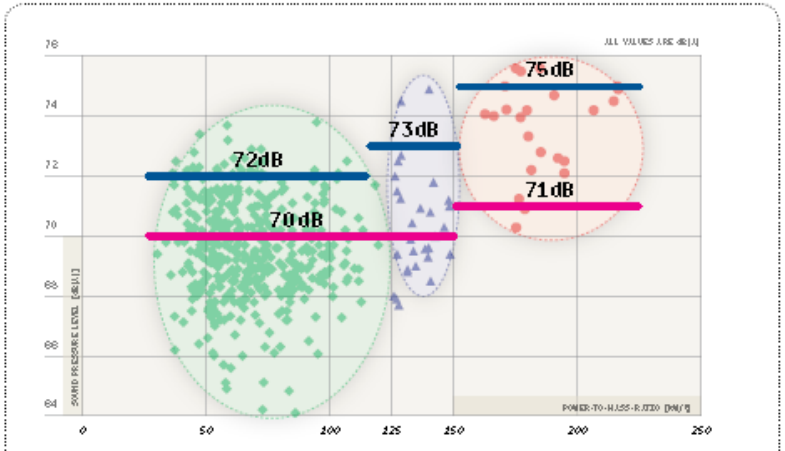
**6.1. Potentially qualifying technologies**

| No. | Technology | Technology class | Mean expected benefit |
|---|---|---|---|
| Q01 | Engine heat storage | 4 | 1.5 g CO2/km |
| Q02 | LED lighting | 1 | 1.3 g CO2/km |
| Q03 | Battery charging solar roof | 3 | 1.9 g CO2/km |
| Q04 | Efficient alternator | 6 | 0.6 g CO2/km |
| Q05 | Thermoelectric generator | 5 | 0.6 g CO2/km |
| | | | |

# New Pass-by Noise Regulation

## M1 vehicles

### STAGE 1 PROPOSALS



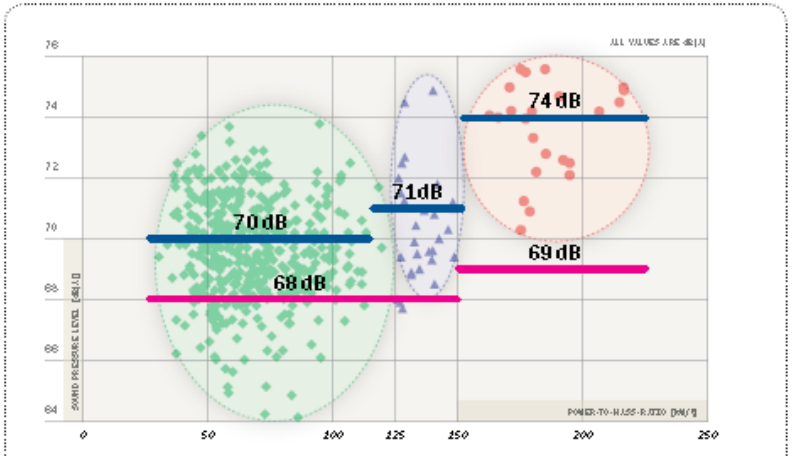

**EC LIMITS**

**70 dB** or **≈40 - 50%**
car families affected
**71 db** or **≈90%**
car families affected

**ACEA LIMITS**

**72dB** or **≈10%**
car families affected
**73dB** or **≈10%**
car families affected
**75 dB** or **≈10%**
car families affected

### STAGE 2 PROPOSALS




**EC LIMITS**

**68dB** or **≈80 - 90%**
car families affected
**69db** or **≈100%**
car families affected

**ACEA LIMITS**

**70 dB** or **≈40%**
car families affected
**71 dB** or **≈30%**
car families affected
**74dB** or **≈40%**
car families affected

Source: ACEA booklet “Setting the right sound level”

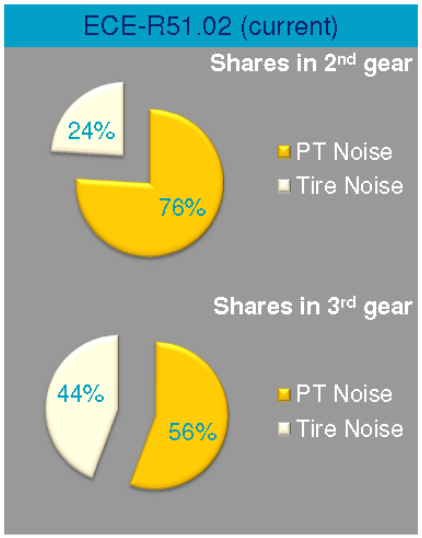
# Technology trend
## Powertrains becoming noisier

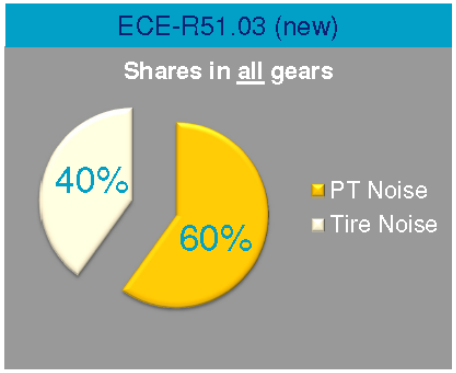
Our OEM customers report typical powertrain noise radiation increases of 2-3 dB due to:

- Higher combustion pressure
- Turbo-chargers also in petrol engines
- Direct gasoline injection
- Faster valve actuation
- Lightweight engine construction

However, some effective technologies being introduced, like integration of exhaust manifold in engine block

# Consequences of new pass-by noise regulation and technology trends




Source: LMS European Vehicle Conference 2012

Tires are more important in new test method and countermeasures need to be developed to reduce their contribution

However, it seems to be difficult to reduce tire contribution below 68 dB(A)

Shielding of tires is difficult to envisage due to technical limitations and users acceptance

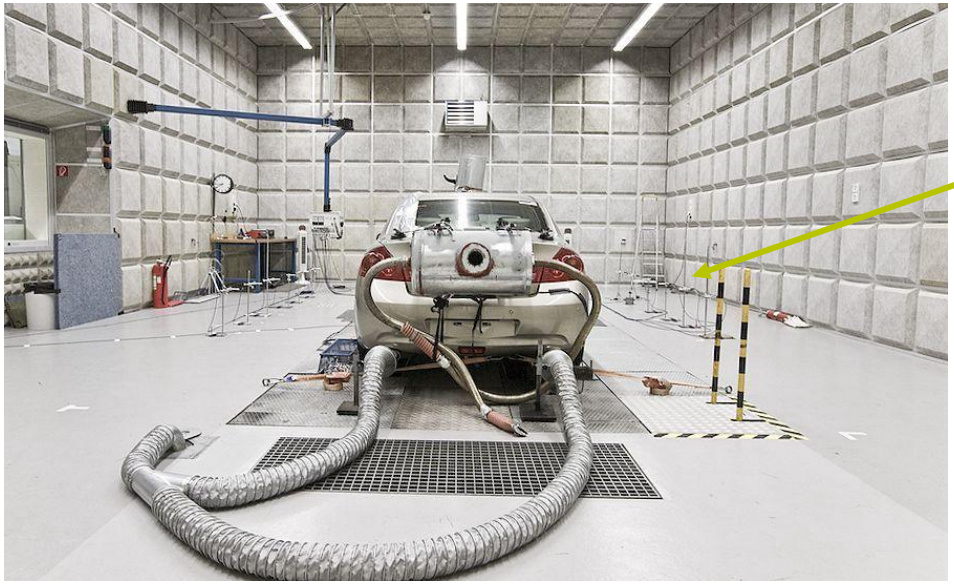
With new limits of 68-69 dB(A) it will be therefore necessary to reduce all other noise sources

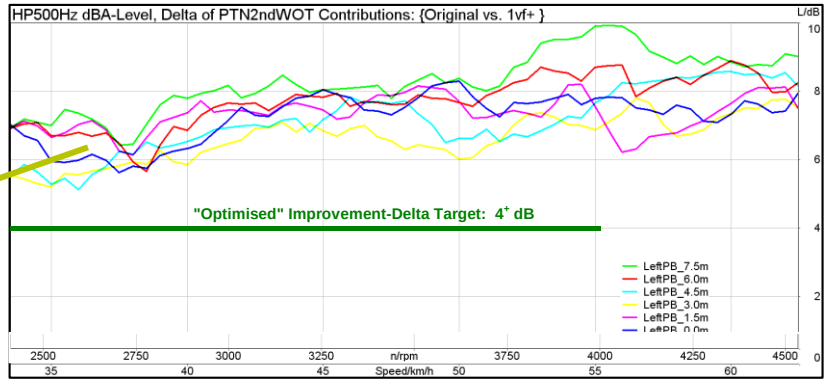
Powertrain and exhaust encapsulation may be necessary

# Powertrain exterior noise reduction
## Example of NISSAN-Autoneum project

Target from OEM - Reduction of 4 dB(A) of the powertrain exterior noise

- By an encapsulation and absorption treatment in engine bay and underbody
- Which satisfies the operational thermal safety of the components.



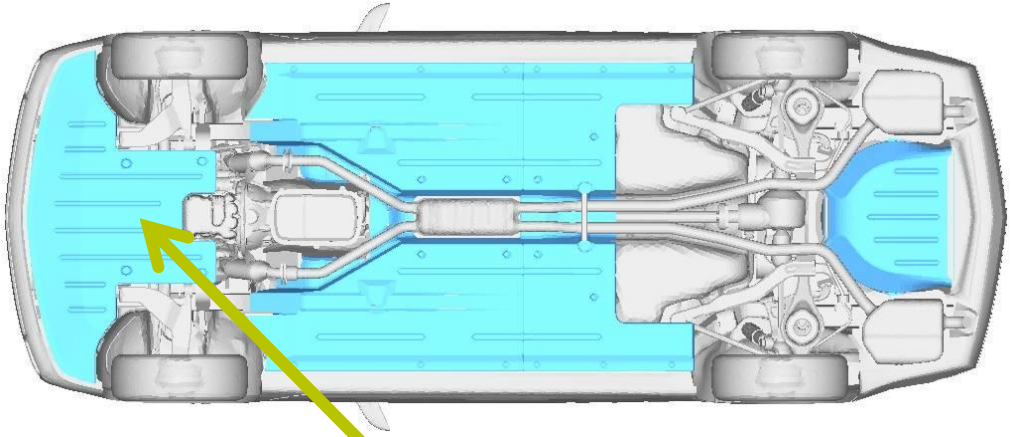



Target met at all exterior microphones
Thermal safety guaranteed

Source: ATZ January 2010

# Under engine shield

## Drag and exterior noise reduction



**Under-engine shield is a key component for aerodynamic drag and exterior noise reduction**

**Up to 5% fuel consumption reduction thanks to aerodynamic underfloor**

→ Aerodynamic design (CFD capabilities required)

→ Super-Lightweight materials required

# Agenda

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# Two approaches to Engine Encapsulation

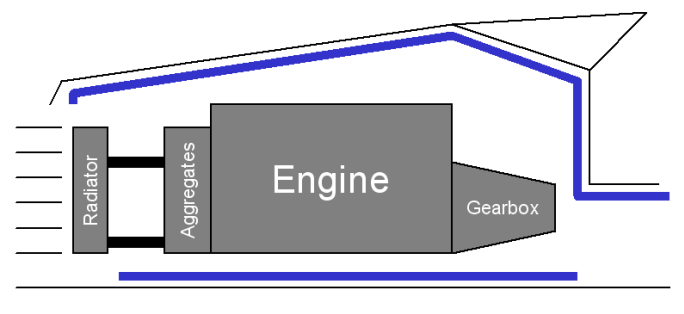
## Body-mounted encapsulation

Advantages:

- Well compatible with current vehicle development processes
- Encapsulation far from heat and vibration

Challenges:

- Minimize air leakage at pass-troughs
- Mounting sequence
- Large surface to be insulated



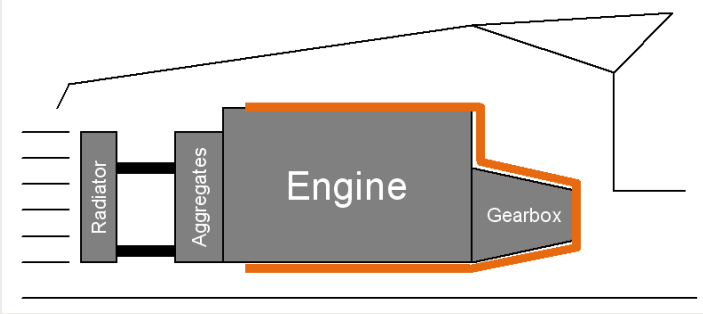

## Engine-mounted encapsulation

Advantages:

- Small surface to be insulated
  → Lower material usage
- Closer to heat and noise source
  → Efficiency

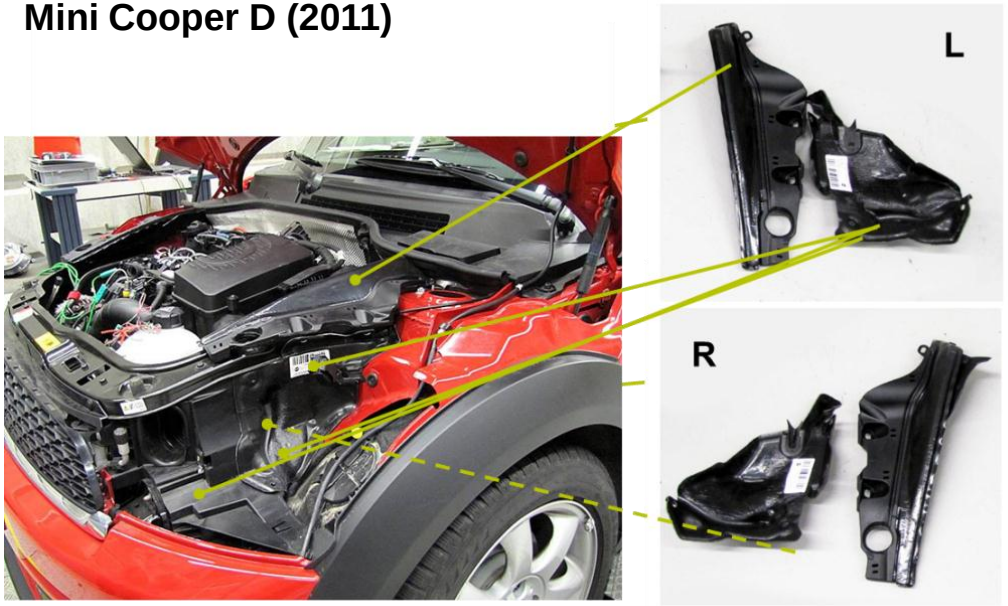
Challenges:

- More heat and vibration
  → development of new materials
- More difficult to realize due to complex geometries and interfaces



# Example of engine encapsulation on the market

**Mini Cooper D (2011)**




**Hoodliner:**

Thermoformed slab foam carrier with non-woven face fabric and rear layer, 0.28kg.

**Engine side closings:**

Noise-absorbing engine side closings, RUS™, 0.41kg (4 parts).

**Under engine shield:**

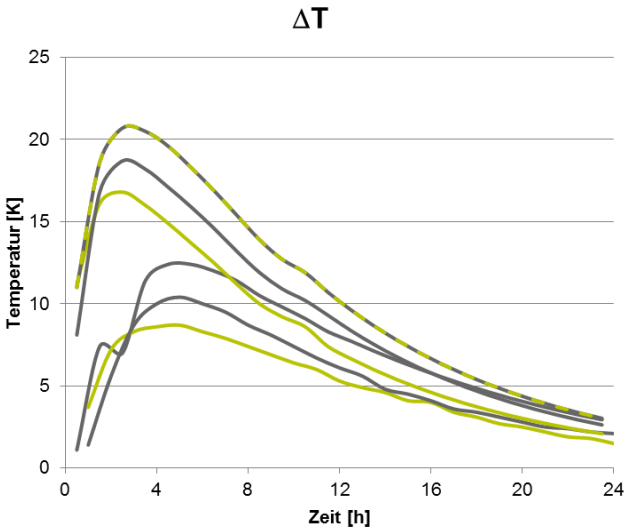
RUS™ carrier on front-wheel-drive version.

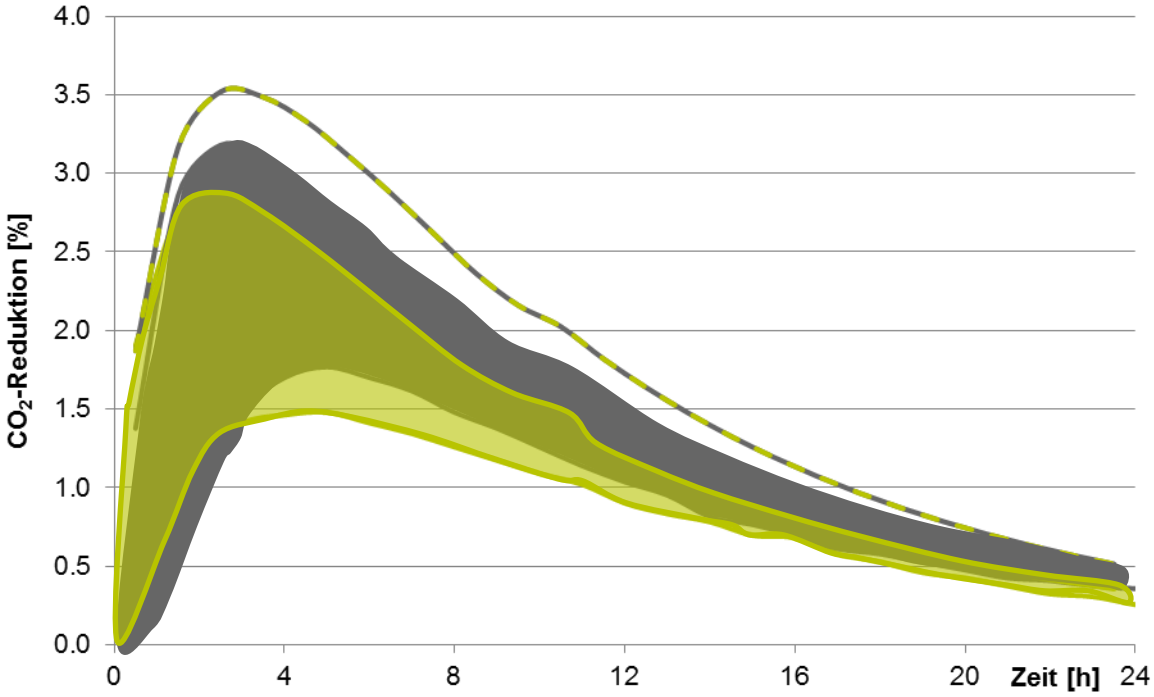
Injection moulded plastic carrier with noise-absorbing inserts on 4-wheel-drive version

# Engine cool-down performance

## ➔ $CO_2$ emissions reduction

| Body mounted | Engine mounted | Body + Engine mounted combined |
|---|---|---|
| B-Segment (Petrol)<br>D-Segment (Diesel)<br>F-Segment (Diesel) | B-Segment (Petrol)<br>J-Segment (Petrol) | B-Segment (Petrol) |

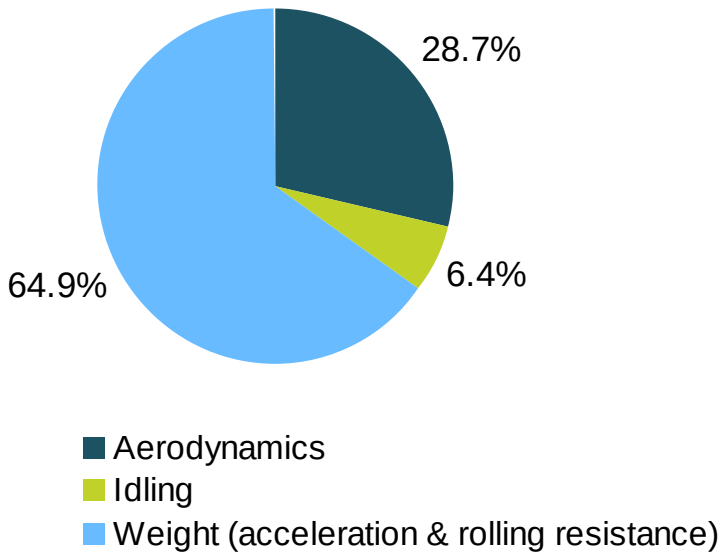



| | Max value | Computed using EU regulation |
|---|---|---|
| B-Segment (Petrol) | 3.18% | 1.70% |
| D-Segment (Diesel) | 2.11% | 0.84% |
| F-Segment (Diesel) | 1.78% | 0.71% |
| B-Segment (Petrol) | 2.86% | 1.76% |
| J-Segment (Petrol) | 1.48% | 0.83% |
| B-Segment (Petrol) | 3.52% | 2.04% |

# The need for lightweight

**Contribution of driving resistance types to fuel consumption during NEDC of mid-size car**




- Weight critical due to rolling and braking losses in conventional cars
- In hybrid and EV, weight must be reduced to allow for heavy battery and extend range

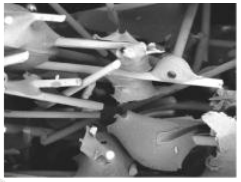
**1 kg of vehicle weight reduction**

**=**

**2.50 to 4.20 € reduction of penalty per vehicle sold in Europe**

# Materials for engine encapsulation
## Lightweight and multifuncional

Engine top cover example



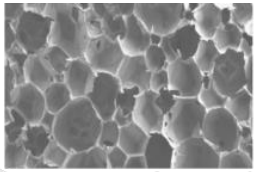
Structure of structural felt

**Theta-Fiber™**

**Lightweight, thermo-acoustic structural material**

| Properties | High thermal resistance | Solid plastic substitution (lightweight) | **Improved vibration behavior** | **High acoustic absorption** | Structural properties | High recycling content |
|---|---|---|---|---|---|---|

Hoodliner example



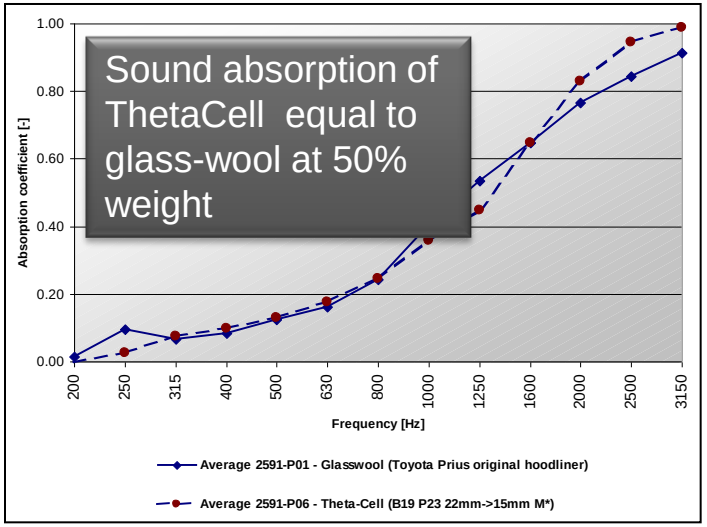
Structure of PUR foam

**Theta-Cell™**

**Reduce weight & increase acoustics**

| Properties | **Super light weight** | Temperature stable | **Acoustic excellence** | Flame resistance | Glass free, no irritations | Versatile layer combinations |
|---|---|---|---|---|---|---|

ThetaFiber
Substitution of solid plastic with integrated absorption and 50% weight reduction



# Ultra Silent ™

## Lightweight textile underbody applications

Lightest product on the market for integrated aerodynamic shielding and acoustics

**RUS™**

**100% PET**

**unique technology product**

| Properties | Super light weight | Recyclabe Glass free, no irritations | Design flexibility to optimize weight and stiffness | **Sound absorption** |
|---|---|---|---|---|

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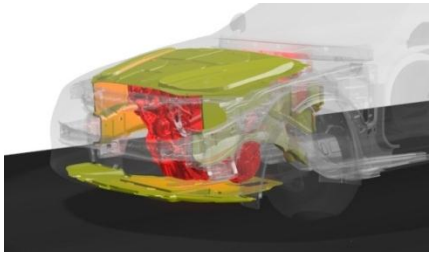
# Advantages of engine encapsulation

- **$CO_2$ and fuel consumption reduction**
- **CO- und HC-Reduction**

→ Catalytic converter reaches operative temperature in shorter times

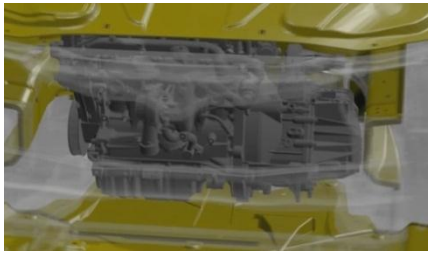


- **Exterior noise**

→ Up to 5dB Exterior noise reduction

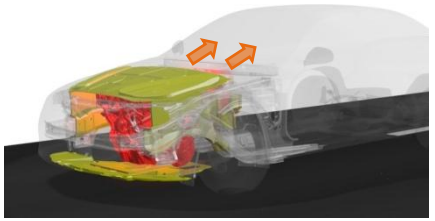
- **Reduction on engine wear**

→ Reduction of friction during the cold starts



- **Higher Comfort during Winter**

→ Faster heat up of the interior of the vehicle, thanks to heat storeage



# Conclusion

- Storage of heat in the powertrain by means of an engine encapsulation is key to further reducing emissions and fuel consumption during cold starts
- Engine encapsulation concepts open new potentials for reducing $CO_2$ and exterior noise simultaneously
- New engine bay architectures are currently in an early development stage with several OEM's in Europe and outside Europe
- To introduce engine encapsulation in a sustainable way one needs to exploit lightweight and multifunctional material technologies