STUDY

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Economic and Scientific Policy

Type approval requirements for the general safety of motor vehicles

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List of Acronyms and Terms

ACRONYM	DEFINITION
ABS	Anti-lock Braking System
ACEA	European Automobile Manufacturers' Association
ASIC	Application-Specific Integrated Circuit
ASTM	American Society for Testing and Materials
bar	The bar is a units of pressure widely used in descriptions of pressure because it is about the same as atmospheric pressure, and is legally recognized in countries of the European Union. 1 bar = 100 kPa (kilopascals) = 1,000,000 dynes per square centimetre (bares)
BASt	German Federal Highway Research Institute
C1	Reference name for passenger car tyres, usually divided into several subclasses depending on tyre width
C2	Reference name for light truck tyres
C3	Reference name for heavy truck tyres
CE Delft	Dutch Centre for Energy Conservation - Centrum voor Energiebesparing
CERM	Centre Etude et Recherche Mécanique Narbonne
CIDAUT	Research and Development Centre in Transport and Energy – Fundación para la Investigación y el Desarrollo en Transporte y Energía
CPX Trailer	Close Proximity Method, to measure tyre/road noise
C_R or RRC	Rolling Resistance Coefficient
CY	Calendar Year
dB	The decibel is commonly used in acoustics to quantify sound levels relative to some 0 dB reference, for sound in air and other gases, relative to 20 micropascals (μPa) = 2×10^{-5} Pa, the quietest sound a human can hear
DEKRA AG	Is a German international service provider with a European focus
DFT	British Department for Transport
DGT	The Spanish Road Traffic Directorate - Dirección General de Tráfico
DVA	Dynamically Vulcanized Alloys
EC	European Commission
ENVI Committee	Environment, Public Health and Food Safety Committee of the European Parliament
EP	European Parliament
ETRA	European Tyre Recycling Association

ETRMA	European Tyre and Rubber Manufacturers' Association
ETRTO	European Tyre and Rim Technical Organisation
ETS	Emissions Trading System
EU	European Union
FEHRL	Forum of European Highway Research Laboratories
FNAUT	French Federation of Transport Users' Associations - Fédération Nationale des Associations d'Usagers des Transports France
G	Wet grip index, ratio between a candidate tyre and the wet performance of the standard reference test tyre
GRB	W orking Party on Noise, from UNECE
GRE	Working Party on Lighting and Light Signalling, from UNECE
GRPE	Working Party on Pollution and Energy, from UNECE
GRRF	Working Party on Brakes and Running Gears, from UNECE
GRSG	Working Party on General Safety Provisions, from UNECE
GRSP	Working Party on Passive Safety, from UNECE
GWP	Global Warming Potential
HRA	Hot Rolled Asphalt
ICP	Intra-Carcass Pressure
IEA	International Energy Agency
IEEP	Institute for European Environmental Policy
IPR	Inflation Pressure Retention
ISO	International Organization for Standardization
IVA	Royal Swedish Academy of Engineering Sciences
LAT	The Laboratory of Applied Thermodynamics, from Aristotle University of Technology
LCA	Life Cycle Assessment
LVL	Low Viscosity Lubricants
M&S	Mud and Snow
Naturskyddsföreningen	Swedish Society for Nature Conservation
NEDC	New European Driving Cycle
NPV	Net Present Value
OEM	Original Equipment Manufacturers, also known as carmakers or automakers
R1	Low noise surface road
R2	Intermediate noise surface road
R3	Noisy surface road

RAL	German Institute for Quality Assurance and Certification - Deutsches Institut für Gütesicherung und Kennzeichnung
RDW	Rijks Dienst Wegverkeer - Dutch Department of Highways
RF	Radio Frequency
RWTÜV Fahrzeug GmbH	Institute for Vehicle Technology, from TÜV Nord Group
SAE	Society of Automotive Engineers
SAW	Surface Acoustic Wave
SFT	Norwegian Pollution Control Authority
SMA	Stone Mastic Asphalt
SPB	Statistic Pass By method, to measure tyre/road noise
SRTT	Standard Reference Test Tyre
T&E	European Federation for Transport and Environment
TLRR	Tyre Low Rolling Resistance
TNO	Netherlands Organisation for Applied Scientific Research - Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek
TPIA	Tyre Performances Integrated Approach
TPMS	Tyre Pressure Monitoring System
TRL Limited	Transport Research Laboratory Limited
TÜV Automotive GmbH	German Technical Automotive Inspections Organizations - Technischer Überwachungsverein
TUG	Technical University of Gdansk
TWG	Tyre Wet Grip
UBA	German Federal Environmental Agency - UmweltBundesAmt
UNECE	United Nations - Economic Commission for Europe
US DOT NHTSA	U.S. Department of Transportation – National Highway Traffic Safety Administration
VCD	Transport Club Germany – Verkehrsclub Deutschland
VTI	Swedish National Road and Transport Research Institute

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Executive summary

This study answers the questions raised by the European Parliament on the proposal for a Regulation concerning type approval requirements for the general safety of motor vehicles COM(2008)316 – 2007/0243(COD). Some difficulties were identified in the Commission's impact assessment. These difficulties centre on availability, for certain measures of the proposal (on mandatory safety devices, tyre requirements, and noise emissions), of alternative and possibly preferable instruments to more effectively achieve the safety and environmental objectives of the proposal.

Below we provide a structural overview of the study. Answers to the specific questions raised by the European Parliament are provided in Chapter 6, while main findings are highlighted at the end of each chapter.

Chapter one: Tyre Pressure Monitoring Systems (TPMS)

This chapter considers the general information available about TPMS, which include a definition of TPMS, a study on TPMS types, an overview of the European manufacturers of TPMS and an analysis of costs, including manufacturing and retail costs (as original equipment and as aftermarket options).

From this chapter several conclusions were reached. It is our opinion the mandatory implementation of direct TPMS will help achieve targeted CO_2 emission reduction, as well as noise reduction while increasing driver's safety. TPMS are currently on the market and have proven their efficiency.

A safety threshold warning, when a tyre reaches 0.3 bar of underinflation or even 0.2 bar, should be implemented in TPMS. This warning is important in order to make drivers inflate their tyres to the pressure for which they were designed.

Chapter two: Tyre Low Rolling Resistance (TLRR)

This chapter analyses the general information available as regards TLRR, including a definition of rolling resistance and the rolling resistance coefficient (RRC), the factors influencing the rolling resistance coefficient, an overview of manufacturers and an analysis of costs, including the values for the RRCs from a selection of commercial tyres and the retail prices of eco and energy saving tyres compared to standard tyres. The influence of rolling resistance on CO_2 emissions and on noise levels has also been studied, as well as the influence of low rolling resistance tyres on safety.

In our view, there is no doubt concerning the benefits of low rolling resistance tyres, especially if they are supported by the implementation of TPMS, in terms of fuel consumption savings and therefore CO_2 emissions reductions.

Chapter three: Tyre Wet Grip (TWG)

In this chapter, the general information available about TWG has been studied, which includes a definition, and the factors influencing wet grip and aquaplaning. A manufacturer overview and a cost analysis were also carried out. No significant differences were found in summer tyres prices compared to tyres with high wet grip performance.

In order to ensure driver safety, wet grip requirements must be set. These wet grip requirements should be complemented by means of ensuring a limited propensity towards aquaplaning, and the adequate handling and cornering behaviour of tyres.

Chapter four: Tyre Low Rolling Resistance and Tyre Wet Grip Optimization. Alternative Policy instruments

This chapter focuses on the use of silica in tyre compounds, explaining the influence of silica on tyre performance and optimization of TLRR and TWG. The effect of silica replacement on the life cycle of tyres has also been studied. The impact of CO_2 reduction objectives on road safety, as well as an evaluation of the impact on noise through the use of TPMS, and through more stringent TLRR and TWG requirements, was carried out by analyzing existing literature and studies.

An apparent intertwined relationship exists between the performance of a tyre on rolling resistance, wet grip, noise emissions, comfort, durability, wear and aquaplaning behaviour. In the design stage of a tyre, an appropriate compromise among all of these performances must be achieved.

Since current state-of-the art tyres do not appear to fulfil the future requirements of the proposed Regulation, it is our opinion that a further increase in these requirements through EP (or Council) amendments to the proposal, would lead to an undue increase in investments to promote research and innovation, without any guarantee that those requirements would be achievable.

A simplification of the implementation schedule seems possible, although a 36-month time frame should be granted for the tyre industry to develop solutions in respect for the new requirements. The possibility of increasing the noise limits in the proposal should also be considered in order to allow the tyre industry to manufacture products with lower rolling resistance and noise emissions, while ensuring continued driver safety.

In any case, noise is a serious health problem that has to be addressed. Improving the quality of roads seems to be a key factor in meeting noise reduction objectives as well as CO_2 emissions targets.

Chapter five: Potential benefits versus cost analysis

This chapter analyses the impact of the use of TMPS and the introduction of the new TWG and TLRR requirements on fuel savings, on tyre durability and on noise reduction. Safety benefits, environmental benefits and acoustic benefits are compared to the costs of implementing mandatory TMPS in vehicles, and the new TLRR and TWG requirements.

The different assumptions which are made by each source studied in order to calculate benefits and costs translate to significant variations in the estimated benefits and costs. In our opinion, the savings on fuel consumption and the health benefits from implementing mandatory TPMS while setting new requirements for wet grip and rolling resistance of tyres, are clear although difficult to evaluate.

Introduction

The present report has studied Tyre Pressure Monitoring Systems (TPMS), as well as Tyre Low Rolling Resistance (TLRR) and Tyre Wet Grip (TWG) requirements analyzing the financial implication for manufacturers, repercussions on consumer retail prices, expected road benefits (including casualty reductions as well as healthcare savings) and environmental benefits (reductions in fuel consumption and noise emissions).

1. Study Objective

The objective of this study is to carry out a short, concise and easily accessible analysis on the proposal for a Regulation concerning type approval requirements for the general safety of motor vehicles COM(2008)316 – 2007/0243(COD).

This regulation proposes the compulsory introduction by 2012 of low rolling resistance tyres in order to achieve savings on fuel consumption and CO_2 emissions. These tyres might also reduce noise. Fuel consumption and CO_2 emissions will further be reduced by the proposed introduction of TPMSs. The European Commission's proposal can be summarized as follows:

- NEW REQUIREMENTS ON TYRES
  - Reduction in noise limits by an average of 4 dB(A). Requirements will apply to new tyre types from 2012 and all new tyres from 2016.
  - New limits on rolling resistance (for reduction of CO_2 emissions). Limits to be applied in two stages: from 2012 and 2016. The proposal also applies to after-market tyres. Further encouragement to improve rolling resistance could be achieved through a (recently proposed) labelling scheme.
  - Type Pressure Monitoring Systems to be mandatory (for CO_2 emissions reductions and safety). TPMS will be required on new car types from 2012 and existing types from 2014.
  - New wet grip requirements based on the requirements in UNECE Regulation 117. To be applied to new car tyre types from 2012 and existing types from 2014.
- IMPACT ASSESMENT CONCLUSIONS
  - Mandatory measures can save around 5,000 lives and 35,000 serious injuries per year across EU25.
  - Tyre measures can contribute around 7g/km towards CO_2 reduction targets.
  - Average vehicle purchase cost increase from all mandatory measures around 200 Euro for cars and 2500 Euro for heavy vehicles.
  - Running costs for motorists likely to be reduced due to improved fuel economy.

This study aims to clarify and complete the European Commission's impact assessment related to the mandatory introduction of TPMSs, and the TLLR and TWG requirements. The study has been expressed in terms of financial implications for manufacturers, repercussions on consumer retail prices, expected road safety and environmental benefits.

This study should answer the following questions:

- Are the Tyre Low Rolling Resistance, Tyre Wet Grip and TPMS proposals adapted to the objectives?

- Can Tyre Low Rolling Resistance negatively impact on safety on Tyre Wet Grip and Tyre longevity?
- What are the expected costs in comparison to the environmental benefits?
- Are there other more effective policy instruments to achieve the targeted reduction of $C0_2$ emissions?
- Are the Tyre Wet Grip limits justified and sufficient?
- Has the Commission given due consideration to the impact of environmental objectives on road safety including aquaplaning and winter road conditions for Wet Grip?
- How relevant is the tabled 120g $C0_2$ target as opposed to already aligning the proposa1 on the forthcoming 95 g $C0_2$ target proposed in the parallel ENVI Committee procedure on the Regulation on setting emission performance standards for new passenger cars?
- Is it appropriate to integrate or consolidate this proposal with the performance standards Regulation into one single instrument?

• In view of achieving clear and effective legislation, is there a basis for simplifying the implementation deadlines and how could this be accomplished?

• What is the basis for noise reduction featuring in the proposal?

- Are there other effective policy alternatives such as the use of noise-optimised road surfaces in noise critical areas or meeting relevant ISO standards for road surfaces?
- How appropriate might it be to isolate the noise reduction objectives of this proposal, and give due consideration to them in a separate legal instrument along with other noise-pollution transport-related measures?

• Would the introduction of a consumer eco-label indicating information on rolling resistance, wet grip and noise be beneficial to the consumer, and allow him to make a better informed choice?

2. Study Approach

The study methodology is based on a thorough literature review, as well as a full analysis of available tyre test reports. This has been complemented by a survey and a feedback from different stakeholders most likely to be affected by type approval requirements and the expertise of the project team.

In order to cover all pertinent issues the following aspects have been carefully analysed: facts and problems from the European Commission's impact assessment relate to the mandatory introduction of TPMS; the TLLR and TWG requirements; and all reports presented to the European Commission and used as a basis for the impact assessment. Among these reports:

- "Motor vehicle tyres and related aspects". Presented by: TÜV Automotive GmbH
- "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars". Presented by: TNO Science and Industry, IEEP – Institute for European Environmental Policy and LAT of Aristotle University of Technology.
- "Integrated assessment of noise reduction measures in the road transport sector". Presented by: TRL Limited and RWTÜV Fahrzeug GmbH.

- "Study SI2.408210 Tyre/Road Noise". Presented by: FEHRL - Forum of European National Highway Research Laboratories, BASt – German Federal Highway Research Institute, TRL – transport Research Laboratory, TÜV Nord and VTI - Swedish National Road and Transport Research Institute.

The study has been performed by an expert working group from CIDAUT that has operated across the relevant scientific disciplines involved in order to present the results that will allow Members of the European Parliament to draw informed conclusions in respect of the mandatory fitting of certain safety measures as well as the road noise and CO_2 reduction measures in the legislative proposal. The working group has used existing knowledge and experience, in particular the opinions of established industry bodies, NGOs, academia, consumer organisations and think tanks. Several reports, fact sheets and position papers from all involved stakeholders have been used, among them:

- "Report PPR077, Tyre/Road Noise – Assessment of the existing and proposed tyre noise limits". Presented by TRL Limited.

- "European tyre industry comments on FEHRL conclusions in tyre-road noise study SI 2.408210". Presented by ETRTO – European Tyre and Rim Technical Organization.

- "Tyre Industry notes on tyre rolling noise and safety performance trade-off" based on TÜV test-report 76230729 data. Presented by ETRMA – European Tyre and Rubber Manufacturers' Association.

- "Quieter tyres: a cost effective way to protect public health" and the position paper on "Environmental standards for motor vehicle tyres". Presented by T&E – European Federation for Transport and Environment.

- "Fact sheet tyre noise". Presented by the Dutch Ministry of Environment.

- "Reduction potential of road traffic noise". Presented by IVA – Royal Swedish Academy of Engineering Sciences.

- "Traffic noise reduction in Europe: Health effects, social costs and technical and policy options to reduce road and rail traffic noise". Presented by CE Delft.

- "Consumer Label for Tyres in Europe". Presented by VTI - Swedish National Road and Transport Research Institute and sponsored by European Federation for Transport and Environment (T&E).

- "A brief cost - benefit analysis of tighter limits in the Tyre Noise Directive" Presented by TNO - Science & Industry.

Chapter one – Tyre Pressure Monitoring System analysis

1. Tyre Pressure Monitoring System: general information and existing data analysis

1.1. Tyre Pressure Monitoring System - definition

A Tyre Pressure Monitoring System (TPMS) is generally an electronic system designed to monitor the air pressure inside all the pneumatic tyres on automobiles, aeroplane undercarriages, straddle lift carriers and other vehicles. These systems report tyre pressure information to the driver of the vehicle either via a gauge, a pictogram display, or a simple low pressure warning light[1].

Currently, the most recent advance with TPMS technology is the introduction of battery-less direct sensor systems which require zero maintenance and are reliable[2]. This is the first of a new class of battery-less TPMS which allows pressure readings on demand immediately from engine ignition and, unlike radio frequency TPMS systems, is also transposable to all tyre construction types.

TPMS are subdivided into two different categories, namely direct (or active) and indirect (or passive) systems, both categories are described below.

- Indirect TPMS: These systems do not use physical pressure sensors. Indirect TPMS measures the "apparent" air pressure, by monitoring individual wheel rotational speeds, and other signals available outside the tyre itself. Most indirect TPMS use the measure that an underinflated tyre has a slightly smaller diameter than a correctly inflated tyre, and therefore, has to rotate at a higher angular velocity to cover the same distance as a correctly inflated tyre.

  Newer developments of indirect TPMS can also detect simultaneous underinflation in all four tyres separately using additional sensors for a vibration analysis of individual wheels or an analysis of load shift effects during acceleration and/or cornering. However these additional sensors add to the complexity and cost of this technology.

- Direct sensor TPMS: These systems employ physical pressure sensors inside each tyre, and a means of processing and sending that information from inside the tyre to the vehicle's instrument cluster. Direct Sensor TPMS can identify simultaneous underinflation in all four tyres in any combination.

  Direct sensor TPMS are designed to specifically cope with the effects of changes in tyre pressure due to ambient temperature changes and road to tyre friction based temperature changes. Friction between the tyre and road surface heats up the tyre and increases its pressure. The alarm activation threshold pressures are usually set according to the manufacturers recommended "cold placard inflation pressures" (in the range from 0.3 to 0.5 bar)[3].

[1] http://en.wikipedia.org/wiki/Tire_pressure_monitoring_system
[2] VisiTyre Batteryless TPMS: http://www.etv.com.au/

Both systems present a series of advantages and disadvantages, according to several sources (TÜV Automotive report on "Motor Vehicle Tyres and Related Aspects"[3], GRRF TPMS Task Force report[4], US DOT NHTSA[5], DEKRA[6], and the experience of CIDAUT's expert working group in the field of tyres and road safety). The following table compares the main features of active and passive systems:

Table 1. Comparison between direct and indirect TPMS

	Direct (Active) Systems	Indirect (Passive) Systems
Measured physical parameters	Pressure and temperature.	Rolling radius.
Hardware	Wheel sensor, units for receiving control and display.	ABS sensors, ABS control unit, display.
Measuring of pressure	Absolute (± 0.1 bar).	Relative (around 30% aberrations from set value).
Measuring of temperature	Absolute (± 2º C).	None.
Target values	Fixed minimum pressure is to be set, only once in sensor's life. The threshold depends on each car maker.	Learning of default value is required. The system includes a reset button to be used every time the tyre is re-inflated or changed.
Detection time	Almost real time, independent of driving manoeuvres, while moving or at rest.	0.6 bar under-inflation is detected within 5 minutes at 130 km/h (Dunlop WarnAir).
Measurements	System reads actual air pressure, no re-calibration needed.	Read speed of tyres. Tyre change or inflation requires pushing reset button.
Tyre sensibility	System works with same performance independently from tyre type.	Performance is strictly linked to tyre type, it can sensibly be worse on certain tyres.
Costs	Comparably high, dependent on the system (estimated value starting from 200 €, excl. mounting for aftermarket systems).	Comparably low (starting value at 60 €, excl. mounting for aftermarket systems).

[3] TÜV Automotive GmbH. Report on "Motor Vehicle Tyres and Related Aspects" Commissioned by the European Commission, Enterprise Directorate General.
[4] GRRF TPMS Task Force Conslusions Report, 16th June 2008.
[5] US DOT NHTSA Docket No 2005-20586
[6] DEKRA. Fachschrift Nr. 55/01

1.2. Market study and manufacturer overview

The first passenger vehicle to adopt TPMS was the Porsche 959 in 1986.

Due to vehicle safety and maintenance economy, TPMS appeared more widely in Europe as an optional feature for top range luxury passenger vehicles, like Audi A8, Mercedes-Benz S-Class and BMW 7 Series. In 1999 PSA Peugeot Citroën decided to adopt TPMS as a standard feature on Peugeot 607. The following year (2000), Renault launched Laguna II, the first high volume mid-size passenger vehicle in the world to be equipped with TPMS as a standard feature.

In the early days of development, to avoid expensive and rather complicated rotating contact wiring, direct TPMS were implemented using radio frequency (RF) technology, together with an electronic control unit fitted inside the vehicle, which provides the necessary processing functionality to interpret pressure data coming from battery powered sensor transmitters within tyre cavities. The system delivers alerts and warnings to the driver.

Different companies (the full list is included in Annex 2) designed first generation TPMS using battery powered radio transmitters, with sensors mounted on a standard tyre valve, and a chassis mounted radio frequency receiver, whose functions can also be integrated in other radio-frequency units mounted on the vehicle, such as Remote Keyless Entry receivers, and Body Control Units.

Typical RF TPMS employ four or five battery powered transmitter-sensors[7], one RF receiver (either stand-alone or integrated in other vehicle electronics), and some other satellite hardware which can perform the function of identifying the tyre position involved in the inflation anomaly. Motor vehicle manufacturers require a battery lifespan of between seven and ten years, so direct TPMS designers use power saving techniques to extend the battery life. The heart of the sensor is a silicon application-specific integrated circuit (ASIC) chip, which can manage critical power saving algorithms and other functions of the sensor.

To overcome the battery issues a new generation of batteryless TPMS is being developed by several companies using different technologies[8]. Some of them are promoting a SAW-based technology while others are using an electromagnetic close-coupling technology to effectively eliminate the battery. Other developments with TPMS include research into the use of energy harvesting devices which may lead to future types of batteryless TPMS. One of the most recent innovations is the introduction of a new class of Original Equipment Manufacturer (OEM) oriented TPMS tyre system, the concept of which is basically the integration of a simple hybrid ceramic circuit inside the body of a standard tyre, allowing cost savings and enabling standardization of remote direct TPMS.

1.3. A comparative implementation cost study

In order to perform a study of implementation costs, three different tables have been drawn up. The first one includes the main automotive industry OEMs and the average price of their vehicles if they are equipped with TPMS. The second table shows the prices of some TPMS systems available on the market in order to implement them in an existing vehicle (after-market). The last table shows the cost of a TPMS system according to a group of five European manufacturers of TPMS systems.

[7] US DOT NHTSA Docket No 2005-20586

[8] VisiTyre (http://www.etv.com.au), Transense (http://www.transense.co.uk) and STE Engineering (http://www.stecom.com).

All prices shown in next table relate to the costs in Spain[9]. Evidently, vehicles have different prices depending on the Member State in which they are purchased, but price ranges generally remain constant. The TPMS price range depends on the OEM, several of them already include TPMS in all new models.

Table 2. TPMS prices depending on OEM

OEM	Number of models with TPMS	Range of TPMS price	Average price
Alfa-Romeo	2	225 - 250 €	235 €
AUDI	In all models	60 - 700 €	300 €
BMW	In all models	included	0 €
Citröen	6	300 €	300 €
FIAT	2	143 - 283 €	210 €
Ford	3	180 €	180 €
Mercedes-Benz	In all models	included	0 €
Lancia	2	250 - 290 €	270 €
OPEL	In all models	200 - 212 €	205 €
Peugeot	2	included	0 €
Renault	6	180 - 300 €	240 €
SAAB	None	-	-
SEAT	In all models	included	0 €
Volkswagen	6	48 - 755 €	350 €
Volvo	None	-	-

The following table shows the prices for aftermarket TPMS sensors and displays. This table does not include installation or delivery costs. Installation costs will strongly depend on the Member State of installation. By way of example, in Spain, the average installation cost for an after-market TPMS is 40 Euro.

Table 3. Aftermarket TPMS prices in Europe

TPMS Kits	Origin	Price
http://www.valenciaimport.com/	**Spain**	189 € + VAT
http://www.mediakit2010.com	**Spain**	169 € + VAT + Delivery
http://www.solostocks.com	**Spain**	145 € + VAT + Delivery
http://www.seehase.de/	**Germany**	135 € + 45 € or 55 € (with display) + VAT + Delivery
http://www.spal.it	**Italy**	192 € + VAT + Delivery
http://www.termbus.es/	**Spain**	150 € + VAT + Delivery
Pressure measurement systems		
http://www.thetyrepressuremonitor.com/	**UK**	17.95 £ + VAT + Delivery
http://www.pirellisafety.com/ – X-Pressure Optic – X-Pressure Acoustic – X-Pressure Acoustic Blue	**Italy**	 50 € + VAT 160 € + VAT 160 € + VAT

The last table shows the estimated cost of a TPMS system according to UNECE GRRF TPMS Report made by Schrader Electronics, Conti-VDO, Knorr-Bremse, EnTire Solutions LLC and Beru[10] (all of them European manufacturers of TPMS systems):

[9] Source: http://www.km77.com
[10] GRRF TPMS Task Force Conslusions Report, 16th June 2008.

Table 4. Estimated manufacturing cost for TPMS

	Content	Estimated Cost/System in 2008 in € (based on today's US volume)	Estimated Cost/System in 2014 in € (if European legislation in place)
Integrated TPMS	**4 TPMS sensors Software/warning strategy and receiver integrated into body controller**	25 €	23 €
Stand alone TPMS	**1 RF receiver 4 TPMS sensors Software/warning strategy in TPMS**	33 €	30 €

As the previous tables show, the TPMS cost depends on the sector involved. The final price for consumers is approximately 250 Euro. And it varies based on wether it is purchased as a feature in new vehicles or in the aftermarket. The maximum average cost for the OEM industry is only 30 Euro. Retail cost is expected to decrease if the new legislation is approved due to economies of scale, especially for after-market systems, although the final price for consumers cannot be accurately estimated.

2. TPMS - scientific evidence

A TPMS helps to improve vehicle safety by means of aiding drivers in maintaining their vehicle tyre pressures. Properly maintained tyres positively contribute to vehicle safety, performance and fuel economy.

From a technical point of view, it can be assumed that there are a number of unknown cases of tyre-associated accidents related to inadequate tyre performance. However, there are other factors contributing to the nature and events of an accident that can only be estimated. Official statistics are unable to shed light on this influence, as they merely allow obviously defective tyres to be considered. Depending on the organisation consulted, the estimations vary: The French Road Safety organisation (Sécurité Routière) estimates that 9% of all road accidents involving fatalities are attributable to tyre under-inflation, while the German DEKRA estimated that 41% of accidents with physical injuries are linked to tyre problems[11]. The Spanish Road Traffic Directorate (Dirección General de Tráfico Española) estimated 0.37% of accidents with physical injuries related to tyre problems in 2006[12]. CIDAUT databases include accidents at a regional level directly studied by our staff: 3.3% of accidents with physical injuries were related directly to tyre problems, resulting in 1 casualty and 19 injuries from a total of 91 casualties and 350 injuries.

On the maintenance side, it is important to realise that fuel efficiency and tyre wear are severely affected by under-inflation. If we also consider that over 40% of vehicle owners in Europe and North America check their tyres less than once a year[13], it is conceivable that 40% or more vehicles currently in use in those areas are running with underinflated tyres.

[11] TÜV Automotive GmbH. Report on "Motor Vehicle Tyres and Related Aspects" Commissioned by the European Commission, Enterprise Directorate General.
[12] DGT (Spanish Road Traffic Directorate). Observatorio Nacional de Seguridad Vial. Anuario Estadístico de Accidentes 2006.
[13] National Center for Statistics and Analysis (NCSA). Fatality Analysis Reporting System.

Several reports[14] conclude that tyre under-inflation is responsible nowadays for over 20 million litres of unnecessary burnt fuel, dumping over 2 million tonnes of CO_2 in the atmosphere, and 200 million tyres prematurely wasted in the world yearly.

The influence of TPMS on tyre manoeuvrability, tyre wear and damage, and acoustic performance of tyres has also been studied. An overview on the effects of underinflation on the performance of a motor vehicle is shown in the following table, the effects are described according to several reports and publications listed in the bibliography.

[14] TÜV Automotive GmbH. Report on "Motor Vehicle Tyres and Related Aspects"; TNO, IEEP and LAT "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO2-emissions from passenger cars"; ETRMA "Tyre industry notes on tyre rolling noise and safety performance trade-offs" and GRRF TPMS Task Force Conclusions report.

Table 5. Effects of underinflation on the performance of a motor vehicle

Criterion	Effects of under-inflation	
Riding comfort	↑	A lowering by 0.5 bar results in a subjective assessment of 1 score better (scaled from 1-10)
Grip on loose surface (sand)	↑	Approx. 3% more traction force when lowering inflation pressure from 2.5 to 1 bar, additionally 30% when lowering from 1 to 0.5 bar
Aquaplaning (water depth > 2mm)	↓↑	Deterioration down to approx. 1.5 bar, then improvement by bell formation of the tread towards the inside (at normal load)
Endurance (test rig)	↓	Lowering by 0.5 bar results in a deterioration of endurance test speed of 15 km/h
Tightness against external impacts (run over a kerb)	↓	Lowering by 0.5 bar causes a defect to occur at a speed of 20% lower
Bead unseating off the rim	↓	The threshold for bead unseating off the rim is between the recommended pressure and 1 to 1.2 bars. For safety reasons, this limit must never be under-cut
Tread wear	↓	A tyre with 20% under-inflation reduces a 30% the total mileage
Rolling resistance	↓	Lowering by 0.5 bar results in 15% higher rolling resistance force
Rolling noise	↓	A deviation of 1 bar to standard inflation pressure raise noise emissions by 2 dB(A) (66%)
Wet grip	→	Effects not significant compared to measured tolerances
Vehicle handling on wet and dry surfaces	?	With a medium-class saloon, a deviation of 0.2 bar on an axle can be noticed in changed vehicle handling and ride
Tyre integrity	↓	Several defects have under-inflation as origin: chafer separation, tread separation, run flat and diagonal/torque cracking
Fuel consumption	↓	Lowering by 0.5 bar results in a 2-5% increase in the fuel consumption
Directional stability at lane change	↓	Lowering by 0.5 bar results in a tendency towards a lateral skid, delayed transmission and spongy steering feel.
Cornering stability	↓	At high speeds, a deviation of 1 bar produces strong and hardly controllable oversteering, resulting in a loss of driving stability
Legend: ↑: improved; ↓: deteriorated; →: unaffected; ?: variable		

The previous table shows that, except for in two cases, the effects of under-inflation on tyres are adverse. The implementation of TPMS in vehicles is one way to solve under-inflation in tyres and its associated problems. The use of TPMS will increase safety and decrease noise as well as CO_2 emissions by means of helping drivers maintain optimised tyre performance.

3. Conclusions

1. Tyre pressure monitoring systems (TPMS) are electronic systems designed to monitor the air pressure inside all the pneumatic tyres of a vehicle.

2. Direct TPMS are more accurate than Indirect TPMS, showing tyre pressure measurements in almost real time.

3. Average direct TPMS costs for OEM are 30 Euro. When purchased as an optional feature, the average final cost for consumers is 250 Euro.

4. Some OEMs already include TPMS in all their vehicles.

5. The effects of tyre underinflation on vehicle performance are adverse from a safety and environmental point of view.

6. TPMS help drivers to maintain appropriate inflation level in vehicle tyres avoiding previously mentioned effects.

7. A safety threshold warning, when a tyre reaches 0.3 bar of underinflation or even 0.2 bar, should be implemented in TPMS. This warning is important in order to make drivers inflate their tyres to the pressure for which they were designed.

Chapter two – Analysis of Tyre Low Rolling Resistance

1. Tyre Low Rolling Resistance: general information and analysis of existing data

1.1. Tyre Low Rolling Resistance - definition

Rolling Resistance is the impediment that occurs when a round object such as a ball or a tyre rolls on a flat surface. It is caused by the deformation of the object, the deformation of the surface, or both. Additional contributing sources include surface adhesion and relative micro-sliding between the surfaces in contact. The coefficient of rolling resistance is generally much smaller for tyres or balls than the coefficient of sliding friction[15].

The primary cause of rolling resistance is hysteresis: A characteristic of a deformable material such that the energy of deformation is greater than the energy of recovery. The rubber compound in a tyre exhibits hysteresis. As the tyre rotates under the weight of the vehicle, it experiences repeated cycles of deformation and recovery, and it dissipates the hysteresis energy loss as heat. Hysteresis is the main cause of energy loss associated with rolling resistance and is attributed to the viscoelastic characteristics of the rubber[16].

Low Rolling Resistance (LRR) are tyres which are designed to improve fuel efficiency of a car by minimising energy wasted as heat as the tyre rolls down the road. Some preliminary studies ("Commission Proposal on the General Safety of Motor Vehicles", Enterprise and Industry Directorate General, European Commission) estimated that the adoption of low-rolling resistance tyres could save 1.5–4.5% of all gasoline consumption, but that current data were also insufficient to compare safety and other characteristics. Low rolling resistance tyres typically incorporate silica in place of carbon black in their tread compounds to reduce low-frequency hysteresis without compromising traction[17].

Factors that contribute

Several factors affect the magnitude of rolling resistance a tyre generates:

- Material - different fillers and polymers in tyre composition can improve traction while reducing hysteresis. The replacement of some carbon black with higher-priced silica–silane is one common way of reducing rolling resistance.
- Dimensions - rolling resistance in tyres is related to the flex of sidewalls and the contact area of the tyre[18]. For example, at the same pressure wider bicycle tyres have less flex in sidewalls and thus lower rolling resistance (although higher air resistance).
- Extent of inflation - Lower pressure in tyres results in more flexing of sidewalls and higher rolling resistance.
- Tread thickness in tyres has much to do with rolling resistance. The thicker the tread, the higher the rolling resistance.

[15] Peck, William Guy (1859). Elements of Mechanics: For the Use of Colleges, Academies, and High Schools. A.S. Barnes & Burr: New York, 135. Retrieved on 2007-10-09.
[16] "Tires and Passenger Vehicle Fuel Economy: Informing Consumers, Improving Performance - Special Report 286. National Academy of Sciences, Transportation Research Board, 2006". Retrieved on 2007-08-11.
[17] http://www.tyres-online.co.uk/technology/silica.asp
[18] US DOT NHTSA Docket No 2005-20586.

Measurement

Rolling resistance coefficient (RRC or C_R) is the value of the rolling resistance force divided by the wheel load. There are, at least, two norms for calculating rolling resistance: the Society of Automotive Engineers (SAE) has developed test practices to measure the RRC of tyres in the US, while ISO 8767 is used to test rolling resistance in Europe. These tests (SAE J1269 and SAE J2452, as well as ISO 8767) are usually performed on new tyres.

1.2. Market study and manufacturer overview

The properties of a large number of commercial tyres are available at the German Federal Environmental Agency (UmweltBundesAmt, UBA) internet home page. These data were recorded in different studies carried out by TÜV Automotive, the Dutch Department of Highways (Rijks Dienst Wegverkeer, RDW) and the British Department for Transport (DFT). There are also reports from the United States National Academy of Sciences Transportation Research Board (Special Report 286 and the March 2003 Green Seal report) on this topic, although they are not easily comparable since the standard tyre size is different from the European one.

The following tables show current values of RRC according to ISO 8767 tests for over 80 commercial tyres. These results have been taken from the UBA home page. The rolling resistance coefficient values proposed by the European Commission are 12 Kg/Tonne for stage 1 (2012) and 10.5 Kg/Tonne for stage 2 (2016).

Table 6. Values of RRC according to ISO 8767 tests

Tyre Manufacturer and Model	Rolling Resistance Coefficient (RRC in Kg/Tonne)
155/65 R14 Summer Tyres	
Conti Eco Contact EP	11.10
Bridgestone B 381 Ecopia	8.70
Michelin energy XT-1	9.90
165/70 R14 Summer Tyres	
Conti Eco Contact EP	9.90
Dunlop SP 10 3e	10.70
Pirelli P 300 Energy	12.00
Goodyear GT 3	9.90
Michelin energy XT-1	10.00
Toyo 330	12.00
Yokohama S 306	11.80
Kumho 758 Powerstar	11.40
Marangoni Trio	11.70
Uniroyal Rallye 580	11.90
165/70 R14 Snow and All-season Tyres	
Conti Winter Contact TS 780	11.00
Dunlop Winter Sport M2	13.00
Pirelli Winter 190 Snowcontrol	12.60
Goodyear Ultra Grip 5	11.80
Michelin Alpin	11.10
Toyo S 940	11.70
Vredestein Snowtrac	11.80
Hankook W400	11.00
Firestone FW 930 Winter	12.20
Goodyear Vector 5	12.00
Pirelli P 2500 Euro	13.10
185/60 R14 Summer Tyres	
Conti Eco Contact CP	11.50
Bridgestone RE 720	12.40
Sava Rapidtex R2	14.10
Kleber Viaxer	13.50
Stunner SV 198	13.00
Fulda Diadem Linero	12.10
Yokohama A 539	11.60
185/60 R14 Snow Tyres	
Conti Winter Contact TS 780	10.70
Bridgstone LM 18	13.50
Pirelli Winter 190 Snowsport	12.10
Kleber Krisalp	12.70
Pneumant P M+S 100	12.10
Nokian Hakkapeliitta	11.50
Gislaved Euro Frost 2	10.90

Tyre Manufacturer and Model	Rolling Resistance Coefficient (RRC in Kg/Tonne)
195/65 R15 Summer Tyres	
Conti Premium Contact	9.70
Dunlop SP Sport 200 E	11.20
Goddyear Eagle NCT 5	11.50
Michelin Pilot Premacy	11.20
Toyo Roadpro 610	11.50
GT Radial Champiro 65	11.30
Barum OR 58	11.50
Marangoni Heron	12.20
Firestone Firehawk FH 700	12.80
Pirelli P6	10.70
195/65 R15 Snow Tyres	
Conti Winter Contact TS 790	11.90
Dunlop SP Winter Sport M3	11.20
Goodyear Ultra Grip 6	9.80
Michelin Alpin	12.00
Toyo S 940	10.00
Marangoni Meteo Grip	11.70
Marshall KW 15	11.00
Yokohama AVS Winter	10.10
Vredestein Snowtrac	10.60
Goodyear Vector 5	12.30
Dunlop All Season M2	12.40
205/55 R16 Summer Tyres	
Conti Premium Contact	10.70
Dunlop SP Sport 9000	10.60
Pirelli P7	13.00
Michelin Pilot Premacy	9.70
Toyo T1-S	12.20
GT Radial Champiro 55	12.30
Vredestein Sporttrac	10.70
Hankook K 102	11.70
205/55 R16 Snow Tyres	
Conti Winter Contact TS 790	10.60
Dunlop SP Winter Sport M3	11.20
Pirelli Winter 210 Snowsport	10.60
Michelin Pilot Alpin	10.70
Toyo S 950	10.10
Vresestein Wintrac	10.30
Hankook W 400	10.40
Firestone FW 930 Winter	11.40
225/45 R17 Summer Tyres	
Conti Sport Contact 2	11.90
Bridgestone SO-3	13.60
Pirelli P Zero Asimmetrico	12.80
Falken FK 451	14.20
Pneumant PN 950 Tritec	12.40
Fulda Carat Extremo	13.20
Marangoni Zate ESC	13.70

According to the tests carried out in 2002 around 64% of currently available summer tyres already met proposed 12 Kg/Tonne limits to be applied from 2012 and around 15% of them already met proposed 10.5 Kg/Tonne requirement to be applied from 2016.

Regarding the winter tyres currently available, around 73% of them met proposed RRC 2012 requirements and only around 16% of them met proposed 2016 requirements. As tests were carried out in 2002, some of those tyres are no longer manufactured and most tyre manufacturers have improved the performance of their tyres and created new models in order to improve RRC. Most of them have achieved reductions of approximately 30% in RRC[19],

[19] Michelin, Bridgestone: http://www.michelin.com/corporate/front/templates/affich.jsp?codeRubrique=91&codePage=PAG_SOL_MICH&lang=EN, http://www.bridgestone.co.jp/english/info/news/2007102303.html

which means most of the new eco and energy saving tyres on the market should comply with 2012 RRC requirements. According to ETRMA, the fact that all European tyre manufacturers have one or two products that already meet future requirements in RRC does not mean that they will be able to make all their lines meet future Regulation requirements.

1.3. A comparative implementation cost study

In order to perform an implementation cost study, two different tables have been drawn up. The first one (on the left) presents the average prices of eco and energy saving tyres currently on the market while the second one (on the right) presents average prices for standard tyres.

Prices in both tables have been estimated from different sources, including Spanish market prices as well as on-line shops[20]. The table should be interpreted in terms of differences between Low-Rolling Resistance tyres and standard ones .

Table 7. Spanish market prices for Eco and Energy saving tyres compared to more regular tyres

Eco and Energy-saving Tyres			Regular Tyres	
Manufacturer and Model	**Tyre price**	**Tyre Size**	**Tyre price**	**Manufacturer and Model**
Conti Eco Contact EP	62.10 €	**165/70 R14 V**	55.60 €	Conti Sport Contact
Dunlop SP 10	51.50 €		51.50 €	Dunlop SP 30
Pirelli P 300 Energy	58.10 €		58.10 €	Pirelli CINTURATO
Michelin Energy XT-1	63.20 €		72.10 €	Michelin AGILIS 41
Goodyear GT 3	57.30 €		51.60 €	Goodyear GT 2
Manufacturer and Model	**Tyre price**	**Tyre Size**	**Tyre price**	**Manufacturer and Model**
Conti Eco Contact EP	64.50 €	**185/60 R14 V**	60.60 €	Conti Sport Contact
Bridgestone Turanza	61.30 €		60.00 €	Bridgestone B
Yokohama AVS	51.60 €		50.80 €	Yokohama S
Michelin Energy	71.20 €		106.10 €	Michelin Pilot Exalto
Manufacturer and Model	**Tyre price**	**Tyre Size**	**Tyre price**	**Manufacturer and Model**
Conti Eco Contact	71.00 €	**195/65 R15 V**	66.25 €	Conti Sport Contact
Dunlop SP 10	69.10 €		64.20 €	Dunlop SP Sport
Goodyear DuraGrip	66.40 €		62.90 €	Goodyear Excellence
Michelin Energy Saver	89.50 €		81.90 €	Michelin Pilot Primacy
Manufacturer and Model	**Tyre price**	**Tyre Size**	**Tyre price**	**Manufacturer and Model**
Conti Premium Contact	100.80 €	**205/55 R16 V**	99.70 €	Conti Sport Contact
Dunlop SP Sport 01	82.90 €		75.40 €	Dunlop SP Sport 3000
Pirelli P6000 Powergy	90.40 €		92.40 €	Pirelli CINTURATO P6
Michelin Energy	106.90 €		107.80 €	Michelin Pilot Exalto
Manufacturer and Model	**Tyre price**	**Tyre Size**	**Tyre price**	**Manufacturer and Model**
Firestone Fuel Saber	142.90 €	**215/50 R17 W**	148.80 €	Yokohama S o C
Bridgestone Turanza ER 30	156.20 €		195.30 €	Bridgstone Expedia S01
Continental Sportcontact 3	199.60 €		207.30 €	Continental Premium Contact
Michelin Primacy	203.80 €		154.70 €	Vredestein Ultrac

.

Although other attributes of low rolling resistance tyres are not the same as regular tyres, (in some cases better and in other worse than regular tyres, they show no general pattern), the difference in price, for tyres sharing same sizes, is small in most cases. Prices may be different in other countries, but the patterns should remain similar. All prices exclude installation costs.

[20] On-line source: http://www.neumaticos-online.es/start.html

2. TLRR - scientific evidence

Rolling friction generates heat and sound energies, as mechanical energy is converted to these forms of energy due to friction. One of the most common examples of rolling friction is the movement of motor vehicle tyres on a roadway, a process which generates sound and heat as by-products[21]. The sound generated by automobile and truck tyres as they roll (especially noticeable at motorway speeds) is mostly due to the compression (and subsequent decompression) of air temporarily captured within the tyre treads. The generated heat raises the temperature of the frictional surface; moreover, this temperature increase typically increases the coefficient of friction itself[22].

Table 8. Values for rolling resistance contribution to fuel consumption for different passenger car situations

Passenger Car	Rolling Resistance contribution to Fuel Consumtion (RRC = 10 Kg/Tonne)
American FTP 75	15 - 20%
American HWFET	25 - 30%
European NEDC	20 - 25%
Japanese 10-15 Mode	15 -20%
City actual use	5 - 20%
Regional actual use	10 - 25%
Motorway actual use	15 - 30%

Rolling resistance is directly correlated with fuel consumption of a car and exhaust emissions. It can be stated that rolling resistance will be responsible for 5 - 30% of fuel consumption in a vehicle[23], although depending on the source this estimation varies. The previous table[24] shows rolling resistance contribution to fuel consumption. Depending on the source the figures show slight changes. At the EU level, the results of the NEDC measurements (the New European Driving Cycle defined in current type approval legislation) state that rolling resistance is responsible for 20 - 25% of fuel consumption.

For petrol and diesel fuelled cars the mass of $C0_2$ emitted in kg is approximately 2.31-2.68 times the litres of fuel consumed respectively (Watts et al., 2005). Moreover a 30% relative difference in rolling resistance coefficient entails a difference in fuel consumption and $C0_2$ emissions of about 5 % for a passenger car in average driving modes (Stenschke, 2005). In general, tyre rolling resistance currently accounts for approximately 30% of the fuel used by the car group so it is an important component governing fuel consumption.

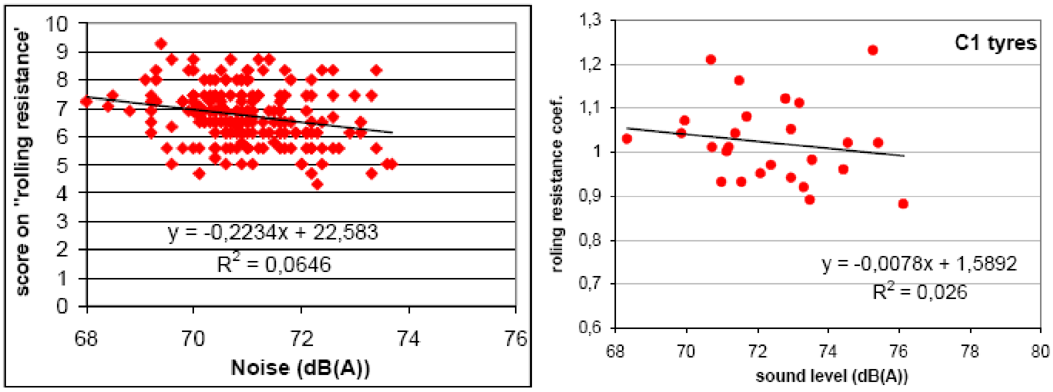
[21] Hibbeler, R.C. (2007). Engineering Mechanics: Statics & Dynamics, Eleventh, Pearson, Prentice Hall.
[22] Peck, William Guy. Elements of Mechanics. New York, p 135.
[23] Sources: http://www.fueleconomy.gov/feg/atv.shtml and http://www.michelin.com/corporate/front/templates/affich.jsp?codeRubrique=91&lang=EN&codePage=PAG_AXE_RECH
[24] Reducing Tire Rolling Resistance to Save Fuel and Lower Emissions, Jerome Barrand, Jason Bokar, Michelin, April 2008, available on http://www.sae.org/technical/papers/2008-01-0154

In the report "CO_2-emissions from passenger cars" carried out by TNO, LAT and the Institute for European Environmental Policy[25], it was concluded that the total reduction potential associated with the increased use of low rolling resistance tyres is estimated for EU-15 at 2.4 CO_2 Mtonne/year in 2012 growing to 5.3 CO_2 Mtonne/year in 2020, which is around 3% CO_2 emissions reduction. Similarly for TPMSs, the overall potential is estimated at 2.0 CO_2 Mtonne/year in 2012 and 9.6 CO_2 Mtonne/year for 2020, which is a potential 2.5% CO_2 emissions reduction.

Vehicle tyre manufacturers place the reduction of tyre rolling resistance high on their list of priorities when designing new tyre types. To some extent, this is driven by the demands of the vehicle manufacturers. As a result, considerable progress has been made in reducing tyre rolling resistance over recent years particularly with the use of different tyre compound materials and attention to tyre weight.

It seems clear from the review of reports[26], especially from the factsheet presented by the Dutch Ministry of Environment, that there is currently no significant relationship between tyre noise and rolling resistance.

Figure 1. Rolling resistance versus noise performance of tyres



Source: Fact Sheet from the Dutch Ministry of Environment

From previous graphs, it can be seen that there is no trend in the plot, and no relationship between noise emissions and rolling resistance. For the same value of rolling resistance there are several tyres with noise values in the range from 69 dB(A) to 73 dB(A). On the other hand, all tyre manufacturers have a tyre model or family that complies with future requirements; this does not mean that it will be possible for the industry to comply with future requirements in all families, sizes and models of tyres.

The opinion of the ERTMA and ETRTO is quite different[27]. They claim that the data used by FEHRL comes from several different sources. The measurements were made on different test tracks, and in some cases the data are not coast-by measurements as prescribed in the Directive, but close proximity noise level measurements. The variety of data used makes comparisons difficult or impossible.

[25] "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO2-emissions from passenger cars". Prepared by TNO Science and Industry, IEEP – Institute for European Environmental Policy and LAT of Aristotle University of Technology.

[26] TÜV report on "Motor Vehicle Tyres". TNO, IEEP and LAT previous report. TRL report on "Integrated noise reduction". FEHRL "Study SI2.408210 Tyre/road noise" ETRMA and ETRTO comments, etc.

[27] "European tyre industry comments on FEHRL conclusions in tyre-road noise study SI 2.408210".

The number of tested tyres was small (171 single tyres for C1 category from a total of 536 C1 Type Approvals made in Europe) and therefore does not allow this set of data to be considered as comprehensive.

In effect, the study results do not show a statistical correlation because it is masked by other uncontrolled variables in the test. For example, tyres with totally different tread patterns were compared, with no idea of the impact of the tread pattern on the noise performance. Yet the tread pattern is the predominant feature that determines coast-by noise. Other factors such as tyre construction and tyre type are also not taken into account. Conclusions drawn from this set of data should be taken with precaution.

3. Conclusions

1. Rolling Resistance is the impediment that occurs when a round object such as a ball or a tyre rolls on a flat surface. It depends on material, dimension and tread thickness of the tyre.

2. Rolling resistance coefficient (RRC or CR) is the value of the rolling resistance force divided by the wheel load.

3. Currently most C1 tyres in the market meet 12 Kg/Tonne (CRR limit value for proposed 2012 requirement). Only around 15% of them already meet 10.5 Kg/Tonne (CRR value for 2016 requirement).

4. Since most tyre manufacturers already include silica in their products, there are no significant differences between low rolling resistance and more regular tyres.

5. Low rolling resistance tyres will have a positive impact on CO_2 emissions reductions.

6. Some studies deduce the relationship between rolling resistance and noise performance of tyres; however their outcomes seem to be problematic due to the applied testing methods.

Chapter three – Tyre Wet Grip analysis

1. Tyre Wet Grip general information and analysis of existing data

1.1. Tyre Wet Grip - description

Grip is affected by the degree to which a tyre is distorted at high frequencies - in other words the degree to which it hits small stones and unevenness in the road surface. Tyre Wet Grip (TWG) is the tyre's ability to keep in contact with the road in the presence of a water layer on the road; this is a key property to ensure driving safety. In order to ensure safety performance of tyres under wet road conditions a minimum wet grip index should be guaranteed.

The tread is the part of a tyre which comes into contact with the road surface. The tread is a thick rubber, or rubber/composite compound formulated to provide an appropriate level of traction that does not wear away too quickly. The tread pattern is characterised by the geometrical shape of the grooves, lugs, voids and sipes. Grooves run circumferentially around the tyre and are needed to channel away water. Lugs are that portion of the tread design that contacts the road surface. Voids are spaces between lugs that allow the lugs to flex.

Hydroplaning, also known as aquaplaning is the condition where a layer of water builds up between the tyre and the road surface. Hydroplaning occurs when the tread pattern cannot channel away enough water at an adequate rate to ensure a dry footprint area. When hydroplaning occurs, the tyre effectively "floats" above the road surface on a cushion of water and loses traction, braking and steering, creating a very unsafe driving condition. When hydroplaning occurs, there is considerably less responsiveness of a steering wheel. Hydroplaning becomes more prevalent with wider tyres.

Factors affecting wet grip of tyres

Several factors affect the magnitude of rolling resistance a tyre generates[28]:

- Treads are often designed to meet specific product marketing positions. Mud and snow (M&S) tyres are designed with higher void ratios to channel away rain and mud, while providing better gripping performance. The rain groove is a design element of the tread pattern specifically arranged to channel water away from the footprint. Rain grooves are circumferential in most truck tyres. Many high performance passenger tyres feature rain grooves that are angled from the centre toward the sides of the tyre. Some tyre manufacturers claim that their tread pattern is designed to actively pump water out from under the tyre by the action of the tread flexing, resulting in a smoother ride in different types of weather.

- Material - different fillers and polymers in tyre composition can improve traction while reducing hysteresis as well as improving grip of tyres.

- Extent of inflation – In order to have the proper performance of tyres according to designed specifications, the inflation pressure must be maintained.

According to UNECE Regulation 117 the wet grip index (G) is the ratio between the performance of the candidate tyre and the performance of the standard reference test tyre.

The Standard Reference Test Tyre (SRTT) means a tyre that is produced, controlled and stored in accordance with the American Society for Testing and Materials (ASTM) Standard E 1136-93.

[28] GRRF TPMS Task Force Conslusions Report, 16th June 2008. Hibbeler, R.C. (2007). Engineering Mechanics: Statics & Dynamics, Eleventh, Pearson, Prentice Hall. And German Federal Environmental Agency (Umweltbundesamt - UBA) “CO2 – Minderung im Verkehr – Sachstandsbericht, September 2003.

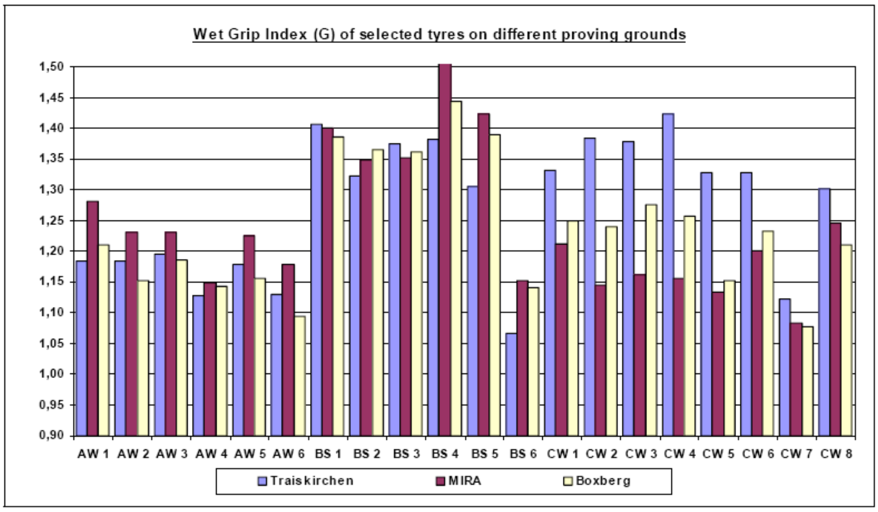
1.2. Market study and manufacturer overview

There are different tyres available on the market. In order to analyse their performance and wet grip, information from different reports[29], fact sheets[30] as well as information from tyre manufacturers have been studied. The values of the wet grip index (G) as well as a comparison in relation to the proposed requirements to new car tyre types from 2012 and existing types from 2014 are listed on the table below.

The method is based on a relative comparison with a standard reference tyre. A relative wet grip index is then calculated. If the wet index equals 100%, it means that the wet grip performance of the tested tyre is equivalent to the ASTM E-1136. If the wet index equals 110%, it means that the wet grip performance of the tested tyre is 10% higher than ASTM E-1136. This ISO standard does not define minimum prescriptions for regulation. This describes the testing method procedures.

Figure 2. Wet grip index values of selected tyres on different testing grounds

Tyre table		
165/70 R14 M+S	AW1	Conti Winter Contact TS 780
	AW2	Dunlop Winter Sport M2
	AW3	Pirelli Winter190 Snowcontrol
	AW4	Goodyear Ultra Grip 5
	AW5	Michelin Alpin
	AW6	Toyo S 940
195/65 R15	BS1	Conti Premium Contact
	BS2	Dunlop SP Sport 200 E
	BS3	Goodyear Eagle NCT 5
	BS4	Michelin Pilot Primacy
	BS5	Toyo Roadpro 610
	BS6	GT Radial Champiro 65
205/55 R16 M+S	CW1	Conti Winter Contact TS 790
	CW2	Dunlop SP Winter Sport M3
	CW3	Pirelli Winter 210 Snowsport
	CW4	Michelin Pilot Alpin
	CW5	Toyo S 950
	CW6	Vredestein Wintrac
	CW7	Hankook W 400
	CW8	Firestone FW 930 Winter



Source: TÜV report on "Motor Vehicle Tyres" and Fact sheet from the Dutch Ministry of Environment

Two interesting results can be drawn from this test: for every tested tyre the value of wet grip index depends on the testing ground, and that dependence is stronger for 205/55 R16 M+S tyres. The influence of the testing ground is one of the reasons why the current norm is being re-examined in order to minimise the influence of the testing ground on test results. Secondly, apparently, 195/55 R15 Summer tyres have an average value of G better than 165/70 R14 and 205/55 R16 winter tyres. Usually winter tyres have better wet grip, in this case there is no information regarding the weather test conditions that may influence test results.

[29] TÜV report on "Motor Vehicle Tyres". TNO, IEEP and LAT previous report. TRL Limited "Report PPR077, Tyre/Road Noise" and ETRMA "Tyre Industry notes on tyre rolling noise and safety performance trade-off"
[30] "Fact sheet tyre noise". Presented by the Dutch Ministry of Environment

1.3. A comparative implementation cost study

A retailer price search has been carried out. By way of example, the prices on the Spanish market excluding installation costs are presented in the following table[31]. Models and sizes are the same plotted in the graph showing wet grip index values. The prices depend on the tyre manufacturer, and for all manufacturers, prices increase with tyre size. No significant differences were found between standard summer tyre prices and tyres with high wet grip performance, results were compared to those from Table 7.

Table 9. Spanish market prices for wet grip tyres shown in Figure 2

	Tyre	Price
165/70 R14 M+S	Conti Winter Contact TS 780	67.00 €
	Dunlop Winter Sport M2	58.40 €
	Pirelli Winter 190 Snowcontrol	62.80 €
	Goodyear Ultra Grip 5	63.20 €
	Michelin Alpin	67.10 €
	Toyo S 940	57.80 €
195/65 R15	Conti Premium Contact	74.30 €
	Dunlop SP Sport 200 E	64.00 €
	Goodyear Eagle NTC 5	64.90 €
	Michelin Pilot Primacy	84.40 €
	Toyo Roadpro 610	60.20 €
205/55 R16 M+S	Conti Winter Contact TS 790	103.80 €
	Dunlop Winter Sport M3	98.50 €
	Pirelli Winter 210 Snowcontrol	96.20 €
	Michelin Pilot Alpin	117.10 €
	Toyo S 950	97.10 €
	Vredstein Wintrac	91.20 €
	Hankook W 400	86.50 €
	Firestone FW 930 Winter	95.70 €

2. TWG - scientific evidence

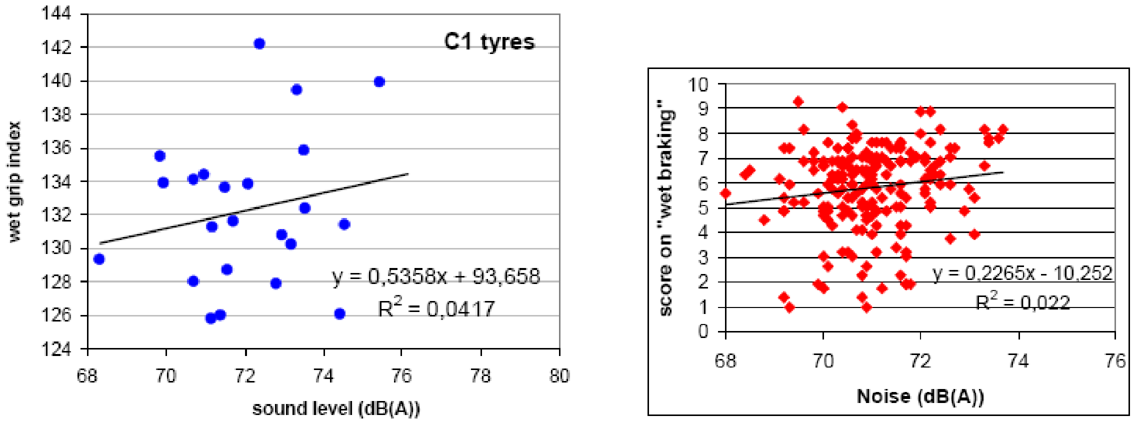
For safety aspects the main problem lies in the braking performance of a car on a wet road surface. A possible method to measure the wet grip performance is UNECE Regulation number 117 Working Party on Breaks and Running Gear (GRF). Given that the SRTT has a fixed dimension (195/75 R14) the case can occur that it is not possible to compare the test tyre and the reference tyre on the same vehicle. For this reason, a possible use of a "control tyre" in conjunction with the reference tyre is described. The test result is the so-called wet grip index.

The use of the SRTT as the reference tyre can be seen as critical. First, because every tested tyre of any dimension is compared to the performance of the SRTT, which includes in many cases the complicated use of the above mentioned control tyre. Another point is that the SRTT does not represent the state of the art of wet braking performance, which is important with regard to possible limit values, which will presumably be related to the wet braking performance of the SRTT. This is one of the results of a test report of the TÜV Automotive GmbH in 2003 (Reithmaier and Salzinger, 2003)[32]. Within the scope of this investigation, the wet grip characteristics of more than 300 automobile tyres were measured. It was found that 90% of the tested tyres, irrespective of their specifications, have wet braking characteristics that, in comparison to the SRTT, were far better than the wet breaking performance of the SRTT (110-140%). None of the tested tyres produced a worse result than the SRTT.

[31] Source of price study: http://www.neumaticos-online.es
[32] TÜV Automotive GmbH. Report on "Motor Vehicle Tyres and Related Aspects" Commissioned by the European Commission, Enterprise Directorate General.

From the Dutch Ministry of Environment fact sheet, based on the results from tests performed by ETRTO, FEHRL and TNO, the following figures are presented:

Figure 3. Wet grip versus noise performance of tyres



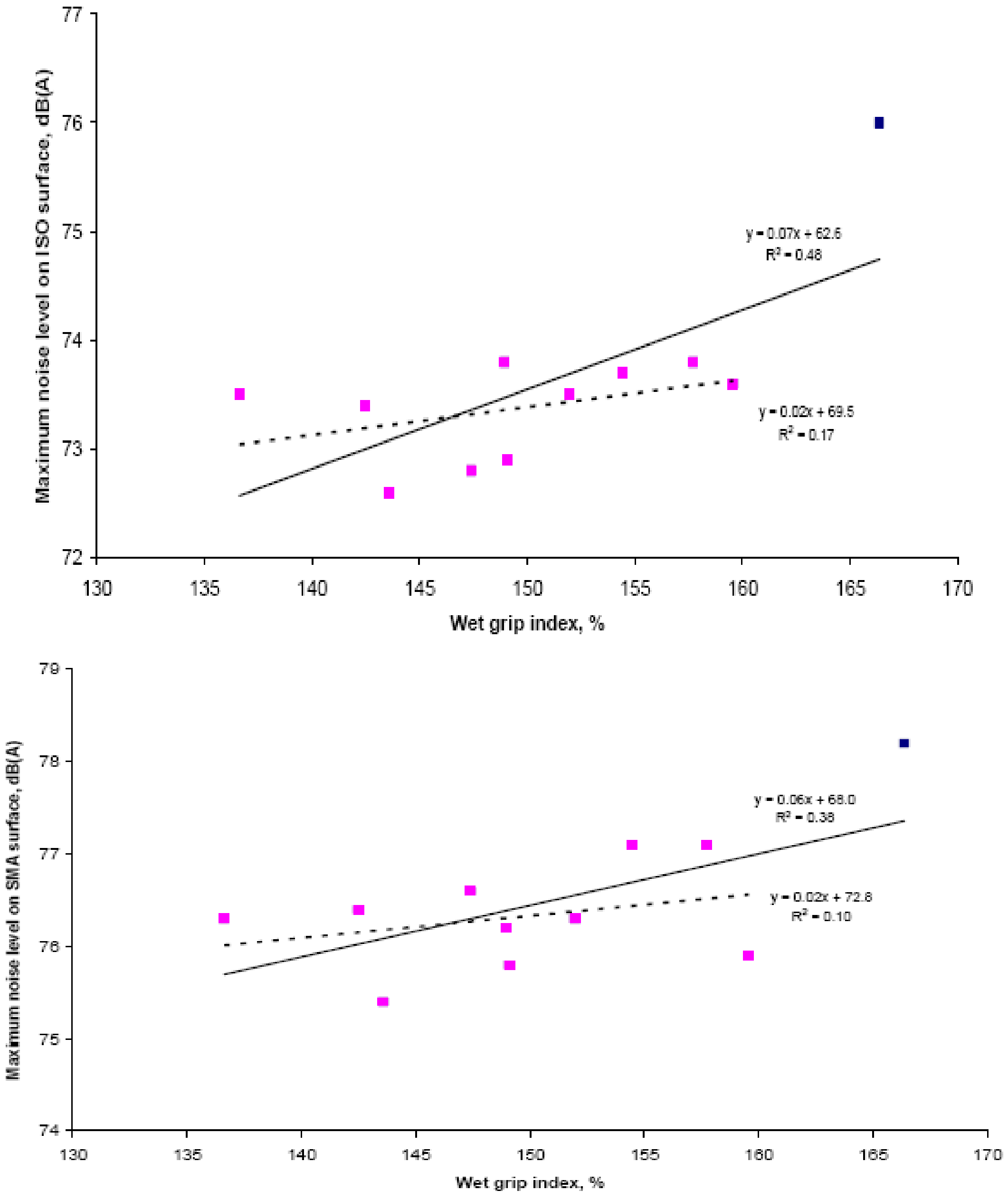
Source: Fact Sheet from the Dutch Ministry of Environment

The Dutch test on relation between noise and wet grip, measured in conformity with UNECE Regulation 117 and ISO 8767 provided for 26 final values. The relationship between noise and wet grip is shown also (on the right), 198 data points from different consumer tests are plotted. The conclusion is analogue to that of the chapter two: there appears to be no significant correlation between the two parameters.

In a recent TRL study of tyre-road noise[33], including noise and wet grip measurements, 11 car tyre sets were used for which noise was measured on an ISO surface at 80 km/h and on a stone mastic asphalt (SMA) 0/10 surface at 65 km/h (Watts et al., 2005). Wet grip was measured as peak friction on the SMA surface at 65 km/h. The results are shown in the following figures:

[33] Published Project Report PPR077, Tyre/Road Noise – assessment Of The Existing And Proposed Tyre Noise Limits, May 2006, TRL Limited.

Figure 4. Maximum noise level versus wet grip index values for several tyres



Source: Project Report PPR077, Tyre/Road Noise from TRL; and ETRTO. "European tyre industry comments on FEHRL tyre-road noise study"

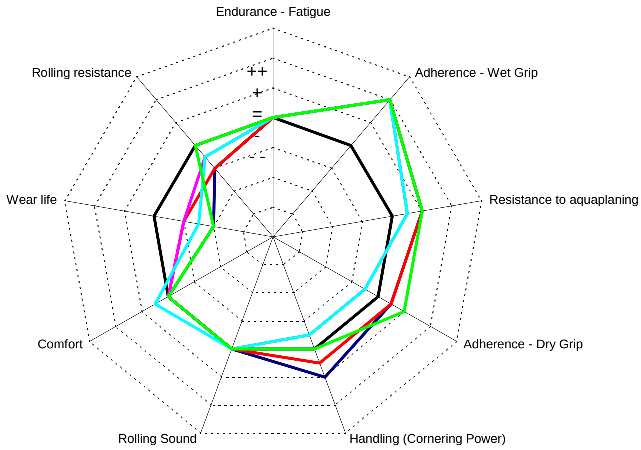
There are large differences in noise emissions for the same tyres depending on the surface they are measured on. According to these graphs, a statistically significant correlation (95% probability) between pass-by noise and wet grip was found, this time on 2 different surfaces (SMA and the ISO10844 surface). The correlation was less significant when one tyre size was eliminated because it could not be measured for wet grip with the correct load, but in fact, the result that would have been obtained under the correct conditions of load would have strengthened the correlation.

In the same study of tyre-road noise, 16 passenger car tyres were measured on a hot rolled asphalt surface. Those summer tyres had the same dimensions but were manufactured by different companies, in this case those 16 represent more than 60% of available summer tyres in its category. A statistically significant linear correlation (99% probability) was found between the measured pass-by noise level and the wet braking.

The tyre manufacturer industry has analysed the results from FEHRL[34] and has reached a different opinion. In its opinion, the "to-be regulated" performance items are not independent from each other and imposing too high constraints on a single property only, will have a negative impact on other properties including safety related ones.

In the following figure they show the balance between properties when designing a tyre:

Figure 5. Tyre design chart showing tyre performances when maximizing for tyre wet grip



Source: ETRMA: European Tyre Industry proposal for Tyre Performances Integrated Approach

This figure shows how wear life, rolling resistance and rolling sound are affected when the tyre is designed maximising wet grip. In order to achieve a better wet grip the performance in some of the other tyre properties is reduced.

ETRTO consider that the fact that some tyres were found to have good noise performance while maintaining acceptable levels of wet grip and aquaplaning resistance does not mean that all tyres can be made to perform in the same way. In its opinion, other unmeasured performance characteristics, such as handling, wear, dry braking, or comfort, for example, must have been adversely affected by the compromise used by the tyre manufacturer to reach the low noise levels, and tyres must remain balanced for all of the performance criteria.

[34] ETRMA and ETRTO. "European tyre industry comments on FEHRL conclusions in tyre-road noise study SI 2.408210". Presented by ETRTO – European Tyre and Rim Technical Organization.

3. Conclusions

1. Tyre Wet Grip (TWG) is the tyre's ability to keep in contact with the road in the presence of a water layer on the road; this is a key property to ensure driving safety. It depends strongly on the tyre tread design.

2. No significant differences were found between the prices of standard summer tyres and tyres with high wet grip performance.

3. It seems there is a relationship between wet grip and noise performance of tyres, although this relationship is not linear.

4. Tyre designs are highly complex, and noise, wet grip, rolling resistance, wear, durability, handling and cornering performances are interconnected.

Chapter four – Tyre Low Rolling Resistance and Wet Grip optimisation. Study of alternative Policy Instruments

1. The use of silica in tyres

1.1. Evaluation on the use of silica

Traditionally, a major problem of tyre designers has been solving the compromise between low rolling resistance and wet grip. Rolling resistance is the amount of energy a tyre absorbs as it revolves and deflects. The lower the rolling resistance, the less fuel is required to propel the vehicle forward. Lowering the rolling resistance, however, has traditionally meant a reduction in wet grip performance, which is of course unacceptable[35].

Tyre manufacturers claim this problem has been solved by the replacement of certain quantities of carbon black with silica in the tyre's tread compound. This replacement has enabled manufacturers to produce tyres which provide improved wet skid properties, better winter performance and lower rolling resistance, all at the same time. The use of silica to increase the performance of TLRR and TWG is a solution taken by all major tyre manufacturers as well as low-cost manufacturers. The tyre industry is currently reaching the limits of tread compound development using silica and further improvement to optimise performance across all tyre attributes will require technological change and related investment and will increase the cost of tyres[36].

The reason why this technology has been considered to be so revolutionary is described as follows: grip is affected by the degree to which a tyre is distorted at high frequencies, in other words, the degree to which it hits small stones and unevenness in the road surface. Grip is also best served by rubber compounds which absorb high levels of energy (high hysteresis compounds). Rolling resistance, on the other hand, is affected by low frequency distortion and the deflection of the tyre as it revolves. Grip also requires compounds which absorb low quantities of energy (low hysteresis compounds). This contrast is why it has been impossible to provide tyres which both reduce rolling resistance and increase wet grip in the past. With the addition of silica, however, tyre manufacturers have been able to produce compounds which have high hysteresis at high frequencies but low hysteresis at low frequencies.

The application of silica gives the rubber a more elastic and flexible structure, especially at low temperatures. This can translate to an increased grip on the road surface of up to 12%. Tyre manufacturers claim it also shortens the braking distance by some 10% and reduces rolling resistance by 15%[37].

1.2. Environmental study of silica replacements in tyre compounds - Life cycle assessment

During 2000 and part of 2001, BLIC (previously the European tyre structure and rubber industry) made a full Life Cycle Assessment study (LCA) of a representative European 195/65 R15 passenger car tyre (summer H rated new carbon black and silica based tread tyre). This study related purely to car tyres, and did not include a truck tyres analysis[38].

The LCA report showed the current environmental load from an average car tyre throughout the life cycle in the European Union.

[35] http://www.tyres-online.co.uk/technology/silica.asp
[36] European Policy Evaluation Consortium (EPEC). “Impact Assessment – Possible Energy Labelling of Tyres”
[37] According to TyreLand-Vredestein.
[38] European Tyre Recycling Association: http://www.etra-eu.org/

Moreover, the LCA study provided insight for tyre manufacturers into the possibilities of improvement of environmental performance of car tyres.

Two versions of the H rated summer car tyre 195/65 R15 were analysed:

- a version with a traditional tread with carbon black as a filler, and,
- a version in which the carbon black in the tread was partly replaced by a silica compound.

The main findings relating to environmental impacts throughout a car tread's life cycle show:

- The use phase makes the highest contribution to the environmental load.
- The most important aspect during the use phase is the fuel consumption that can be attributed to the rolling resistance.
- Over the life cycle, silica model car tyres make a lower environmental impact than those with a traditional tread, having carbon black as filler. The main difference between the two versions related to the level of rolling resistance in the use phase.
- Car tyre/road contact noise is potentially an important aspect, but its specific magnitude cannot yet be determined.
- Car tyre debris emitted during the use phase contributes a relatively modest amount to the overall life cycle compared with fuel consumption induced by the rolling resistance phenomena, and lower than the car tyre's contribution to engine exhaust emissions.
- The average end-of-life scenario makes a relatively small contribution to the overall load of the life cycle.
- A significant point from the LCA is that the global magnitude of these environmental impacts during the use phase can be largely influenced by external factors, such as driver behaviour. The tyre producers understand that they need to address this aspect as well, and will increase efforts towards a better education of consumers.

Tyre recyclers, civil engineers, material users and government authorities have identified a broad array of applications and myriad of products for tyres at the end of their life. These uses are independent of silica content in tyres, meaning that new tyres with silica compounds are equal in terms of recycling to previous models.

2. The impact of environmental objectives (CO_2 emissions) on road safety

As shown in previous chapters, according to the FEHRL study[39] and data from the Dutch Ministry of Environment fact sheet, there is currently no clear trend between low rolling resistance and wet grip. There are tyres in the market that achieve the proposed limits in noise emissions and rolling resistance with a better wet grip index than standard tyres. On the other hand, the ETRTO document reviewing the results from the FEHRL[40] report, the results from the TRL study and Figure 5 from ETRMA demonstrate a relationship between different tyre properties.

[39] "Study SI2.408210 Tyre/Road Noise". Presented by: FEHRL - Forum of European National Highway Research Laboratories; BASt; TRL, TÜV Nord and VTI.
[40] "European tyre industry comments on FEHRL tyre-road noise study SI 2.408210". Presented by ETRTO

According to an investigation by the German Federal Environment Agency (UBA)[41], with reference to the German market only, these tyres show a potential reduction of 4.4 million tonnes of CO_2 for 2010 and 5.4 million tonnes of CO_2 for 2020.

Regarding tyre wear and safety in low rolling resistance tyres, a comprehensive competitive study was made in Europe in 2004 & 2005. Within this study, 183 tyre lines were analysed and tyres were purchased by TÜV directly on the European replacement market as consumers would do. Wet braking tests were achieved by TÜV. Rolling resistance tests were done by TÜV using the ISO 18164 test. Wear tests were carried out on public roads by CERM (Centre d'Etude et de Recherche Mécanique de Narbonne)[42].

Table 10. European tyre segments and brands covered in TÜV study as shown in Michelin 2005 IEA presentation

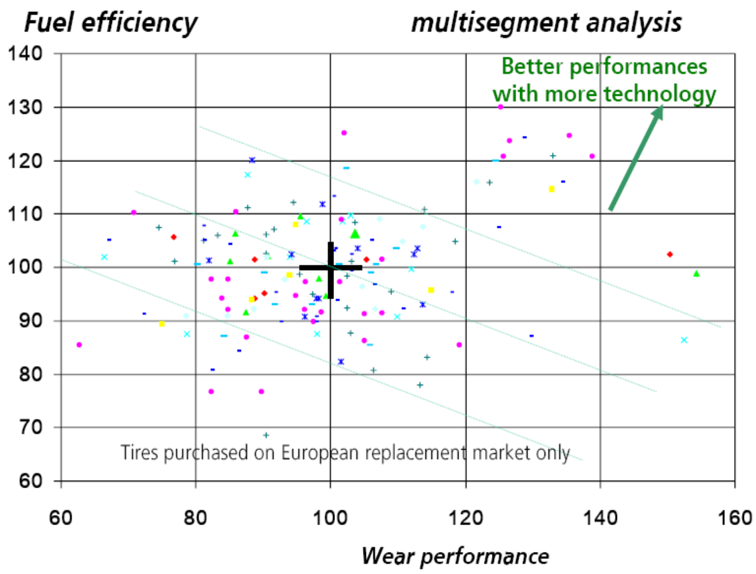
12 European tyre segments were covered		
Segment	**Tyre size**	**Number of tyre lines**
Summer broad	195/65 R15 H	28
Summer entry	175/70 R13 T	12
Summer entry	175/65 R14 T	14
Summer high performance	205/55 R16 W	25
Sport entry summer	195/50 R15 V	11
Sport summer	225/45 R17 Y	12
4x4 all season	265/70 R16 H	6
4x4 summer high performance	255/55 R18 V	6
Light truck summer 4 - 5 PR	205/65 R15 102 T	6
Light truck summer 8	215/75 R16 110 T	9
Winter broad	195/65 R15 T	26
Winter high performance	205/55 R16 H	22
4x4 winter performance	255/55 R18 H	6

20 brands were also covered (entry to premium)			
Brand	**Number of tyre lines**	**Brand**	**Number of tyre lines**
Barum	2	Kormoran	3
BFGoodrich	12	Kuhmo	2
Bridgestone	17	Michelin	17
Continental	17	Nokian	5
Debica	3	Pirelli	16
Dunlop	17	Semperit	2
Firestone	8	Toyo	4
Fulda	11	Uniroyal	13
Goodyear	17	Vredestein	2
Kleber	13	Yokohama	2

All data were analysed by market segment. For each segment and for the 3 performances (wear, wet braking and rolling resistance) the average of the segment sample was calculated to obtain the position of each tyre relative to the average of the segment sample. Those comparisons were then possible inside each market segment to see if there was a specific segment pattern, but also across segments to see if some general pattern existed. The results are shown in the next graph.

[41] German Federal Environmental Agency (Umweltbundesamt - UBA) "CO2 – Minderung im Verkehr – Sachstandsbericht, September 2003.
[42] Dominique Aimon, from Michelin. Presentation on IEA / nov 2005.

Figure 6. Fuel efficiency versus wear performance of tyres



Source: Dominique Aimon, from Michelin presentation on IEA 2005.

The authors of the study concluded that:

- No pattern exists either by segment or across segments
- Tyres which are very good on wet braking can also be good in rolling resistance.
- Tyres which are very good in wear performance can also be good in rolling resistance.

The expected thresholds for tyres presented in the European Commission's proposal[43] in rolling resistance and in wet grip, related to noise and CO_2 emissions do not draw a clear conclusion on how they affect road safety issues. All authors studied to some extent the link between tyres and driving safety from a technical point of view. All of them concluded that currently there are tyres that meet future requirements while ensuring road safety performance, although the costs of those tyres are different depending on the manufacturer and on the tyre family.

ETRTO, in their comments to the FEHRL report[44], indicate that the fact that some tyres were found to have good noise performance while maintaining acceptable levels of wet grip and aquaplaning resistance does not mean that all tyres can be made to perform in the same way. Some other, unmeasured performance characteristics, such as handling, wear, dry braking, or comfort, must have been adversely affected by the compromise used by the tyre manufacturer to reach the low noise levels. The tyre industry can not design tyres that only respond to 3 performance characteristics.

[43] Regulation concerning type approval requirements for the general safety of motor vehicles COM(2008)316 – 2007/0243(COD).
[44] "European tyre industry comments on FEHRL tyre-road noise study SI 2.408210". Presented by ETRTO.

3. An acoustic evaluation of TMPS as well as TWG and TLRR

3.1. Evaluation of TPMS

As shown in chapter one, the influence of underinflation is adverse in terms of safety, CO_2 emissions and noise. TPMS can clearly help drivers to maintain optimal inflation pressures. According to ETRMA[45], the correct tyre inflation pressure is essential for delivering the tyre performance aimed at by the developers and all efforts must be made to guarantee proper setting and maintenance of the inflation pressure. As explained in table 5 in chapter one, a deviation of 1 bar to the standard inflation pressure raises noise emissions by 2 dB(A). Although TPMS will not decrease noise emissions, they will avoid increases due to underinflation.

It is difficult to accurately evaluate the impact of TPMS on noise emissions. According to UNECE GRRF TPMS[46] it is clear that a large amount of vehicles are running with underinflated tyres in Europe. The mandatory introduction of TPMS will suppose an overall decrease in tyre noise emissions, although it is not possible to estimate a figure.

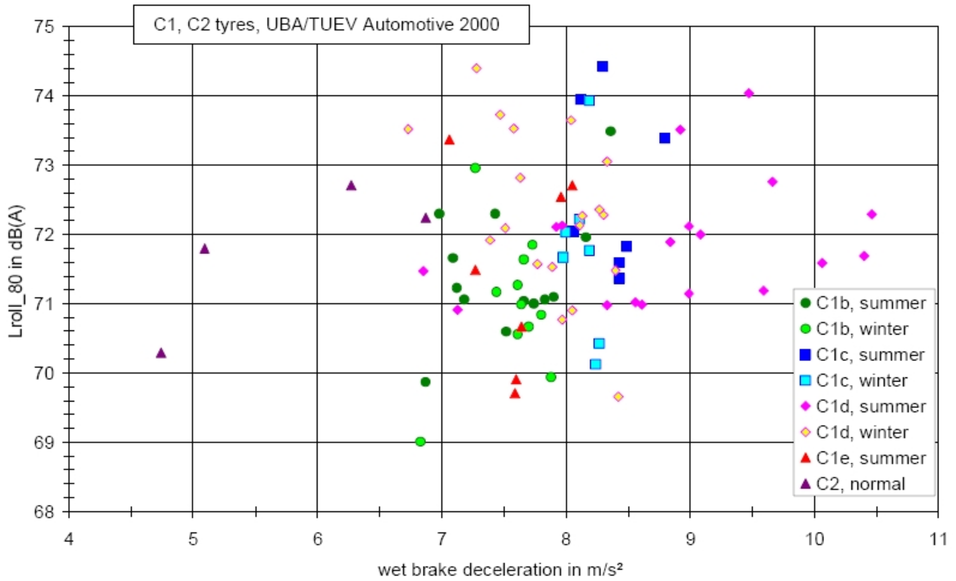
It seems reasonable to include TPMS in vehicles, since the introduction of direct TPMS is already mandatory for all vehicles sold in the U.S. Furthermore, given that most manufacturers share platforms in the European and the U.S. markets, the OEM costs of implementing direct TPMS systems in vehicles in Europe is limited.

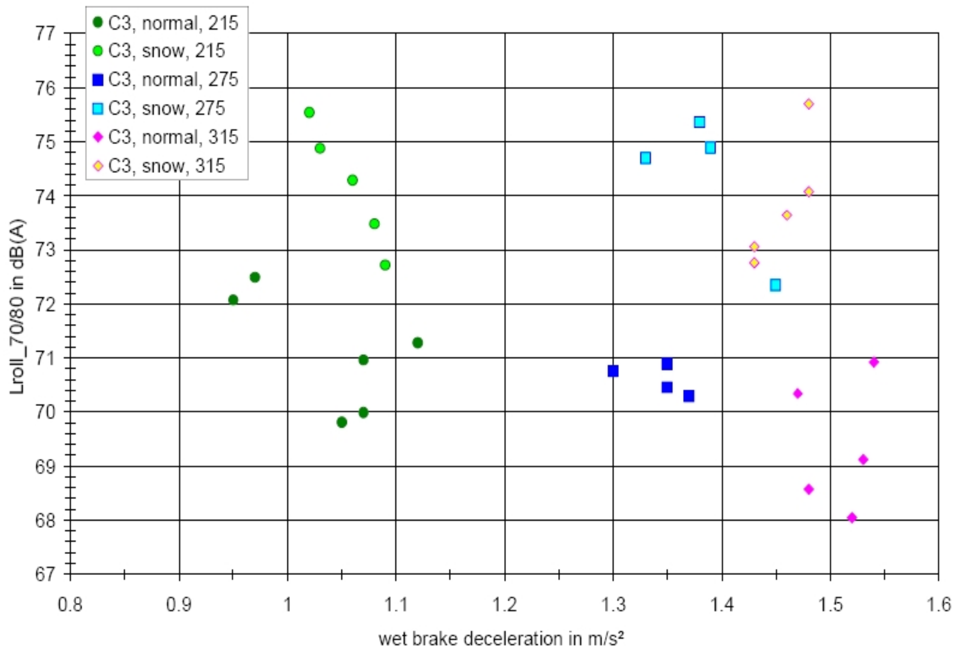
3.2. Evaluation of TWG and TLRR

According to the FEHRL report[47], measurements of wet grip performance and rolling resistance were carried out on C1, C2 and C3 tyres. The wet grip performance was determined by tests in which a vehicle was decelerated using a four-wheel ABS braking system from 85 km/h to stand still. No clear trend could be found for C1 tyres while C2 tyres tend to show a positive trend (i.e. increasing noise levels with increasing deceleration levels). However, this trend was only based on the result of one particular tyre and was not confirmed by the results for C3 tyres, where a clear influence of tyre width and use category on the deceleration values could be seen but, again, no clear correlation with tyre/road noise levels was found. Both behaviours and test results are shown in the following figures.

[45] ERTMA: European Tyre Industry proposal for Tyre Performances Integrated Approach document.
[46] UNECE GRRF TPMS: "Draft Cost/Benefit analysis TPMS for M1 vehicles".
[47] "Study SI2.408210 Tyre/Road Noise". Presented by: FEHRL, BASt, TRL, TÜV Nord and VTI.

Figure 7. Wet brake versus noise performance of C1, C2 and C3 tyres

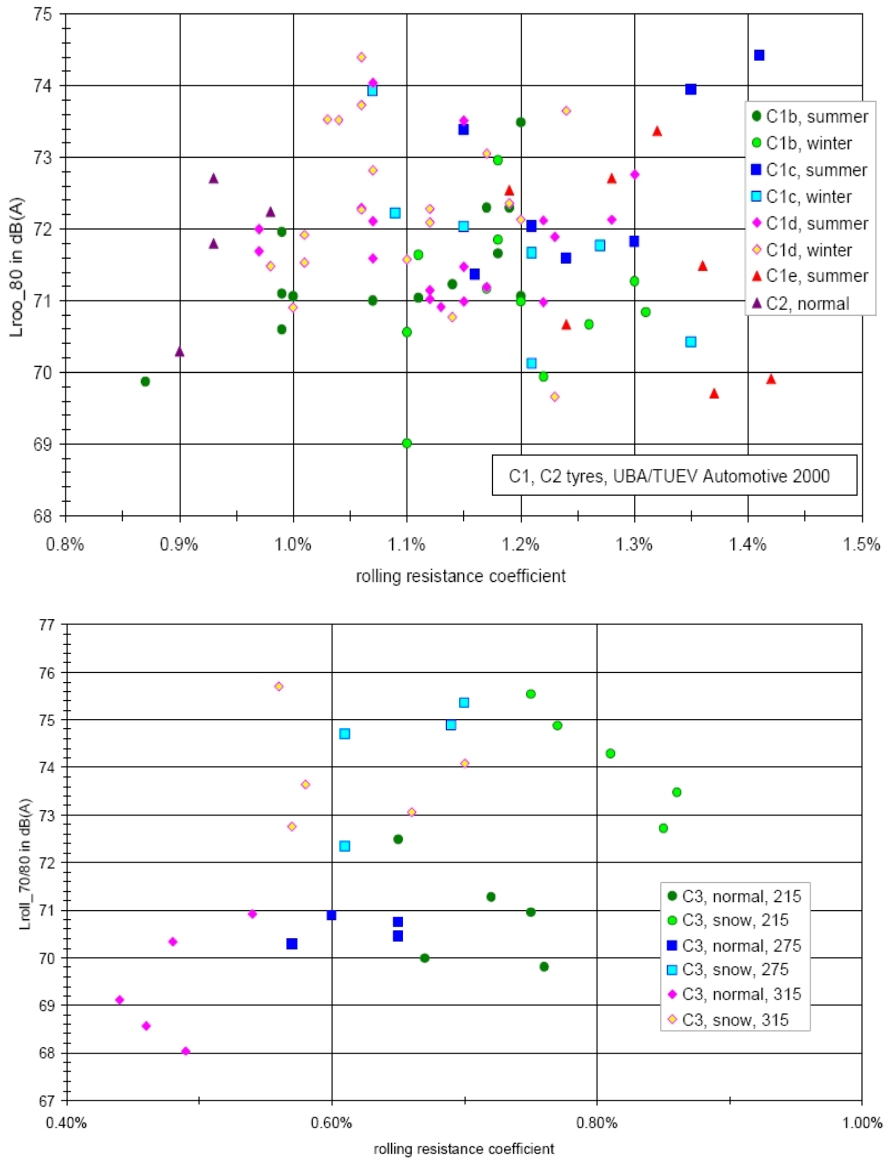




Source: "Study SI2.408210 Tyre/Road Noise". Presented by: FEHRL, BASt, TRL, TÜV Nord and VTI

Regarding the comparison of tyre/road noise levels and rolling resistance coefficients, once again no clear tendencies could be found for C1 tyres. For example C1 winter tyres appear to show a negative trend as regards the rolling resistance coefficient (i.e. a decreasing tyre/road noise level with an increasing rolling resistance coefficient), but C1 summer tyres show exactly the opposite trend and no significant trends in either direction can be seen for the other C1 classes.

Figure 8. Rolling resistance versus noise performance of C1, C2 and C3 tyres



Source: "Study SI2.408210 Tyre/Road Noise". Presented by: FEHRL, BASt, TRL, TÜV Nord and VTI

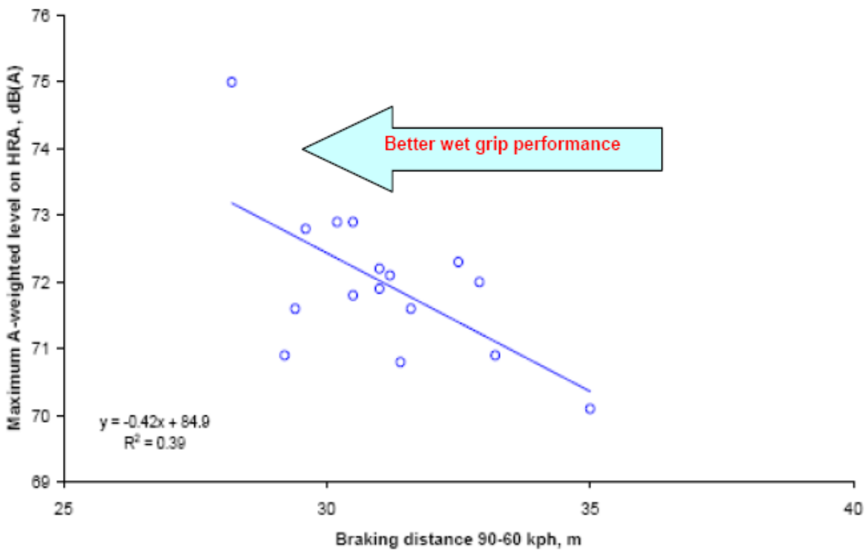
Finally, no significant relationship between noise and aquaplaning speed could be detected in these plots. A possible influence of tyre width on aquaplaning speed is indicated with wider tyres tending to aquaplane at lower speeds, as might be expected, although any dependency in this regard is not strongly noticeable through the available data.

The Swedish National Road and Transport Research Institute (VTI) and the Technical University of Gdansk (TUG) test results were also studied. The data included the results of noise tests, wet friction and rolling resistance of nearly 100 tyres. Tyre/road noise emission was measured with a CPX trailer (close proximity tyre/road noise measurements) and on a laboratory drum. These results were also added to the database.

The comparison of tyre/road noise levels measured on the laboratory drum and rolling resistance is shown the following figures. All figures in this chapter confirm the results presented in the previous section.

On the other hand, the following figure was presented by the tyre industry[48]. It shows the results from a test performed by TRL Limited on its study of tyre-road noise[49]. 16 different passenger car tyres were measured on a hot rolled asphalt surface. Those summer tyres had the same dimensions but were manufactured by different companies, in this case those 16 represent more than 60% of available summer tyres in its category. They found a statistically significant linear correlation (99% probability) between the measured pass-by noise level and wet braking. Please note that the wet grip test results are shown in braking distance (meters) and therefore a shorter distance indicates better performance. Also a possible outlier is plotted in the graph, that point influences the value of correlation.

Figure 9. Braking distance versus noise performance of 16 different summer tyres



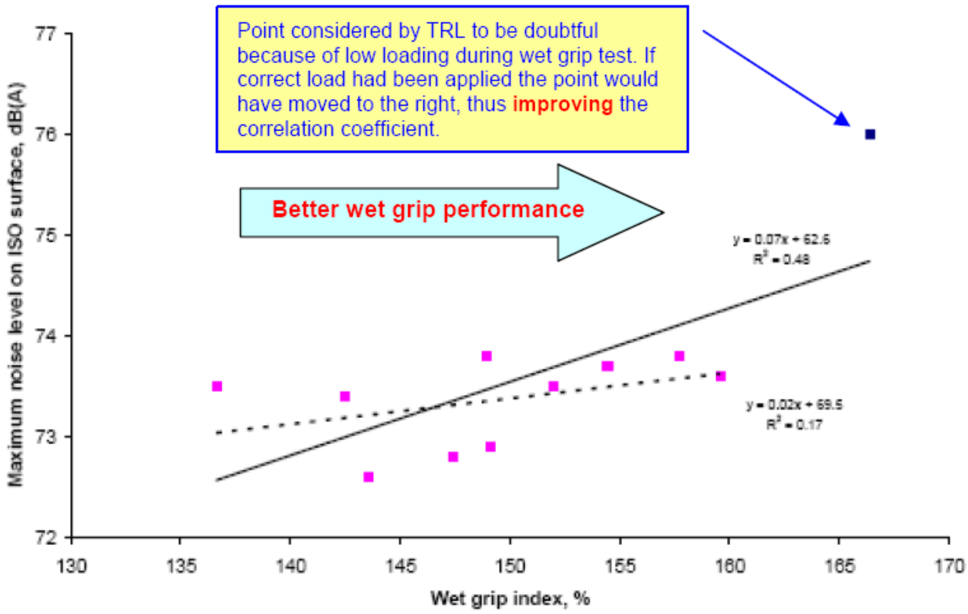
Source: ETRTO and TRL Limited

As shown on Figure 4, in the same study a correlation between pass-by noise and wet grip was found.

[48] ETRTO: "European Tyre Industry comments on FEHRL conclusions in Tyre-road noise study SI2.408210

[49] TRL Limited: Project Report PPR077, Tyre/Road Noise – Assessment Of The Existing And Proposed Tyre Noise Limits.

Figure 10. Wet grip index versus noise performance of 11 different tyres



Source: ETRTO and TRL Limited

4. Analysis of alternative Policy Instruments and Eco-Innovations

Across the European Community there exists a range of legislative and policy related procedures that are intended to have an impact on current and future levels of tyre/road noise as well as on CO_2 emissions. Those instruments were reviewed in the CO_2-emissions from passenger cars report[50] and in the integrated assessment of noise reduction measures report[51]. Some of the most significant results from those reports are summarised in this section.

Road surface replacement policies

Some countries have adopted policies that ensure that when roads are replaced or resurfaced, lower noise surface materials are used. For example, in the United Kingdom, the Government's 10 year investment plan for transport (Department of the Environment, Transport and the Regions, 2000a) is aimed at implementing transport policy which will, amongst other objectives, help to reduce the impact of traffic noise from trunk roads. The plan requires that over its duration, 60% of the trunk road network in England will be resurfaced with lower noise road surfaces, including the replacement of all sections surfaced with concrete.

[50] "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars". Prepared by TNO Science and Industry, IEEP and LAT.
[51] "Integrated assessment of noise reduction measures in the road transport sector". Presented by: TRL Limited and RWTÜV Fahrzeug GmbH.

Also in the UK, The Mayor of London's draft London Ambient Noise Strategy (Greater London Authority, 2002) sets out a proposal for London's roads to *“use noise reducing surfaces, where practicable and cost effective, and where they meet safety and other criteria".*

In the Netherlands, the "Roads To The Future" scheme (Wegen naar de Toekomst, 2000), an innovation programme run by the Ministry of Transport, Public Works and Water Management, is predominantly aimed at seeking smart solutions for mobility and infrastructure. It provides incentives for solutions to accessibility problems in consultation and co-operation with external partners, such as interest groups, technical experts and road users. It is also a legal requirement in the Netherlands that roads carrying traffic above a certain volume be surfaced/resurfaced with porous asphalt. This treatment process commenced in 1987.

Noise modelling of road materials

Work by the French in the late 1990's to update the vehicle noise emission values used in the French road traffic noise prediction models resulted in a determination of three different surface classes (Dulau et al, 2000):

• Low noise R1 - thin asphalt concrete 0/6, 0.10, porous asphalt 0/10,

• Intermediate class R2 - cold applied macadam, bituminous concrete 0/10, 0/14,

• Noisy class R3 - cement concrete, surface dressing and thin bituminous concrete 0/1.

Similarly in the UK the standard traffic noise prediction model provides corrections for low noise porous surfaces. Clearly, including different emission factors in the prediction model take account of the effects of different surfaces on traffic noise. It highlights the economic and social benefits of lower noise surfaces which, in turn, helps encourage their wider use in new constructions.

Environmental labelling of tyres

An alternative to type approval would be to use the concept of noise labelling. In such an instance, surfaces are tested using an officially recognised test method, but prescribed limits for the performance of the surface are not set. Such an approach has a background in legislation but does not enforce limit values.

Tyres that meet certain noise criteria (often in tandem with other environmental criteria) may be marked with an environmental label, which would certify the product is environmentally friendly, at least in relation to other products. It is feasible that the use of such labelling might influence consumers in their purchases. The following lists examples of environmental labelling systems for tyre/road noise that are currently operating in Europe.

- German Blue Angel: Managed by RAL (the German Institute for Quality Assurance and Certification) and developed with the support of the German Federal Environmental Agency (UBA). Criteria for awarding of the label have been specified for low noise and fuel-saving automobile tyres (RAL _ UZ89) and retreaded tyres (RAL _ UZ I).

- The Nordic Swan: This is the official Nordic eco-label and was introduced by the Nordic Council of Ministers. Tyres for light as well as heavy vehicles are products for which the label can be obtained, and retreaded tyres are also eligible.

The European Commission has already proposed a Directive of the European Parliament and of the Council on labelling of tyres with respect to fuel efficiency and other essential parameters[52].

Current and future mobile air conditioners influence on fuel consumption and CO_2 emissions

The use of a mobile air conditioner brings about additional CO_2 equivalent emissions which are considered to be either direct or indirect.

The direct emissions originate from the leakage of (high Global Warming Potential, GWP) coolant from the system during the airco's lifetime as well as from coolant spillage during regular service and end of life service. The indirect emissions are emitted through the tailpipe of the car and are caused by the additional fuel consumption of the car's engine to operate the air conditioner compressor and the generator for operating the fans of the air conditioner. Additionally, the weight of the system induces an elevated rolling resistance and inertia which both demand more engine power, i.e. more fuel and thus increase the tailpipe CO_2 emission.

The EC has proposed several measures to reduce greenhouse gas emissions from passenger cars in the next decade. The EC aims at reducing greenhouse gas emissions from airco's by a ban on the high GWP R134a as a refrigerant for all mobile air conditioner systems as from 2011. As a result of this legislation, the auto industry will be challenged to develop new systems which use low GWP refrigerants as an alternative to R134a. Parallel to these developments, the industry investigates possibilities to improve existing systems, as such legislation is not proposed for other parts of the world and as the EU is leading on switching to such alternatives.

Tyre-pressure retention technologies

In the last decade a lot of measures and technologies have been developed to maintain the appropriate inflation of tyres longer. One of the first measures to be taken was to replace the air inside tyres with nitrogen. With nitrogen, diffusion is 30 to 40 percent slower than oxygen[53]. As a result, nitrogen maintains tyre pressure longer than air.

Chemical companies[54] have developed technological advancements in tyre inner liners field. These technologies include both nano-composites and dynamically vulcanized alloys (DVA). These are basically sealants which are poored into the chamber and which better insulate it, deminishing the propensity of the tyre to deflate. Results indicate several benefits including reductions in tire cure time, liner gauge thickness, inflation pressure retention (IPR) and intra-carcass pressure (ICP), as well as more than a 20 percent improvement in tire durability as expressed by "mileage to failure" ratings[55].

Policy measures suitable for implementation of engine friction reduction technologies

From the TNO, IEEP and LAT report[56] an interesting study on policy measures to implement engine friction reduction technologies was presented. Lubricants are produced by the oil industry in close cooperation with engine manufacturers. As a result, the lubricant market is theoretically independent from the car industry but strongly influenced by it. This is an important characteristic that should be taken into consideration before any effort or measure to support these technologies is decided upon.

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[52] http://ec.europa.eu/energy/strategies/2008/doc/2008_11_ser2/tyres_labelling_directive_proposal.pdf
[53] www.proservice.pl/admin/pliki/E32507-Nitrogen.pdf
[54] Exxon Mobile,
[55]http://www.exxonmobilchemical.com/Public_PA/WorldwideEnglish/Newsroom/Newsreleases/chem_nr_021105.asp
[56] "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars".

Any policy aiming at the reduction of engine friction should focus both on the engine design and production process and additionally, the lubricant aftermarket.

The main policy instruments that can be adopted in due course to increase the market share of low viscosity lubricants (LVL) are similar to those proposed for energy efficient tyres and are summarised below:

- Warranty limitations. The first and most important issue for any policy is to ensure that the drivers will be able to use any lubricant corresponding to the engine specifications without risking the validity of the engine warranty.

- Purchase incentive programme. An important and very effective measure to reduce the engine friction of the whole fleet and not only of new vehicles should target replacement lubricants. As presented, with current lubricant and fuel prices, the net cost for purchasing LVL is close to zero. Through the adoption of a purchase incentive program a faster introduction of LVL will be achieved as the drivers are going to have a stronger motive to move towards this solution. The cost for the state in this case is expected to be fairly low and will be compensated by the advantages of CO_2 emissions reductions.

- The creation of a database with engine and lubricant data. Such a database will help drivers decide which lubricant is the most efficient for their vehicle. Such a measure can be combined with a wider effort to inform drivers about what is the best solution according to their individual needs. For example, most drivers are unaware about other factors that should be considered when purchasing a lubricant such as climate conditions and vehicle use.

- Labelling programme. Combined with a broader customer support scheme (database etc), labelling could be applied for LVL in order to support the market of more efficient lubricants. In parallel to the actions described here, measures that will stimulate a further development in engine and lubricant technology are of significant importance.

5. Conclusions

1. The use of silica has enabled tyre manufacturers to produce tyres which provide improved wet grip, better winter performance and lower rolling resistance, all at the same time. The use of silica has no detrimental impact on tyre life cycle.

2. Setting rolling resistance limits for tyres might have an impact on road safety. In order to avoid adverse effects on traffic safety, suitable limits on wet grip performance should be established.

3. Low rolling resistance tyres, assisted by tyre pressure monitoring systems will have a positive impact on CO_2 and noise emissions reduction.

4. There are other policy instruments and eco-innovations which may have a positive impact on CO_2 and noise emissions reduction.

5. An integrated approach of currently existing and available technologies (e.g. more efficient air-conditioners) will bring additional CO_2 reductions.

6. An integrated approach to decrease noise emissions should be considered, the noise reduction potential of roads seems to be higher than the potential of tyre noise reduction.

7. Currently 46% of C1 tyres already fulfil future noise requirements, approximately 15% of existing C1 tyres meet 2016 rolling resistance requirements. But only around 5% fulfil both requirements at the same time.

8. Regarding C3 professional off road tyres, currently less than 1% of existing tyres, are normally used on unpaved roads. In this case tyre/road noise should not be considered.

9. It is feasible that the use of environmental labelling might influence some consumers in their purchases. In our opinion consumers perceive tyres with good environmental performance to fare badly in other aspects, hence ecolabel's impact might be limited.

Chapter five - Potential benefit versus cost analysis

In this chapter, different cost-benefit reports have been studied. In those reports the use of TMPS as well as new TWG and TLRR limits potential impact on safety, CO_2 emissions and noise reduction is estimated using different assumptions. These reports have been analysed and compared to estimated costs of fulfilling those requirements.

1. Safety costs versus benefits analysis

Two reports[57] regarding cost versus safety benefit analysis for implementing TPMS as a solution for tyre-related accidents have been studied.

In the TÜV report, they use German DEKRA and MHH data and knowledge to estimate the number of tyre-related accidents, from 2003, and use an assessment period of 10 years. Their benefits are evaluated at Calendar Year (CY) 2001 accident cost figures. In this study, it is assumed that 3.3% of all tyre-related accidents could be pressure related. The number of tyre-related accidents and injuries in Germany caused by pressure problems for the next ten years was estimated by means of extrapolating this trend.

These quantitative figures were then converted into Euros by applying an accident cost per injury (by severity) and property damage (by accident category) estimation. By multiplying each quantitative figure by its cost factor, accident costs of tyre-related accidents and injuries caused by tyre pressure problems were calculated.

The prices for a mandatory TPMS involve certain imponderable factors, as the assumed price deflation of the costs depends to a large extent on the implementation rate of this technology. 2003 market prices, on which this calculation was based, are relatively high. They used a price-deflation of 5% p.a. due to economies of scale and technological progress.

The following table shows the results from this report:

Table 11. Tyre related accidents and TPMS cost estimations, source TÜV

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cost of tyre related accidents in Million €	32.2	31.9	31.7	31.4	31.2	31.0	30.8	30.7	30.5	30.4
Cost equipment direct TPMS in Million €	1400	1331	1265	1202	1143	1086	1032	981	932	886
Cost equipment indirect TPMS in Million €	350	333	316	301	286	272	258	246	234	222

[57] "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars". Prepared by TNO Science and Industry, IEEP and LAT. UNECE GRRF TPMS. "Draft Cost/Benefit analysis TPMS for M1 vehicles".

In this table, average prices from direct and indirect TPMS have been used, in the original report two cases (low and high prices) were considered.

In the UNECE GRRF TPMS Report, the safety benefits are calculated estimating that between 41 and 96 million cars have tyres underinflated by 0.5 bar and more.

They estimate between 0.1 and 1% of fatal accidents, and accidents having generated injuries, are caused by underinflation. The social cost per year, associated with accidents throughout Europe, is estimated to be 160000 million Euro[58]. This estimation is larger than TÜV's due to the fact that it considers the whole of Europe instead of just Germany. It is also considered that 0.5% of these accidents are caused by underinflated tyres, which means that the social cost becomes 800 million Euro.

Assuming there are 229 million vehicles in Europe, the safety benefit at individual level would be around 3.5 Euro per car and per year. In order to estimate the costs per vehicle, they used estimated manufacturing cost of 30 Euro (which is the worst case scenario of Table 4). Assuming an increase of 35% in order to estimate the manufacturing cost for OEM, there results a total cost per vehicle of 40 Euro.

According to this report, and only considering safety, the cost of implementation is 40 Euro per vehicle and the benefits are 35 Euro per vehicle and in a time period of ten years[59].

2. CO_2 emissions reductions costs versus benefit analysis

In this section, the effect of rolling resistance and TPMS on CO_2 emissions will be examined. As presented, rolling resistance plays an important role in the energy balance of the vehicle and has significant contribution to fuel consumption. Rolling resistance is determined mainly by the tyres of the vehicle. Therefore the most important technology to reduce vehicle rolling resistance that will be studied here is low rolling resistance tyres (LRRT) assisted by TPMS to ensure tyres work at the designed inflation level during its lifetime.

A short review of relevant literature[60] has revealed the range of the CO_2 reduction potential of energy efficient tyres but also some other interesting issues. Tables 12 and 13 summarise the reduction potential retrieved from various bibliographic sources and reports. According to CO_2 emissions report, two major approaches can be distinguished: reduction potential expressed with regard to a certain rolling resistance decrease (usually 10%) or reduction potential expressed in relation to the generalised idea of a low rolling resistance tyre. It is estimated that the second equals approximately a 20% reduction of the resistance factor. Finally there is no referenced methodology on which these estimates were based. Due to the lack of a predefined protocol, most of them are based either on measurements that were conducted under different conditions or on calculations that adopted different assumptions. Therefore the numbers presented cannot be directly compared.

[58] Source The European Road Safety Action Programme: A shared responsibility. http://www.irfnet.eu/images/roundtable/Theologitis.pdf

[59] Ten years is the expected lifetime of a vehicle.

[60] "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars". Prepared by TNO Science and Industry, IEEP and LAT. UNECE GRRF TPMS. And UNECE GRRF TPMS. "Draft Cost/Benefit analysis TPMS for M1 vehicles".

Table 12. Rolling resistance decrease and associated CO_2 emission benefit

	Source					
	LAT	IEEP	CARB	NRDC	Penant	IEA
Rolling resistance factor decrease	10%	-	10%	20%	-	10%
CO2 emissions benefit	1.70%	2%	2%	3-4%	3-4%	1.00%

In addition to the application of low rolling resistance tyres, TPMSs were also investigated. Coast down measurements conducted by LAT in the framework of this programme showed that a 0.5 bar reduction of the tyre pressure from the nominal value (20% deflation) resulted in a 10% increase of the tyre friction factor. Qualitative model runs indicate that such an increase results in a 2.5% increase of the fuel consumption over NEDC.

According to UNECE GRRF TPMS[LVI] the range for fuel savings is 0.3-2.1% and the tyre wear rage 6.3-13.3%. A review of the TPMS potential is presented in the following table:

Table 13. Different estimations of TPMS CO_2 benefit assuming 0.5 bar deflation avoided

	Source			
	LAT	Stock 2005	Hakanen & Jukka	GRRF TPMS
TPMS CO2 benefit assuming 0.5 bar deflation avoided	2.50%	3%	3%	2.10%

Considering that the majority of the vehicles run constantly on underinflated tyres (70% of all tyres are underinflated on average by 15%), it can be concluded that a TPMS system is necessary in order to achieve the maximum benefit from any tyre type. A combination of both technologies (i.e. TPMS with low rolling resistance tyres) is estimated to improve fuel efficiency in real driving conditions by 4-6%.

Due to the complexity of the problem it is difficult to make a detailed assessment of the potential for the EU-25. The tyre market and everyday use varies between countries. According to TNO, IEEP and the LAT report, and for the purposes of their study and the needs of future scenario calculations, several assumptions regarding the reduction potential and the costs of TLRR and TPMS were made. In this report various technical and non-technical options for reducing the CO_2-emissions of passenger cars and vans are compared on the basis of CO_2-abatement costs, i.e. the net costs to society per unit of CO_2 avoided. For this purpose the following formula was used:

$$CO_2\ abatement\ costs = \frac{investment - NPV(lifetime\ fuel\ cost\ savings)}{lifetime\ CO_2\ reduction}$$

The net costs equal the investment costs minus the net present value (NPV) of the lifetime fuel savings (based on fuel price excluding taxes). To calculate the NPV an interest rate of 4% was used. For vehicle technologies, a constant average annual mileage of 16,000 km and an average vehicle lifetime of 13 years were estimated. For other options the lifetime may be different. It could be argued that, in the calculation of net present value of the lifetime fuel savings, the annual mileage should be differentiated over time to reflect that new cars generally drive more kilometres per year than older cars. However, since this was a first order assessment of CO_2-abatement costs, the proposed simplified approach was considered sufficient.

Lifetime fuel cost savings are dependent on the fuel cost (fuel price excluding taxes). In this report CO_2-abatement costs were calculated for 4 different scenarios assuming different values for the oil price and related costs of fuels. Gas costs in this table are prices at the filling station excluding taxes and including the amortised costs of infrastructure.

For LRRT an average 3% improvement in fuel consumption was considered at a manufacturer cost increase of 42 Euro (60 Euro retail price increase) whereas for TPMS an average 2.5% fuel economy was considered at a manufacturer incremental cost of 50 Euro. These prices were multiplied by a factor of 1.16 in order to account for investment costs.

The following tables show the cost estimations for low rolling resistance tyres and TPMS:

Table 14. CO_2 abatement cost estimation due to low rolling resistance tyres

CO_2 abatement cost estimation for TLRR					
Case	Case 1	Case 2	Case 3	Case 4	
Additional manufacturer costs	42	42	42	42	€/vehicle
Investment costs	49	49	49	49	€/vehicle
CO_2 reduction	3.00%	3.00%	3.00%	3.00%	
CO_2 emission	192	192	192	192	gCO_2/km
Base fuel consumption	0.065	0.065	0.065	0.065	l/km
Yearly mileage	16000	16000	16000	16000	km
Yearly CO_2 emission	3.07	3.07	3.07	3.07	tonne
Yearly CO_2 Savings	0.09	0.09	0.09	0.09	tonne
Fuel price	0.21	0.3	0.4	0.6	€
CO_2 abatement costs	139	109	73	15	€/tonne

As presented in this table, the CO2-abatement costs for LRRT are 139 Euro per tonne of CO_2 for a 0.21 Euro per litre fuel price and approximately 15 Euro per tonne of CO_2 for a 0.61 Euro per litre fuel price for a 2.5 years tyre lifetime (40,000 km). The carbon prices in Europe's emissions trading system (ETS) in 2008 were in the range between 28.75 Euro per CO_2 tonne in July to 15.00 Euro in per CO_2 tonne in November[61]. The fact that tyres are replaced several times throughout the vehicle's lifetime makes it difficult to define who shoulders and how the additional costs of low rolling resistance technology. It can be expected that the initial costs will be covered by vehicle manufacturers because through the use of low rolling resistance tyres, the vehicle energy performance is improved and the vehicle gains competitive advantage.

[61] http://www.eex.com/en/

Table 15. CO_2 abatement cost estimation due to the implementation of TPMS

CO_2 abatement cost estimation for TPMS					
Case	Case 1	Case 2	Case 3	Case 4	
Additional manufacturer costs	50	50	50	50	€/vehicle
Investment costs	58	58	58	58	€/vehicle
CO_2 reduction	2.50%	2.50%	2.50%	2.50%	
CO_2 emission	192	192	192	192	gCO_2/km
Base fuel consumption	0.065	0.065	0.065	0.065	l/km
Yearly mileage	16000	16000	16000	16000	km
Yearly CO_2 emission	0.09	0.09	0.09	0.09	tonne
Yearly CO_2 Savings	0.09	0.09	0.09	0.09	tonne
Fuel price	0.21	0.3	0.4	0.6	€
CO_2 abatement costs	5	-20	-50	-98	€/tonne

For the TPMS solutions, the facts were quite different. Presently, these systems are mostly fitted at OEM level and their price is much lower than that of TLRR, while their benefit lasts for a lifetime and is strengthened by the reduction of tyre wear and safety improvements. It is estimated that CO_2-abatement costs of TPMS are negative in all scenarios except the 0.21 Euro per litre one. The gains of TPMS application are not reflected in the type approval test which means that vehicle manufacturers are not rewarded for introducing them. Therefore, the relatively low costs of TPMS should burden the vehicle buyer.

3. Noise reduction costs versus benefits analysis

This cost versus benefit analysis of noise reduction measures presents the results from FEHRL report[62], the results from TNO as presented by T&E[63], as well as the comments from ETRMA and ETRTO regarding both documents.

The report from FEHRL calculates the value of 1 dB(A) reduction in traffic noise, using an EU-wide figure for the valuation of noise reductions to each household per year. This report estimates the typical passenger car life at 16000 km, new vehicle registration for 2004 14.12 million non-commercial vehicles and that 35% of existing tyres in classes C1A to C1C already meet the proposed 2012 noise limit.

This report values the benefit of road noise reduction in the EU25 at 25 Euro per dB per household and per year. They have taken 204 million as the number of households, so the benefit per dB reduction per annum is 5500 million Euro per dB and per year. New requirements will result in 0.9 to 2.3 dB(A) noise reduction. This means that the actual benefit would be 4950 to 12650 million Euro per year. According to their calculations, over a ten year period, the expected benefit would be 48000 to 123000 million Euro.

When asked about expected costs for the industry, ETRTO estimated the figures to be 2000 million Euro per year, although in FEHRL's opinion those figures maybe overestimated.

[62] "Study SI2.408210 Tyre/Road Noise".
[63] "A brief cost - benefit analysis of tighter limits in the Tyre Noise Directive"

ETRTO comments on this report: The benefits calculated by FEHRL seem inordinately high. Benefits of this magnitude are rarely if ever seen in the real world, and the tyre industry thinks it is very unrealistic to justify the proposed noise limits by claiming such exaggerated gains for the public. The costs of implementing the proposed changes, only for the C1 category of tyres, are estimated at over 3000 million Euro for the European tyre industry.

This estimate takes into account the amount to be spent on research and development for redesigning 70% of industry tyre lines in a very short period of time, and the costs of making new moulds. Of course, even if the investment capacity was available, the technology is not presently available to guarantee that all tyres can be reduced to the levels proposed in the FEHRL report.

There is a second cost-benefit analysis made by TNO. This time the benefits are presented in three cases, quieter tyres, quieter roads and both. This is done in order to consider all possible options for tyre-road noise reduction. The results of the cost-benefit analysis are summarised in the table below.

Table 16. Cost-benefit analysis for tyre-road noise reduction, source TNO

		OPTION 1	OPTION 2				OPTION 3
		Quieter tyres for passenger cars	Quieter road surfaces at relevant locations				options 1 + 2
			Communal roads	Provintial + state roads	Motorway	Total	Total
Reduction of tyre-road noise emission [dB(A)]		2.3	2.3	4	5	2.7	4.2
Extra cost tyres	Total extra cost all vehicles per year (billion €)	8.6					8.6
Extra cost roads	Total cost all roads per year (billion €)		12.9	7.2	0.47	20.6	20.6
Combined costs (tyres + roads)	Total cost per year (billion €)						29.2
Benefits	Total benefit per year (billion €)	13.3				15.5	24.4
Cost / Benefit per dB(a)							
Extra cost tyres per dB(A)	Total extra cost all vehicles per year per dB(A) (billion €)	3.7					
Extra cost roads per dB(A)	Total cost all roads per year per dB(A) (billion €)		4.3	1.8	0.09	6.2	
Combined costs (tyres + roads) per dB(A)	Total cost per year per dB(A) (billion €)						6.9
Benefits per dB(A)	Total benefit per year per dB(A) (billion €)	5.8				5.8	5.8

In this case, the introduction of quieter road surfaces will strongly depend on the will and funding of national and local authorities, whereas quieter tyres will benefit the whole EU. The introduction of noise limits on surfaces should depend on each Member State, in order to take into account differences in consumer behaviour as well as weather conditions.

One of the conclusions in these reports is that the basic figure of 27 Euro benefit due to the noise reduction per dB(A) per household per year[64] does not account well for savings in health expenditure by Member States, which should be considered to be an additional benefit. In the wealthier EU Member States the figure per dB per household per year might well be double the figured used in this brief study.

Another interesting data, provided by the Dutch Ministry of Environment, claims that the financial benefit for their Government is estimated to be 300-400 million Euro, saved on noise barriers.

According to the Fact Sheet from the Dutch Ministry of Environment, the noise impact on health is significantly higher then the impact of passive smoking, and equivalent to the impact of particles. In Europe, road traffic is the dominant source. The nuisance of road traffic is concentrated along city main streets, regional roads and highways.

[64] HARMONOISE project: http://www.harmonoise.org/

4. Conclusions

1. Regarding tyre pressure monitoring systems (TPMS), they are currently on the market and have proven their efficiency.

2. Mandatory implementation of accurate TPMS will help increase safety while decreasing CO_2 and noise emissions due to underinflation.

3. TPMS final cost increase for customers is estimated at 100 Euro. The CO_2 and noise reduction benefit and especially the safety benefit exceed the implementation costs.

4. Setting tyre low rolling resistance requirements will have a positive impact on decreasing CO_2 emissions.

5. In order to ensure driver safety a complementary wet grip requirement should also be set.

6. There is no doubt that rolling noise has a negative impact on health. Tyre noise requirements have to be set in order to decrease traffic noise emissions.

7. Nevertheless, the European Commission noise requirements for tyres seem to be too high in order to ensure safety, in relation to tyre manufacturers' current state-of-the art tyre models.

Chapter six – Conclusions of the Study

In this chapter, the conclusions of the study are presented. The conclusions answer the questions raised by the Committee on Internal Market and Consumer Protection regarding the European Commission's impact assessment in the proposal for a Regulation concerning type approval requirements for the general safety of motor vehicles COM(2008)316.

Complementing the answers herewith presented, main findings are highlighted at the end of each chapter.

Question 1 - Are the Tyre Low Rolling Resistance, Tyre Wet Grip and TPMS proposals adapted to the objectives?

1.1. The impact of Tyre Low Rolling Resistance on safety, and the trade-offs between Tyre Wet Grip, Tyre Longevity and Tyre Low Rolling Resistance:

There is a relationship between low rolling resistance, wet grip, durability and noise performance of tyres. Apparently, the expected thresholds for tyres presented in the type approval requirements for the general safety of motor vehicles in rolling resistance and in wet grip do not draw a clear conclusion on how they affect road safety. There might be a decrease in wet grip performance of tyres if too stringent limits are set for rolling resistance.

1.2. How pertinent is the Commission's policy of promoting Tyre Low Rolling Resistance and introducing mandatory TPMS (which combined, are expected to provide 7g $C0_2$ gains) versus alternative policy instruments or eco innovations (e.g. on air conditioning)?

It seems clear that the use of tyres with low rolling resistance will improve the energy performance of a vehicle and thus decrease its CO_2 emissions. The improvement depends on many different factors such as the tyre and the vehicle, but also the weather conditions, the use of the vehicle, the quality of the street and maintenance. Introducing direct TPMS as a mandatory device will support CO_2 emissions reductions. In our opinion the Commission's policy is very pertinent.

1.3. What are the expected costs in comparison to the environmental benefits?

When a cost versus benefit analysis is performed, especially when it involves so many variables (manufacturer costs, vehicle estimations, large numbers of countries, roads, drivers, etc), many complex assumptions are made. In such cases cost benefit results should be examined carefully.

Although it is difficult to present accurate figures, in our opinion the environmental benefits including the health impact exceed the expected costs. The implementation of direct TPMS and the low rolling resistance requirements complemented by wet grip requirements will have a positive environmental impact while ensuring driver safety.

1.4. Are there other more effective policy instruments to achieve the targeted reduction of $C0_2$ emissions?

To the best of our knowledge, there are not any more efficient policy instruments to achieve the targeted reductions than the ones proposed. Nevertheless, there are other complementary measures that in an integrated approach could achieve further reductions in CO_2 emissions.

This integrated approach should include currently existing and available technologies (more efficient air-conditioners, low viscosity lubricants, etc.), eco-driving (automatic engine shut-offs at standstill) and actions to promote research and improvement on road surfaces.

1.5. Although Tyre Wet Grip requirements compensate for the introduction of Tyre Low Rolling Resistance requirements, these Wet Grip limits depend on the appropriateness of the Low Rolling Resistance limits. Consequently, are the Tyre Wet Grip limits justified and sufficient?

Tyre wet grip limits are justified in order to ensure tyre performance on wet surfaces. Although they might not be sufficient, a tyre is a complex system, and there are other characteristics as handling and wear performances that should be considered.

1.6. Has the Commission given due consideration to the impact of environmental objectives on road safety including aquaplaning and winter road conditions for Wet Grip?

In our opinion, the Commission has centred its consideration on the impact of environmental objectives on road safety only to wet grip. As shown in the trade off charts (see Figure 5), tyre performance is a trade-off among several characteristics, setting wet grip requirements only might not be sufficient.

1.7. How can we achieve a balance of these techniques to meet the safety and $C0_2$ reduction objectives of the proposal?

Currently, tyre manufacturers include silica in all their products in order to decrease rolling resistance and improve the energy efficiency of vehicles. In order to fully develop safety products as well as to implement those tyres in their production lines they will require a 36-month time frame. In our opinion, a period of 36 months between changes of requirement should be granted in order to meet the safety and CO_2 reductions objectives of the proposal.

1.8. Do the Commission's proposals for these requirements effectively safeguard against a negative impact on safety, particularly from low-cost tyre brands/products with low performance in key safety criteria?

Tyres manufactured in Europe are controlled and quality proven. Low-cost tyres imported from Asian markets, especially from China, Korea and India, might result in a negative impact on safety. Current legislation depends on each Member State and the Commission’s proposals do not set enough controls to ensure quality of all tyre products on the EU market.

Question 2 - How relevant is the tabled 120 g $C0_2$ target as opposed to already aligning the proposa1 on the forthcoming 95 g $C0_2$ target proposed in the parallel ENVI Committee procedure on the Regulation on setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce $C0_2$ emissions from light-duty vehicles (COM(2007)0856-2007/0297(COD)), Rapporteur, Guido Sacconi?

2.1. Can a clear link be drawn between this proposal and the Council (Sarkozy/Merkel) draft compromise on eco-innovations of the performance standards Regulation?

From our point of view a clear link can be drawn between this proposal and the Council draft compromise on eco-innovation of the performance standards Regulation.

2.2. Is it appropriate to integrate or consolidate this proposal with the performance standards Regulation into one single instrument?

It might be appropriate to integrate the proposal with the performance standards Regulation.

Question 3 - In view of achieving clear and effective legislation, is there a basis for simplifying the implementation deadlines and how could this be accomplished?

CIDAUT believes there is a basis for simplifying the implementation deadlines. The new requirements can be consolidated by means grouping wet grip, the first rolling resistance and noise requirements at one time-point, and the second rolling resistance requirements at a second date.

Question 4 - What is the basis for Noise reduction featuring in the proposal?

4.1. Given the increase in the number of low-noise vehicles, has the Commission given due consideration to the overall level of tyre/road noise for low noise vehicles in different traffic situations where vehicles and pedestrians are in close contact (e.g. inner city traffic at low speed)?

In our opinion the Commission has given due consideration to different traffic situations. Although no specific consideration appears to have been given to pedestrians and cyclists avoiding accidents because, in some occasions, they hear the noise a vehicle emits through its tyres (and not the engines) in lower speed traffic conditions in inner cities.

4.2. Are there other effective policy alternatives such as the use of noise-optimised road surfaces in noise critical areas or meeting relevant ISO standards for road surfaces?

CIDAUT's opinion is that there are other policy alternatives, research and development activities as well as new requirements for road surfaces which should be considered. The use of noise-optimised road surfaces as a complementary measure would achieve better noise reductions. The amount of noise-reduction and the effectiveness of those measures are not clearly valued.

4.3. How appropriate might it be to isolate the noise reduction objectives of this proposal, and give due consideration to them in a separate legal instrument along with other noise-pollution transport-related measures?

CIDAUT believes noise emissions have a clear negative impact on health. Although further research has to be done in order to achieve better noise reduction in populated areas, we believe noise reduction objectives should stay in this proposal.

Question 5 - Would the introduction of consumer eco-label indicating information on rolling resistance, wet grip and noise be beneficial to the consumer, and allow him to make a better informed choice?

The introduction of a consumer eco-label should have a positive impact and will allow consumers to make better informed choices, although tyre labelling could also perversely negatively affect the broad objective of CO_2 emissions reductions since overall consumer behaviour tends to point to the fact that the majority of consumers are likely to value better wet grip and durability over lower fuel consumption, by valuing the short term (purchase price) and potential longer term (tyre longevity) savings made on cheaper tyres with higher rolling resistance. The impact is also expected to be very different between Member States depending on their established patterns of consumer behaviour.

ANNEXES

Annex 1. Full list of References

- VisiTyre Batteryless TPMS: http://www.etv.com.au/

- TÜV Automotive GmbH. Report on "Motor Vehicle Tyres and Related Aspects" Commissioned by the European Commission, Enterprise Directorate General.

- "Review and analysis of the reduction potential and costs of technological and other measures to reduce CO_2-emissions from passenger cars". Prepared by TNO Science and Industry, IEEP – Institute for European Environmental Policy and LAT of Aristotle University of Technology.

- "Integrated assessment of noise reduction measures in the road transport sector". Presented by: TRL Limited and RWTÜV Fahrzeug GmbH.

- "Study SI2.408210 Tyre/Road Noise". Presented by: FEHRL - Forum of European National Highway Research Laboratories: BASt – German Federal Highway Research Institute, TRL – transport Research Laboratory, TÜV Nord and VTI - Swedish National Road and Transport Research Institute.

- "Report PPR077, Tyre/Road Noise – Assessment of the existing and proposed tyre noise limits". Presented by TRL Limited.

- "European tyre industry comments on FEHRL conclusions in tyre-road noise study SI 2.408210". Presented by ETRTO – European Tyre and Rim Technical Organization.

- "Tyre Industry notes on tyre rolling noise and safety performance trade-off" based on TÜV test-report 76230729 data. Presented by ETRMA – European Tyre and Rubber Manufacturers' Association.

- "European Tyre Industry proposal for Tyre Performances Integrated Approach (TPIA)". Presented by ETRMA – European Tyre and Rubber Manufacturers' Association.

- "Quieter tyres: a cost effective way to protect public health" and the position paper on "Environmental standards for motor vehicle tyres". Presented by T&E – European Federation for Transport and Environment.

- "Fact sheet tyre noise". Presented by the Dutch Ministry of Environment.

- "Reduction potential of road traffic noise". Presented by IVA – Royal Swedish Academy of Engineering Sciences.

- "Traffic noise reduction in Europe: Health effects, social costs and technical and policy options to reduce road and rail traffic noise". Presented by CE Delft.

- "Consumer Label for Tyres in Europe". Presented by VTI - Swedish National Road and Transport Research Institute and sponsored by European Federation for Transport and Environment (T&E).

- "A brief cost - benefit analysis of tighter limits in the Tyre Noise Directive" Presented by TNO - Science & Industry.

- "Noise Trade-Offs: A real example of how tyres are designed" Presented by Michelin

- US DOT NHTSA Docket No 2005-20586

- Federal Statistical Office Germany (Statisches Bundesamt Deutschland): Accident reports by police at accident location

- DEKRA. Fachschrift Nr. 55/01
- Assogomma/Federpneus: "Campagna Sociale Pneumatici Sotto Controllo"
- Dirección General de Tráfico. Observatorio Nacional de Seguridad Vial. Anuario Estadístico de Accidentes 2006.
- National Center for Statistics and Analysis (NCSA). Fatality Analysis Reporting System
- Institute for Traffic Accident Research and Data Analysis (ITARDA), Japan.
- CIDAUT report on TPMS prepared for Fitsa
- BERU AG. http://www.beru.com
- Bundesverband Reinfenhandel http://www.bundesverband-reifenhandel.de
- GRRF TPMS Task Force Conslusions Report, 16th June 2008.
- Hibbeler, R.C. (2007). Engineering Mechanics: Statics & Dynamics, Eleventh, Pearson, Prentice Hall, 441-442.
- Peck, William Guy (1859). Elements of Mechanics: For the Use of Colleges, Academies, and High Schools. A.S. Barnes & Burr: New York, 135. Retrieved on 2007-10-09.
- "Tires and Passenger Vehicle Fuel Economy: Informing Consumers, Improving Performance -- Special Report 286. National Academy of Sciences, Transportation Research Board, 2006". Retrieved on 2007-08-11.
- http://www.tyres-online.co.uk/technology/silica.asp
- "Schwalbe Tires: Rolling Resistance".
- "Greenspeed test results". Retrieved on 2007-10-27.
- Williams, John A. Engineering Tribology. New York : Cambridge University Press (2005).
- C. Michael Hogan, Analysis of Highway Noise, Journal of Soil, Air and Water Pollution, Springer Verlag Publishers, Netherlands, Volume 2, Number 3 / September, 1973.
- Gwidon W. Stachowiak, Andrew William Batchelor, Engineering Tribology, Elsevier Publisher, 750 pages (2000) ISBN 0750673044.
- http://www.afdc.energy.gov/afdc/vehicles/fuel_economy_tires_light.html
- Low Rolling Resistance Tires (Website). Energy Efficiency and Renewable Energy, U.S. Department of Energy. Retrieved on 2007-08-11.
- California State Fuel-Efficient Tire Report: Volume I California Energy Commission, July 2003. Retrieved on 2007-08-11.
- Tire and Fuel Efficiency California Energy Commission, June 2006. Retrieved on 2007-08-11.
- Green Seal Report
- California has low-resistance tire laws - AutoblogGreen
- Daws, J.W.; Larson, R.E. & Brown, J.C. (March 2007), "The Impact of Plus-Sized Wheel/Tire Fitment on Vehicle Stability", Tire Science and Technology 35(1): 23–40, doi:10.2346/1.2698541, http://scitation.aip.org/getabs/servlet/GetabsServlet?prog=normal&id=TSTCAU000035000001000023000001&idtype=cvips&gifs=yes . Retrieved on 28 May 2008

- B. N. J. Persson, U. Tartaglino, O. Albohr And E. Tosatti (2004). "Sealing is at the origin of rubber slipping on wet roads". Nature Materials 3 (7 November): 882–885. doi:10.1038/nmat1255.
- German Federal Environmental Agency (Umweltbundesamt - UBA) “CO_2 – Minderung im Verkehr – Sachstandsbericht, September 2003.
- UNECE GRRF TPMS. “Draft Cost/Benefit analysis TPMS for M1 vehicles”. Contributors: Schrader Electronics, Conti-VDO, Knorr-Bremse, EnTire Solutions LLC and Beru.
- EU Directive 2001/43/EC of the European Parliament and of the Council of 27 june 2001 amending Council Directive 92/23/EEC relating to tyres for motor vehicles and their trailers and to their fitting, Official Journal of the European Communities L211 pp. 25-46, Brussels, 4 August 2001.
- Proposal for a Regulation of the European Parliament and of the Council concerning type-approval requirements for the general safety of motor vehicles, European Commission, Brussels, March 2008.
- Tyre road noise – Volume 1, Final Report S12 408210 for the European Commision – DG Enterprise, FEHRL, Brussels, 2006.
- WG HSEA, Valuation of Noise, EU working group on Health and Socio-economic Aspects, December 2003.
- Position Paper on the Effectiveness of Noise Measures, WG HSEA, Brussels, February 2005.
- P. van Beek, EU Road Traffic Noise Policy in the Past, Present and Future, TNO report 030119, Delft, July 2004
- EffNoise - Service contract relating to the effectiveness of noise mitigation measures Stage 1 Report, Konsalt /Wölfel / Lärmkontor, Report for DG Environment, July 2003.
- Cost-effectiveness of noise measures, Final report for Netherlands Ministry of Housing, Spatial Planning and the Environment, KPMG, February 2005.
- Stille Vooruitgang - Rendement van het Innovatie Programma Geluid, (Silent Progress – Output of the Dutch Noise Innovation Programme) Rebel Group Advisory, December 2007
- “Can you hear us? Why it is finally time for the EU to tackle the problem of noise from road and rail traffic”, T&E,Brussels 2008.
- J. Jabben: Baten van Geluidmaatregelen, Een inventarisatie voor weg- en railverkeer in Nederland, RIVM report no. RIVM 680300002, Bilthoven 2007.

Annex 2. List of major tyre pressure monitoring system (TPMS) manufacturers

- Stemco's BatRF http://www.batrf.com
- Advantage PressurePro LLC http://www.advantagepressurepro.com
- SmarTyre Systems http://www.smartire.com/company
- Siemens VDO, http://www.vdo.es/products_solutions/cars/replacement-parts/tpms/
- Beru AG, http://www.beru.com/english/produkte/tss.php
- Knorr-Bremse, http://www.knorr-bremse.com/html/com/index_com_en.php
- TRW Automotive, http://www.trw.com/productsandtechnologies
- ETV Corporation PL (VisiTyre) http://www.etv.com.au/GoDelta.htm
- Pacific Industries http://www.pacific-ind.com/eng/product/flash_E.swf
- Conti/Teves http://www.conti-online.com/generator/www/de/en/cas/cas/themes/products/electronic_brake_and_safety_systems/tire_pressure_monitoring_systems/tpms_210205_en.html
- WABCO http://www.wabco-auto.com/
- Schrader-Bridgeport http://www.schrader.co.uk
- EnTyre Solutions LLC http://www.entire-solution.com/English/company.htm
- NIRA Dynamics AB (Tire Pressure Indicator) http://www.niradynamics.se
- Transense Technologies plc http://www.transense.co.uk/technologies/applications/tpms/
- IQ-mobil GmbH (RDKS) http://www.iqmobil.com/index.php?m=RDKS&language=en
- APRI s.r.o. http://www.apri.cz/index.php?page=produkty&typ=tpms
- STE Engineering http://www.stecom.com/

Annex 3. Relevant stakeholders' commentaries on the tender questions

During this study, CIDAUT carried out a survey among stakeholders most likely to be affected by type approval requirements. Their answers were carefully analyzed. The most relevant commentaries to the survey are presented next:

Question 1 - Are the Tyre Low Rolling Resistance, Tyre Wet Grip and TPMS proposals adapted to the objectives?

1.1. The impact of Tyre Low Rolling Resistance on safety, and the trade-offs between Tyre Wet Grip, Tyre Longevity and Tyre Low Rolling Resistance:

According to TÜV Automotive and CERM, the Dutch Ministry of Environment and T&E it is not possible to identify a common pattern either by tyre segment or across different segments. Tyres which are very good in wet braking can also be very good in rolling resistance. Tyres which are very good in wear performance are also good in rolling resistance.

Apparently, the expected thresholds for tyres presented in the type approval requirements for the general safety of motor vehicles in rolling resistance and in wet grip do not draw a clear conclusion on how they affect road safety.

On the other hand, in ETRMA and ETRTO opinion the trade-off charts shown in chapter two (Figure 5) clearly demonstrate that if a tyre is optimized for rolling resistance, wet and dry grip will be significantly reduced and if a tyre is optimized for noise performance only, aquaplaning and wet grip will be degraded.

1.2. How pertinent is the Commission's policy of promoting Tyre Low Rolling Resistance and introducing mandatory TPMS (which combined, are expected to provide 7g C02 gains) versus alternative policy instruments or eco innovations (e.g. on air conditioning)?

Most of the stakeholders think the Commission's policy referred above is pertinent, although the integration with other eco-innovations (e.g. more efficient air conditioners, engine friction reduction technologies) could achieve a better reduction.

It seems clear that the use of tyres with low rolling resistance can improve the energy performance of the vehicle and CO_2 emissions. The improvement depends on many different factors such as the tyre and the vehicle, but also the weather conditions, the use of the vehicle, the quality of the street and maintenance.

It is estimated that the use of low rolling resistance tyres decreases type approval measurement fuel consumption by approximately 2%, whereas under real world driving conditions this reduction is higher, estimated at approximately 3%. There are small differences between T&E, TÜV Automotive, TNO, IEEP and LAT on one side, and ETRMA and ETRTO estimations on the other.

Regarding the introduction mandatory TPMS, almost all stakeholders agree they can achieve 2.5% CO_2 reductions. Tyre industry supports mandatory introduction of accurate TPMS.

1.3. What are the expected costs in comparison to the environmental benefits?

When a cost benefit analysis is performed, especially when it involves so many variables (manufacturers cost, vehicle estimations, large amount of countries, roads, drivers, etc), a lot of complicated assumptions are made. In such cases cost benefit results should be examined carefully.

In this study, several costs versus benefits analysis are shown. Depending on the source different results are presented:

- According to TNO, IEEP and LAT report the expected fuel efficiency due to combining TPMS and TLRR is 4-6%, while the cost increase for both measures is around 100-110 Euro in the retail price.
- ETRTO estimates the cost of implementing the proposed changes, only for the C1 tyre category, to be over 3000 million Euros for the European tyre industry. This estimation takes into account the amount to be spent in R&D for redesigning 70% of tyre lines in a very short period of time.

Regarding the cost-benefit analysis of noise requirements, the differences between sources consulted are even larger. In this case there are also health benefits, although it was not possible to find a cost analysis of the health impact.

- According to TNO Science & Industry report, the monetised benefits for introducing stricter tyre noise limits (13300 million Euro) well outweigh the costs (8600 million Euro). The monetised benefits of road resurfacing (15500 million Euro) are less than the costs (20600 million Euro). The benefits of quieter roads take effect immediately after construction. The benefits of quieter tyres may take about 3.5 years to reach the full effect. The application of both quieter tyres and quieter road surfaces results in additional noise reduction.
- The Dutch Ministry of Environment, claims that the financial benefit for their Government is estimated to be a 300-400 million Euro, saved on noise barriers.

1.4. Are there other more effective policy instruments to achieve the targeted reduction of $C0_2$ emissions?

Opinions to these questions are quite different.

- T&E, Environmental Protection UK and FNAUT think the proposed policy instruments are the only effective instruments which address tyres, whose role quasi substantial can cannot be overlooked. The SFT also thinks there are no more effective policy instruments.
- On the other hand, ACEA thinks that there is a more cost-efficient approach; they think an integrated approach including technology, prescriptive legislation, eco-driving, taxation, etc.
- UBA and Naturskyddsföreningen also think that there are other more effective policies, for instance regulation of speed limits, but they support low rolling resistance tyres as an efficient instrument.
- Bridgestone believes there are other options, for example Directive 2005/32/EC on eco-design of Energy-using Products (EuP) allowing wider eco-design flexibility by producers for complex products; there can be more effective provisions for allowing safety and energy efficiency of tyres.
- VTI thinks that tyre labelling can also be very effective to achieve targeted CO_2 reductions.
- TNO, IEEP and LAT report on CO_2-emissions from passenger cars[38] analyses several options for CO_2 reduction, such are technical measurements, efficient driving and alternative fuels.

1.5. Although Tyre Wet Grip requirements compensate for the introduction of Tyre Low Rolling Resistance requirements, these Wet Grip limits depend on the appropriateness of the Low Rolling Resistance limits. Consequently, are the Tyre Wet Grip limits justified and sufficient?

T&E, the Environmental Protection UK, SFT, Deutsche Umwelthilfe, VTI and VCD think tyre wet grip limits are not sufficient.

While FNAUT, Bridgestone, ETRMA, ETRTO and Naturskyddsföreningen think they are sufficient. Tyre Manufacturer Industry claim that designing tyres only responding to 3 performance characteristics is not possible without compromising other important performances.

1.6. Has the Commission given due consideration to the impact of environmental objectives on road safety including aquaplaning and winter road conditions for Wet Grip?

All consulted stakeholders think the commission has given due consideration except VTI and the tyre manufacturer industry.

ETRMA claims that with the proposed EC regulation limits, there are doubts that safety will not be compromised. In their opinion it is demonstrated clearly in the trade off charts (see Figure 5) that if optimizing a tyre for rolling resistance, wet and dry grip will be significantly reduced and if optimizing a tyre for noise, aquaplaning and wet grip will be degraded.

1.7. How can we achieve a balance of these techniques to meet the safety and $C0_2$ reduction objectives of the proposal?

All involved stakeholders think the proposal objectives can be achieved, although they have different recommendations: Tyre Industry proposed a change in noise requirements in order to guarantee the safety while other organizations, such as T&E, believe this balance to be easily achievable.

1.8. Do the Commission's proposals for these requirements effectively safeguard against a negative impact on safety, particularly from low-cost tyre brands/products with low performance in key safety criteria?

In addition to previous commentaries regarding the European tyre industry capability to meet proposed standards while maintaining safety levels, most stakeholders are concerned about quality safeguards against low-cost tyres. ETRMA is very concerned about tyres exportation from China, Korea and India; in its opinion the quality levels of their products and the existing normative are not sufficient to guarantee the performance of these products.

Question 2 - How relevant is the tabled 120 g $C0_2$ target as opposed to already aligning the proposa1 on the forthcoming 95 g $C0_2$ target proposed in the parallel ENVI Committee procedure on the Regulation on setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles (COM(2007)0856-2007/0297(COD)), Rapporteur, Guido Sacconi?

Most stakeholders consulted believe it is appropriate.

2.1. Can a clear link be drawn between this proposal and the Council (Sarkozy/Merkel) draft compromise on eco-innovations of the performance standards Regulation?

Most stakeholders do not think a clear link can be drawn. Only ACEA, ExxonMobil and Naturskyddsföreningen believe a clear link could be drawn.

2.2. Is it appropriate to integrate or consolidate this proposal with the performance standards Regulation into one single instrument?

Only VTI and ExxonMobil think it is appropriate to integrate the proposal with the performance standards Regulation.

Question 3 - In view of achieving clear and effective legislation, is there a basis for simplifying the implementation deadlines and how could this be accomplished?

- VTI, ExxonMobile, ACEA and Tyre Industry believe that a simplification of implementation deadlines is possible and necessary.
- ACEA proposed to reconsider a simplification in the procedure and implementation dates while double checking the cost-effectiveness of measures and ensuring technology neutrality.
- ETRMA considers that two simple mechanisms in combination would enable the desired transition to the new technical requirements within the same overall timeframe. They propose to apply the "date of manufacture" as the reference point to identify which tyres must meet the specified new requirements at any given time. They also proposed to consolidate the entry into effect of wet grip, stage 1, rolling resistance and noise requirements at one time-point (2016), and the stage 2, rolling resistance requirements in 2020.
- UBA, the Dutch Ministry of Environment, VTI, Environmental Protection UK, T&E and IVA consider traffic noise problem to be a health issue. They believe it is more than urgent to introduce tyre noise limits and that no delay should be allowed. In fact, some of them proposed to bring forward the deadline.

Question 4 - What is the basis for Noise reduction featuring in the proposal?

4.1. Given the increase in the number of low-noise vehicles, has the Commission given due consideration to the overall level of tyre/road noise for low noise vehicles in different traffic situations where vehicles and pedestrians are in close contact (e.g. inner city traffic at low speed)?

Most stakeholder consulted, including ACEA, believe the Commission has given due consideration to the overall level of tyre/road noise in different traffic situations.

4.2. Are there other effective policy alternatives such as the use of noise-optimised road surfaces in noise critical areas or meeting relevant ISO standards for road surfaces?

IVA, SFT, FNAUT, ACEA, ERTMA and ExxonMobile consider that the use of noise-optimised road surfaces is an effective policy, not as an alternative but as a complementary measure.

Almost every stakeholder contacted believes that both measures will achieve better results, although they disagree in the amount of noise-reduction and the effectiveness of those measures.

4.3. How appropriate might it be to isolate the noise reduction objectives of this proposal, and give due consideration to them in a separate legal instrument along with other noise-pollution transport-related measures?

ACEA is the only stakeholder contacted which believes that isolation of noise reduction objectives would be appropriate.

Question 5 - **Would the introduction of consumer eco-label indicating information on rolling resistance, wet grip and noise be beneficial to the consumer, and allow him to make a better informed choice?**

All stakeholders consider the introduction of a consumer eco-label to be potentially beneficial to the consumer and possibly it will allow making a better informed choice. VTI report on consumer label presents several interesting results and conclusions.

Annex 4. List of stakeholders contacted

- Bridgestone NV/SA
- Continental AG
- Deutsche Umwelthilfe e.V.
- Dutch Ministry of Environment
- Environmental Protection UK
- European Automobile Manufacturers Association (ACEA)
- European Transport Safety Council (ETSC)
- European Tyre and Rubber Manufacturers' Association (ETRMA)
- ExxonMobil Chemical Company
- Federation Nationale des Associations d'Usagers des Transports France (FNAUT)
- Freight Transport Association (FTA)
- German Federal Environment Agency (UBA)
- Norwegian Pollution Control Authority (SFT)
- Royal Swedish Academy for Technical Sciences (IVA)
- Schrader Electronics Ltd
- Swedish National Road and Transport Research Institute (VTI)
- Swedish Society for Nature Conservation (Naturskyddsföreningen)
- The European Federation for Transport and Environment (T&E)
- Torfaen County Borough Council
- Transport Club Germany (VCD - Verkehrsclub Deutschland)
- Working Group Noise EUROCITIES