



TPMS System Quick Technical Review

International Energy Agency

15th - 16th Nov 2005

Kevin Stock – BDM Northern Europe



TPMS – Contents






















Contents

- 1/ Typical vehicle set-up re Tire Pressures.
- 2/ Benefits of a TPMS system
- 3/ TPMS Market Details
- 4/ TPMS System Types
- 5/ TPMS Requirements for EU and US markets
- 6/ TPMS Displays Trends among OEMs
- 7/ Typical System Set-Up
- 8/ TREAD Act details

1/ Typical vehicle set-up re Tire Pressures

Example of a European Tire Placard Pressure plate.

LUFTDRUCK		PRESSURE		PRESSION		PRESIÓN	
für kalte Reifen		for cold tires		des pneus froids		de inflado	
Geschwindigkeit Speed Vitesse Velocidad							
				bar	psi	bar	psi
205/60 R16	bis up to 210 km/h			2,1	30	2,1	30
	hasta 130 mph			2,5	36	2,8	41
	über over 210 km/h			2,2	32	2,2	32
	plus de más de 130 mph			2,6	38	3,0	44
225/55 R16 245/45 R17	bis up to 210 km/h			2,1	30	2,1	30
	hasta 130 mph			2,2	32	2,5	36
	über over 210 km/h			2,2	32	2,2	32
	plus de más de 130 mph			2,5	36	2,9	42
Warme Reifen: Warm tires up to:				Pneus échauffés jusqu'à: Neumáticos calientes hasta:			

The tire pressures alter with load

The tire pressures alter with speed

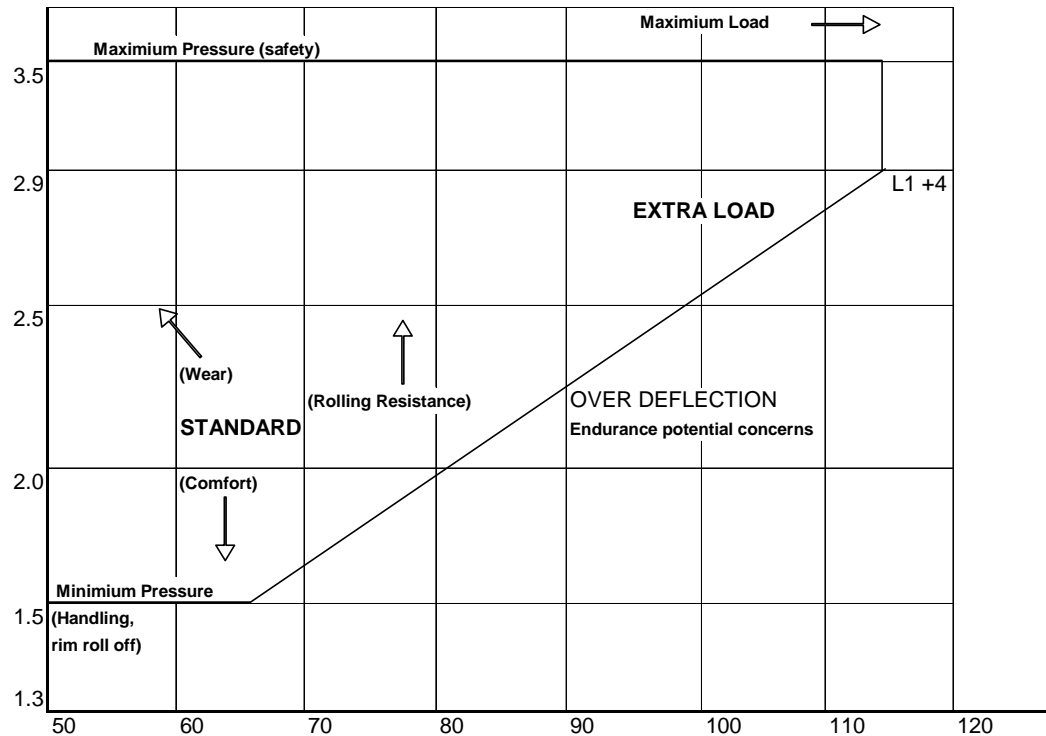


1/ Typical vehicle set-up re Tire Pressures PC



The reasons for setting tire pressures per axle are a combination of load carrying requirements and ride comfort. Source: ETRTO

A TYRE IS CAPABLE OF CARRYING A LOAD THANKS TO ITS INTERNAL AIR PRESURE



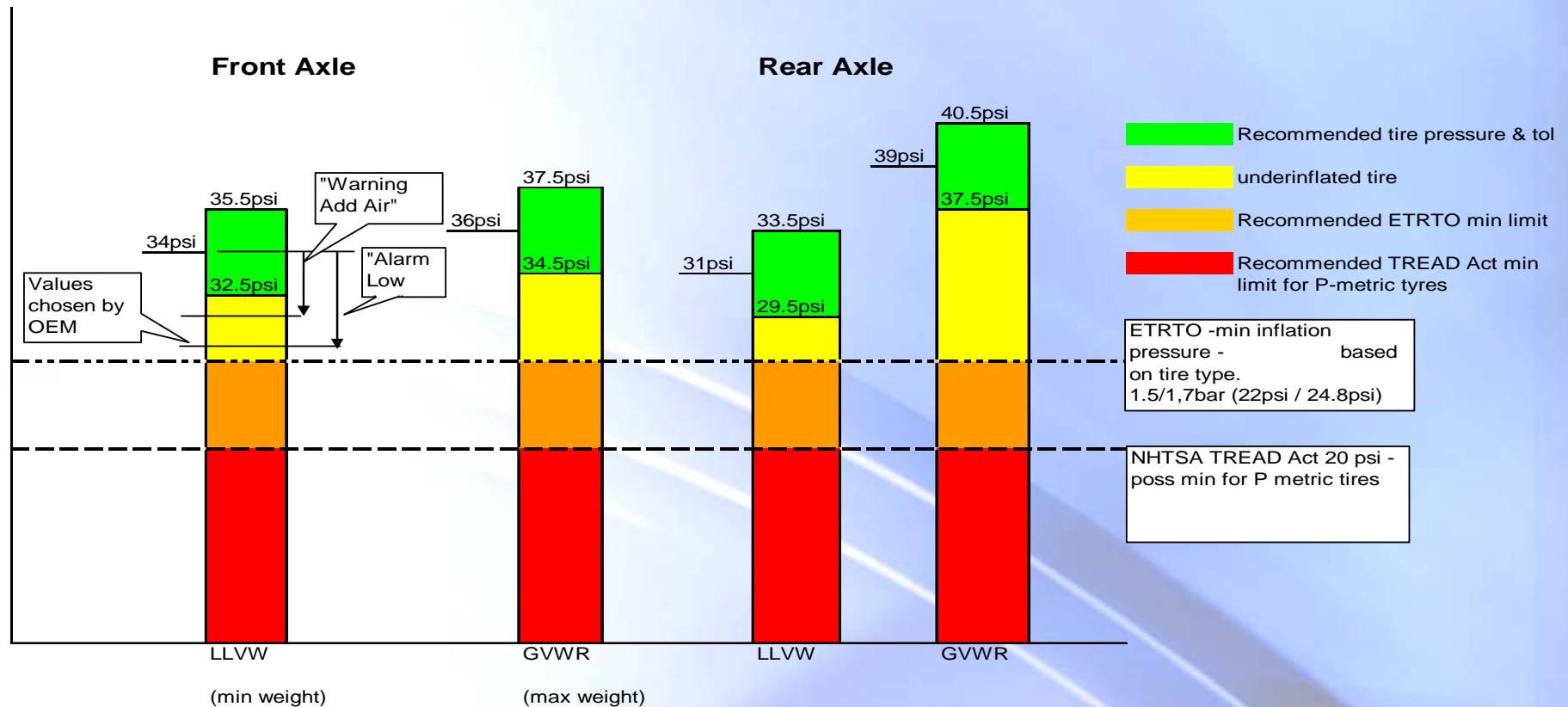
Load, Pressure and Deflection greatly influence Tyre performances

Extract from European Tyre and Rim - Technical Organisation - Engineering Design Formator - 2002

2/ Benefits of a TPMS system

• Air pressure is required to allow tire to support the weight of the vehicle. There is a minimum pressure for each vehicle based on tire type and size and differing load in the vehicle. In some cases tire pressure also need to be altered with speed.

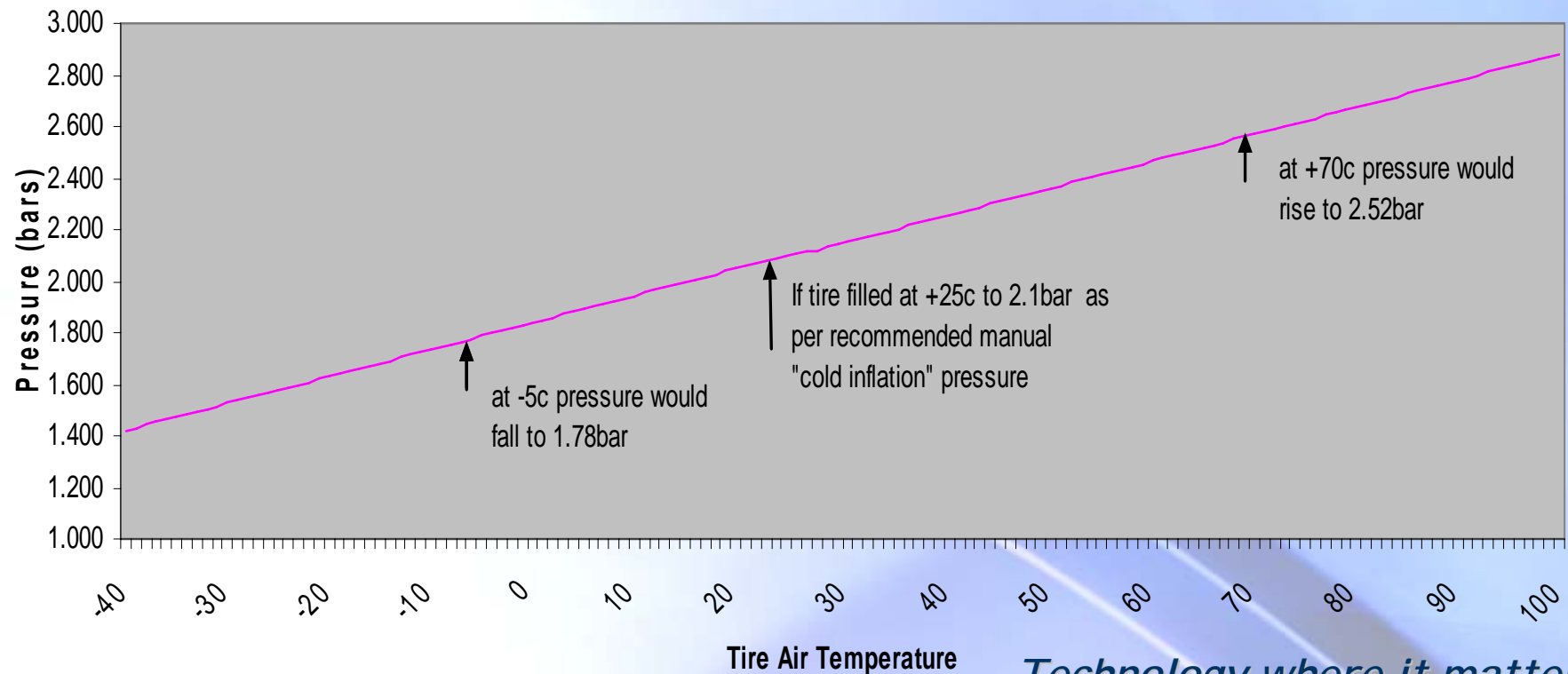
Typical European Built Vehicle - Tire Pressures vs. Load



2/ Advantages of a TPMS system

- Tire pressures alters naturally with ambient air temperature. Pressure also increases when the vehicle is driven due to the flexing of the tire's sidewalls and tread as a result of vehicle load and engine input as this generates heat.
- A tpms system always monitors pressure regardless of temperature and warns if too low.

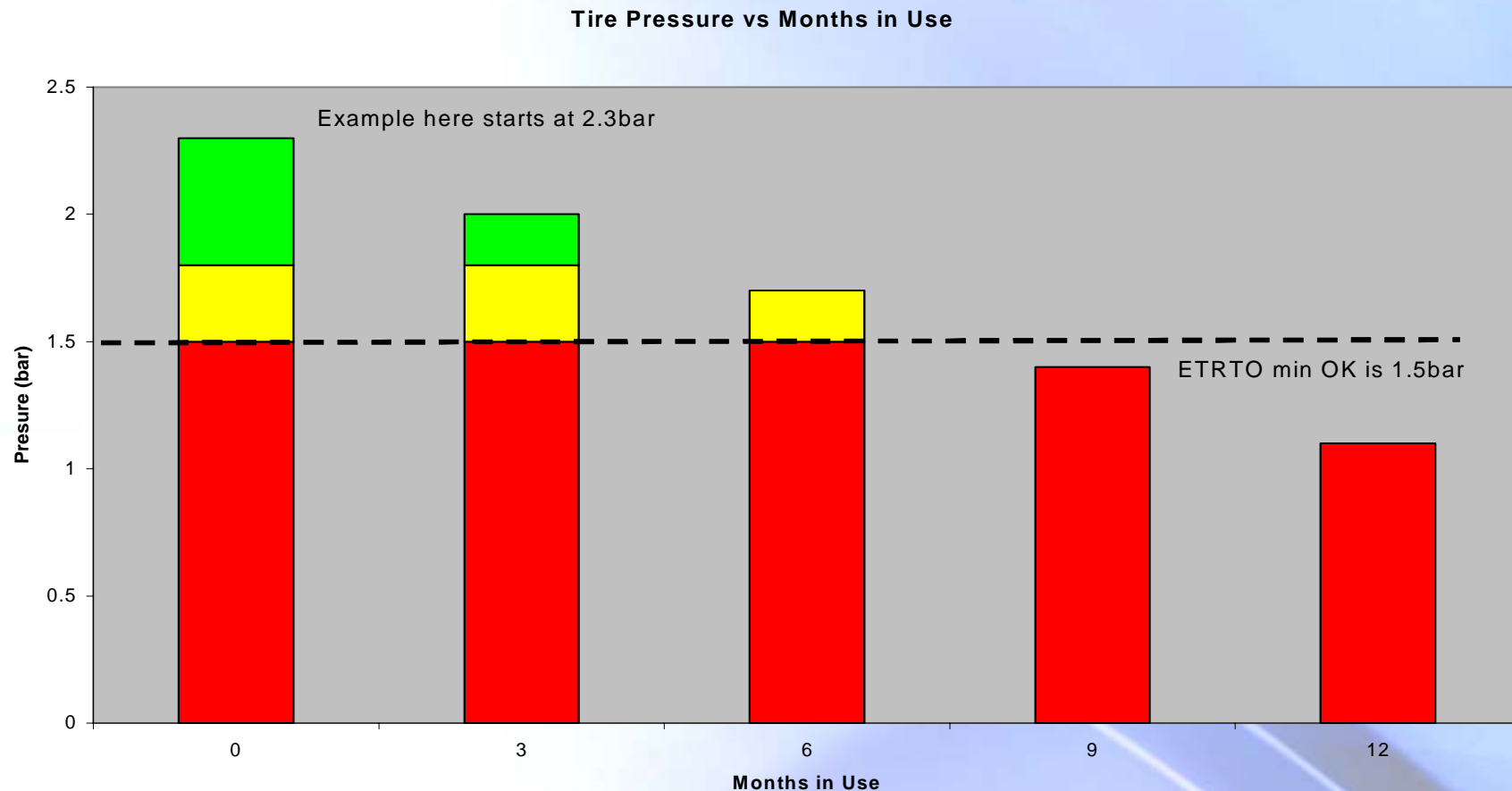
Pressure Vs Temperature





2/ Advantages of a TPMS system

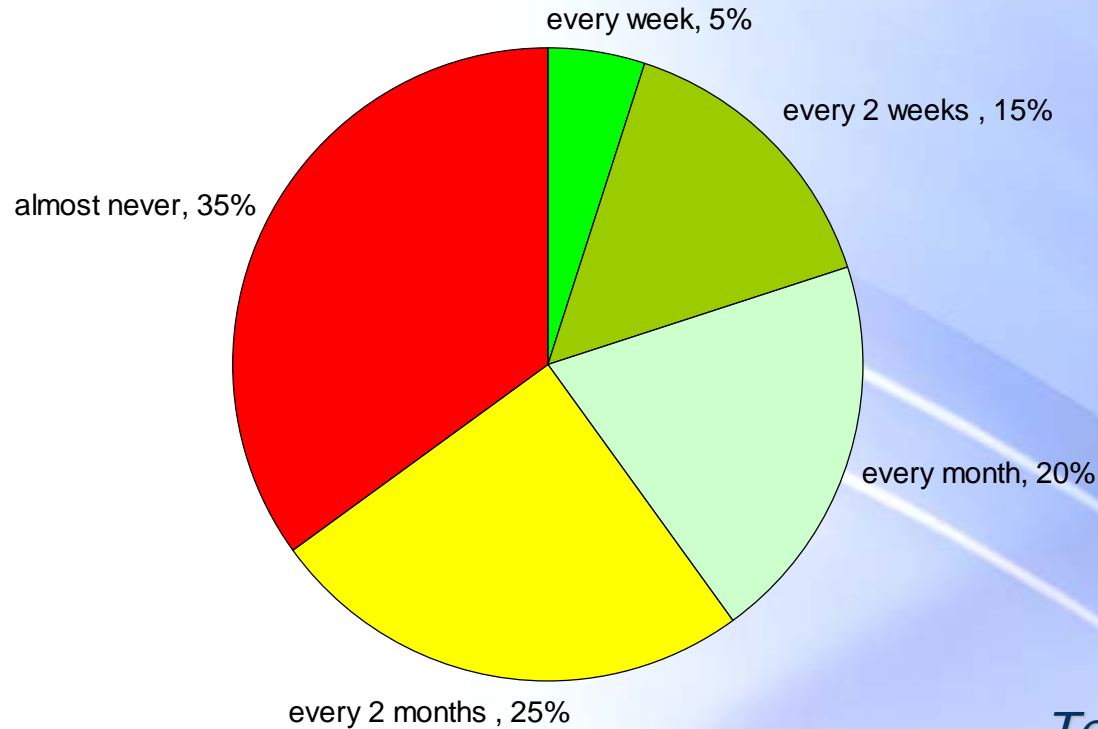
- PC Wheel assemblies loose air pressure normally at @ 0.2bar / 3 months (0.9psi / month) due to several factors but mainly due the simple fact a tire / wheel assembly is a permeable device.
- A tpms system always moniters tire pressure and warns when too low.
-source Pirelli



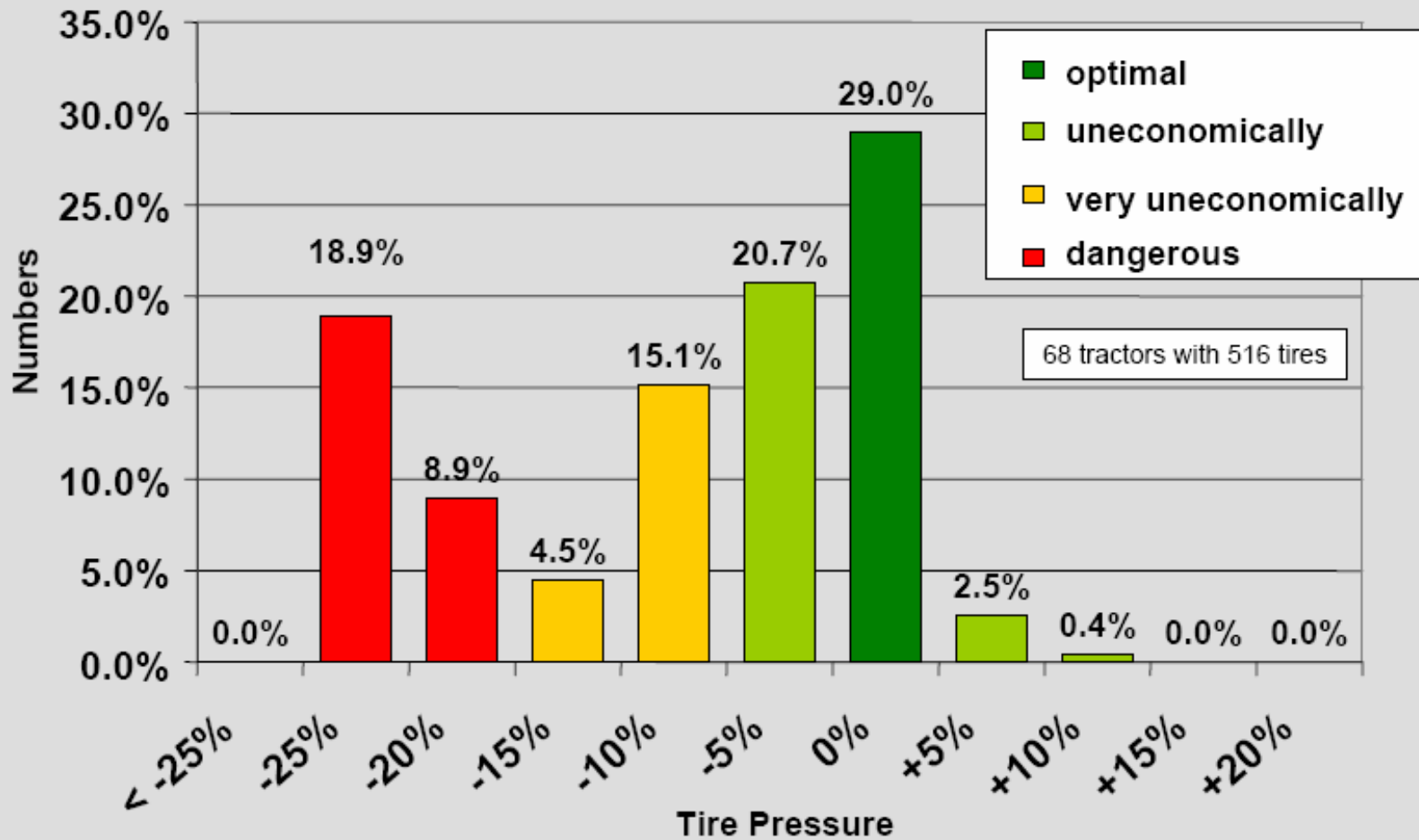


2/ Advantages of a TPMS system

- Vehicle owners are not regularly checking actual tire pressures on the vehicle.
 - @ 5% check every week
 - @ 15% check every two weeks
 - @ 20% check every month
 - @ 25% check every two months
 - @ 35% almost never check till something happens
- A tpms system always monitors if pressure is too low – covers the 35% of owners who don't check pressures plus 100% of drivers in event of a puncture.



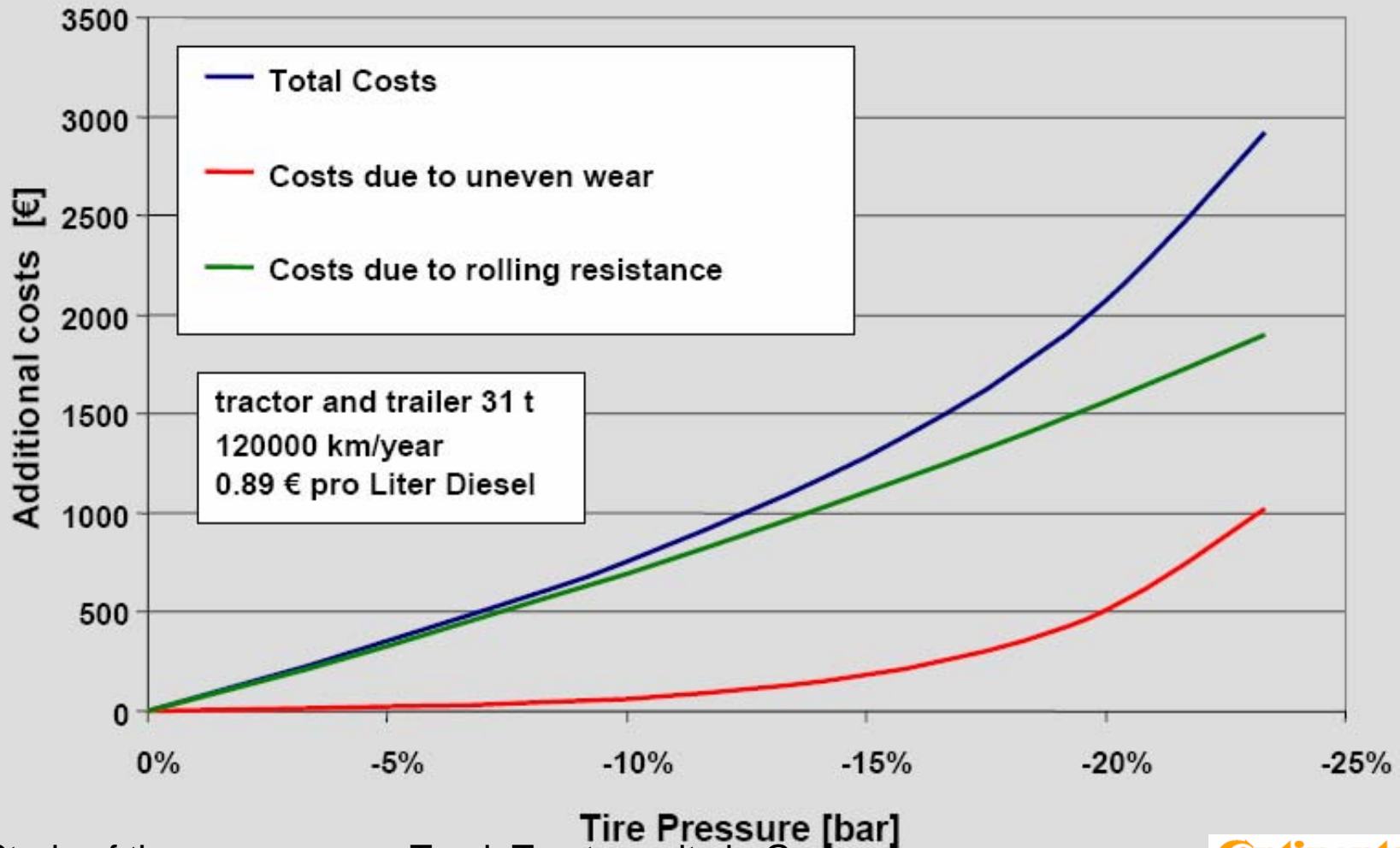
2/ Advantages of a TPMS system



Study of tire pressures on Truck Tractor units in Germany

Source : 

2/ Advantages of a TPMS system



Study of tire pressures on Truck Tractor units in Germany

Source : 



2/ Advantages of a TPMS system

Approximate 70% of all tires are underinflated.

In average the tire pressure is approx. 15% too low!

**This causes avoidable costs of 875 €
per vehicle per year.**

Study of tire pressures on Truck Tractor units in Germany

Source :





2/ Advantages of a TPMS system

Study of forecourt tire pressure gauges show they can indicate correct pressure but be upto 0.45 bar low in terms of real pressure. (survey done in Paris area)

Pressure target (bar) (car manufacturer recommended cold pressure)	2.3
--	-----

Petrol station details	Petrol Station	Petrol station gauge	Petrol station gauge reading	Digital gauge reading	Pressure value (bars)
Champion Petrol Station Montesson (78)					2.28
Shell Petrol Station Houilles (78)					2.23
BP Petrol Station Maison Laffitte (78)					2.05
BP Petrol Station Le Vesinet (78)					2.15

2/ Advantages of a TPMS system

Study of forecourt tire pressure gauges show they can indicate correct pressure but be upto 0.45 bar low in terms of real pressure. (survey done in Paris area & in Glastonbury UK)

Petrol Station Gauge (bar)	Digital Gauge Reading (bar)	Mis-reading (bar)	Mis-reading (psi)
2.3 bar	2.28 bar	-0.02 bar	0.29 psi
2.3 bar	2.23 bar	-0.07 bar	1.03 psi
2.3 bar	2.05 bar	-0.25 bar	3.67 psi
2.3 bar	2.15 bar	-0.15 bar	2.20 psi
2.3 bar	2.12 bar	-0.18 bar	2.64 psi
2.3 bar	2.24 bar	-0.16 bar	2.35 psi
2.3 bar	2.25 bar	-0.15 bar	2.20 psi
2.3 bar	2.20 bar	-0.10 bar	1.47 psi
2.3 bar	2.09 bar	-0.21 bar	3.08 psi
2.4 bar	2.37 bar	-0.03 bar	0.44 psi
2.4 bar	2.28 bar	-0.22 bar	3.23 psi
2.4 bar	1.95 bar	-0.45 bar	6.61 psi

Study of forecourt tire pressure gauges to be done in the US. However early studies show a high % (currently around 30% - 50%) have no gauges at all!



2/ Benefits of a TPMS system



The NHTSA estimates of the benefits of TPMS fitment in human terms in the US with its population of ~ 240M people are:

- 1/ reduction in accidents ~ data not stated
- 2/ reduction in injuries ~ 8400 per annum
- 3/ potential lives saved ~ 120 per annum

If this was applied to Europe, with 450M people, the possible reduction in injuries and deaths could be in the order of:

- 1/ reduction in accidents ~ data not established yet.
- 2/ reduction in injuries ~ 15,120 per annum
- 3/ potential lives saved ~ 220 per annum

The fitment of TPMS could help to contribute to the EU commission's target of reducing fatalities by ~20,000 lives as referred to in the "EU White Paper – European transport policy for 2010 : time to decide" (COM(2001) 370)

1 fatality in 9 on french auto routes is due to under-inflated tires (source Securitie Routier)



2/ Benefits of a TPMS system

Introduction – why is TPMS needed – possible benefits



- Tire Wear increases with incorrectly inflated tires (under and over inflated)

- 0.2bar under – inflated 10% reduction in tire life
 - 0.4bar under – inflated 25% reduction in tire life
 - 0.6bar under – inflated 50% reduction in tire life
- source Continental

- Fuel Consumption increase with incorrectly inflated tires (vehicle load, driving style, tire type etc effects these numbers)

- 0.2bar under – inflated 1% increase in fuel
- 0.4bar under – inflated 2% increase in fuel min
- 0.6bar under – inflated 4% increase in fuel min

If vehicles had correct tire pressure then potential to save in Germany alone 200million litres of fuel. *If all of EU then potential to save 700million litres of fuel (estimated SEL)*

-source Continental

- Under inflated tires

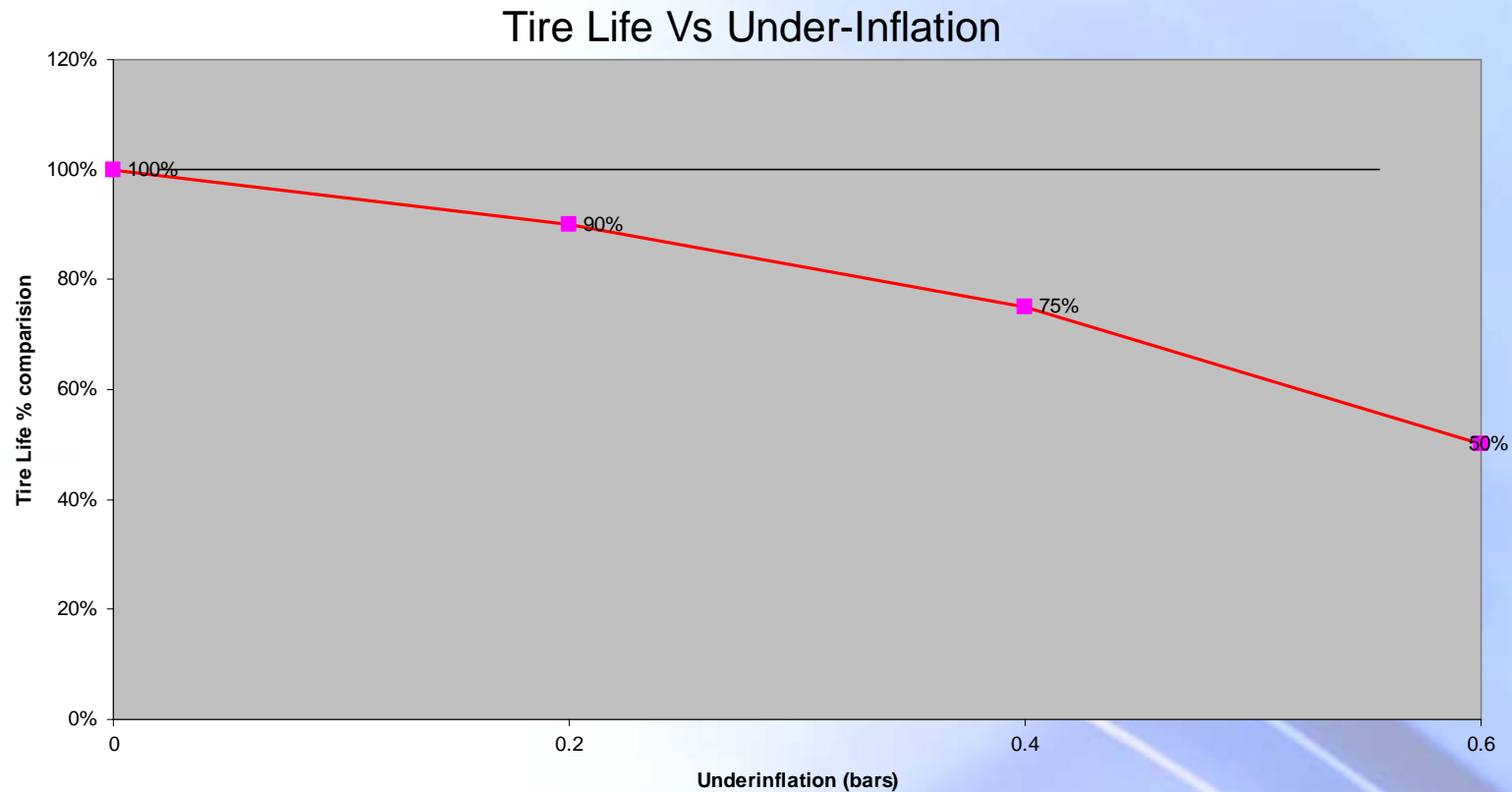
- 0.5bar under – inflated tires reduce lane changing ability
- 0.5bar under - inflated tires can promote oversteer if on one axle
- Tires under 1.5 bar have a greatly reduced ability to resist aqua-planning.
- under – inflated tires reduce vehicle stability. The greater the amount of under-inflation of tires the greater reduction in vehicle stability.

-source Beru

2/ Benefits of a TPMS system

- Tire Wear increases with incorrectly inflated tires (under-inflated)

- 0.2bar under – inflated 10% reduction in tire life
 - 0.4bar under – inflated 25% reduction in tire life
 - 0.6bar under – inflated 50% reduction in tire life
- source Continental

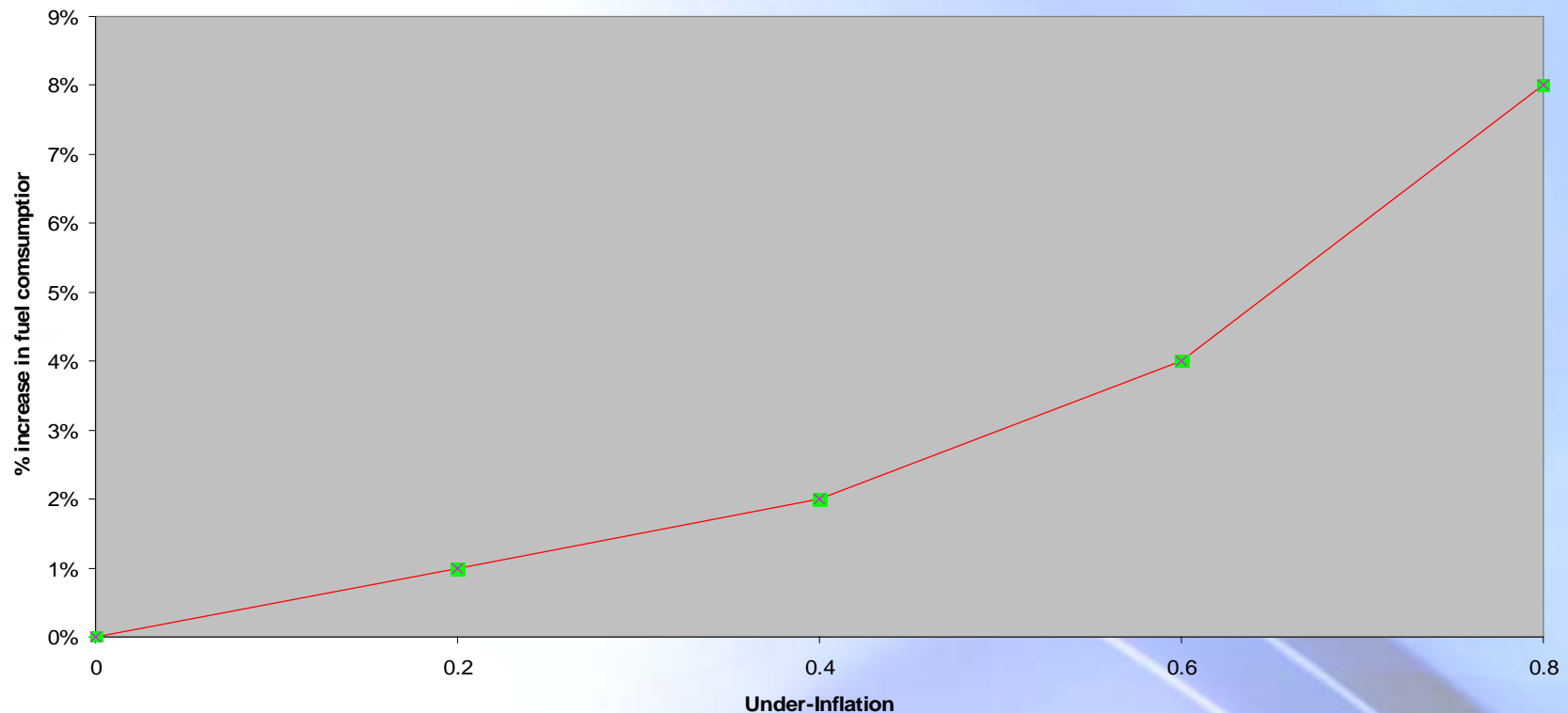


2/ Benefits of a TPMS system

•Fuel Consumption increase with incorrectly inflated tires (data is assumed to be an average of a wide range of tires and conditions. (Test data required for a wide arrange of tires, loads and driving conditions)

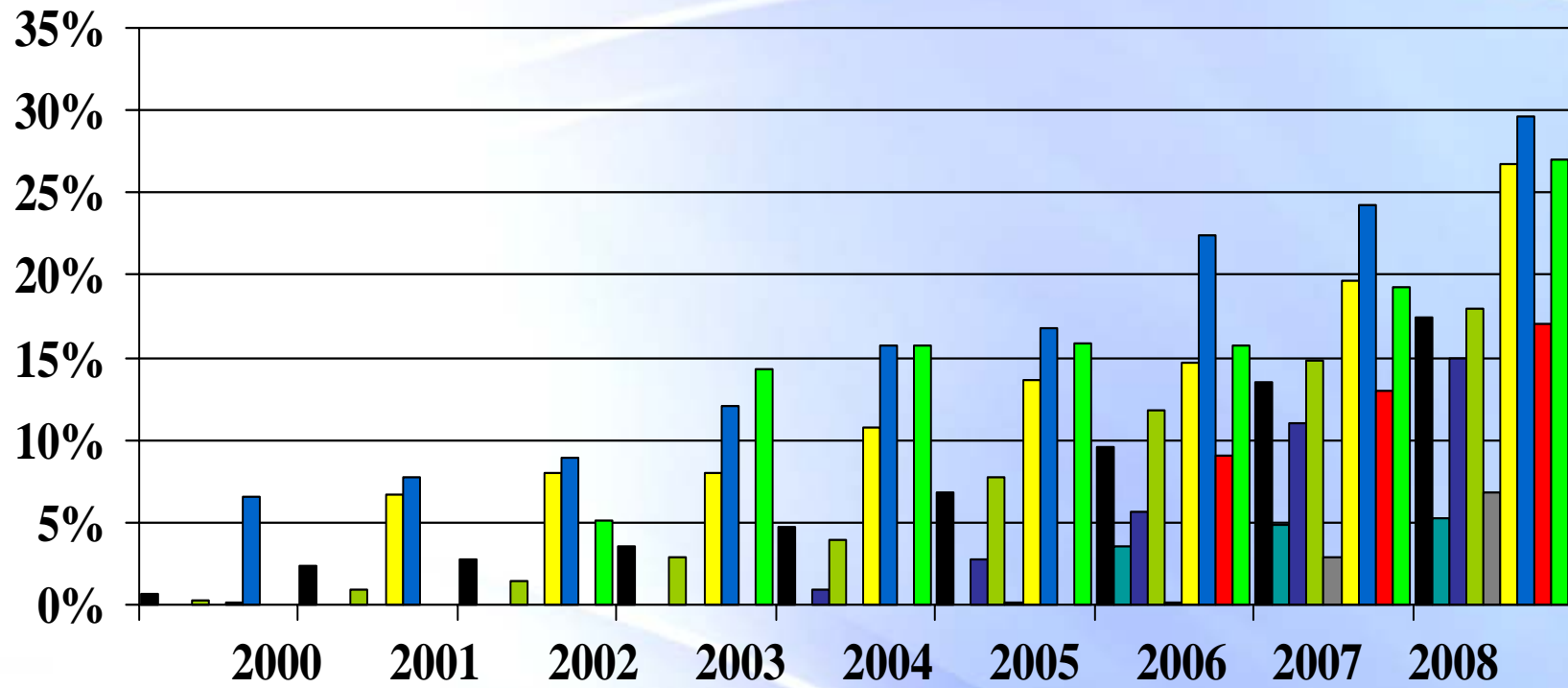
- 0.2bar under – inflated 1% increase in fuel
- 0.4bar under – inflated 2% increase in fuel min
- 0.6bar under – inflated 4% increase in fuel min

Increase in Fuel Consumption Vs Under-Inflation





3/ TPMS Market Details - Europe – Direct Systems





4/ TPMS System Types & ISO

1/ Indirect TPMS

Uses the ABS wheel speed sensors, as a min, often combined with data from ESP and steering wheel sensors.

Principle: calculates an effective theoretical rolling wheel diameter and when pressure drops the theoretical rolling wheel diameter reduces which is detected by an increase in wheel speed detected by the ABS sensor.

Advantages:

a/ if a 4 channel ABS system already fitted to vehicle then system costs could be low. (\$10 -\$20)

Disadvantages:

a/ Requires an input to state when tire pressure is OK to allow rolling wheel diameter to be calculated. Often this is in the form of a reset switch – If driver inflates tires to incorrect pressures then detection pressure could be lower than specified threshold. (poss safety issues)

b/ Current systems need 30% or more loss of pressure to allow detection. The % loss depends on speed and at low or high speeds % increases.

c/ Tires from different suppliers can have an appreciable difference in stiffness and therefore effective rolling diameter effecting detection of low tire pressure

d/ All 4 wheel low pressure detection (most common pattern) is very hard / impossible to detect until pressure is very low.

e/ If **no** ABS fitted or only 3 channel system then can be costly to update (\$110+)



4/ TPMS System Types

2/ Direct TPMS

Uses wheel mounted sensors, as a min, poss combined with data from manifold pressure sensor.

Principle: has a calibrated internal pressure sensor which measures actual tire air pressure and transmits data to central receiver / display.

Advantages:

- a/ as internal pressure sensor is calibrated at manufacture no need for driver to reset pressure thresholds when tire pressures altered with load – automatic
- b/ works with all normal tire types
- c/ works at all speeds and when stationary if needed.
- d/ can be used as a “tire gauge” if no gauge available to driver.
- e/ can be configured to show which tire(s) is under-inflated.

Disadvantages:

- a/ Sensor cost is always a small add-on to vehicle cost – (~ 28E / \$35 in very high volume)
However fuel savings (and reduced tire wear) will offset this cost inside life of the vehicle



4/ TPMS System Types

Direct TPMS vs poss cost savings

Uses wheel mounted sensors, as a min, poss combined with data from manifold pressure sensor can sense changes in pressure as little as 80mb which indirect cannot.

Cost savings:

16,000Kms / 10,000 miles/yr with typical mpg of 25mpg with correct tire pressure.

If Under-inflated by 0.4bar ave would increase consumption by 2% reduce tire life, typically 32,000kms, (20,000 miles) by 25% .

If fuel was 1.2E/L (£4.3 UK gal) and tire cost was ~ 75E (£50) increased cost would be:

Fuel increase cost ~ 49E (£38.4) Tire increase cost ~35E (£24.65)

Cum increased cost 84E (£59.16)

Compared to cost of adding direct TPMS and if only actually delivers 50% improvement then effective payback could be as quick as 12 months (£59.16 saving x50% - £30 cost)



5/ TPMS requirements for EU & US Markets

1/ For US market to meet TREAD Act requirements mean even Small Volume Manufacturers have to fit 100% of US bound models with TPMS from 1st Sept 2007. FMVSS138 with test procedure under TP138

Performance Standard is set at 25% under-inflation warn driver within 20 mins.

2/ For EU market currently no legislation exists but market trends are pushing TPMS fitment as either a standard feature on premium or sports models or for lower cost models as a cost option.

ISO – Working Group WG\TC 22 has worked on defining TPMS types – but as of today has not set a Performance Standard

Comment:

To deliver a real benefit in terms of CO₂, tire life, economy, safety and reduction in accidents, injuries, and fatalities then the EU Commission would need to draw up a min performance standard for tpms

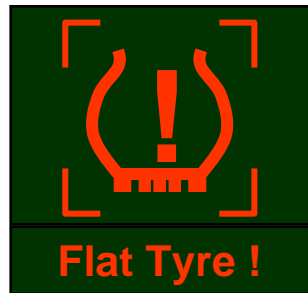
An example: Warn driver of an under-inflated tire(s) within 10 mins if pressure was equal to or more than 20% under-inflated.



5/ TPMS requirements for EU & US Markets

Current TPMS display requirements for US

Driver Telltale and displays are shown below



The base “Bulb” Option

Function	Color	Label	Symbol	Display
Low Tire Pressure Telltale (that does not identify which tire has low pressure)	Yellow	Low Tire. Also see FMVSS 138		_____
Low Tire Pressure Telltale (that identifies which tire has low pressure)	Yellow	Low Tire. Also see FMVSS 138		_____
Tire Pressure Monitoring System Malfunction Telltale 9	Yellow	TPMS	_____	_____

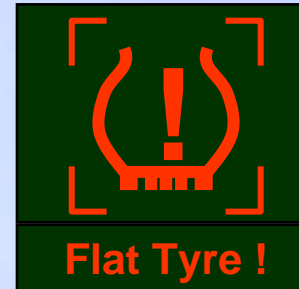
TREAD Act FMVSS 138 Requirements for displays



The basic “Warning by Location” type option

6/ TPMS Display Trends among OEMs

Driver Telltale and displays in early vehicles equipped with TPMS were often simple text messages and warning icons such as:



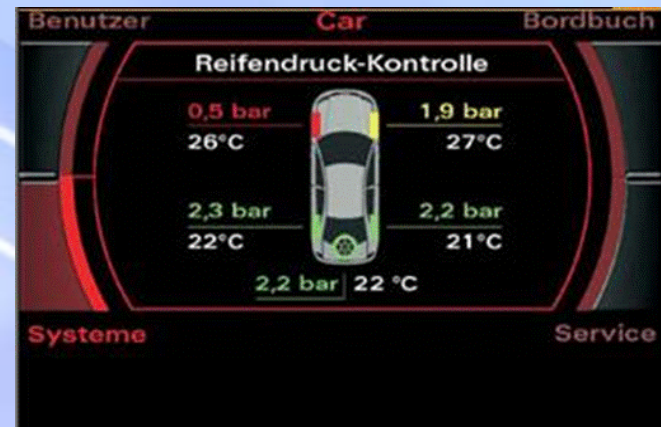
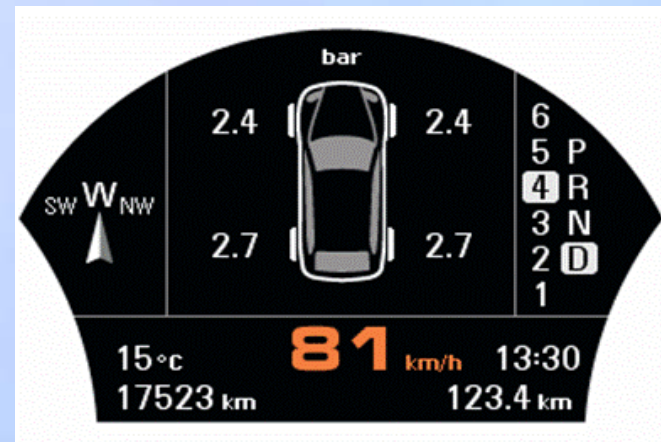
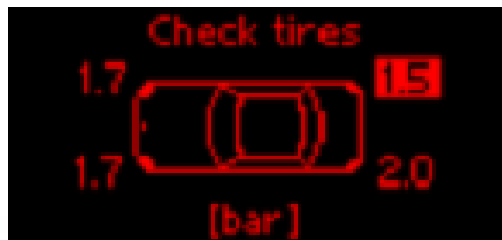
However the simple symbol format can be easily confused and if there is no position details then driver has to check all 4 tires with gauge possibly to see which tire needs air adding if “low tire” message used.

With Low profile tires then in some cases visually hard to see which tire is low.

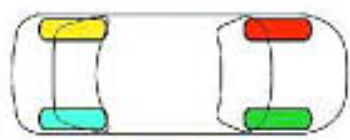
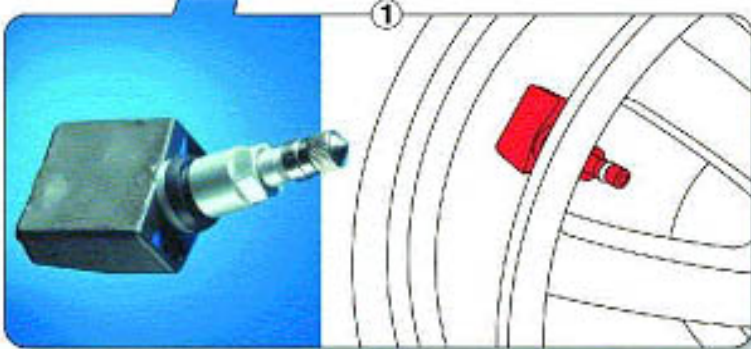
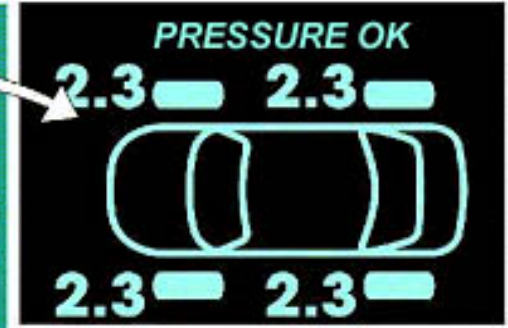
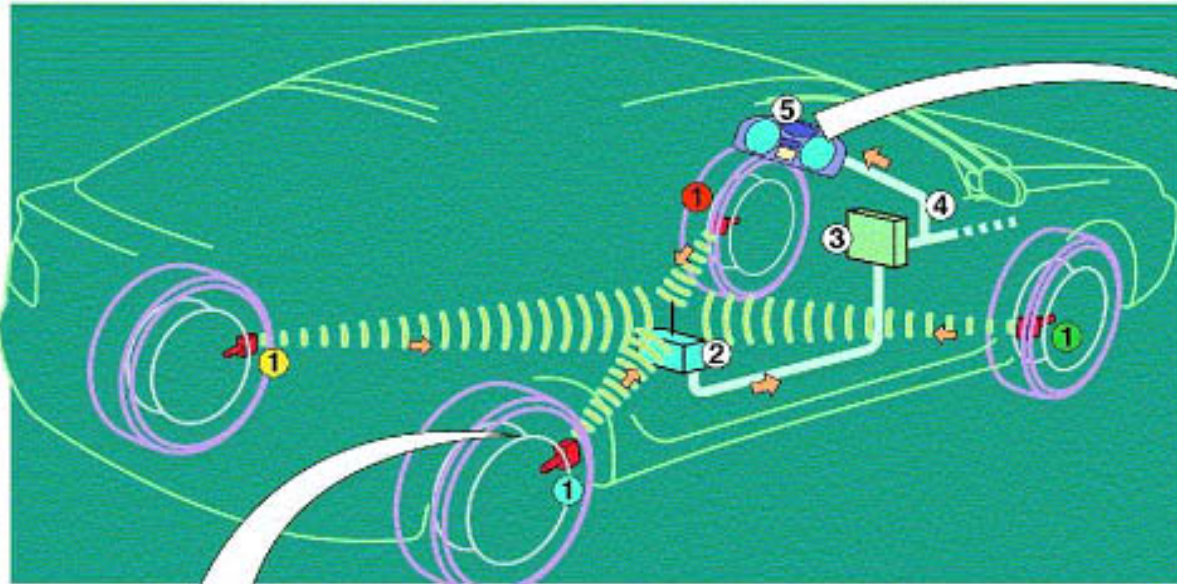


6/ TPMS Display Trends among OEMs

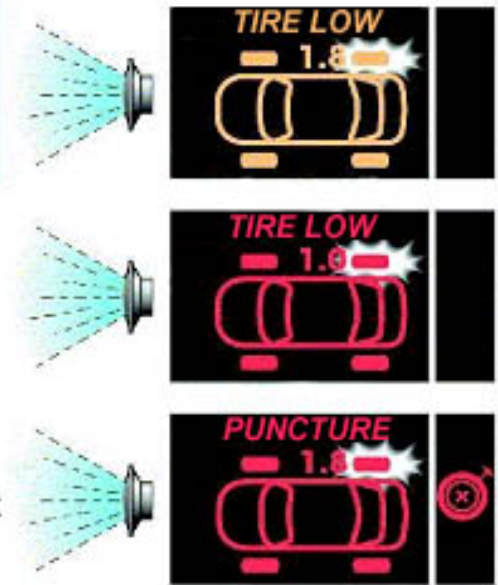
General trend towards showing the driver which tire pressure or which tire has low pressure or a puncture . (examples warning + pressures + temp in some cases)



7/ Typical TPMS System and options



- 1) Pressure Sensor
- 2) Receiver
- 3) Electronic Control Unit
- 4) Data line CAN/VAN
- 5) Display Unit



Tire Pressure Monitoring System





10/ TREAD Act Summary – Requirements for Testing



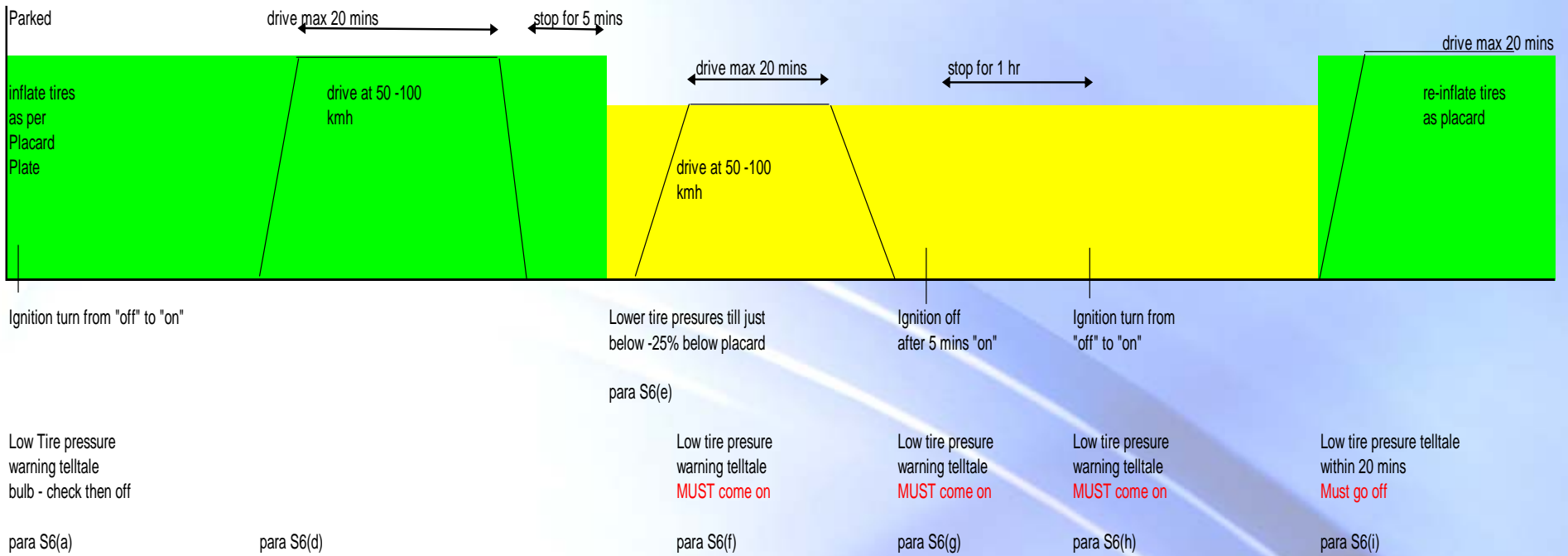
All vehicles from 1 sept 2007 have to have a TPMS – even small volume manufacturers

NHTSA published at the same time as FMVSS 138 a Test Requirement TP-138-00

The basis of the test sequence are set out below;

NHTSA Test Procedures for Low Tire Pressure Warning Telltale Functionality / Compliance

Clause S6. (Tread Act)





Summary & Conclusions

- Inflation pressure, if not correct, has an effect on fuel economy.
- Need to assess test a wide range of tire types under differing loads and pressures to assess potential savings / losses as current available data is only an guide.
- Drivers don't check tire pressures very often and this leads to a general under-inflation of tires and therefore an increase in fuel consumption of ~ 1% - 4% poss more (CO2 emissions also increased)
- Under-inflated tires increase tire wear.
- Technology exists already to have TPMS added to vehicles.
- EU should set an min performance standard to improve safety, improve emissions and improve tire life. (poss other bodies as well)
- Tire gauges at petrol stations are generally in-accurate and contribute to poor fuel consumption.
- 85% of punctures are related to tires with a history of under-inflation.