Transmitted by the expert from ETRTO

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(68th GRB, 12-14 September 2018,
agenda item 6)

WET GRIP TEST METHOD IMPROVEMENT for Passenger Car Tyres (C1)

Overview of Tyre Industry / ISO activities

GRBP 68th session

Geneva
September 12-14th, 2018

- **CURRENT REGULATORY FRAMEWORK**
- **CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES**
- **ISO ACTIVITIES - TECHNICAL DIRECTIONS**
- **TIMELINE**

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CURRENT REGULATORY FRAMEWORK

ISO 23671:2015
Passenger car tyres — Method for measuring relative wet grip performance
UNDER REVISION

TYRE LABELLING
Europe EC 1222/2009 - Test method in Annex V (*Reg. 228/2011*) *
… but also Brazil, Korea, Japan, …
*UNDER REVISION
direct reference to UN R117 will be made for wet grip test method

TYPE approval - UN R117.02 – Test method in Annex 5(a)
(minimum requirement on WET grip for homologation)

GTR16
Global Technical regulation

- **ISO test method for PSR wet grip is currently a key reference for several regulations in Europe and worldwide**
- **This standard is under revision: the experience accumulated so far by the Industry and by the EU Member States Authorities indicated an opportunity for developing further improvements on the accuracy of the test method (see slide #10).**

- CURRENT REGULATORY FRAMEWORK

- **CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES**

- ISO ACTIVITIES - TECHNICAL DIRECTIONS

- TIMELINE

CURRENT WET GRIP TEST - TECHNICAL PRINCIPLES

For the calculation of the wet grip index of a candidate tyre, the wet grip performance of the **candidate tyre is compared to the reference tyre ASTM SRTT 16"** (**S**tandard **R**eference **T**yre **T**est).

→ Thus it is a **COMPARISON TEST**.

The wet grip index can be measured with one of the 2 following methodologies (today considered as equivalent):

TRAILER

using a trailer towed by a vehicle

1 tyre mounted on a specific tool

OUTPUT

peak braking force coefficient (μ peak)

highest value of the ratio braking force / vertical load

VEHICLE

using an instrumented passenger car

1 set of 4 tyres mounted on a commercialized vehicle

OUTPUT

Average Deceleration (AD)

measured during braking

CURRENT WET GRIP TEST - APPLICABLE REFERENCE TYRES (ASTM)

SRTT 16”

ASTM F2493 P225/60R16

*Must be used as **reference tyre** to determine the relative wet grip performance of the candidate tyre*

SRTT 14”

ASTM E1136 P195/75R14

*It **can be** used to verify / certify **track friction properties** (one of the 2 possible methods)*

CURRENT WET GRIP TEST - TECHNICAL PRINCIPLES

Mathematical corrections are applied to align the results when the tests are performed in different conditions: i.e. different test locations (tracks) or different weather conditions (temperatures).

$$G(T) = \frac{\mu_{candidate\ tyre}}{\mu_{SRTT16}} 1{,}25 + A \cdot (Temp - T_0) + B \cdot (\mu_{SRTT16} - \mu_0)$$

This ratio is a **raw index** of the measured friction of the candidate tyre vs the SRTT16'' at the tests conditions (Temp, μ_{SRTT16})

Linear correction in temperature to estimate the value of the index at the reference temperature T_0

Linear correction in friction to estimate the value of the index at the reference friction (track) μ_0

The mathematical corrections (coefficient A and B) depend on category of use of the candidate tyre:

- **Normal Tyres**

- **Snow Tyres (all tyres marked M+S**, including the tyres marked also 3PMSF)

REPRODUCIBILITY OF THE CURRENT WET GRIP TEST

The current wet grip test method **allows the necessary flexibility** in terms of testing conditions: *possibility to test using different tools (vehicle/trailer), on different tracks (wide friction range for tracks), and in different periods of the year (wide temperature range).*

When the test was firstly developed, it appeared to grant both **a good repeatability** (same test conditions = same test results) and a good reproducibility (different test conditions = same grade).

Anyhow the **reproducibility of the test is not in line with the initial evaluations**.

In other words, when different set of testing conditions (within the allowed ranges) are adopted to test the same tyre, the same grade might not be always granted.

REPRODUCIBILITY OF THE CURRENT WET GRIP TEST

This problem was identified in the ***Final Report on the Review study on the Regulation (EC) No 1222/2009 on the labelling of tyres (March 2016):***

> ***8.4 Improvement of test standards and conditions***
> *Several sources, including independent consumer organizations, indicate that there is incoherence between the labelled performance and the measured performance of a tyre. Tests performed by Member States Authorities ("MSAs") confirm the lack of reproducibility of the tests, hinted by third parties. This also implies that in disputes, MSAs might have difficulties to prove incorrect labelling due to the* ***low reproducibility*** *of results.*
> *According to MSAs, a large part of this problem is due to different conditions for the tests*
> *[…] Especially the braking test on wet surface for measuring wet grip gives rise to large differences in test results.*

Following the experience accumulated after the implementation of EU label Reg. 1222, **Tyre Industry progressively recognized the problem and indicated opportunities for improvements** in the same Review Study

> ***8.4.1 Wet grip test standard***
> ***The experience accumulated so far by the Industry and by the MSAs on wet grip test standards is indicating an opportunity for developing further improvements on the accuracy of the test method.***
> *[…]*
> *Due to the wide intervals of allowed test conditions, a number of correction factors were adopted for calculating the wet grip. Examples of this are the correction factors for the surface friction coefficient ('b' = μ/grip) and temperature ('a') that are not working as intended and have a large influence on the result. Hence, there is a large difference in results if a tyre is tested at different conditions and correction factors are used to make results comparable.*

- CURRENT REGULATORY FRAMEWORK
- CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES
- **ISO ACTIVITIES - TECHNICAL DIRECTIONS**
- TIMELINE

Following preliminary collaboration among EUROPE, USA and JAPAN, the revision of the existing ISO 23671:2015 for PSR was launched last Sept 14th, 2017;

An ISO (global) "technical table" is currently in place:
The WET GRIP Working Group (**TC31/WG12**) was established with the aim to

By priority

1. Improve the reproducibility of the current ISO,

2. Try to keep on average similar wet grip indexes values and ratings as current test procedure (minimize gaps with the current worldwide regulations)

3. Drive the **global standardization & promote harmonization worldwide**

ISO TECHNICAL ACTIVITIES

Step 1 – Identification of the parameters affecting the dispersion of the test

✓ ✓ *completed*

Step 2 - three Round Robin Tests using TRAILER methodology

✓ **tests activities completed**
… analysis almost finalized
(ref. ETRTO / ISO)

Step 3 – 1 Round Robin Tests Using VEHICLE methodology

… tests activities completed
Analysis ongoing

Step 1 – Identification of the parameters affecting the dispersion

The **parameters having an influence on the variability of test method** were listed exhaustively
The ones to be analyzed to be better controlled in the future test method were identified:

	CURRENT ISO TEST METHOD	
Tyre typologies	**Normal tyres**	**Snow tyres (M+S)** **Including severe snow (M+S & 3PMSF)**
Methodologies	**Vehicle method** **Trailer method**	
Conditioning of test tyres	break-in = 2 braking runs	
Wet Track Grip	MTD = 0,7 ± 0,3 mm **BPN = 42-60 or µSRTT14 = 0,7 ± 0,1**	
Wet Track Temperature	5-35 °C	2-20 °C
Correction equation & coefficients	TRAILER: $G(T) = \frac{\mu_{test}}{\mu_{SRTT16}} 1.25 + a \cdot \Delta T + b \cdot \Delta\mu$	$\mu_{0-SRTT16} = 0{,}85$
	VEHICLE: $G(T) = \frac{BFC_{test}}{BFC_{SRTT16}} 1.25 + a \cdot \Delta T + b \cdot \Delta\mu$	$BFC_{0-SRTT16} = 0{,}68$
	a= – 0,4232 b= – 8,297	a = 0,7721 b = 31,18

Step 2 - Two Round Robin Tests using TRAILER methodology

Three huge tire testing plans were carried out for a total of 37 tires - **1163 results!**

Tyres were tested on different tracks, using the trailer of each participant, in different periods of the years, for a total of
16 different test sites/trailer in EU (ETRTO), Japan (JATMA) and USA (USTMA).

Agreed direction

- **Stabilization of the tyre** performance prior testing
- **Better definition of the track surface (one method)**
- **Consider the specificity of tyre typologies for the temperature conditions and the corrections formulas**

TYRE BREAK-IN (CONDITIONING)

Tyre Break-In (conditioning) was identified as an important source of variability
- The 2 braking runs considered by current regulation are not enough

Proposed approach:

*The tyres should be **stabilized in performance prior testing**. In all cases, tyre designed tread depth and designed tread block or rib integrity shall not change significantly with break-in, which means the pace and "severity" of the break-in needs to be carefully controlled to avoid such changes.*

TRACK GRIP

- In the current method, the grip of the track can be controlled with one of two criteria

  BPN **[42-60]** or μ SRTT14" **[0,6-0,8]**

  Anyhow there is **no correlation between the 2 criteria** → this point is an important source of variability between different test centers.

  Also the reference tyre **SRTT14'' will be discontinued**

- **SRTT 16'' will be used NOT ONLY AS REFERENCE TYRE, BUT ALSO FOR TRACK VALIDATION IN PLACE OF [SRTT 14 or BPN]**
  - ✓ **Replacement of SRTT14 and discontinuation of BPN measurement**
  - ✓ **A source of variability eliminated**

- **Recent EU-USA agreement for friction range $\mu_{SRTT16"}$ [0.65 ; 0.90]**

TYRE TYPOLOGIES

3 different typologies of tyres should be treated differently within the wet grip test procedure

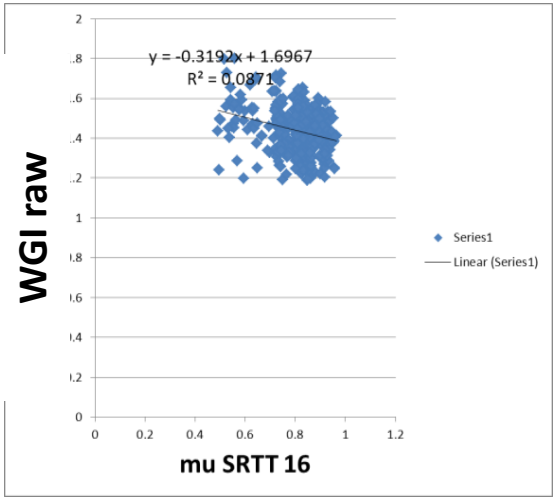
R117 category of use / markings	Normal -	Snow M+S - not 3PMSF	Snow for use in severe snow conditions M+S and 3PMSF
Examples of commercialized products and intended performance	 e.g. tyres named SUMMER Designed to perform best in warm weather and are **not typically used at low temperature**	 e.g. tyres named ALL SEASON in USA intended to perform across most temperature ranges. They are designed also for use in lower temperatures but not at the level of a Severe Snow (Winter) tire. They **can operate at higher temperatures**, without the typical limitations of Severe Snow (Winter) tires	 e.g. tyres named ALL SEASON in EU guarantee the min snow traction of a Severe Snow (Winter) tire. They are **also designed to operate at higher temperatures**, without the typical traction limitations of Severe Snow (Winter) tires  e.g. tyres named WINTER Severe Snow tires are designed to perform best in severe cold weather conditions and are **not typically used during extended warm weather conditions**
WET GRIP test CONDITIONS	T ref = 20 12-35 ˚C	T ref = 15 5-35˚C	T ref = 10 5-20 ˚C

each tyre typology has its own behavior vs friction & temperature

→specific /different correction formulas and coefficients shall be applied

CORRECTION FORMULAS – BASIC IDEA

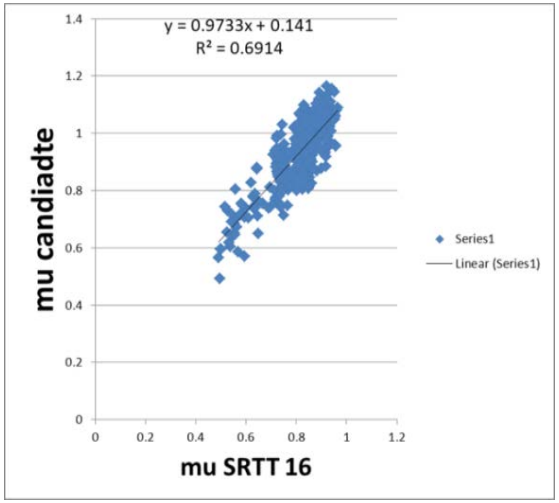
$$\text{WGI raw} = \frac{\mu_{candidate\ tyre}}{\mu_{SRTT16}}$$



No relation between Ratio WGI raw and µ-SRTT16

Correction should NOT be applied to WGI raw (as done today)

$$\mu_{candidate\ tyre}$$



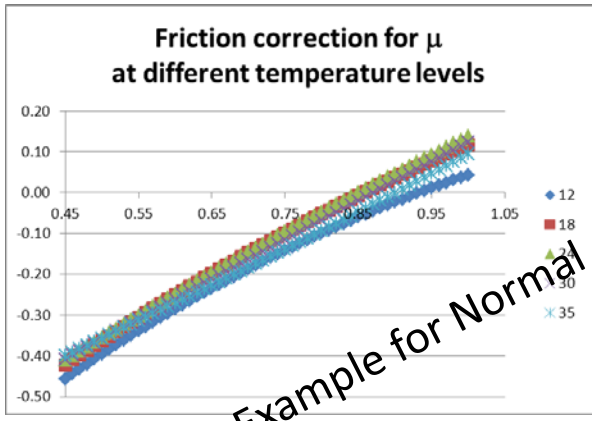
Evident linear relation between µ-cand and µ-SRTT16 (track friction)

Correction should be applied directly to µ-cand tyre

CORRECTION FORMULAS – BASIC IDEA

The grip of the track has a strong influence on the results.

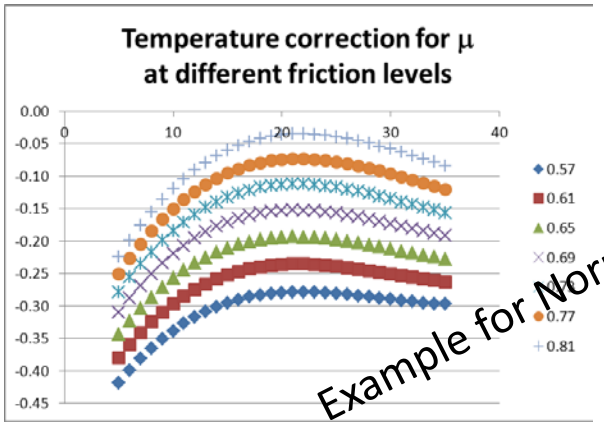
The MTD (Mean Texture Depth) has also a minor influence (linear)



Example for Normal

μ(test) vs track grip μ(SRTT16) approximately linear

The temperature (especially the low temperature for normal tyres) has also an influence (even if lower than the grip)



Example for Normal

μ(test) vs Track temperature T approximately quadratic

$$correction = f(\Delta T, \Delta\mu, \Delta MTD) = a\Delta\mu + b\Delta T + c\Delta T^2 + (d\Delta\mu^2\Delta T) + e\Delta MTD$$

a, b, …, e
different depending on tyres typologies

CORRECTION FORMULAS

G(T) must NOT be based on: raw μ candidate / raw μ SRTT16" (as done today),
but be based on: μ candidate at reference conditions / μ SRTT16" at reference conditions

FROM

$$\boldsymbol{CURRENT} \quad \boldsymbol{G(T)} = \frac{\mu_{test}}{\mu_{SRTT16}} \mathbf{1.25} + \boldsymbol{a}\cdot\Delta\mathbf{T} + \boldsymbol{b}\cdot\Delta\boldsymbol{\mu}$$

TO

$$\boldsymbol{NEW} \quad \boldsymbol{G(T)} = \boldsymbol{K} * [\mu_{test} - (\boldsymbol{a}\,\Delta\boldsymbol{\mu} + \mathbf{b}\,\Delta\mathbf{T} + \mathbf{c}\,\Delta\mathbf{T}^2 + \mathbf{e}\Delta\mathbf{MTD})]$$

a, b, c, e
different depending
on tyres typologies

where:

$\Delta T = T_{test} - T\ ref$
$\Delta\mu = \mu_{SRTT16} - 0.85$
$\Delta MTD = MTD - 0{,}8$

K *is a factor to grant consistency between future revised standard and current standard*

K value under confirmation

CORRECTION FORMULAS

- **Correction coefficients [a, b, c, e]** are optimized for each tyre typology:
  They **minimize the dispersion using all Round Robin Test measurements**
  1163 data points of 37 different tires (18 "Normal", 9 "M+S", 10 "3PMSF")

- The d coefficient of the term $\Delta\mu^2\Delta T$ was recently removed after confirmation that it is not statistically significant

REFERENCE CONDITIONS		
Mu SRTT 16" ref	0.85	
Temp ref N	20	°C
Temp ref M+S	15	°C
Temp ref 3PMSF	10	°C
MTD ref	0.80	

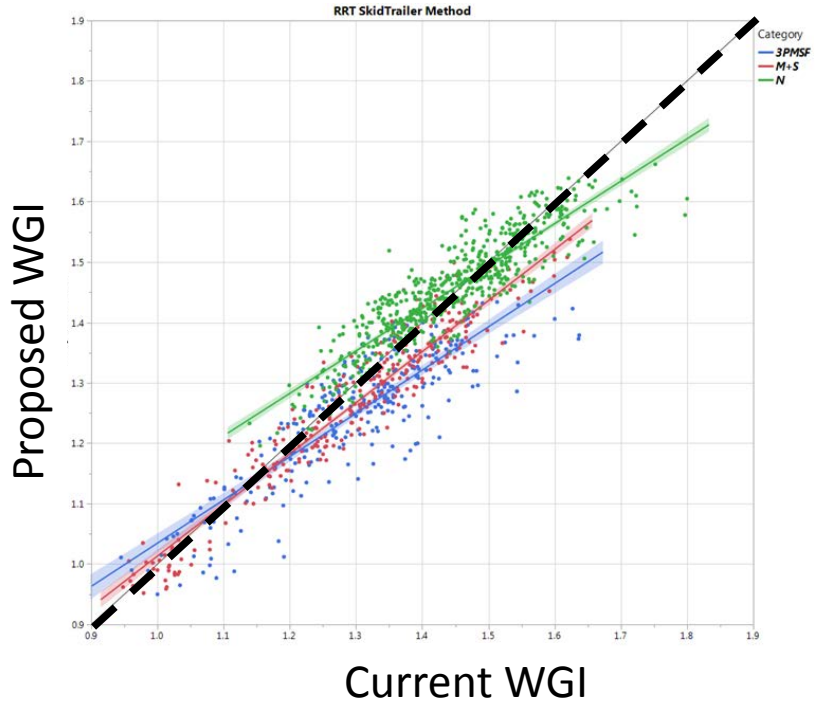
CALCULATED COEFFICIENTS RMA*+RRT1+RRT2 (excl. outliers)					
Tyre type	a DeltaMu16	b DeltaT	c DeltaT^2	d DeltaMu16^2*DeltaT	e DeltaMTD
NORMAL	0.99757	0.00251	-0.00028		0.07759
M+S (only)	0.87084	-0.00025	-0.00004		-0.01635
3PMSF (Severe Snow)	0.67929	0.00115	-0.00005		0.03963

DISPERSION and WET GRIP VALUES – PROPOSED vs CURRENT procedure

- With the new proposed approach, **the dispersion of the test is significantly reduced for each tyre typology**

	Data Points	Current WGI	Proposed WGI	W-STDEV Evolution
Weighted Std NORMAL	596	0.083	0.064	-24%
Weighted Std M+S	285	0.077	0.059	-23%
Weighted Std 3PMSF	282	0.088	0.059	-34%

- Proposed v/s Current Wet Grip Index (WGI) values



On average, similar WGI values as current procedure

The proposed procedure grants more stability (vs tests conditions) than current procedure: possible differences in WGI (proposed and current) on single tests results depend on the conditions

K factor can be further optimized also to align proposed and current procedure

Step 3 – Round Robin Tests Using VEHICLE methodology

Some of - **but not all** - the technical findings on trailer can be automatically transposed to vehicle methodology.

ETRTO (EU only) is carrying-out dedicated test campaign on vehicle; main purposes are:

1. to **compare the variability of both TRAILER and VEHICLE methodologies**
2. to check the **correlation between the two modified** methods (both methods should give same Index)

Based on today information, the **directions for the VEHICLE method could be similar to the trailer**:

- **Better definition of the track surface**
- **Restricting the testing conditions ranges**
- **Revised mathematical corrections formulas (different from the trailer ones)**
- **Stabilizing of the tyre prior the Wet Grip test**
- **Tyres Inflation Pressure adjusted depending on actual load of the vehicle**
- **Technical specification for vehicle to be used and further limitations**

ACTIVITY ONGOING

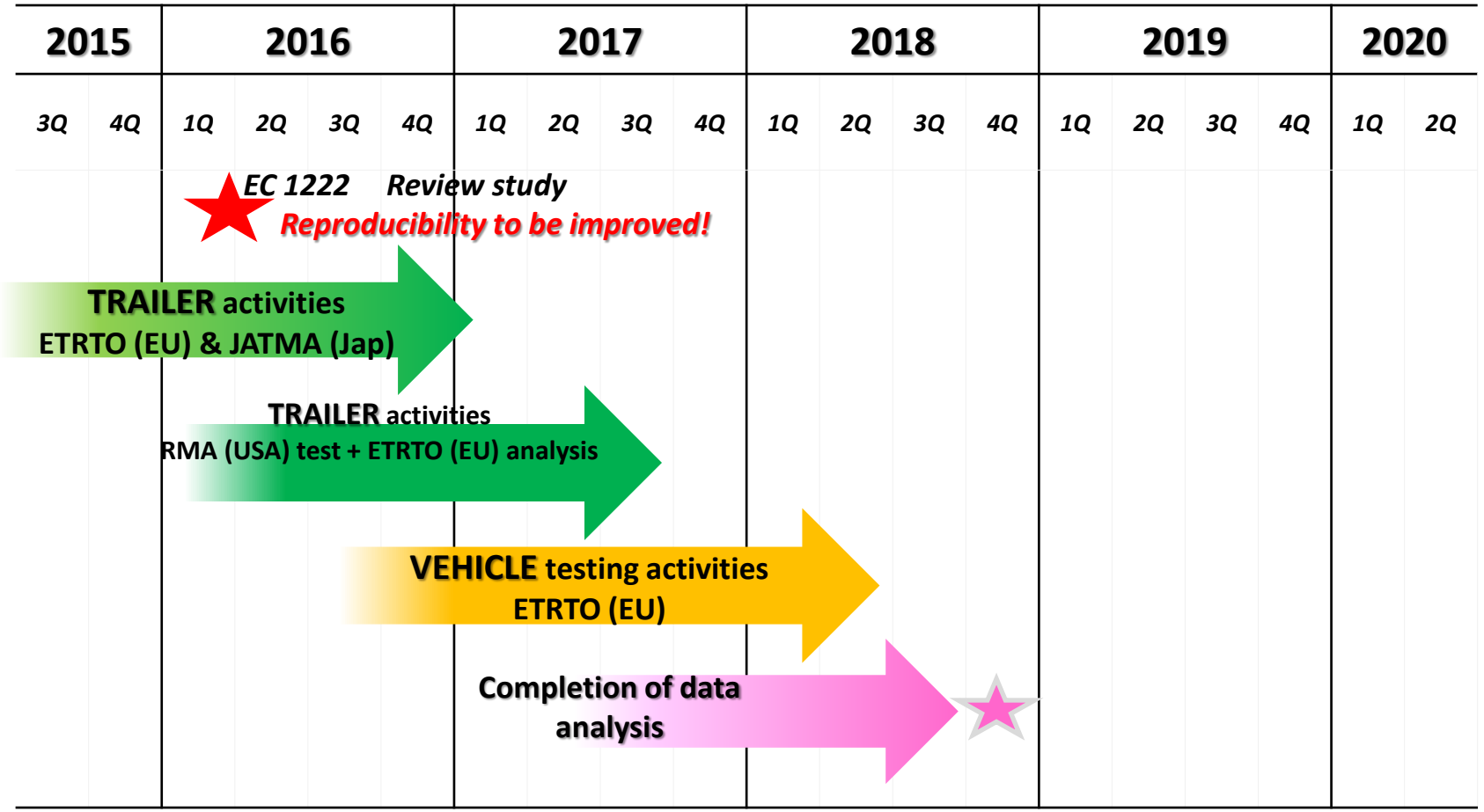
- CURRENT REGULATORY FRAMEWORK
- CURRENT WET GRIP PROCEDURE - TECHNICAL PRINCIPLES
- ISO ACTIVITIES - TECHNICAL DIRECTIONS
- **TIMELINE**

TIMELINE

ACTIVITIES ENLARGED AT ISO level

- Robust technical approach

- Worldwide Harmonization



APPENDIX

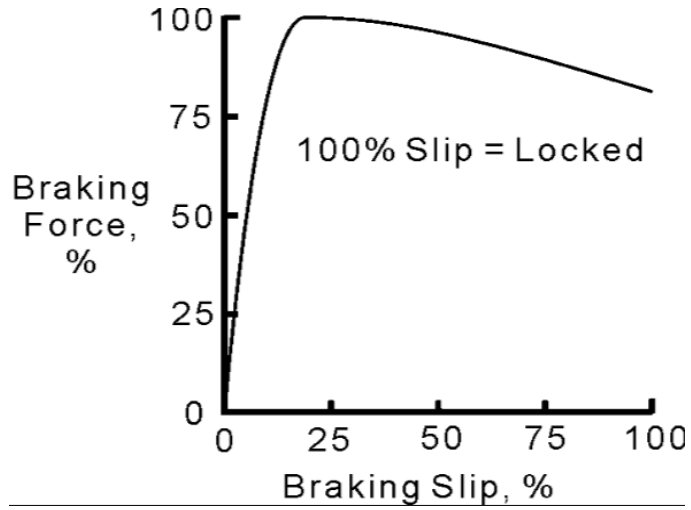
WET GRIP TEST METHOD - CURRENT REGULATORY FRAMEWORK

TRAILER METHODOLOGY

The tyre to be tested is fitted on a specific position for measurements (test position)

The brake in the test position is applied maintaining the specified speed (65 km/h) and the specified Load (depending on the Load Index of the tyre) until test-tyre lock-up

The ratio braking force / vertical load is acquired in real time: the highest value of this ratio provide the wet grip performance of the tyre.
It is called **tyre peak braking force coefficient (μ peak)**



WET GRIP TEST METHOD - CURRENT REGULATORY FRAMEWORK

VEHICLE METHODOLOGY

An instrumented passenger car, equipped with an Antilock Braking System (ABS).

Starting with a defined initial speed, the brakes are applied on four wheels at the same time to activate the ABS

The **average deceleration** is calculated between two pre-defined speeds (80→20km/h).

VEHICLE METHODOLOGY USING CONTROL TYRE SET (BRIDGE TEST)

Where the candidate tyre size is significantly different from that of the reference tyre (SRTT), a direct comparison on the same instrumented passenger car may not be possible.

In that case the comparison between a candidate tyre and a reference tyre is obtained through the use of a control tyre set (so called “bridge”) and two different instrumented passenger cars.

CAR 1
Control
Vs
SRTT

+

CAR 2
Candidate Tyre
Vs
Control

Candidate Tyre
Vs
SRTT