



European Commission

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STUDY ON TYRES ABRASION TEST METHOD DURABILITY INVESTIGATION

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April, 28th 2022

CONFIDENTIAL

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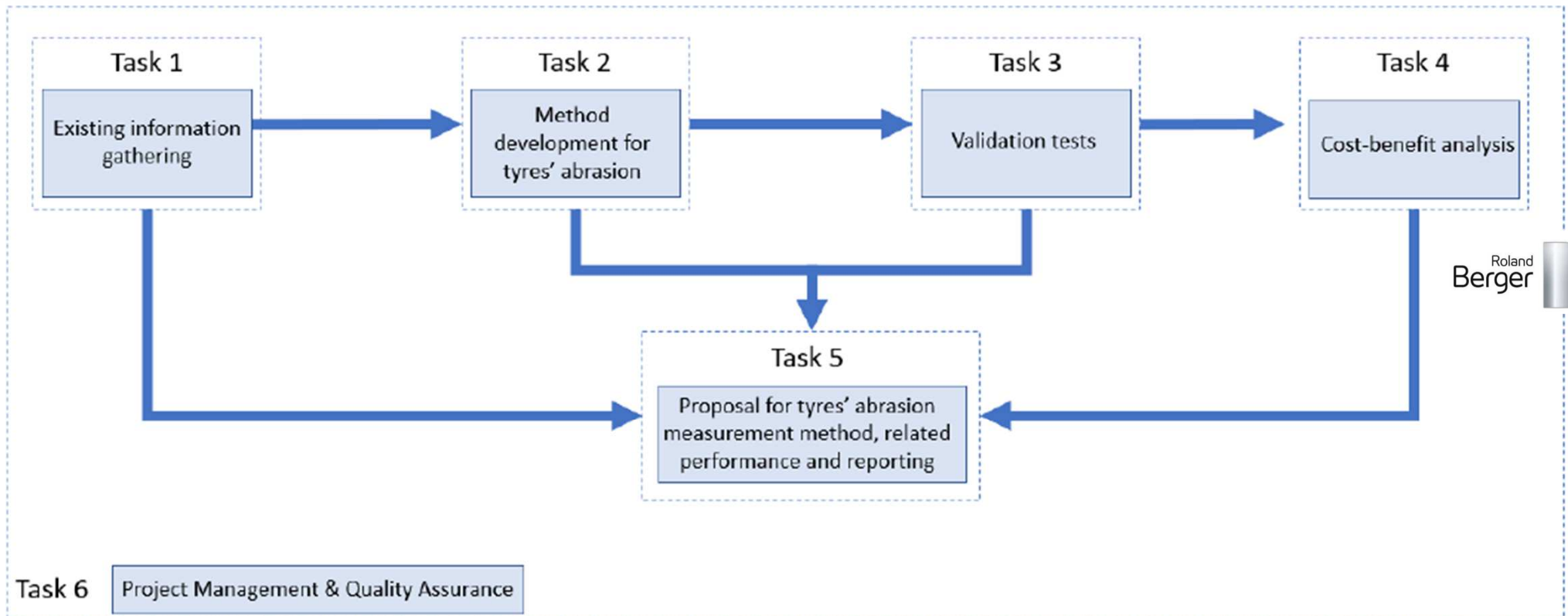
1. Objective
2. Project structure
3. Data gathering and literature review
4. Driving Severity Number (DSN)
5. C1 Tyres
6. C3 Tyres
7. Timing

OBJECTIVE

- Study performed under contract for the European Commission
- Scope: C1, C2, C3 tyres
- Conclude a test method for measuring tyre abrasion using vehicle in Proving Ground:
 - ✓ Test track characterisation and tolerances
 - ✓ Vehicle preparation
 - ✓ Test cycle description
 - ✓ Tyre measurements and frequency
 - ✓ Abrasion rate calculation and run-in
- Investigate its connection with mileage
 - ✓ Abrasion rate
 - ✓ Tread depth
- Define classes for European Tyre labeling and limits for Euro 7

PROJECT STRUCTURE

TASK DEFINITION



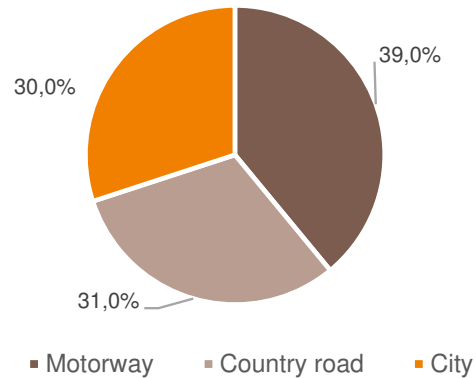
DATA GATHERING & LITERATURE REVIEW

SURVEY

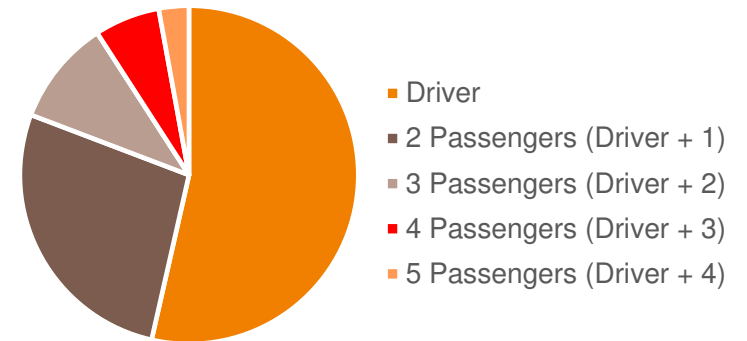
- ⊕ 248 surveys
- ⊕ 35 questions
- ⊕ 7 % participation

(Example of extracted information for C1 tyres)

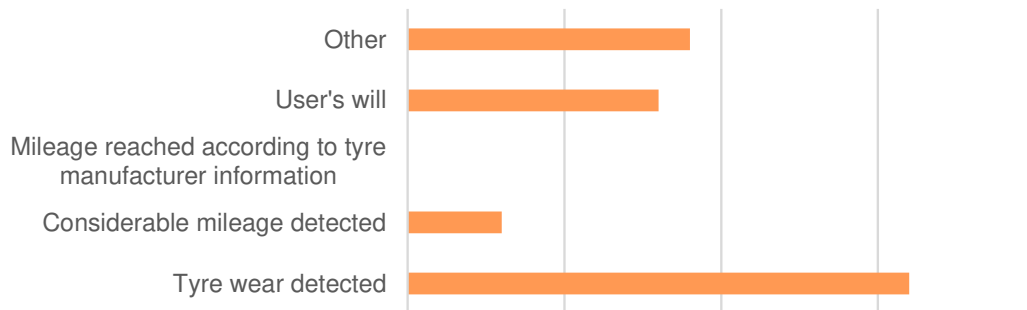
Average percentage of passenger car driving in terms of road distance



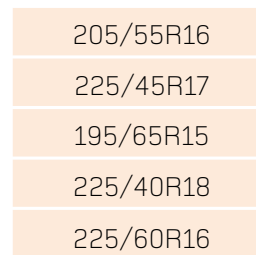
Average occupation of passenger cars



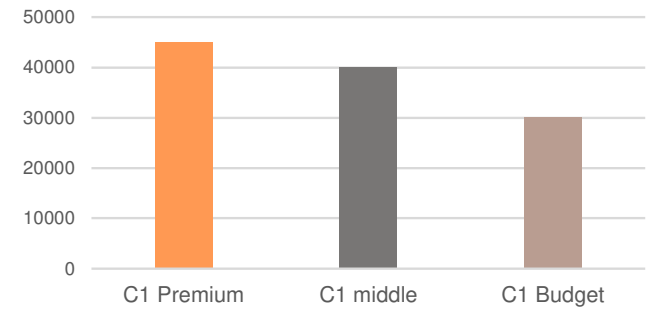
Most common reason for changing tyres on a passenger car?



Most common tyre sizes:



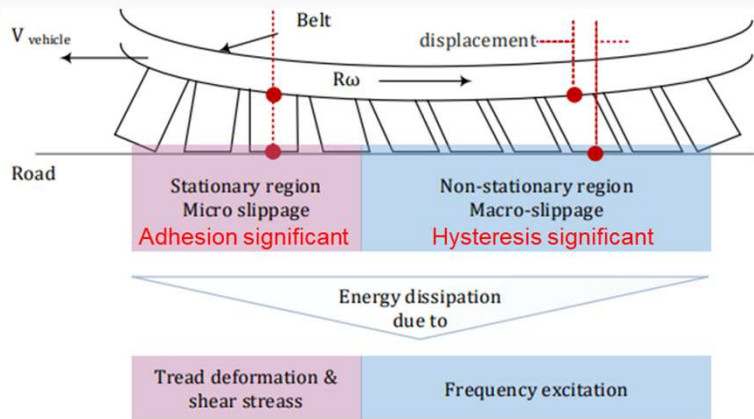
Average mileage before changing the tyres (km)



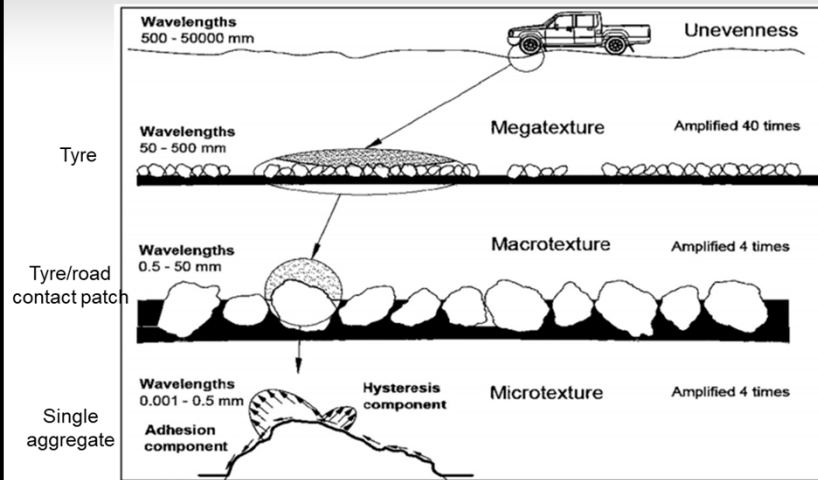
DATA GATHERING & LITERATURE REVIEW

IMPORTANT FACTORS AFFECTING TYRE ABRASION

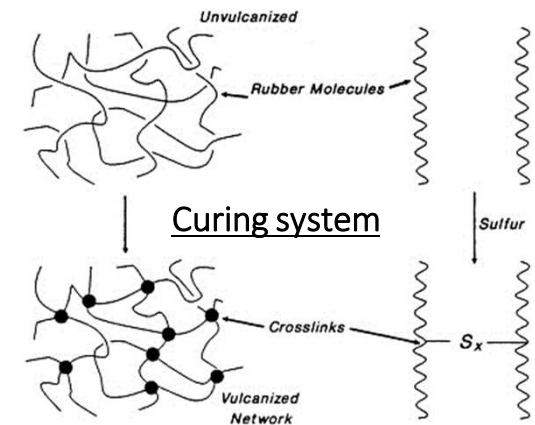
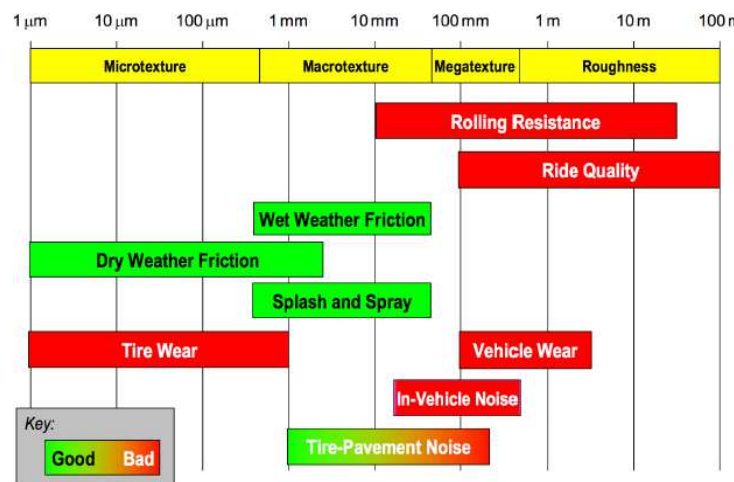
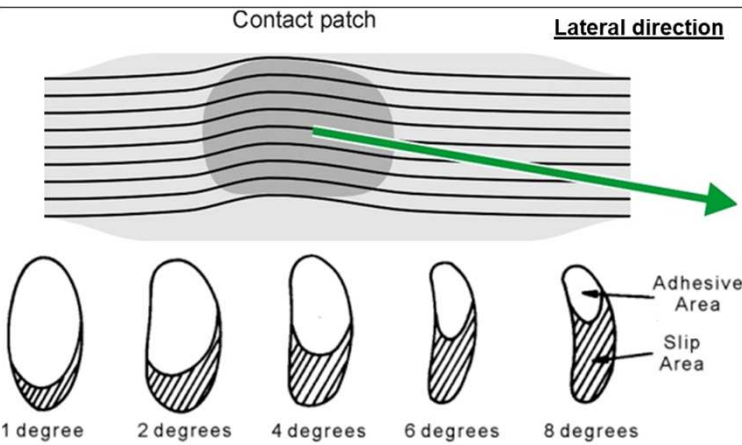
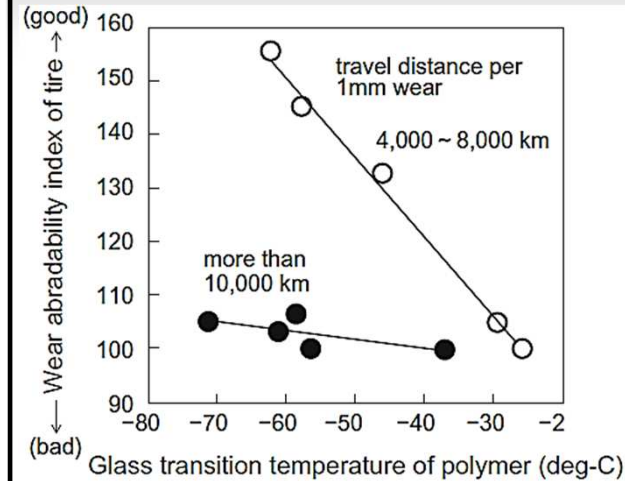
Vehicle operation/Driving behaviour



Road surface texture



Tyre tread material

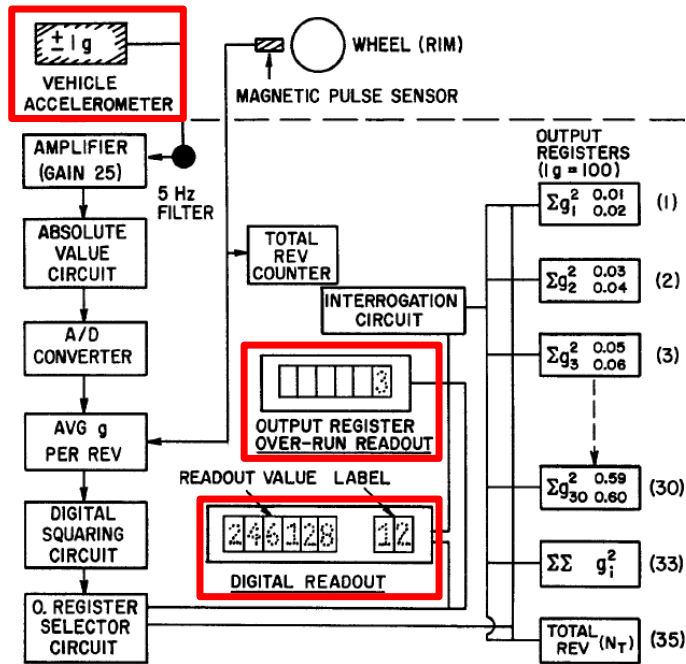


DRIVING SEVERITY NUMBER (DSN)

Driving Severity Measurement consists of an accelerometer for monitoring lateral accelerations, wheel revolution counter and a module for signal processing and read-out.

The basic task of the DSM is measurement of the average g-value per wheel revolution. It provides information regarding cornering intensity influenced by route terrain, vehicle speed and driver behaviour

The output of the system is an index called Drive Severity Number (DSN) which has direct correlation with tyre wear rate



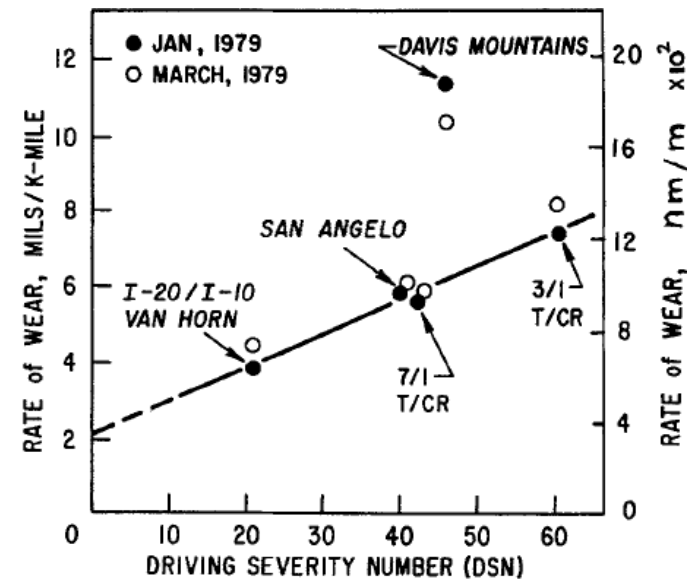
$$E_y^w = F_y^2 / (bC_{F\alpha})$$

$$F_{y_vehicle} = W_{vehicle} / g \cdot V^2 / R = W_{vehicle} g_i$$

$$g_i = V^2 / (Rg)$$

$$DSN = \frac{1}{N} \sum \left(\frac{g_i}{100} \right)^2 \left(\frac{F_z}{F_{z,R}} \right)^2$$

$$DSN_T = \frac{[\Sigma \left(\frac{g_i}{100} \right)_y^2 + 0.2 \Sigma \left(\frac{g_i}{100} \right)_x^2 \left(\frac{F_z}{F_{z,R}} \right)^2]}{N}$$

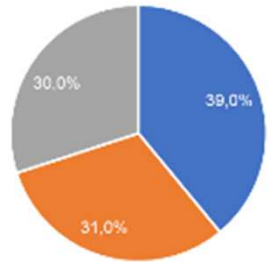
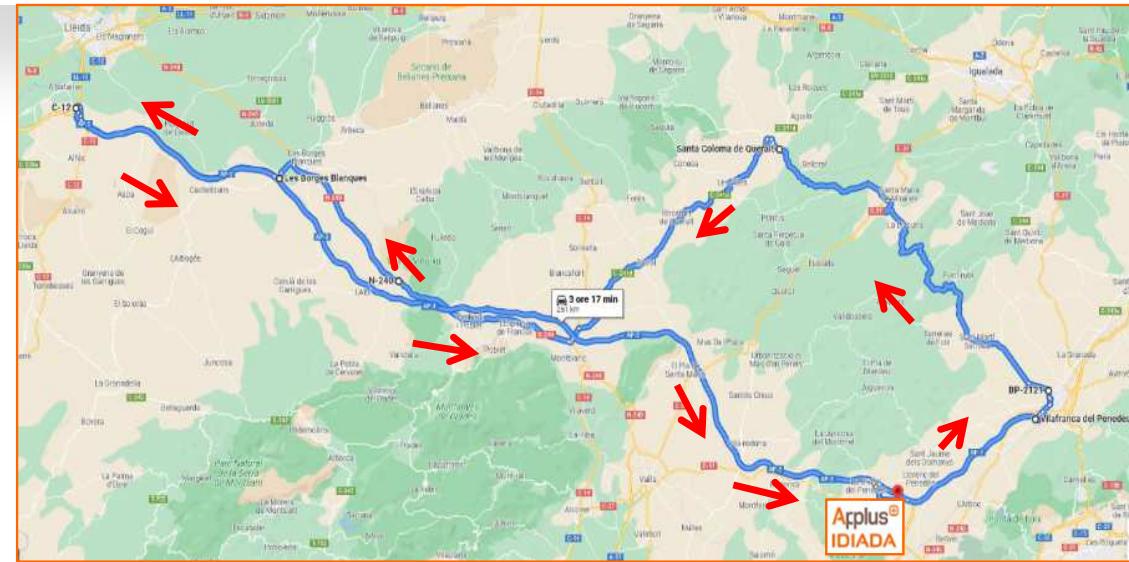


C1 TYRES

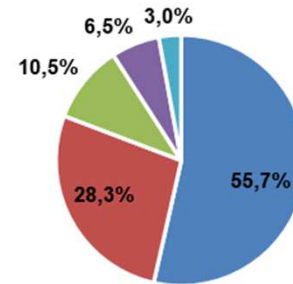
PUBLIC ROAD

Abrasion rate under real driving conditions

- C1 SRTT tyres (2 sets)
- 2x C-Segment reference vehicle
- Mileage accumulation ≈ 7.500 km $\approx 25\%$ tyre life
- Public road route
- Road distribution % predefined in Task 1
- Loading condition predefined in Task 1



■ Motorway ■ Country road ■ City



- Driver
- 2 Passengers (Driver + 1)
- 3 Passengers (Driver + 2)
- 4 Passengers (Driver + 3)
- 5 Passengers (Driver + 4)

ROAD DISTRIBUTION		
Road type	Km	%
City road	92	27 %
Country/Mountain	117	34 %
Highway	135	39 %

C1 TYRES

MEASUREMENTS

Inspection Interval on C1 Public Road Testing											
C0	P1	P2	P3	C4	C8	C12	C16	P20	C24	P28	C32
0 km	350 km	700 km	1.050 km	1.400 km	2.800 km	4.200 km	5.600 km	7.000 km	8.400 km	9.800 km	11.200 km

- Cx = Complete inspection = weight + groove depth + hardness
- Px = Partial inspection = weight

Set 2: Extended Milage accumulation

Weight: Tyre + rim + air

Tread depth

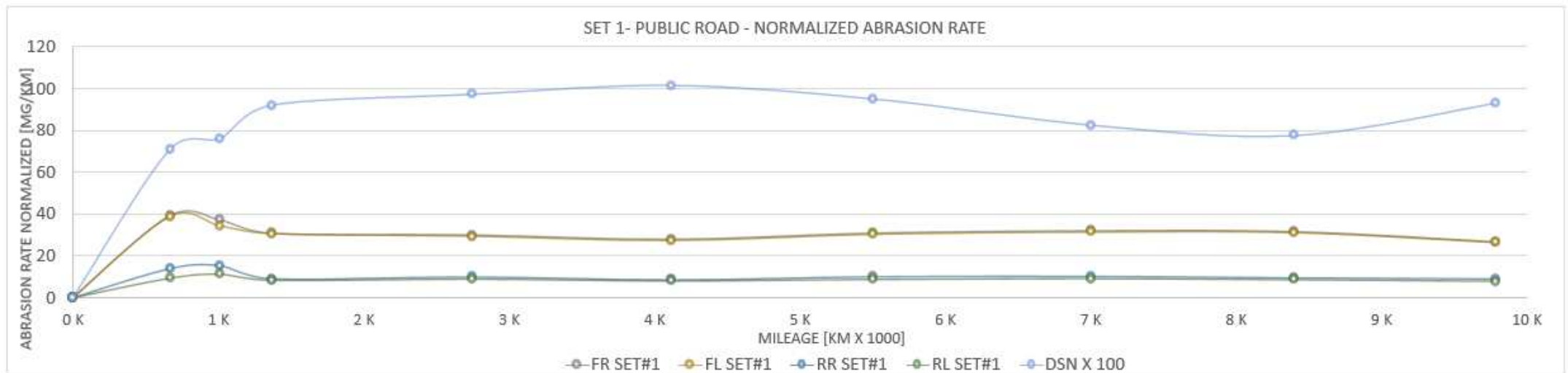
Hill & Toe



C1 TYRES

ABRASION RATE OPEN ROAD

The following graph shows the **normalised abrasion rate** during open road tests.



During the tyres run-in, the graph shows an increase on normalised abrasion rate with the lowest DSN (Driving Severity Number) on all the cycle.

After 1.000 km the abrasion rate stabilizes during the rest of the test cycle.

C1 TYRES

ACCELERATE TEST CYCLE ON PROVING GROUND

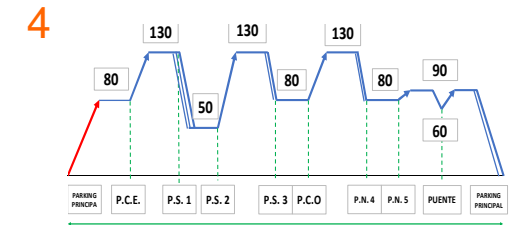
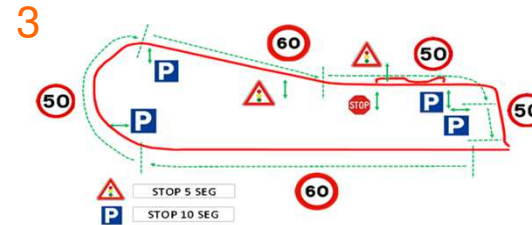
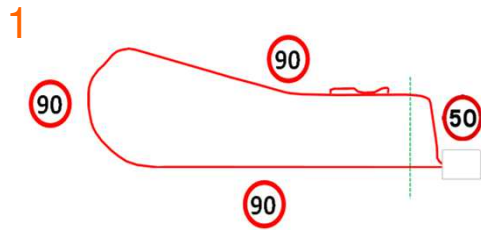
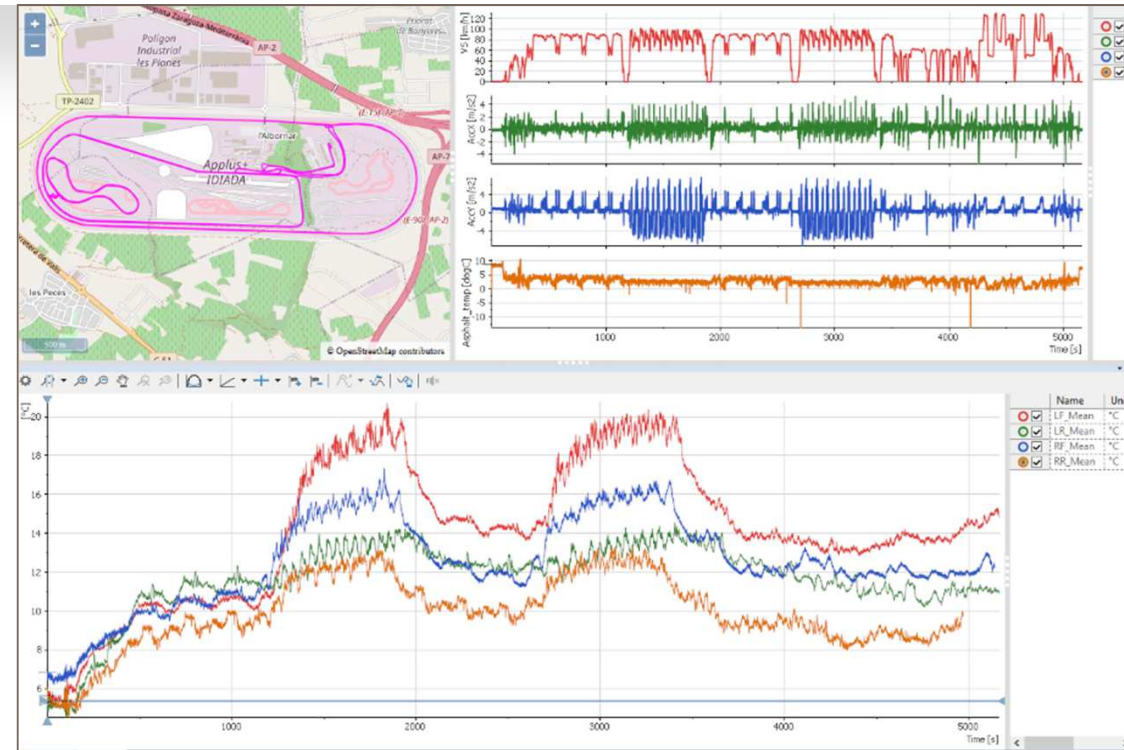
Accelerated test cycle for C1 tyres consist on 4 different sequences with different repetitions of each one. Total distance is around **6 times** lower than open road normal driving distance

Sequence 1: General Suburban sequence used for worm up and cool down tires and including braking events at 90kph starting speed.

Sequence 2: Dry Handling to accelerate lateral loads.

Sequence 3: City simulation sequence including brakes events at low speed.

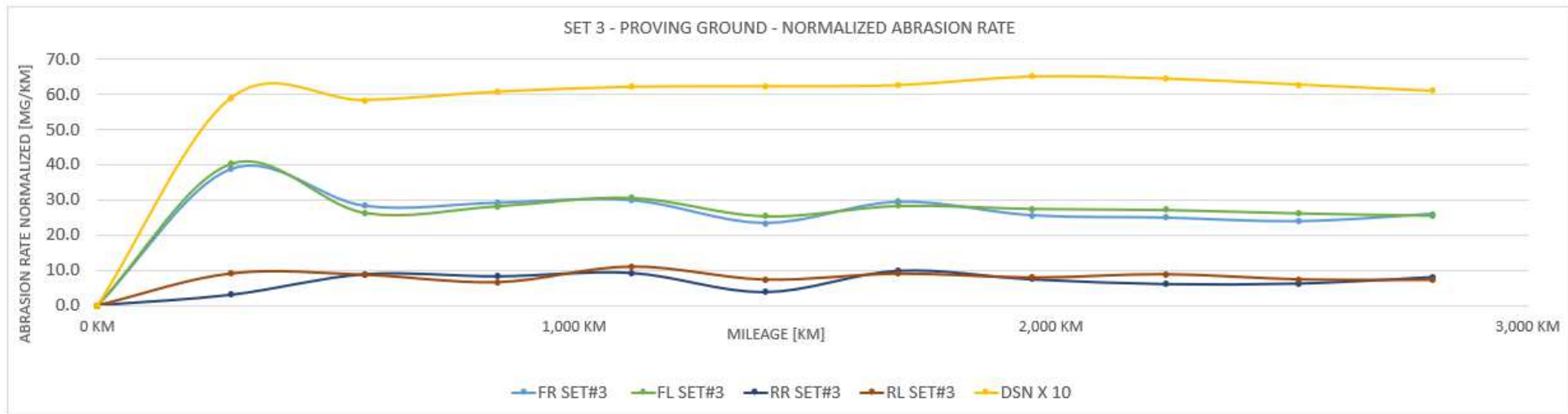
Sequence 4: Highway sequence including brakes at high speed and length.



C1 TYRES

ABRASION RATE ACCELERATED CYCLE ON PG

The following graph shows the **normalised abrasion rate** during accelerated tests in proving ground.



During the tyres run-in, the graph shows an increase on the normalised abrasion rate.

After 280 km. of accelerated cycle, that are equivalent to approximate 2.000 km the normalised abrasion rate stabilizes during the rest of the test cycle.

C1 TYRES

RUN-IN

The effect of the run-in does increase the mass loss due to the tyre nibs or any other material which covers the brand new tyre surface for this specific tyre, in this case the SRTT tyre. This increase is not so significant but what it can be observed is that the tyre nibs and surface treatment could affect negatively to the abrasion rate.

1. Possibility to limit the extra abrasion rate during first 280 kms
2. Convenience to calculate average abrasion rate disregarding the first 280 kms



C3 TYRES

PUBLIC ROAD

Vehicle: Heavy duty tractor truck
GMW: 18.000 kg



Loading Conditions:

Criteria: 80% of the tyre load index
SRTT 315/70 R22.5 -> Load index (154) 3.750 Kg -> Wheel weight requested ≈ 3.000 kg / wheel

Tractor weight	Wheel weight Left Hand/ Tyre Pressure*	Wheel weight Right Hand / Tyre Pressure*
Front Axle	3095 Kg / 7,1 bar	3026 Kg / 6,9 bar
Rear Axle	3001 Kg / 6,8 bar	3026 Kg / 6,9 bar

C3 TYRES

MEASUREMENTS

Inspection Interval on C3 Public Road Testing										
C0	P1	P3	P5	P7	P9	C12	P18	C24	P30	C36
0 km	420 km	1.260 km	2.100 km	2.940 km	3.780 km	5.040 km	7.560 km	10.080 km	12.600 km	15.120 km

- Cx = Complete inspection = weight + groove depth + hardness
- Px = Partial inspection = weight

Weight: Tyre + rim + air



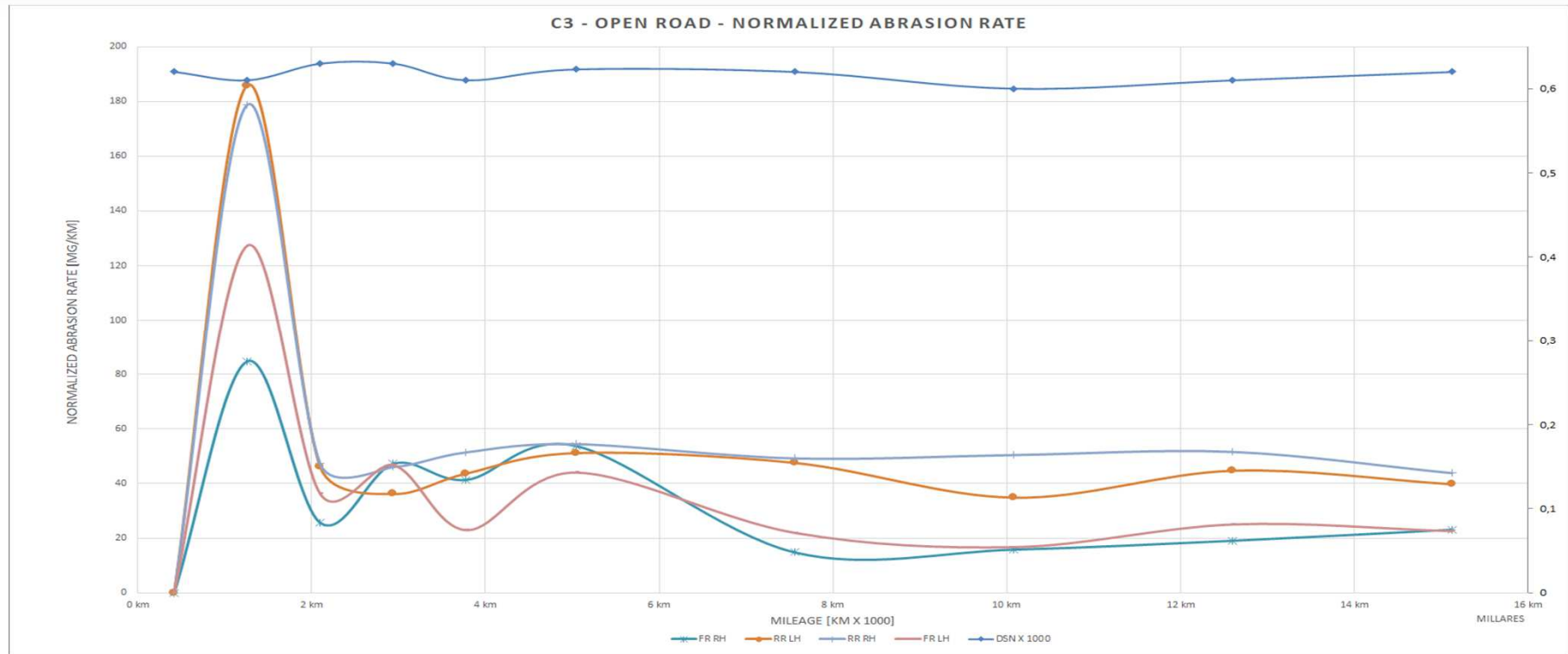
Tread depth



C3 TYRES

ABRASION RATE OPEN ROAD

The following graph shows the **normalised abrasion rate** during open road tests for C3 tyres



Stable normalized abrasion rate is seen after the first 6000 kms. Higher for rear tyres caused by the load condition

C3 TYRES

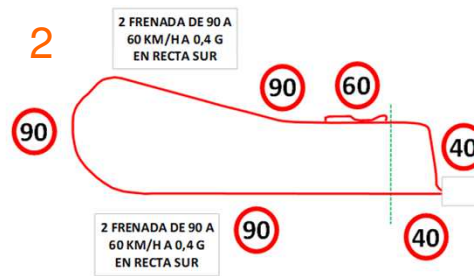
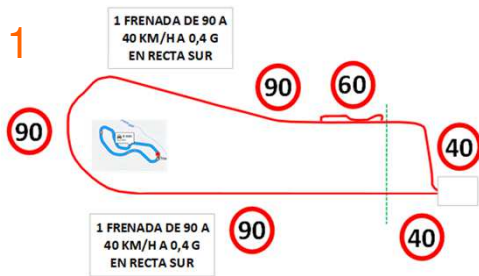
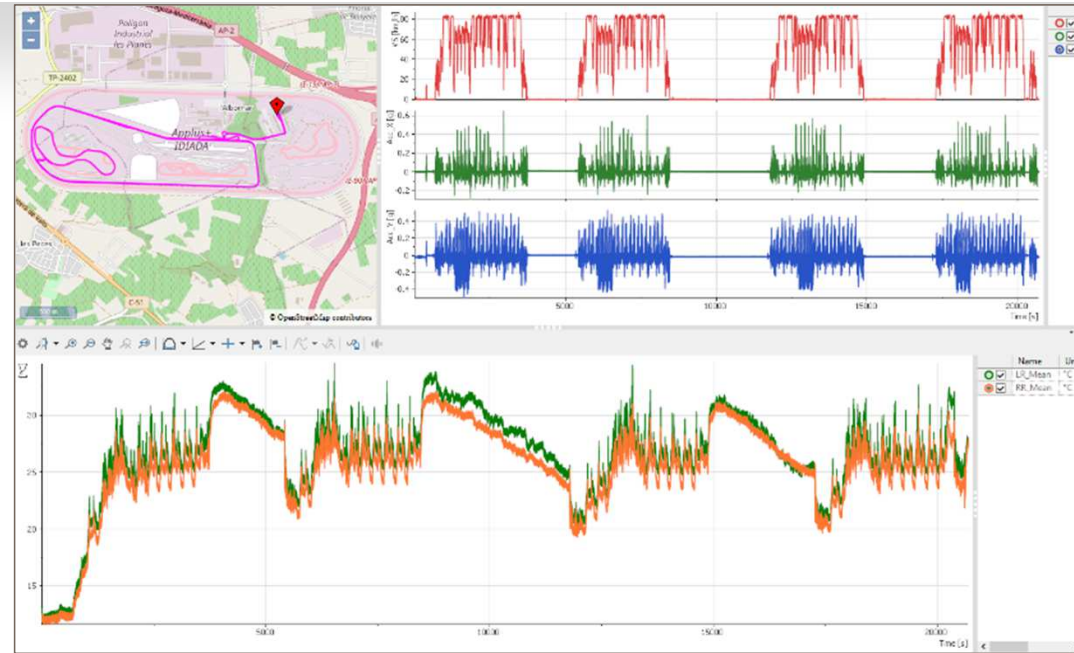
ACCELERATE TEST CYCLE ON PROVING GROUND

Accelerated test cycle for C3 tyres consist of 3 different sequences with different repetitions of each one.

Sequence 1: General sequence including brakes events from 90 to 40 kph.

Sequence 2: General sequence including brakes events from 90 to 60 kph.

Sequence 3: Mountain sequence simulation on handling track.





T H A N K Y O U
F O R Y O U R K I N D A T T E N T I O N



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