





# STUDY ON TYRES ABRASION TEST METHOD DURABILITY INVESTIGATION

RICARD ANADÓN, SENIOR PROJECT MANAGER TYRES AND WHEELS

April, 28<sup>th</sup> 2022



# — Contents —



- 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





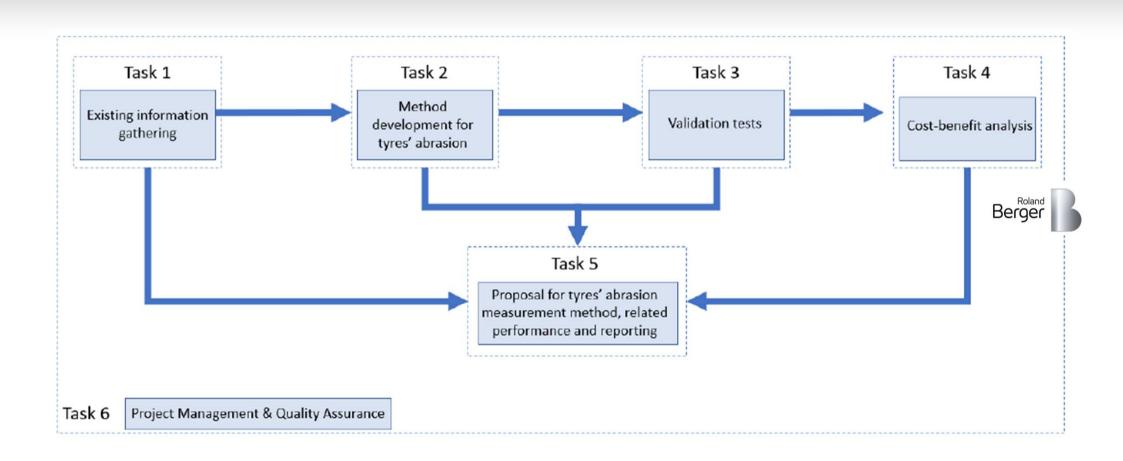
- Study performed under contract for the European Commission
- Scope: C1, C2, C3 tyres
- Conclude a test method for measuring tyre abrasion using vehicle in Proving Ground:
  - ✓ Test track characterisation and tolerances
  - ✓ Vehicle preparation
  - ✓ Test cycle description
  - ✓ Tyre measurements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

## PROJECT STRUCTURE

Arplus<sup>®</sup>

TASK DEFINITION

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### Data gathering & literature review

Applus<sup>⊕</sup> IDIADA

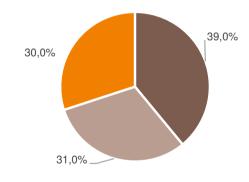


SURVEY

- 9 248 surveys
- 35 questions
- 7 % participation

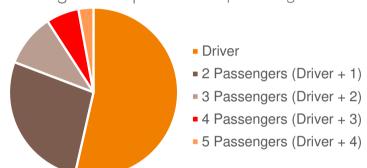
#### (Example of extracted information for C1 tyres)

Average percentage of passenger car driving in terms of road distance

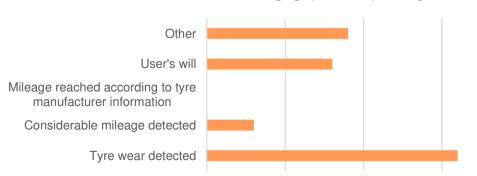




Average occupation of passenger cars



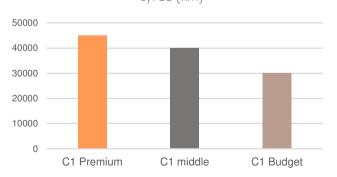
Most common reason for changing tyres on a passenger car?



Most common tyre sizes:

| 205 | 5/55R16 |
|-----|---------|
| 225 | 5/45R17 |
| 195 | 5/65R15 |
| 225 | 5/40R18 |
| 225 | 5/60R16 |

Average mileage before changing the tyres (km)



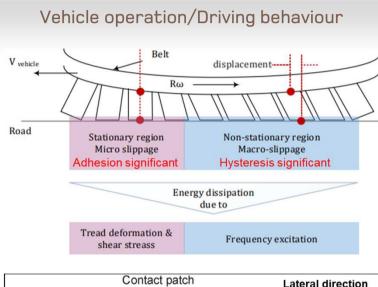
### DATA GATHERING & LITERATURE REVIEW

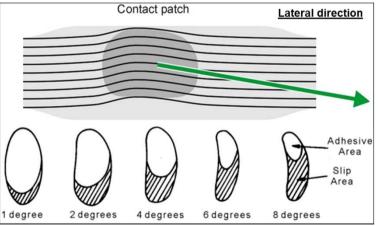
IMPORTANT FACTORS AFFECTING TYRE ABRASION

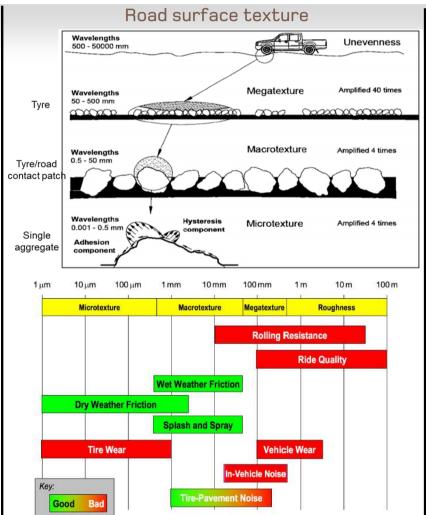


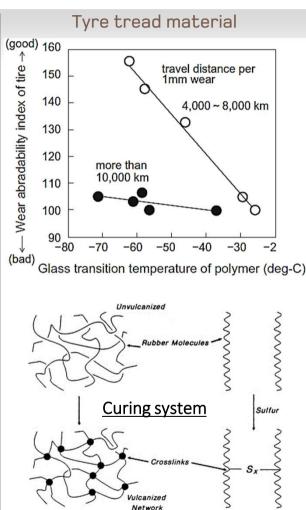


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# Driving Severity Number (DSN)

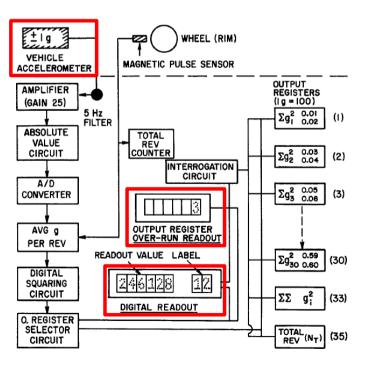


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Driving Severity Measurement consists of an accelerometer for monitoring lateral accelerations, wheel revolution counter and a module for signal processing and read-out.

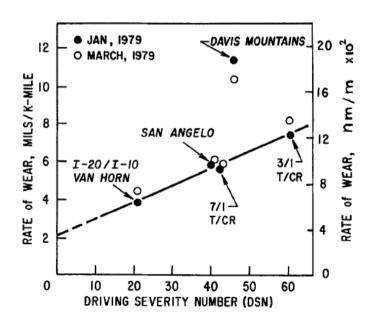
The basic task of the DSM is measurement of the average g-value per wheel revolution. It provides information regarding cornering intensity influenced by route terrain, vehicle speed and driver behaviour

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



$$E_y^{\mathrm{W}} = F_y^2/(bC_{F\alpha})$$
 $F_{y\_\mathrm{vehicle}} = W_{\mathrm{vehicle}}/g \cdot V^2/R = W_{\mathrm{vehicle}}g_i$ 
 $g_i = V^2/(Rg)$ 
 $DSN = \frac{1}{N} \sum_{i=1}^{N} \left(\frac{g_i}{100}\right)^2 \left(\frac{F_z}{F_{z,R}}\right)^2$ 

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



#### C1 TYRES Public Road

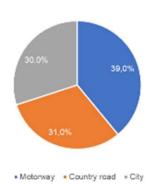


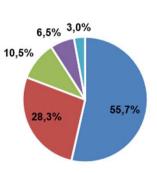
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#### Abrasion rate under real driving conditions

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







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

| m            | (SED)                                | 1000              | tiraginiti   | Second de<br>Inhanes Presse   | 100  | Allemone<br>de Legeres             | Argentian<br>Line Robins 600           | CAMP CAMP                   | iguelada                             | Carrie                               | I Direction   |
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| ROAD DISTRIBUTION |     |      |  |  |  |  |  |  |  |
|-------------------|-----|------|--|--|--|--|--|--|--|
| Road type         | Km  | %    |  |  |  |  |  |  |  |
| City road         | 92  | 27 % |  |  |  |  |  |  |  |
| Country/Mountain  | 117 | 34 % |  |  |  |  |  |  |  |
| Highway           | 135 | 39 % |  |  |  |  |  |  |  |

### C1 TYRES MEASUREMENTS





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|    |    |    | In       | spection Ir | nterval on | C1 Public F | Road Testir | ng  |     |           |
|----|----|----|----------|-------------|------------|-------------|-------------|-----|-----|-----------|
| CO | P1 | P2 | P3       |             | C8         | C12         | C16         | P20 | P28 | C32       |
|    |    |    | 1.050 km |             |            |             |             |     |     | 11.200 km |

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

Weight: Tyre + rim + air



Tread depth



Set 2: Extended Milage accumulation

Hill & Toe

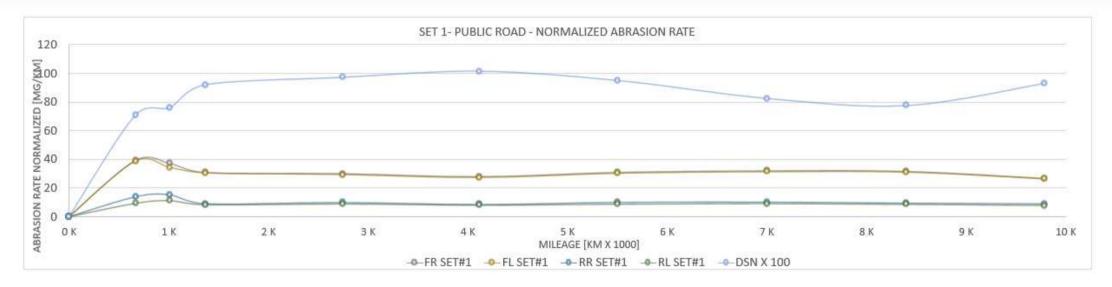


# — C1 TYRES — ABRASION RATE OPEN ROAD



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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



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Accelerated test cycle for C1 tyres consist on 4 different sequences with different repetitions of each one.

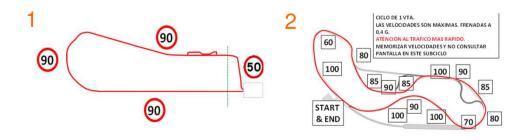
Total distance is around 6 times lower than open road normal driving distance

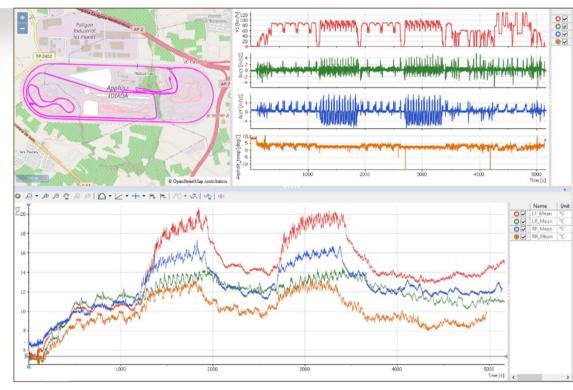
Sequence 1: General Suburban sequence used for worm up and cool down tires and including braking events at 90kph starting speed.

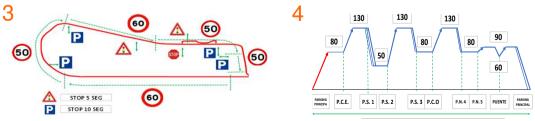
Sequence 2: Dry Handling to accelerate lateral loads.

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

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





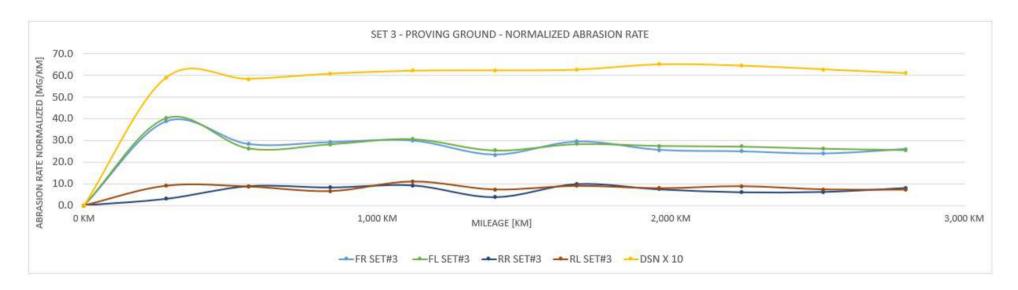


# — C1 TYRES — ABRASION RATE ACCELERATED CYCLE ON PG



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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.

The effect of the run-in does <u>increase the mass loss</u> 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



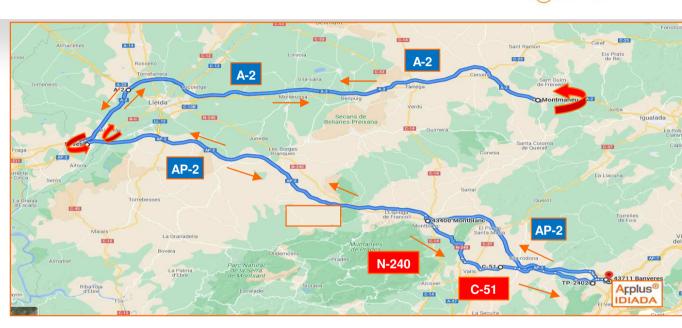
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Vehicle: Heavy duty tractor truck

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  $\approx$  3.000 kg / wheel

| Tractor weight | Wheel weight<br>Left Hand/ Tyre<br>Pressure* | Wheel weight<br>Right Hand / Tyre<br>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





|      |             |          | I        | nspection Int | terval on C3 Pul | blic Road Tes | sting    |           |           |           |
|------|-------------|----------|----------|---------------|------------------|---------------|----------|-----------|-----------|-----------|
| CO   | C0 P1 P3 P5 |          | 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



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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



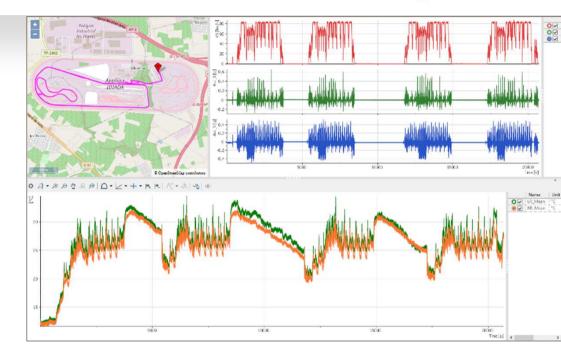
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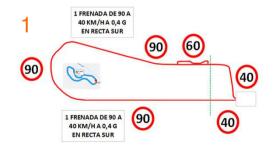
Accelerated test cycle for C3 tyres consist of 3 different sequences with different repetitions of each one.

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

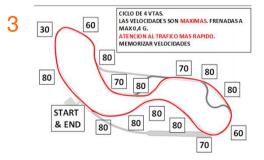
Sequence 2: General sequence including brakes events from 90 to 60 kph.

Sequence 3: Mountain sequence simulation on handling track.











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|   | M4                       | M2                | M3                | M4.                      | ME   | M6                | MZ                | M8                       | Mo                 | M10               | M44        |                   | M12               | M13                      | M14               | M15               |
|---|--------------------------|-------------------|-------------------|--------------------------|--|-------------------|-------------------|--------------------------|--------------------|-------------------|------------|-------------------|-------------------|--------------------------|-------------------|-------------------|
|   | M1                       |                   |                   | M4                       | M5   |                   | M7                |                          | M9                 | M10               | M11        |                   |                   | -                        |                   | _                 |
|   | jun-21                   | jul-21            | ago-21            | sep-21                   | oct-21   | nov-21            | dec-21            | jan-22                   | feb-22             | mar-22            | apr- 2     | 2 m               | ay-22             | jun-22                   | jul-22            | ago-              |
|   | V22<br>V23<br>V24<br>V25 | V26<br>V28<br>V29 | V32<br>V33<br>V34 | V36<br>V38<br>V38<br>V39 | V41<br>V42<br>V43                                | V44<br>V45<br>V46 | V48<br>V50<br>V51 | W03<br>W03<br>W04<br>W05 | 00 V06 V08 V08 V09 | V10<br>V12<br>V13 | V14<br>V15 | V17<br>V18<br>V19 | V20<br>V21<br>V22 | V23<br>V24<br>V25<br>V26 | V27<br>V28<br>V29 | V31<br>V32<br>V33 |
| TYRES ABRASION TENDER   |                          |                   | .                 |                          |  | - - -             |                   | .                        |                    | 2222              | 2 2 .      |                   |                   |                          |                   |                   |
|   |                          |                   |                   |                          |  |                   | 1 1 1 1           |                          |                    | 1 1 1 1           |            | 1 1 1             |                   |                          |                   | 1 1 1 1           |
| Task 1  |                          |                   |                   |                          | D1   |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Task 1.1  | -                        |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Task 1.2  |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   | <u>_</u>          |                          |                   |                   |
| Task 2  |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            | D                 | 2                 |                          |                   |                   |
| Task 2.1 & Task 2.2   | 4                        |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Methodology/Discussion/Preparation                            |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Car 1 setup   |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Official test C1 - Run-In + Open Road + Full inst measure     | -                        |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Results and measurement review                                | 4                        |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Accelerated test C1 + Full instrumentation measure            |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Car 2 setup   |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Official test C1 - Run-In + Open Road + Full inst measure     |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Truck setup   |                          |                   |                   |                          |  |                   |                   |                          |                    | ļļļ               |            | ļļ                |                   | ļļļ                      |                   |                   |
| Official test C3 - Run-In + Open Road                         |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Results and measurement review                                |                          |                   |                   |                          | <u> </u>   |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Accelerated test C3   |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Reporting C1 Tyres  | 4                        |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Full inst. verification & Tyre run-in conclusions & Reporting |                          |                   |                   |                          | ļļļ  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Tyre run-in method proposal                                   |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Abrasion method proposal + connection with mileage            |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   | -                 |                          |                   |                   |
| Reporting C3 Tyres  |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Full inst. verification & Tyre run-in conclusions & Reporting |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Tyre run-in method proposal                                   |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Abrasion method proposal + connection with mileage            | 4                        |                   |                   |                          | ļļ   |                   | _                 |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Task 3  |                          |                   |                   |                          | ļļļ  |                   |                   |                          |                    |                   |            |                   |                   |                          | D3                |                   |
| C1 validation + Official test C1                              |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| C3 validation + Official test C3                              |                          |                   |                   |                          | <u> </u>   |                   |                   |                          |                    | ļļļ               |            |                   | ļļļ               |                          |                   |                   |
| Measurement data verification & conclusions                   | 4                        |                   |                   |                          |  |                   |                   |                          |                    | ļļļ               |            |                   |                   |                          |                   |                   |
| Confirmation connection abrasion & mileage + Reporting        |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Task 4 - RB   |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   | D4                |
| CBA   |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| ask 5   |                          |                   |                   |                          | <del>                                     </del> |                   |                   | 4-4-4-4-                 |                    |                   |            |                   |                   |                          |                   | D <sub>5</sub>    |
| Test conditions & specifications                              | 4                        |                   |                   |                          | <u> </u>   |                   |                   |                          |                    | <u> </u>          |            |                   |                   |                          |                   |                   |
| Mathematical formula for tyre's abrasion rate                 |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |
| Proposal for tyre's abrasion limits                           |                          |                   |                   |                          |  |                   |                   |                          |                    |                   |            |                   |                   |                          |                   |                   |



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