Coast-by drum indoor method ISO TC31 WG11, ISO 20908

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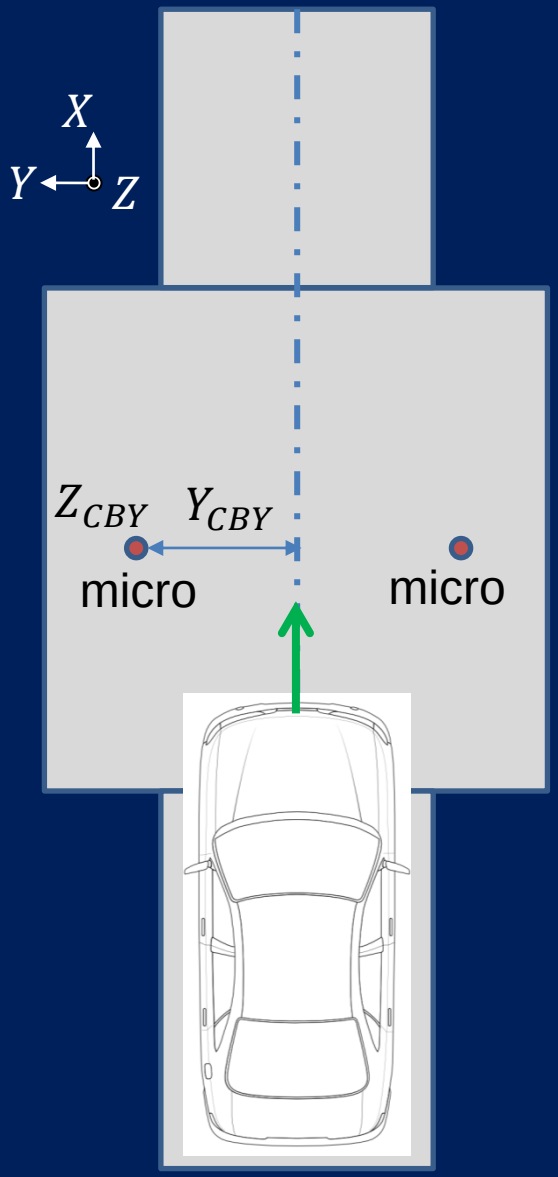
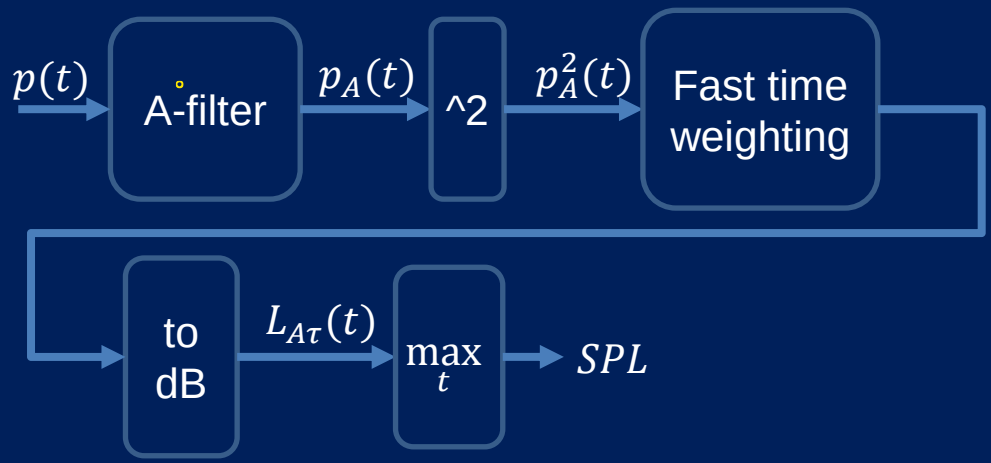
Reminder of existing method ISO 13325

Reminder: Tyre coast-by sound emission measurement



- *Measurement allowing to measure the tyre sound emissions without including other sounds:*
  - Free rolling, engine off, speed from 70 to 90 kph
  - Micros at 7.5 m (Y_{CBY}) of the axle, height 1.2 m (Z_{CBY})
- *Standardized track (ISO 10844-2014)*
- *Calculation for each speed:*



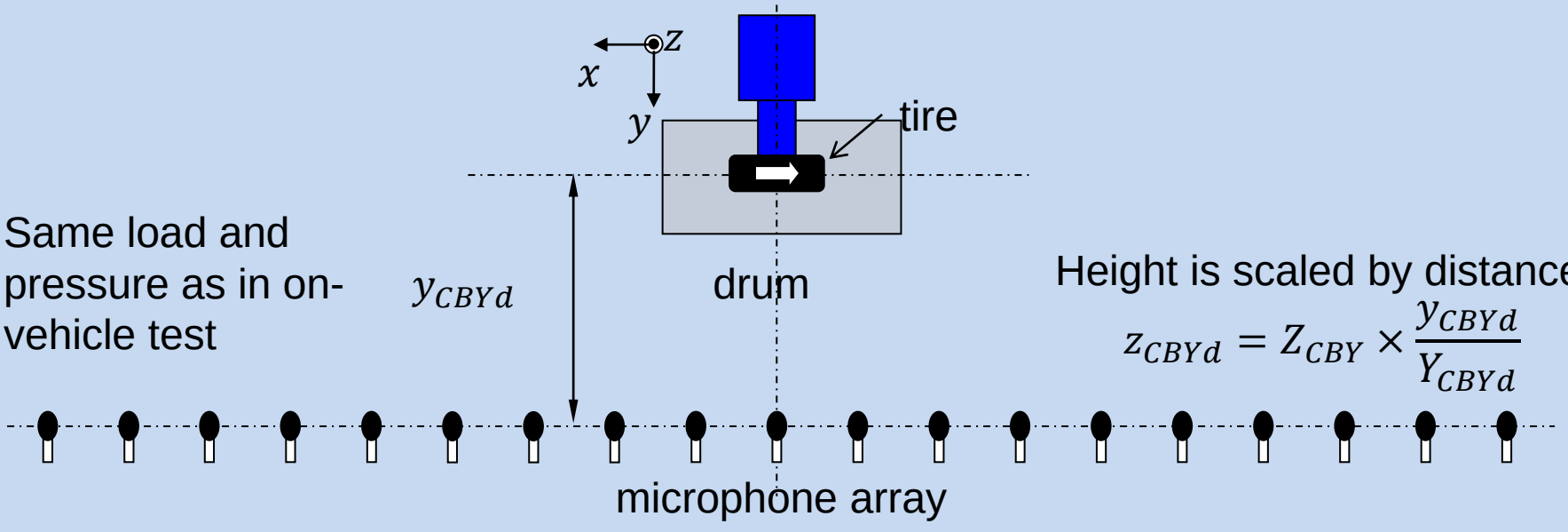
- *Linear regression to get noise @ 80 km/h:*
  - $L = a \lg \frac{V}{V_{CBY}} + L_{CBY}$

ISO TC31/WG 11 proposal for tyre sound emission indoor measurement: Coast-by Drum method

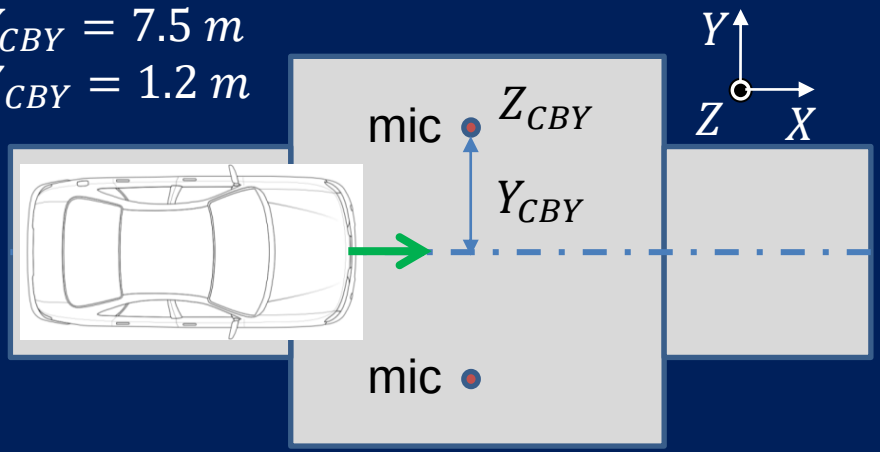
Current method assessment, possible progress

- *Current method presents dispersions coming mainly from:*
  - Track variation, up to 4 dB(A)
  - Vehicle variation
  - Outdoor environment variation (weather, background noise)
- *Expensive (track, test duration and availability, vehicle…)*
- *Possible improvement : laboratory indoor measurement:*
  - Controlled environment
  - No vehicle effect
  - Surface could be better standardized
  - Better operational efficiency (cost, scheduling, resources)
- ***Objective: develop an indoor sound emission measurement method:***
  - **Same measurement concept (vehicle/tyre passing in front of microphone)**
  - **Correlated with current methods (UN R117 & ISO 13325), same reading**
  - **Usable for tire homologation (UN R117 and other regulation)**
  - **Compatible with indoor measurement for vehicle (ISO 362-3, UN R51-3)**

Method Concept



$Y_{CBY} = 7.5\ m$
$Z_{CBY} = 1.2\ m$

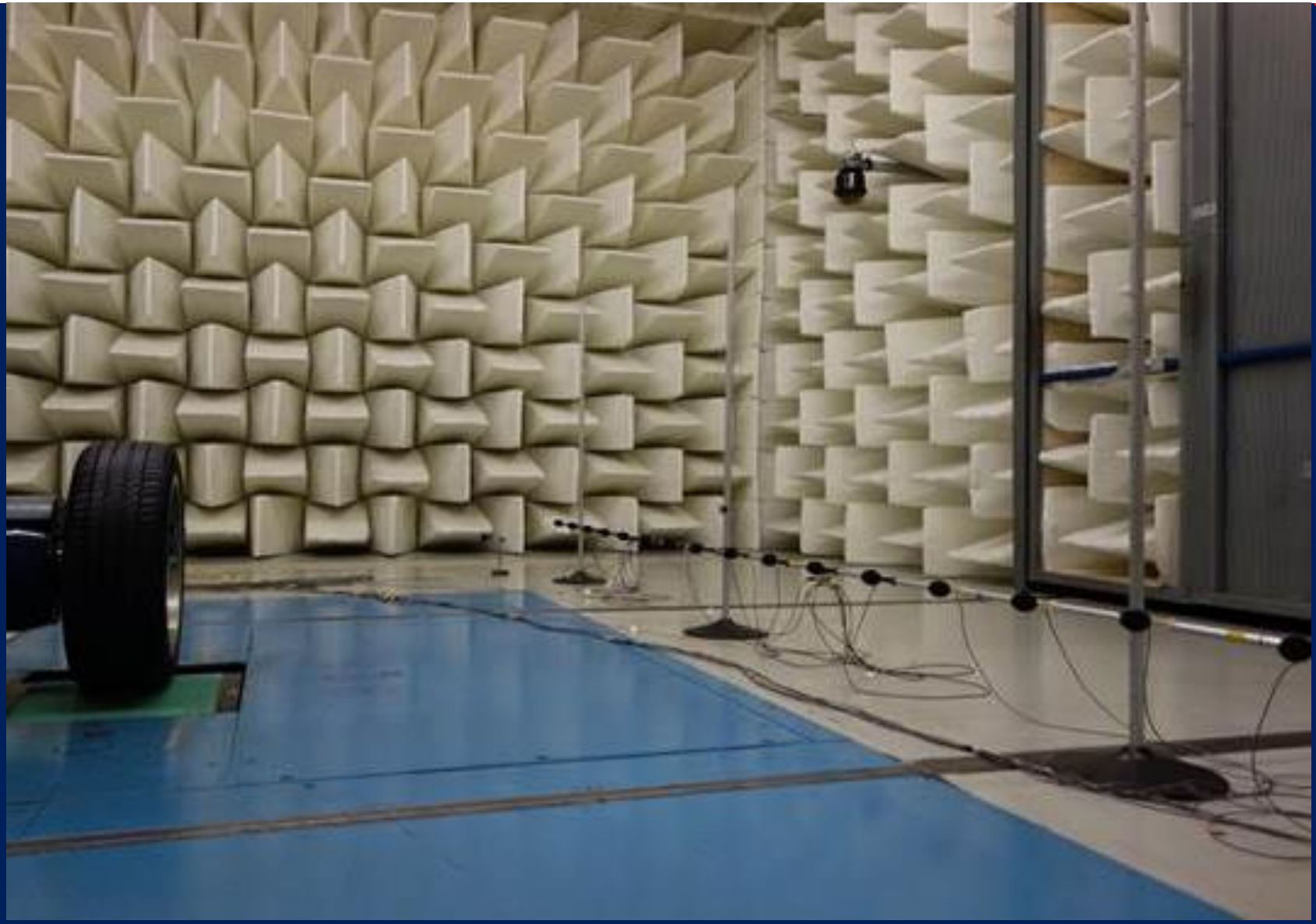


- *Microphone array line corresponds to the microphone trajectory in on-vehicle test..*
- *Sound pressure corrected by distance*
- *Different microphone(s) setup (linear, circular, moving)*

Facilities and test conditions example

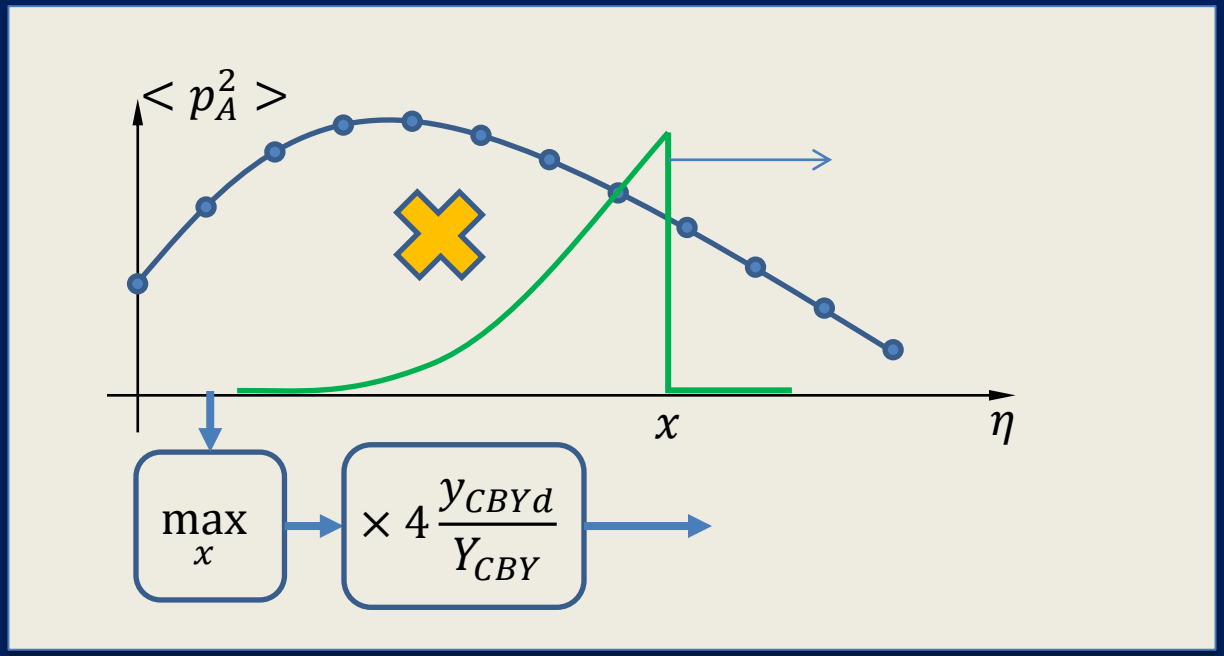
- *Semi-Anechoic room*
  - Conform to standard ISO 3745
  - Temperature controlled 23±3 °C
- *Measurement drum*
  - Diameter 2.7 meters
  - Rolling surface width 0.45 m
  - Surface: resin replicating an ISO 10844 track
  - Driven at several constant speeds °
- *Tyre conditions*
  - Load requested by UN R117
  - Pressure requested by UN R117
  - Slip and camber angles : 0 degree

Implementation example

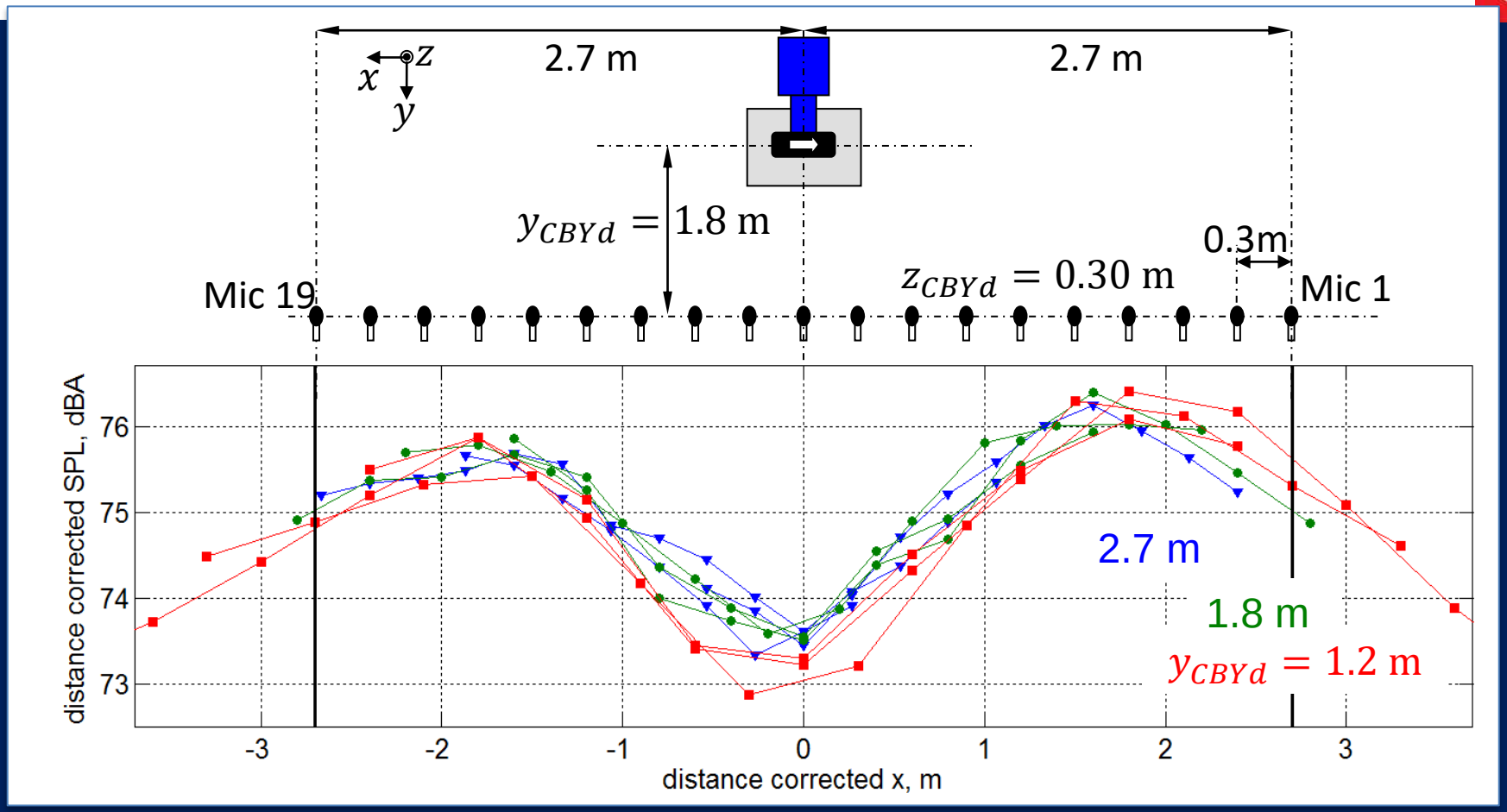


Data treatment

- *A-filter microphone signals* $p(t) \rightarrow p_A(t)$
- *Compute mean square pressure at each microphone (T = 10s):* $P_A(x) = \frac{1}{T}\int_0^T p_A^2(t)\,dt$
- *Apply moving exponential window in space:* $P_{FA}(x) = \frac{1}{V}\int_{x_{min}}^{x} P_A(x) e^{-\frac{x-\eta}{V\tau}}\,d\eta$
- *Corrections: distance, "4 tyres", maximal value :* $L_V = 10\log_{10}\left(4\frac{y_{CBYd}}{Y_{CBY}}\frac{\max\limits_x P_{FA}(x)}{p_0^2}\right)$
- *Linear fit of* L_V *vs logarithm of speed (as in the on-vehicle test)*



Detail and limit of microphones setup



- ⊙ $\propto 1/y$ *works reasonably for* Y_{CBYd} *≥1.80 m*
- *Main part of the sound field is captured.*
- ⊙ *Indoor facility size can be reduced with an acceptable measurement:*
  - It not necessary to have 7.5 meters between tyre and microphone line
  - Different microphone setup possible : linear, circular, one moving microphone

Correlation to track measurement

- *Different factors can affect the indoor measurement, as:*
  - The drum diameter
  - The horn effect
  - The semi anechoic room performances
  - The rig carrying and loading the tyre on the drum
- *ISO 20908 then requests a correlation to track measurement for eachh drum*
- *Alignment process (C1 tyres)*
  - Request at least 9 C1 tyres (5 Normal, 4 3PMSF, optional Special) to be measured using both ISO 13325 and ISO 20908 methods
  - These measurements allow to establish corrections applied to drum results
  - Lab accepted if following conditions are met:
    - > Difference (track,drum) <= 5 dB(A) for each tyre
    - > Linear correlation coefficient shall confirm an R2 value higher than 0.85
    - > After correction, Difference (track,drum) <= 1 dB(A) for each tyre
  - Alignment process renewed each 2 years, or track/drum surfaces renewed

ISO 20908 Uncertainties

- *Current estimated performances, uncertainties (from ISO 20908 DIS)*

Tyre category	Run-to-run dB	Day-to-day[a] dB	Site-to-site dB
C1 and C2 tyres	0,3	0,5 to 0,9	2.2

[a] The actual measurement uncertainty for the day-to-day situation is dependent on which kind of test room, e.g. open test room, or which kind of climatic control is used. A lower temperature variation causes a smaller measurement uncertainty.

- *Uncertainties main and dominant factor is the drum surface to surface variation, as for ISO 13325 on track method, which tracks are defined by ISO 10844.*
- *As for ISO 13325/R117, lower uncertainties will mainly be reached by decreasing the surface to surface variability.*

Conclusion

- *Results:*
  - New on-drum indoor method allowing:
    - > Same measurement concept: vehicle/tyre passing in front of microphone
    - > Drum surface replicating the reference test track
    - > Data treatment (averaging stabilized results) emulating CBY data treatment
    - > No vehicle effect or variation
    - > Controlled environment
    - > Potential to use more reproducible surfaces
  - Correlation of indoor and outdoor measurement insuring reliable measurement
- *Future actions*
  - Additional correlation survey with different pattern types, drums and tracks (ongoing by ISO TC31 WG11, including thin replica concept test)
  - Standardization of test surfaces for both drum and tracks, offering a lower track to track variation to decrease uncertainties
  - Implementation in regulation, assuming acceptable performances of the drum method

Thin surface concept for drums

Future new drum surface concept

- *Concept 1 : molding and reproducing a 10844 surface:*
  - Will be experimented by ISO WG11
  - Only an experimental plan, as the reference surface (an ISO 10844 existing track) will evolve among time and cannot be reproduced identically for ever.

  ISO TC31/WG11 sets up measurement plan using a unique surface concept.

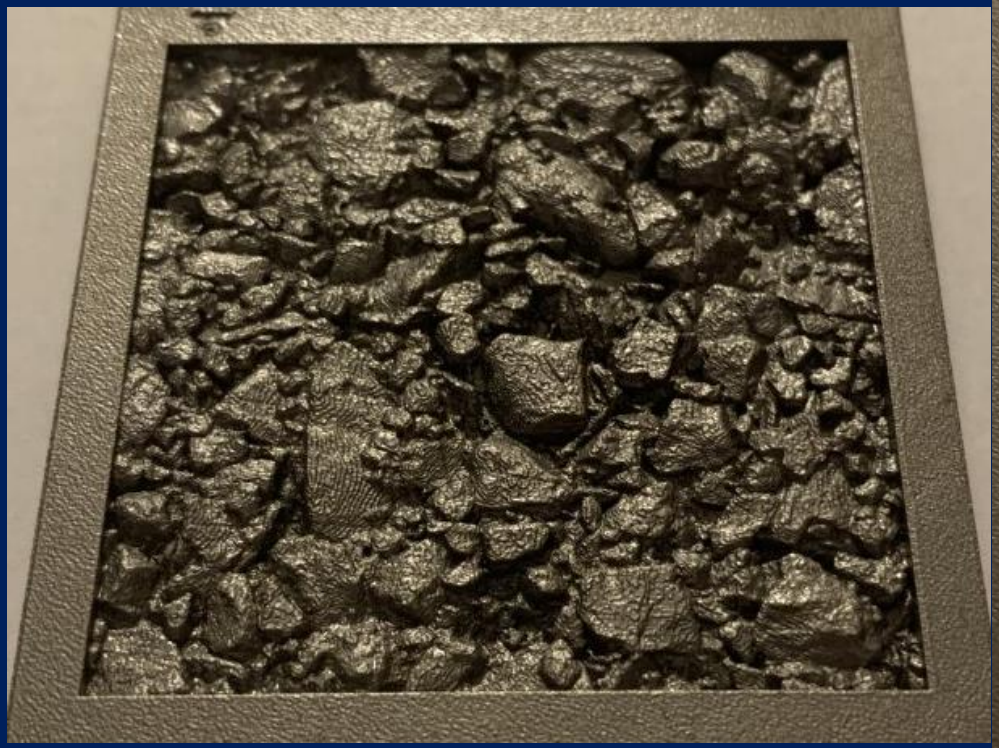
- *Concept existing track mold to replicate the track surface*
  - A 10844:2014 track is molded, using polyurethan.
  - The polyurethan mold is used to create thin surfaces to be fixed on the drums
  - Each drum then have a surface identical to the track surface, and to the other drums surfaces.
  - An experimental plan allows to check/demonstrate:
    - The correlation drums to track
    - The correlation drum to drum
    - The impact of other factors (drum diameter, semi-anechoic room design, rig impact)

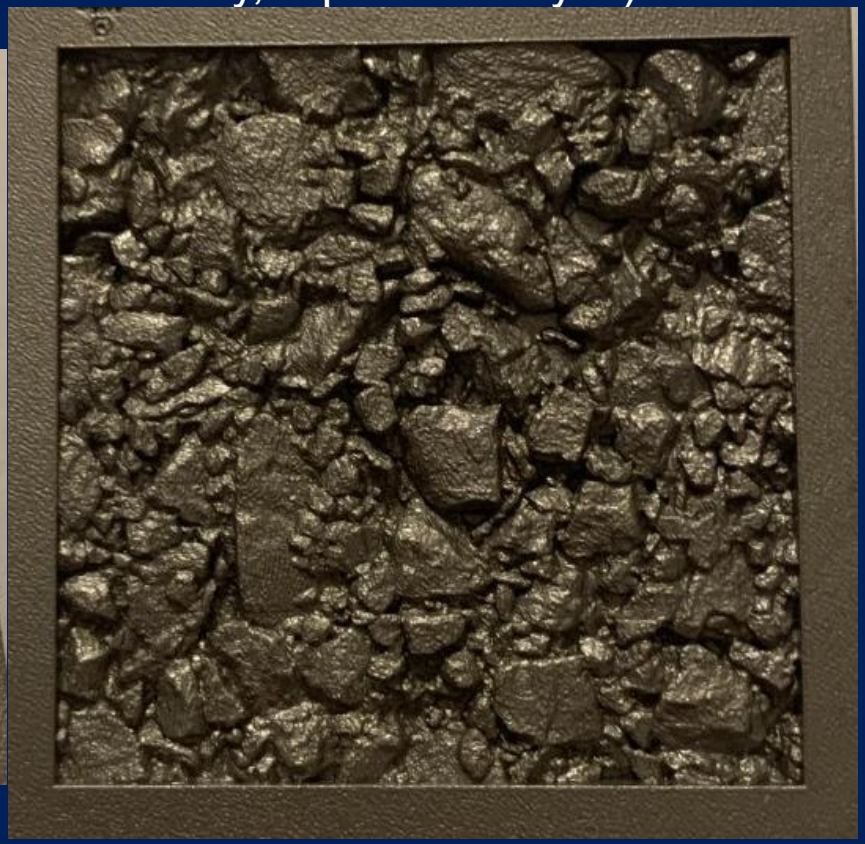
Thin surface illustration, experimental plan

- *Six drums with different diameters and one track currently in the plan*
- *A set of about 20 tyres (C1 Normal/3PMSF/Special and C2) will be tested on track & drums*
- *Experimental plan on going, delayed by logistic/covid issues.*

Numerical definition and 3D metallic printing

- *Concept:*
  - numerical definition, e.g. build by scanning/averaging existing tracks
  - 3D metallic printing of the full drum surface, or segments to be reproduced/molded. Milling could be considered as well.
  - The concept need be fully build, technically and economically validated, for sound measurement performance (representativity, reproducibility…)





Thanks for your attention

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