Introduction of virtual testing in acoustic certification

ACOUTRAIN Final Conference
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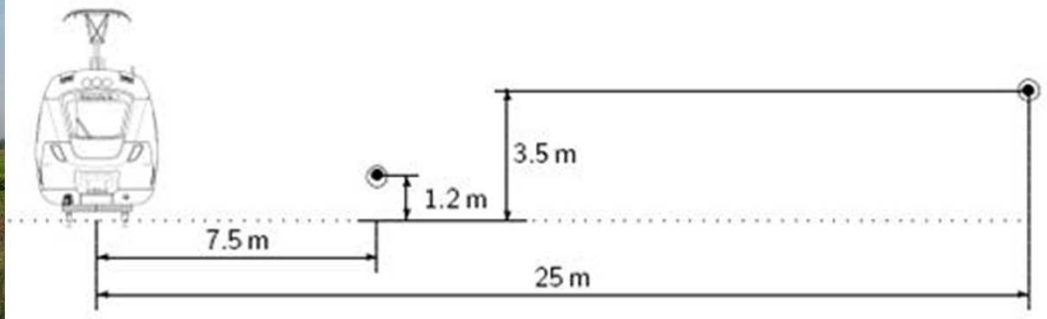
Context

TSI Noise (2011)– Assessment of rolling stock Technical

- specifications of the rolling stock
  - Stationary noise
  - Starting noise
  - Pass-by noise – at 80 km/h and at maximum speed
  - Interior noise of locomotives, multiple units and driving trailers
- A reference low-noise track is necessary for pass-by measurements.
- The limiting value concerns the equivalent A-weighted sound pressure level at 7,5 m distance from the track (25m for HS-trains).



Context

The NOI TSI issues

NOI TSI tests are costly and time consuming:

- 4 to 6 months of duration, 4 weeks of effective work
- Around 70k€ for a EMU/DMU certification (classic speed), from 65k€ to 90k€ for high speed train certification, depending on the network where the measurements take place
- For 1 manufacturer, 2 to 4 TSI certifications are required per year

- In many cases where certification is required, we talk about an extension to approval: the design of new vehicle is closely based on the design of a reference vehicle, already certified

- This “heavy” process could hamper the development of innovative solutions and the consequence could be that no noise reductions are implemented

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Basic concepts for VT

- **Virtual testing** in a certification process means that the tests that sustain the certification are partially* (or completely) carried out with numerical simulations.

  It means that simulation models are used for the assessment of regulatory (enforced by law) essential requirements, e.g. Noise TSI in ACOUTRAIN.

- Virtual test in acoustic consists of modeling the vehicle as a set of noise sources (train = set of noise sources) which is then called **virtual vehicle** (VV).

- This virtual vehicle is handled in a **numerical tool** for simulating the noise of the train, **at stationary and pass-by** (starting noise has not been considered in ACOUTRAIN: the dominant source for this case are traction noise sources for which acoustic behaviour during starting phase is really difficult to model)

* The VT process will be a combination between measurement and numerical simulation results.

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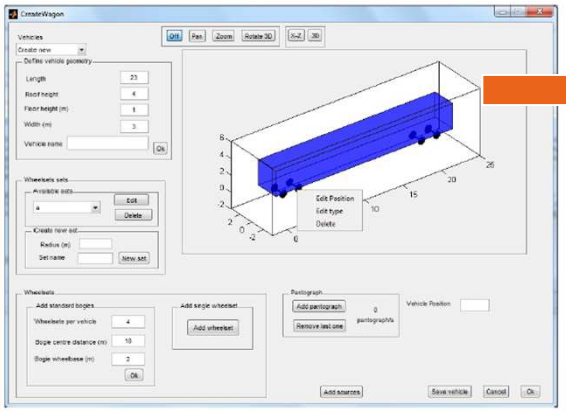
Basic concepts for VT

- Therefore, VT will deal with:
  - Numerical tools with specific numerical approach
  - Noise source modelling: noise source characterization and representation
  - Noise sources integration within the train: integration effect
- And, as real tests and virtual tests live together:
  - Propagation of noise in a complex environment (ground effect, topology effect)
  - Track characterization

Example:

Cooling-system sound source

Numerical tool



Virtual vehicle-model with all sound sources

Simulation of pass-by

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Essential requirements

- A **virtual test procedure, which is a more flexible and less expensive alternative to the field tests,** should be developed**.**
- **Virtual testing** should be an **alternative to real testing** then **both procedures should remain as equals** to improve flexibility.
- For the new procedure to be **equivalent to the established one** there are some requirements that should be fulfilled:

1. **The TSI limit value is set for predefined operational and environmental conditions as well as receiver positions. These conditions should be identical for the new virtual test procedure.**
2. **The output result from both procedures should be equivalent. It is a prerequisite that the choice of test procedure should not affect the decision to accept or reject a vehicle.**
3. **The reliability or the standard uncertainty of both procedures should be comparable.**

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Preliminary recommendations for virtual testing

- The process proposed in ACOUTRAIN should answer the following questions:
  - How could we use numerical simulation in a certification process? In which cases?
  - Which numerical tool should be used? How to reliably build a virtual vehicle?
  - How can we make sure that the procedure is reliable enough to draw conclusions on the compliance of the vehicle according to TSI NOI?

- VT process should include elements of validation. ACOUTRAIN project is to assure reliability in the process with:
  - A verification procedure that verifies the numerical tool
  - A validation procedure that validates the virtual vehicle

- The approach proposed in ACOUTRAIN should have been validated. However, it will be shown in the next presentation that lot of efforts have still to be made for implementing the method.

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Application cases

To delimit the scope of VT, some application cases for virtual testing have been identified at the beginning of the project, that correspond to the cases for which virtual testing could benefit:

- Case 1: Modification of a brake system that influences the roughness of the wheels
- Case 2: Exchange or modification of a sound source
- Case 3: Adding encapsulation or shielding
- Case 4: Transposing measurements made on any track to a TSI conforming track
- Case 5: Measuring stationary noise and calculating pass-by noise
- Case 6: Different formation of multiple units

Application cases

From these application cases list, the most relevant/urgent to be tested in VT:

- Case 1: Modification of a brake system that influences the roughness of the wheels
- Case 2: Exchange or modification of a sound source
- Case 3: Adding encapsulation or shielding
- Case 4: Transposing measurements made on any track to a TSI conforming track
- Case 5: Measuring stationary noise and calculating pass-by noise
- Case 6: Different formation of multiple units

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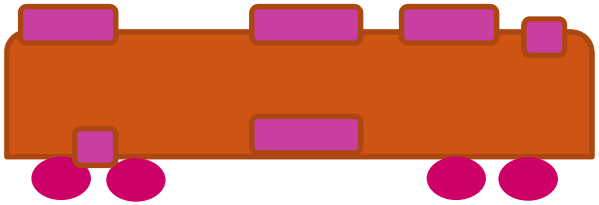
A priori VT approches for the application cases

- Case 2: Exchange or modification of a sound source

This case is naturally indicated for the so-called **Extension of Approval approach**

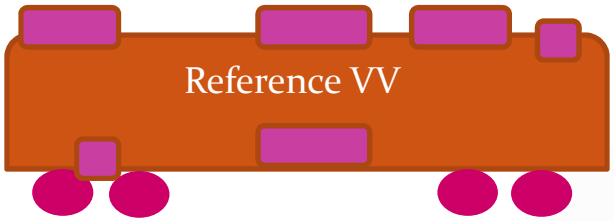
Preliminary to EoA:

Virtual vehicle for a similar vehicle



Equivalent?

Stationary and pass-by noise measurement



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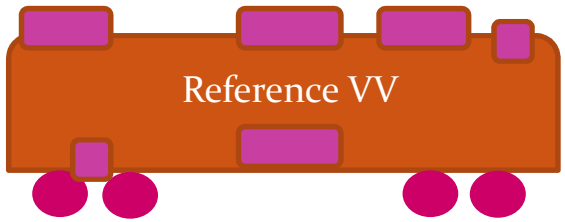

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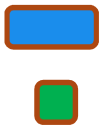
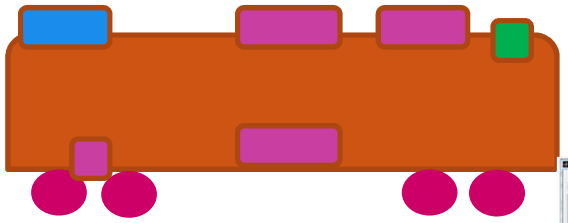
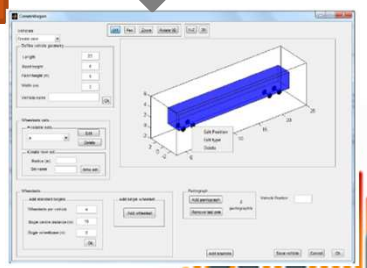


Caracterisation of
new sound sources

Reference VV
modified into VV for
the vehicle under test



Virtual vehicle for the new vehicle



If $LpA_{eq,calc\ new} < LpA_{eq\ limit}$,
then the coach is certified

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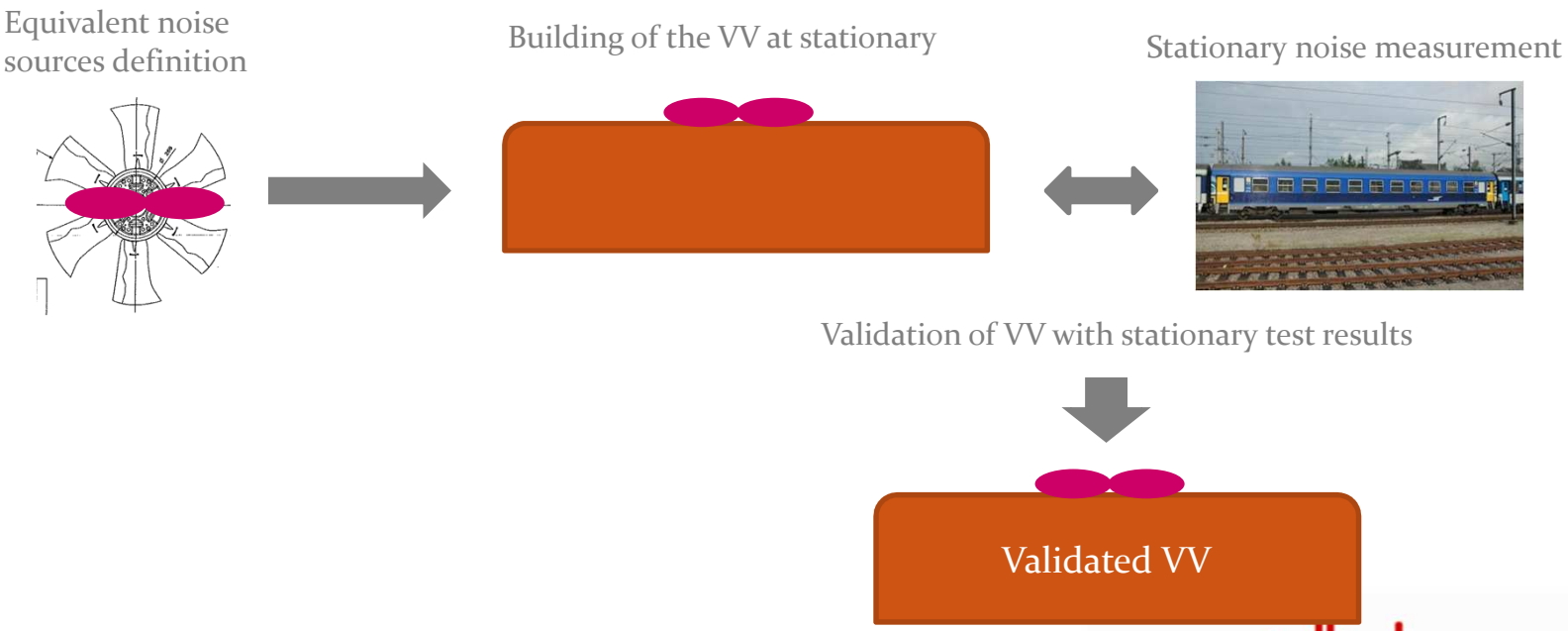
A priori VT approches for the application cases

- Case 4: Transposing measurements made on any track to a TSI conforming track
- Case 5: Measuring stationary noise and calculating pass-by noise

These 2 cases are foreseen to be assessed with a **hybrid approach**

For the hybrid approach, some measurement results are available for the vehicle global model validation



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Validated VV

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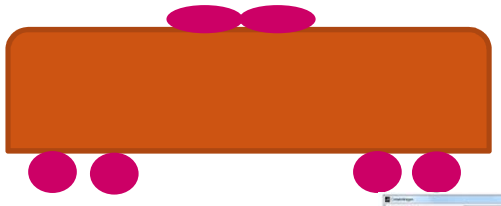
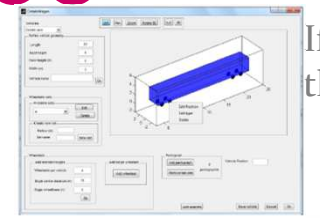
Rolling noise assessment with validated numerical tool





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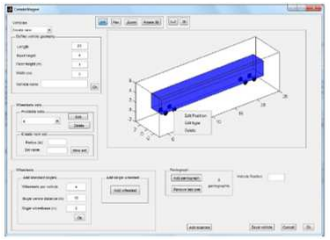
Needs for VT implementation

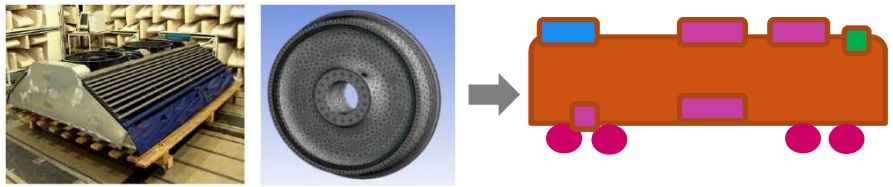
- Numerical tool with relevant and reliable performances

→ *1st session, 2 next presentations*



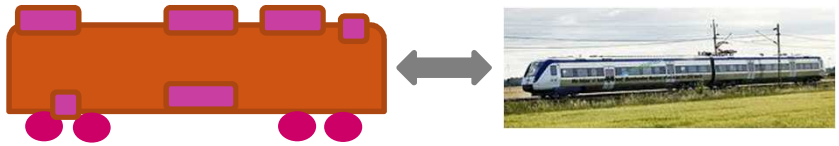
- Sources characterization
  - Vehicle specific noise sources
  - Rolling noise

→ *2d session presentations*



- Validation procedures

→ *4th session presentations*



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Thank you for your attention!