



Integration effects

ACOUTRAIN Final Conference

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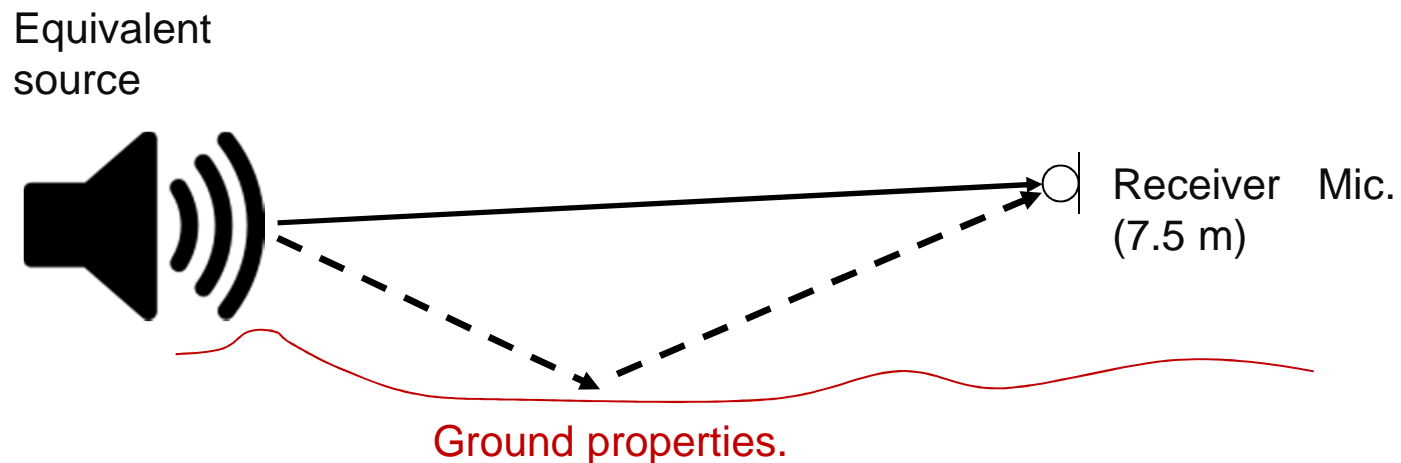
Outline

- Integration effects and virtual homologation
- Measurement of integration effects
- Computation of integration effects
 - Roof mounted sources
 - Under frame mounted sources
- Conclusion & Discussion



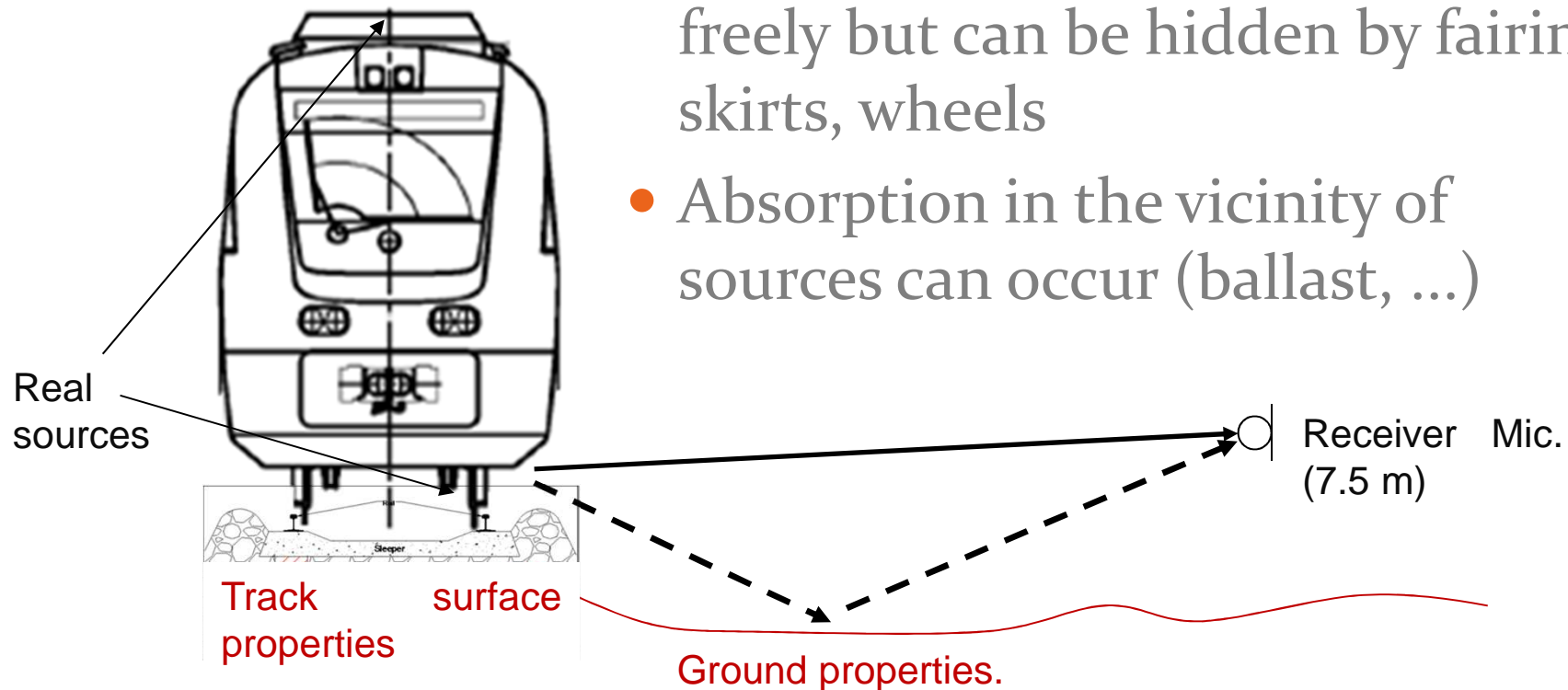
Integration effects and virtual homologation (1)

- The Acoutrain software computes the SPL at a receiver position due to several (moving) sources
- The source is radiating in free field



Integration effects and virtual homologation (2)

- The real sources are not radiating freely but can be hidden by fairings, skirts, wheels
- Absorption in the vicinity of sources can occur (ballast, ...)



→ Integration effects ('Insertion Loss - IL' related to specific receiver position)

Measurement of integration effects (1)

- Measurement of transfer functions $(L_{p,art} - L_{W,art})$ on “generic” rolling stock
[N.B.: compact source or reciprocal measurement!]
- Determination of Insertion Loss (IL) spectra (measured vs. measured FRF or measured vs. computed free field FRF)



Alstom measurements
(validation of SITARE)



Measurement of integration effects (2)

Alternatively, benefit from TSI measurements at standstill

- Measurement of sound pressure due to each source operated separately
 - Comparison with computed or measured sound pressure without any obstacles → IL
- Database with 'generic' transfers (IL)
- Can such a database be sufficiently representative?



Computation of integration effects: methods

- Analytical models (only sufficiently simple geometries)
- Ray tracing models (real geometries can be treated)
- Boundary Element Methods BEM (computationally heavy, low freq, not tested within ACT)
- Energy BEM (mid to high frequency method)



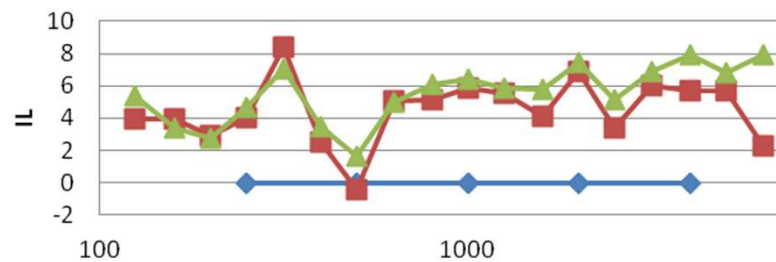
Computation of integration effects: applications

- Roof mounted equipment:
Model has to take into account diffraction:
an analytical diffraction model and ray tracing have been tested
- Under frame or bogie mounted equipment:
Complex geometries: multiple reflections, diffraction, absorption (ballast), ...
Ray tracing and Energy BEM have been tested

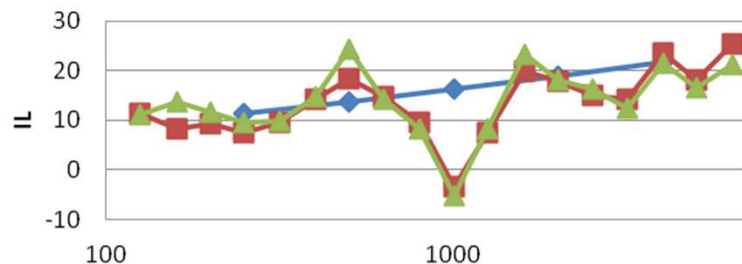


Computation of integration effects: Roof mounted (1)

- Testing of analytical model (uniform theory of diffraction) vs. ray tracing on a simplified geometry (thin barrier)



—◆— Ray tracing mic2
—■— Measured mic2
—▲— Analytic mic2



—◆— Ray tracing mic5
—■— Measured mic5
—▲— Analytic mic5

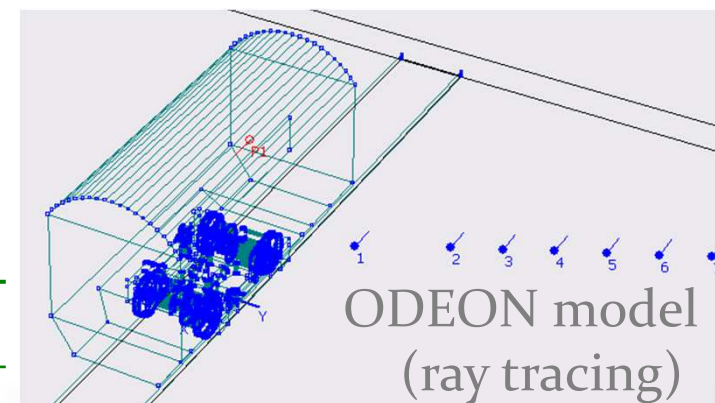
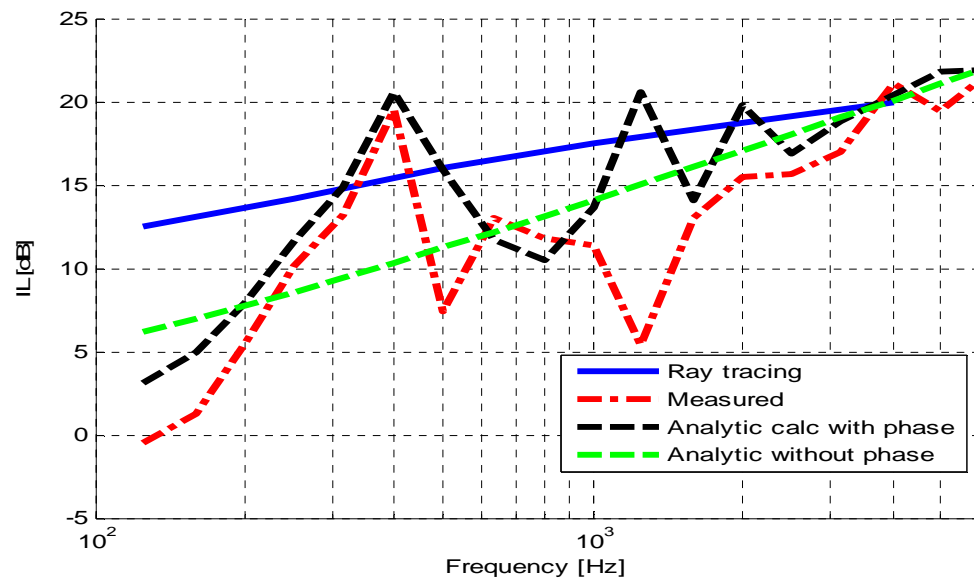


Reciprocal measurement



Computation of integration effects: Roof mounted (2)

- Testing of analytical model (uniform theory of diffraction) vs. ray tracing on a real train



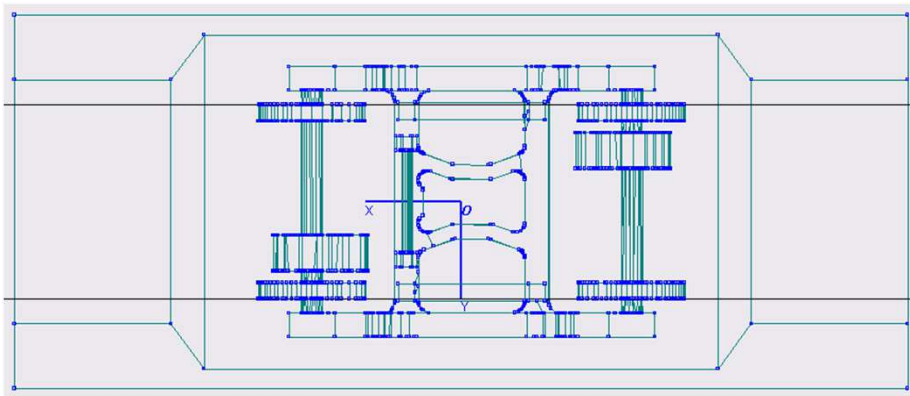
ODEON model (ray tracing)

dBA	measured	analytical with phase	analytical without phase	ODEON
SPL w/o fairing	61.2	61.4	61.4	61.0
SPL with fairing	51.2	48.5	48.7	44.2
IL	10.0	12.9	12.7	16.8

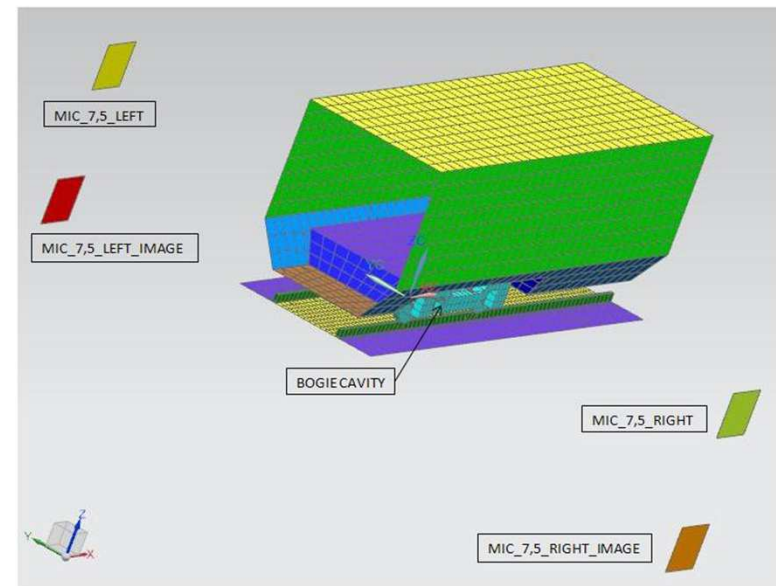


Computation of integration effects: Under frame/ bogie mounted (1)

- Testing of ODEON (ray tracing) vs. SONOR (eBEM)



ODEON model (ray tracing)



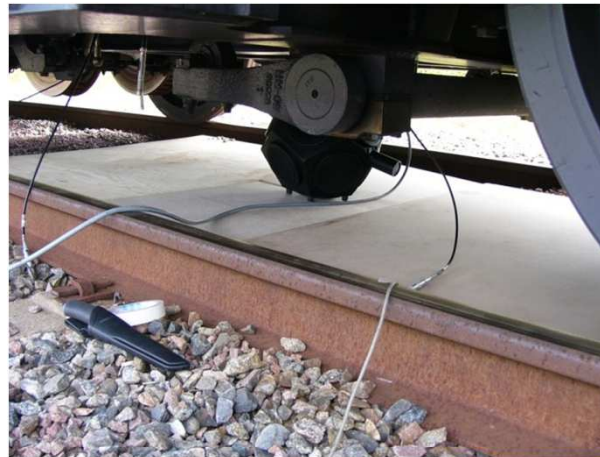
SONOR model (energy BEM)

Computation of integration effects: Under frame/ bogie mounted (2)

- Comparison with BT measurements on Regina train



Artificial source in bogie
cavity



Reflecting surface as a
“slab track “ imitation

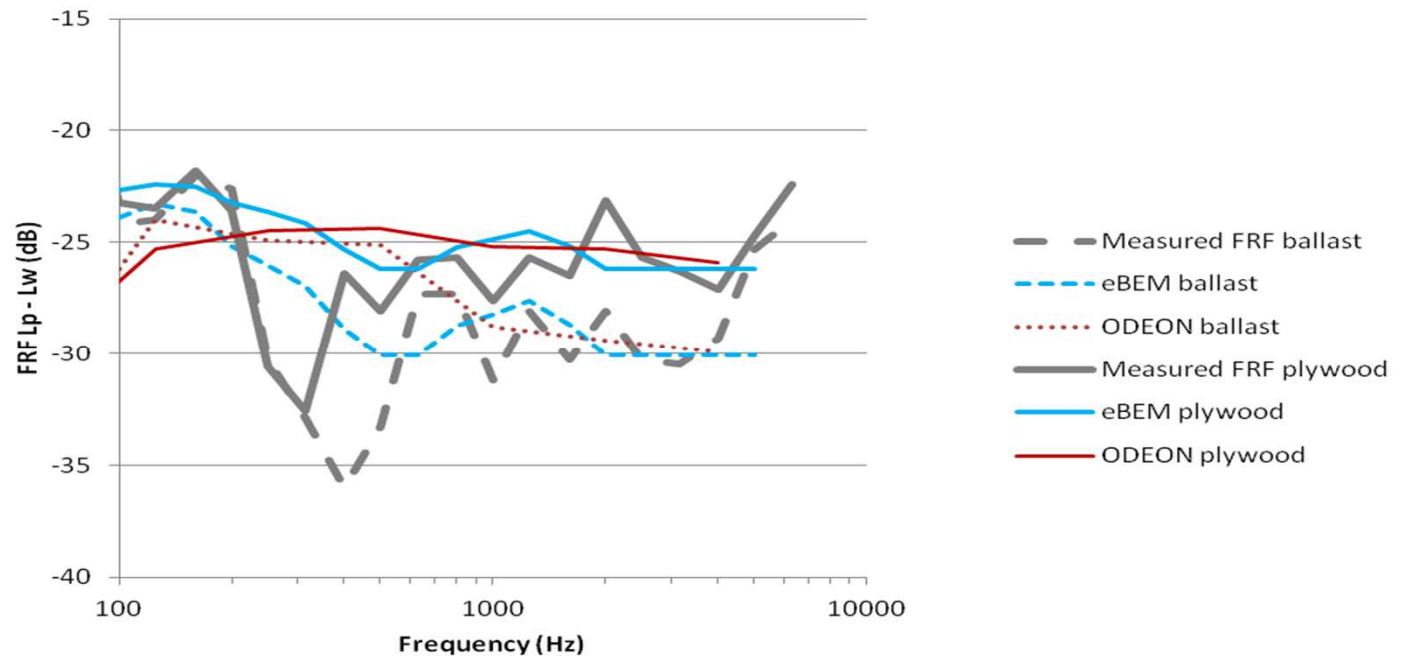


Computation of integration effects: Under frame/ bogie mounted (3)

Measurements

Ray tracing

Energy BEM




	Measure d [dBA]*	eBEM [dBA]	error eBEM [dBA]	ODEON [dBA]	error ODEON [dBA]
ballast	61.7	61.5	0.2	62.6	0.9
plywood	64.0	65	1.0	65.3	1.3



Lessons learned

- Roof mounted equipment :
 - Main effects: shielding & diffraction
 - Point source + simple geometry: Analytical models can be very precise
 - Real geometries: Ray tracing, ...
 - A good source representation is necessary for a correct prediction of integration effects
 - The performed predictions are not sufficiently precise yet
- Bogie / under-frame mounted equipment:
 - Main effects: shielding & absorption (ballast)
 - Point source models may be sufficient
 - Satisfactory simulation results



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- Detailed results can be found in ACOUTRAIN deliverable 3.6: ‘Model for geometrical integration transfer functions to be integrated in the global simulation model’





Thank you for your attention!





Summary

Type of source:

- roof/ underframe?
- directive source?



Type of integration effects: 

- Shielding
- Diffraction
- Absorption

Choice of a tool

- Analytical
- Ray tracing
- (energy) BEM
- (experimental) database

