
CERN

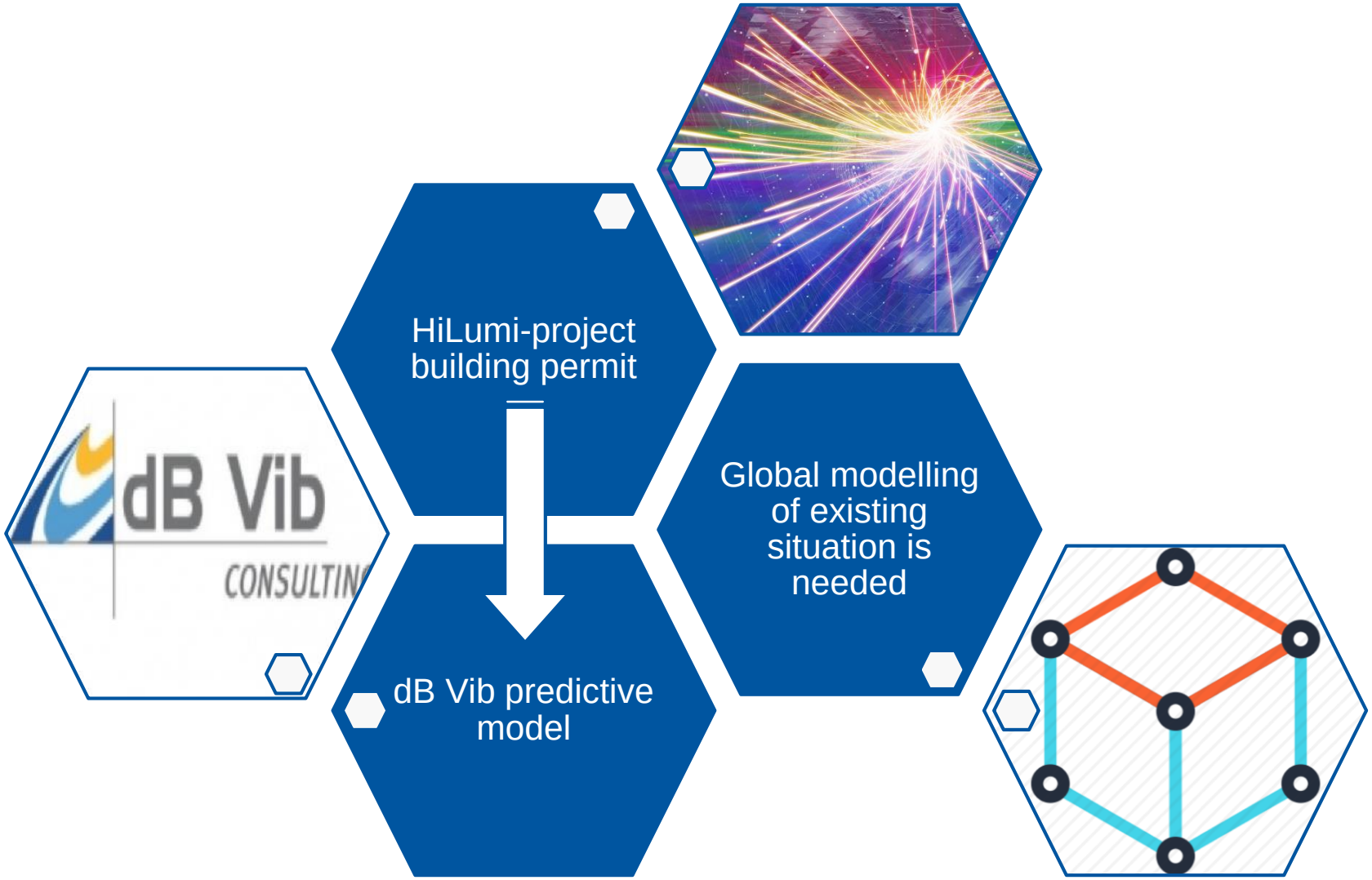
école normale supérieure paris—saclay

HL-LHC buildings : acoustical modelling

Quentin Goestchel
HSE-SEE-SV

Table of contents

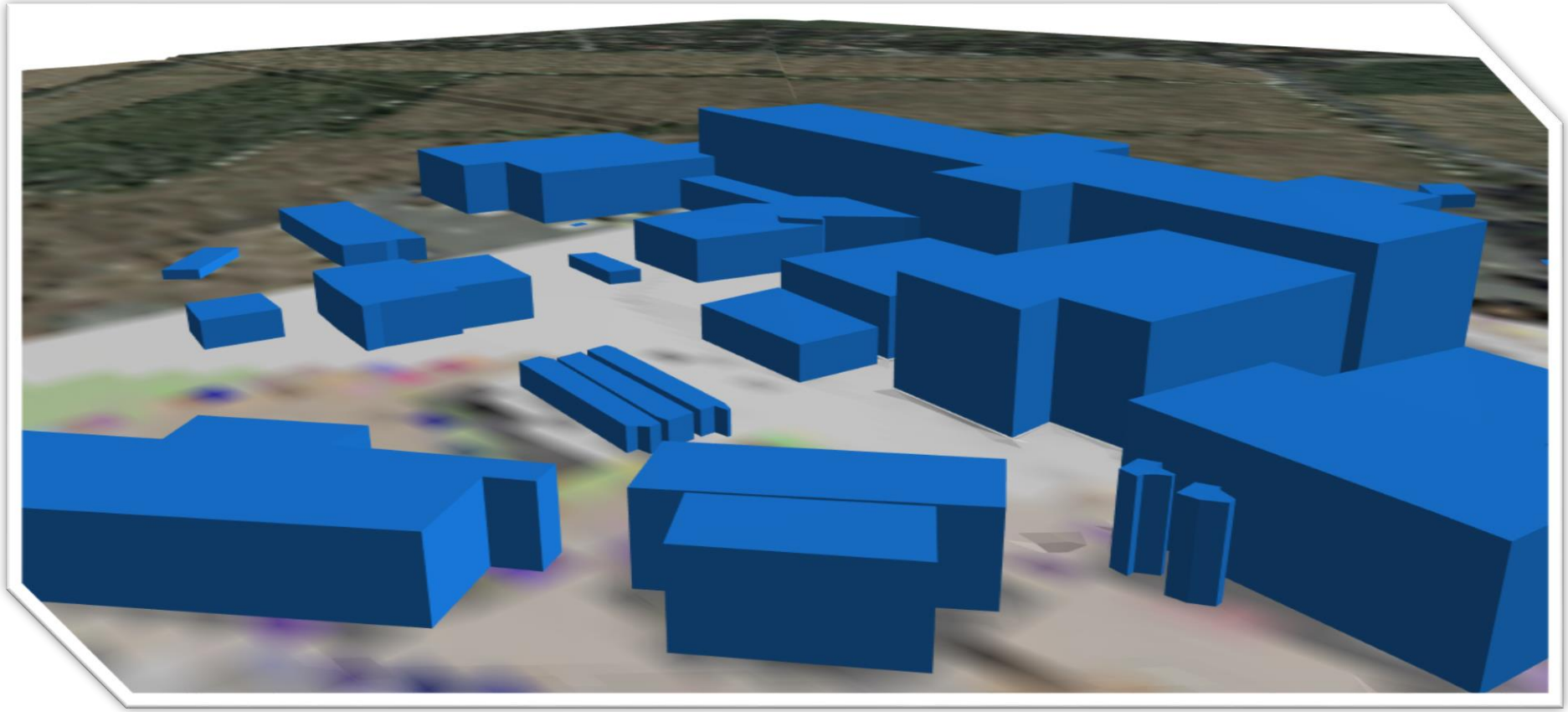
Internship objectives



Basic mapping

- Building shapes & background images:

SMB-SE-DOP& Google Maps



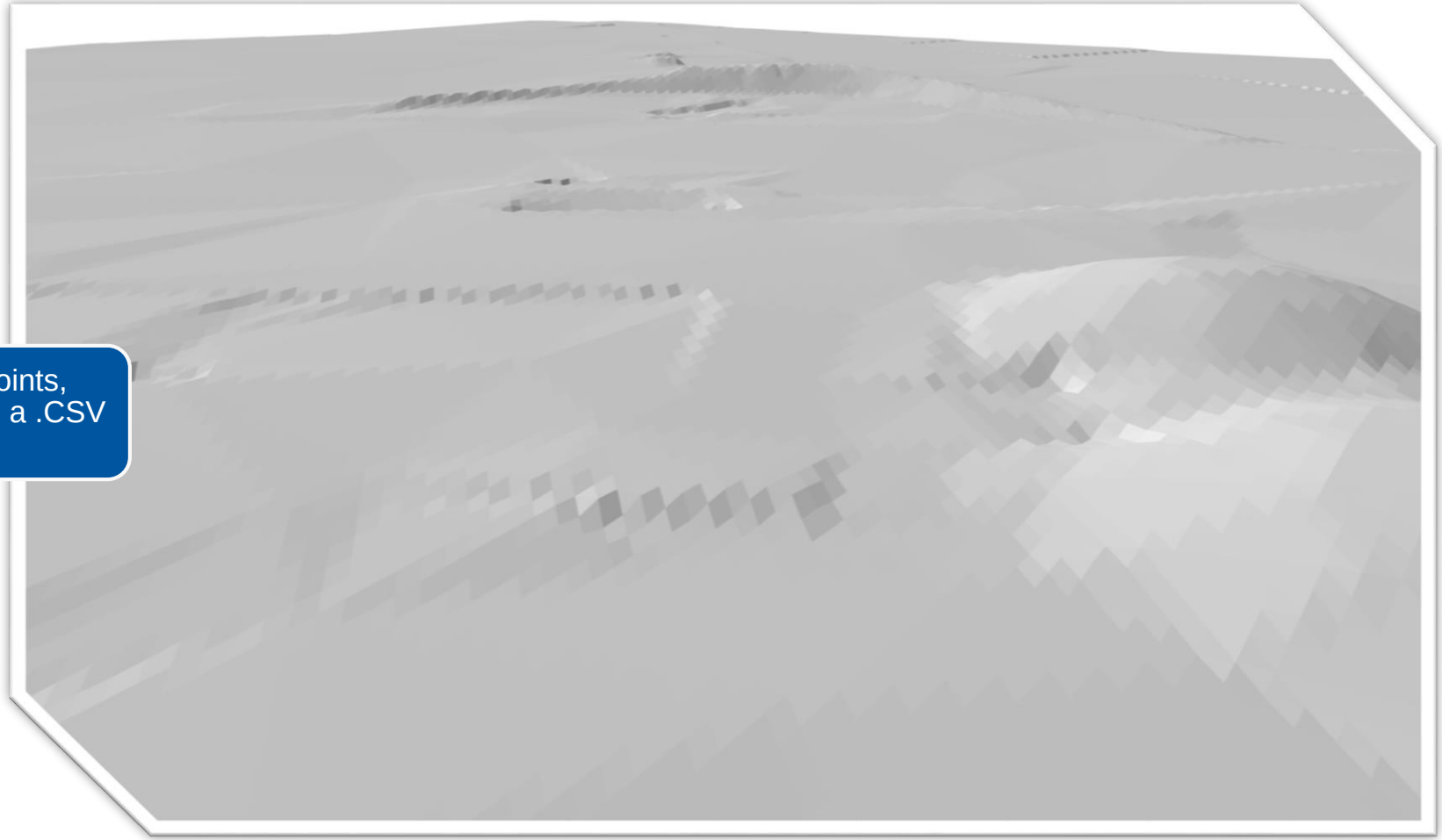
Point 5 buildings

Basic mapping

- Topography:

Drone measured points, sorted as (X,Y,Z) in a .CSV file

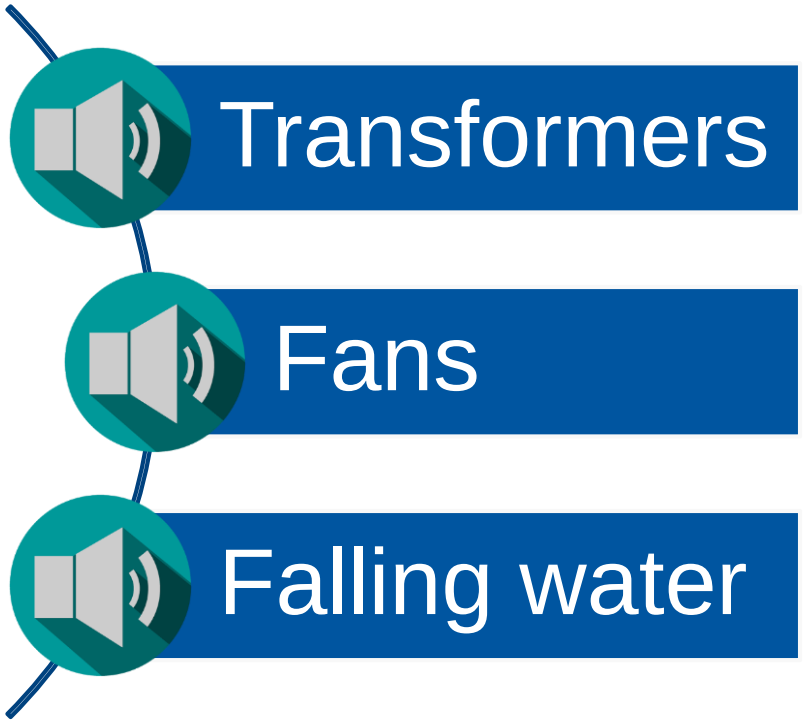
MNT « Modèle Numérique de Terrain » SMB-SE-DOP



3D visualisation of SMB altitude points

Sound sources

- Punctual & surface sound sources:

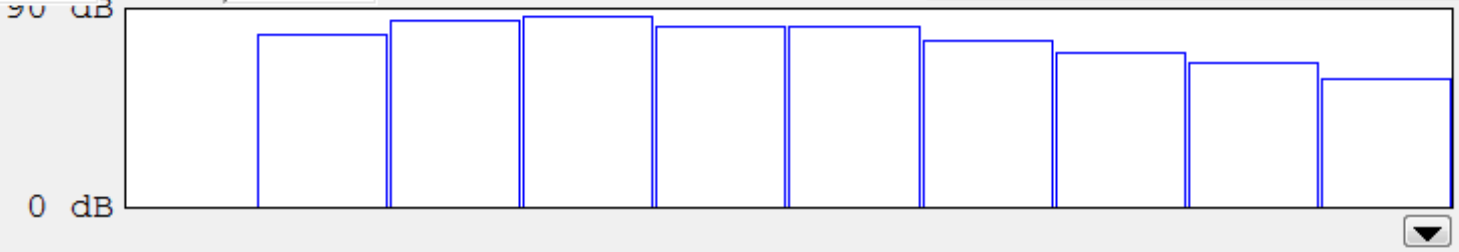


Name of the sound source: SE-Transformer 9MVA

Class:

Overall level /dB: A: 81.9 LIN: 90.5

Spectrum type: Octave bands (linear)

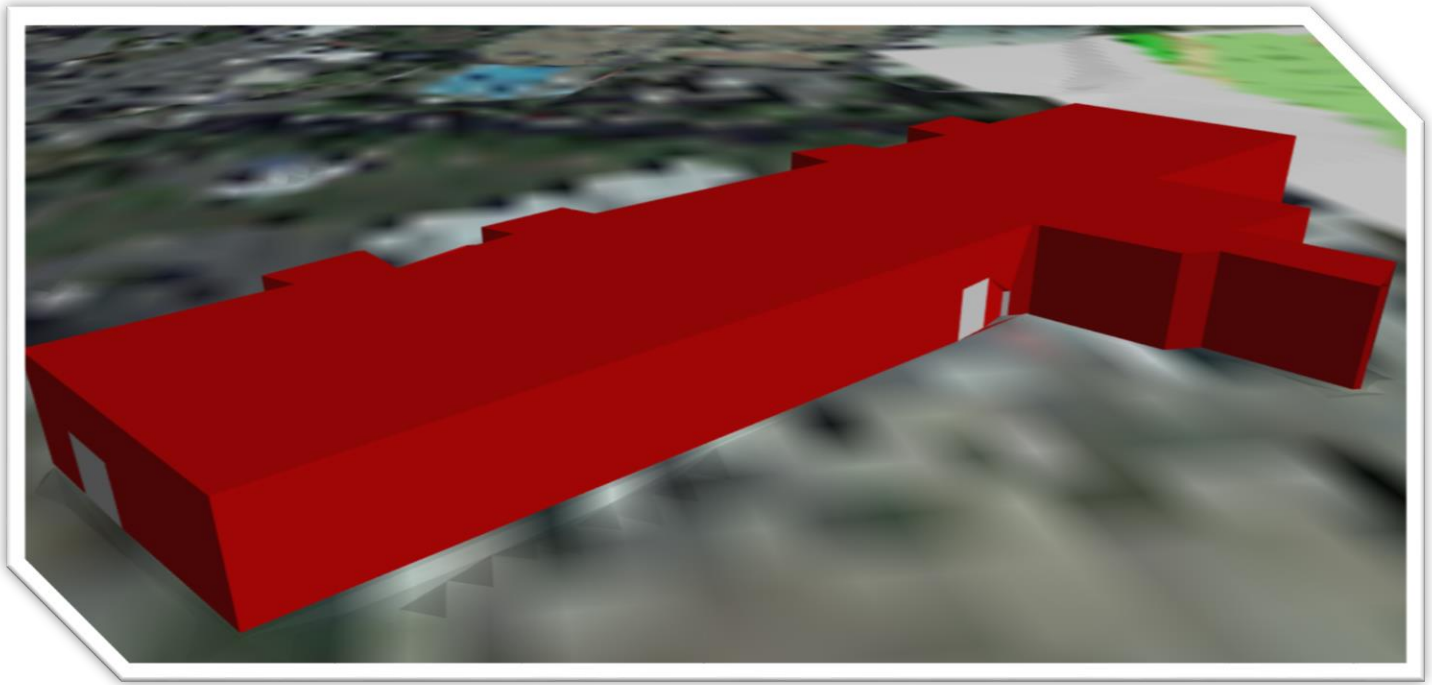


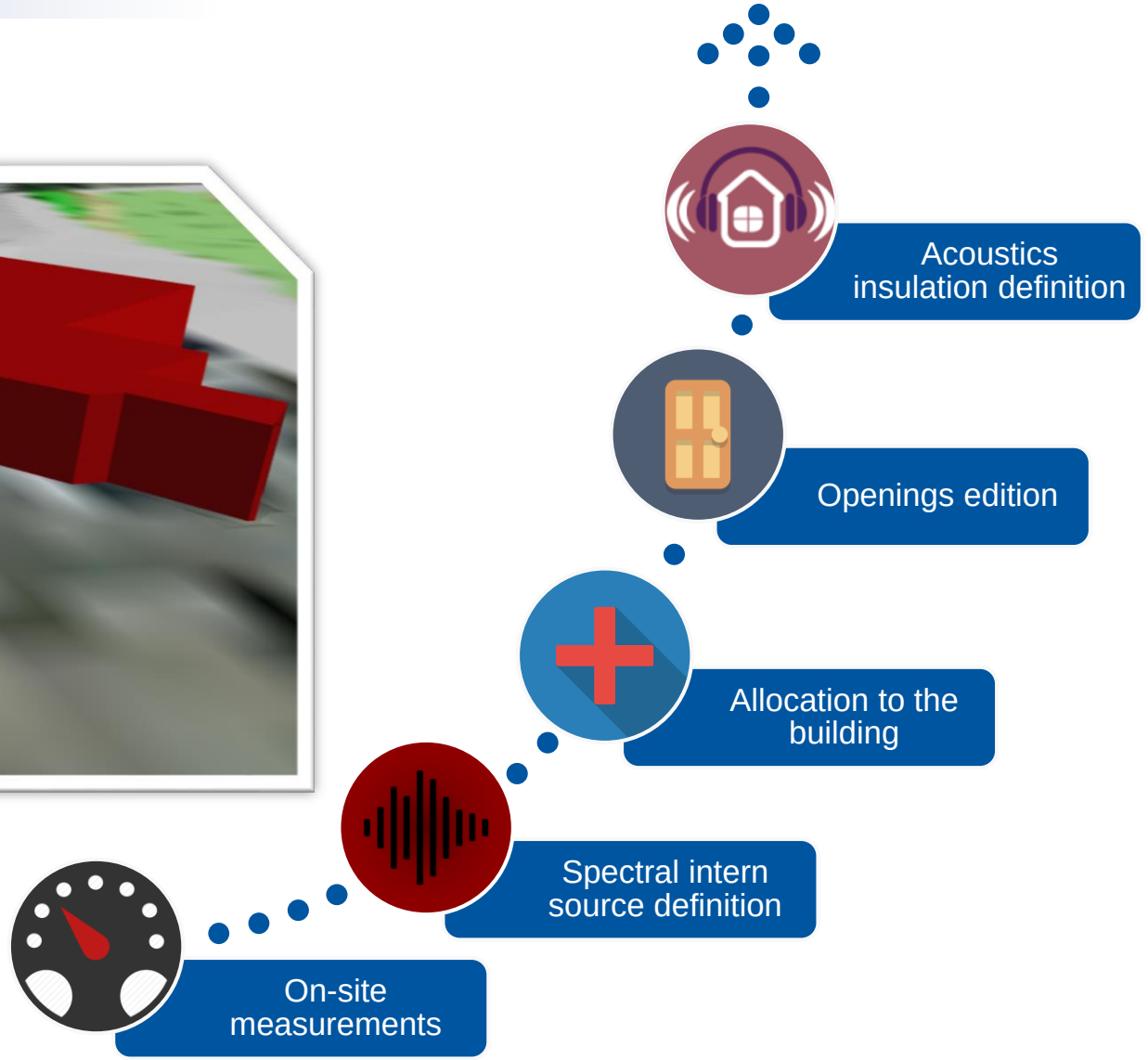
f /Hz	16	31.5	63	125	250	500	1000	2000	4000	8000
Lw/dB	-99.0	78.5	84.5	86.5	81.5	81.5	75.5	70.5	65.5	58.5

Spectral data provided by CERN or constructors

Sound sources

- Noisy buildings:

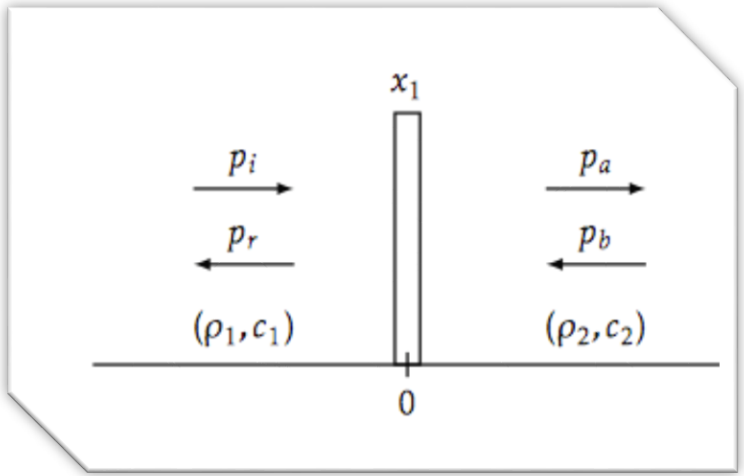




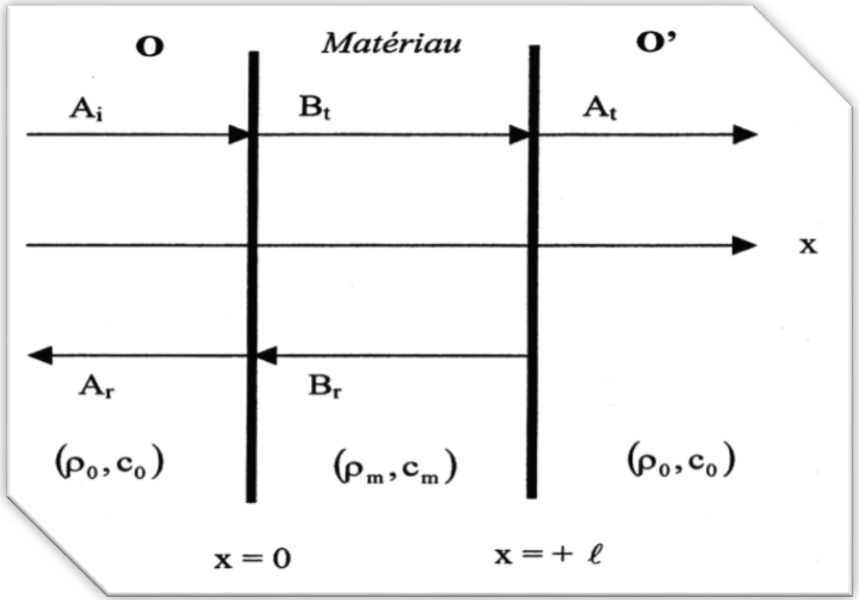
Transmission loss index

- Models

Homogeneous-rigid material model :

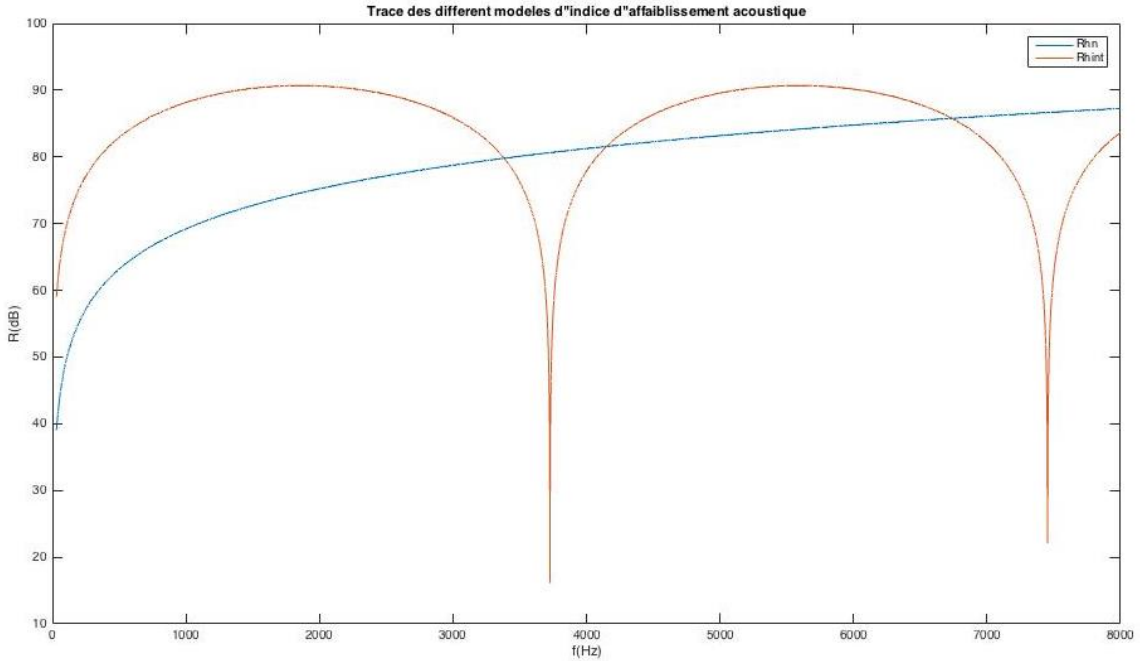


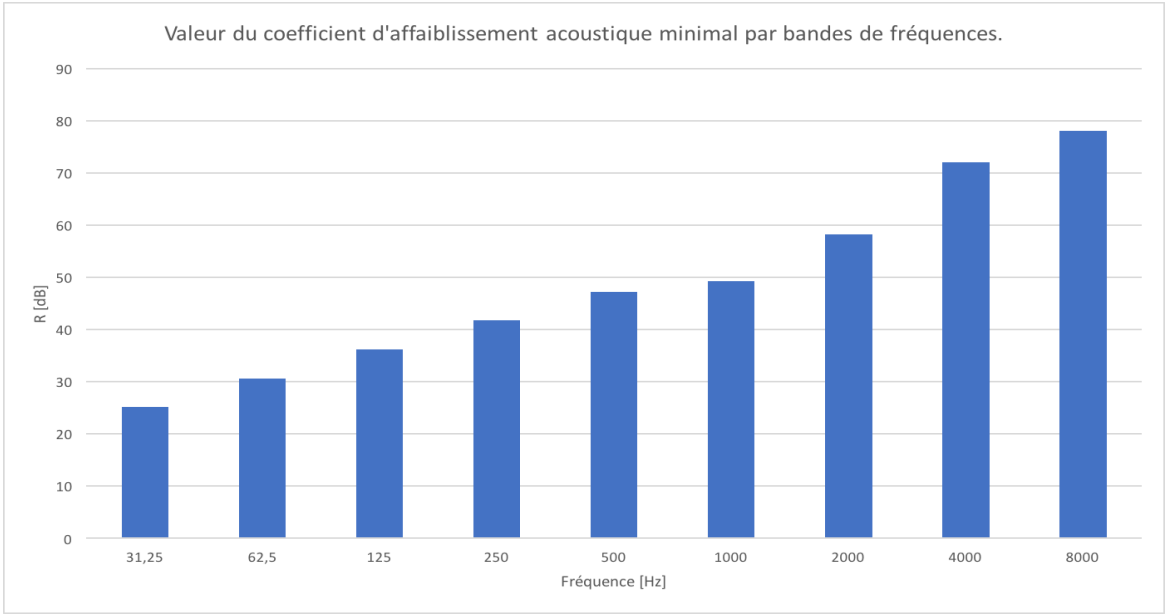
Porous-elastic material model :



Transmission loss index

- Utilisation





Numerical integration per frequency band + minimum

Numerical propagation

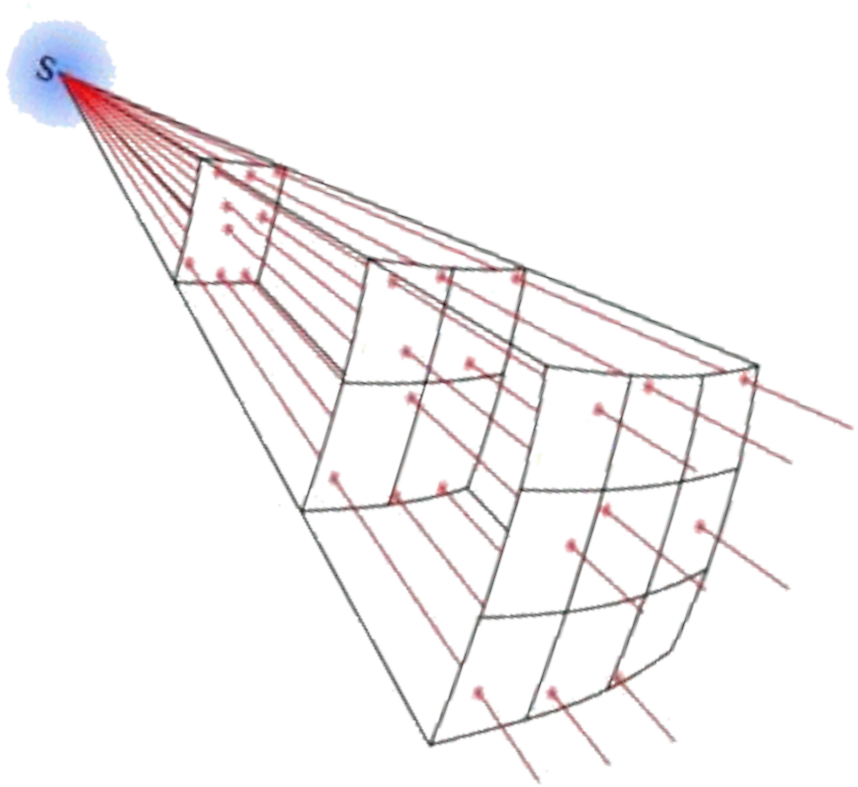
- Hypothesis: Two cases of applicability

Homogeneous case: null vertical gradient of sound celerity from source to receiver

Favorable case: positive vertical gradient of sound celerity from source to receiver

Numerical propagation

- Method:



- Discretization of noise sources
- Determination of sound power per frequency band
- Calculation of probability of favourable conditions
- Search for propagation paths between each source and receiver
- On each propagation path
  - Calculation of the attenuation
  - Calculation of the long-term sound level
- Local calculation of the long-term sound level

Numerical propagation

- Calculation & total long-term sound level:

Sound level at a receiver point, for a path S→R:

i indice is for both favorable and homogeneous conditions

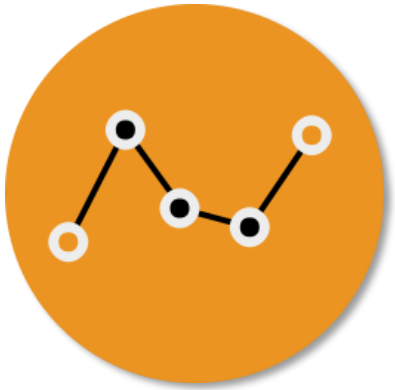
$$\begin{cases} L_i = L_{w,0,dir} - A_i \\ A_i = A_{div} + A_{atm} + A_{dif,i} \end{cases}$$

The total Long-term sound level, at point R:

For one frequency band, summing all energies from the N paths

$$L_{tot,LT} = 10 \times \log\left(\sum_n 10^{\frac{L_{n,LT}}{10}}\right)$$

Numerical propagation



- Geometrical divergence:

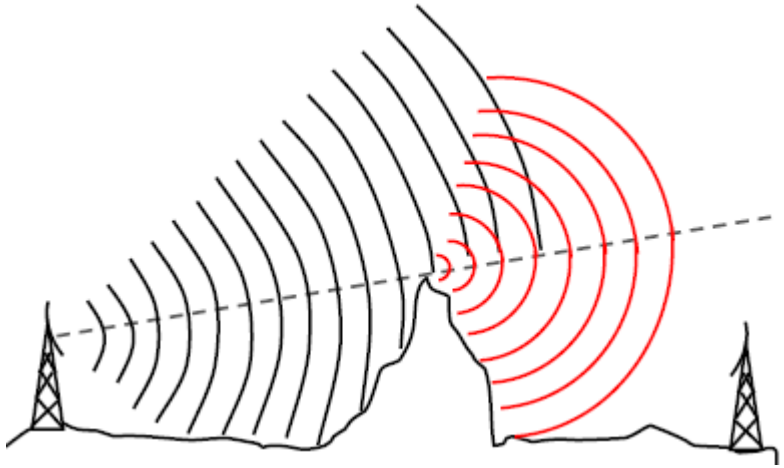
$$A_{div} = 20 \times \log(d) + 11$$

- Atmospheric absorption:

$$A_{atm} = \alpha_{atm} \cdot d/1000$$

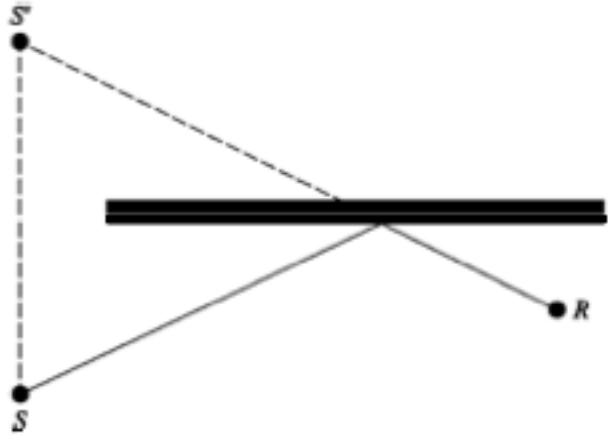
Value and calculation of α_{atm} are detailed in ISO 9613-1

Numerical propagation



- **Diffraction:**

A_{dif} term is calculated for ground and obstacles



- **Reflection:**

$L_W{}' = L_W + 10 \times \log(1 - \alpha_r)$

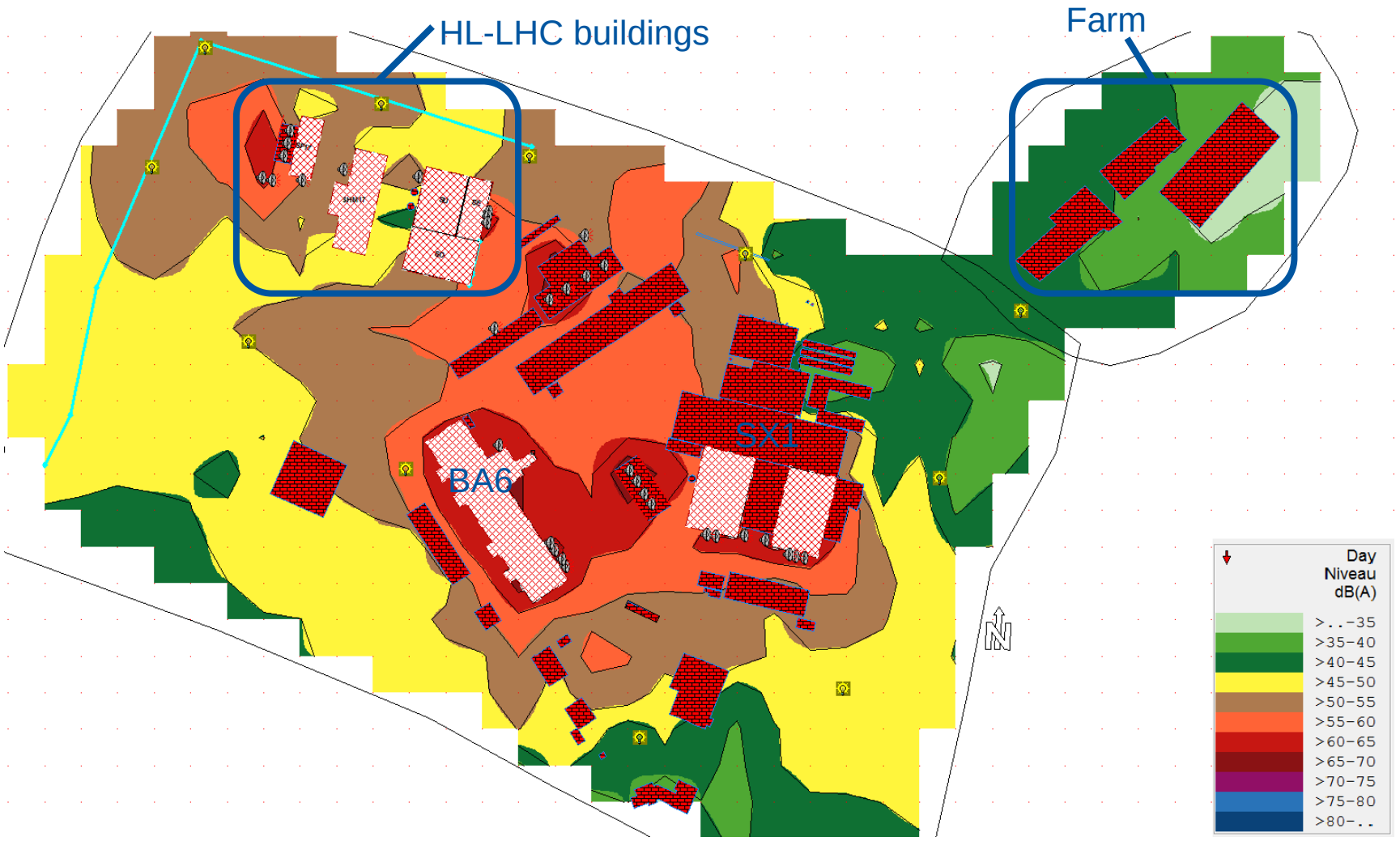
Issued S' point considered as a new source

Results

- Point 1(Suisse)

« Ordonnance sur la protection contre le bruit du 15 décembre 1986 »

Legal sound level in the resident house :
- Day : 56 dB(A)
- Night : 46 dB(A)



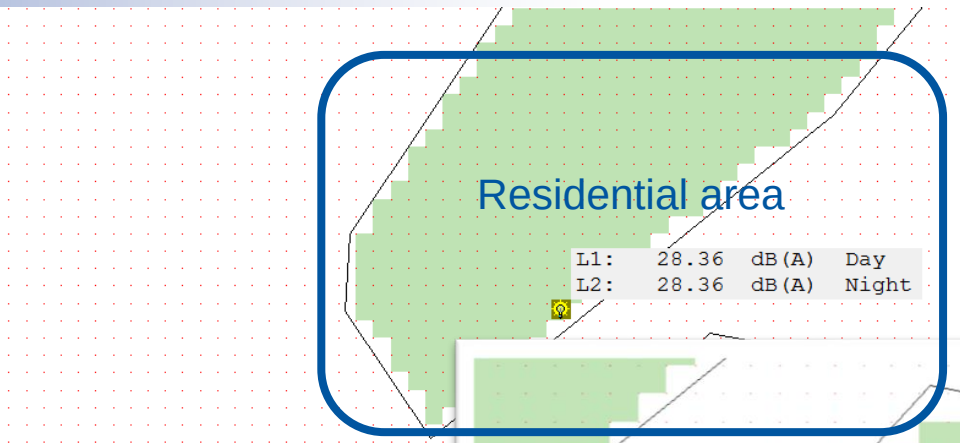
Results

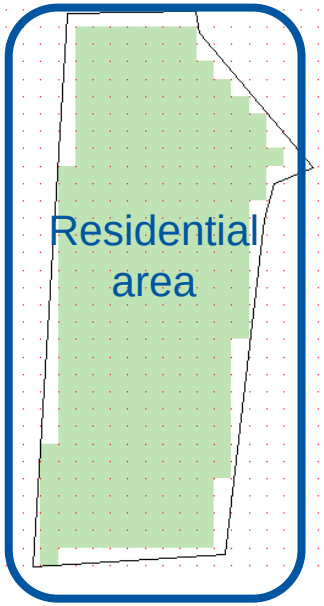
- Point 5(France)

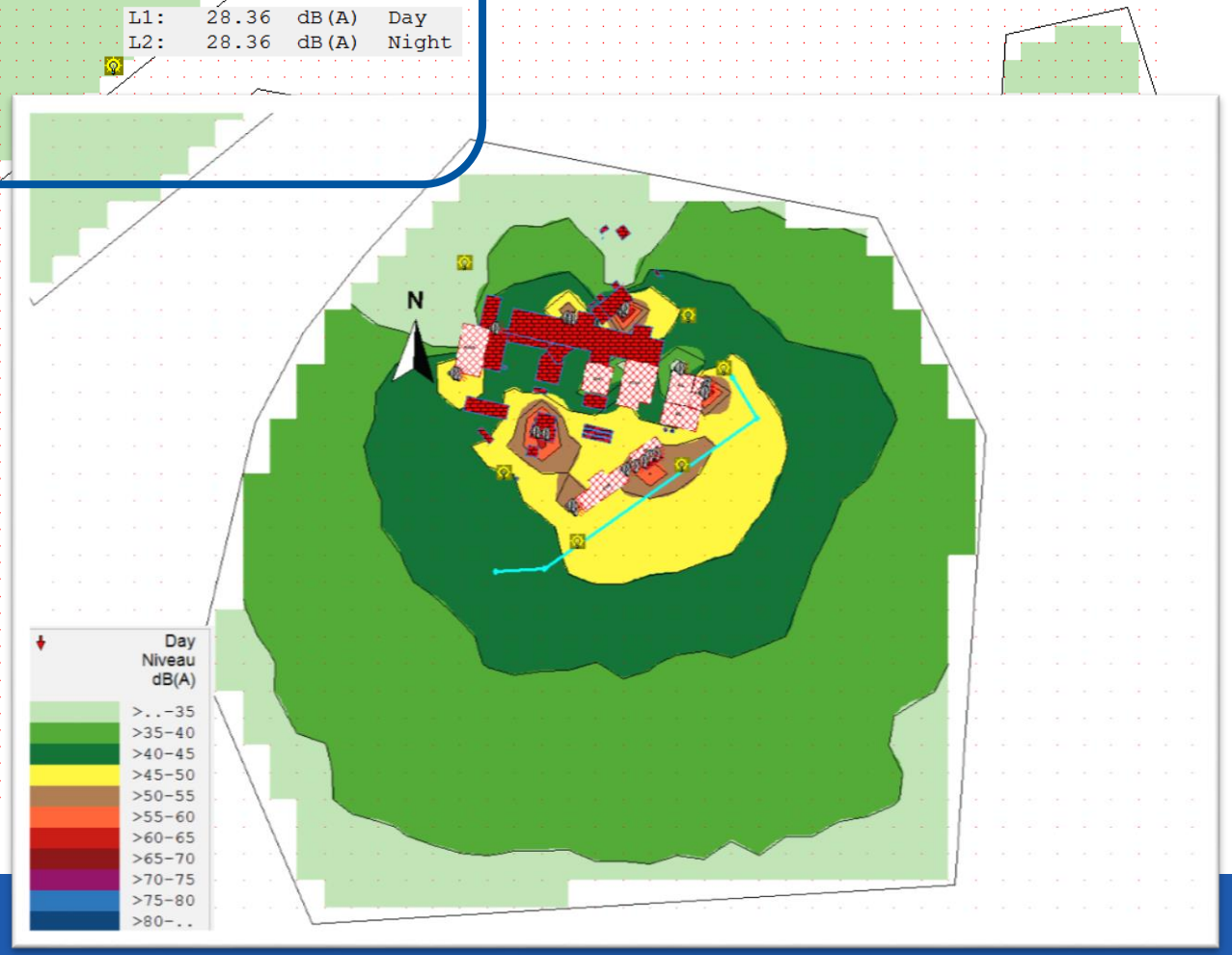
« Arrêté du 23 janvier 1997 »

Legal Levels at CERN limit:
- Day : 70 dB(A)
- Night : 60 dB(A)

Emergence reglemented zone:
- Day: 39 dB(A)
- Night: 32,5 dB(A)







Conclusion

Sound levels from the model respect the regulation

Some points of the model correspond with reality

There is points with a 35 dB(A) gap between the model and reality

The model needs to be reajusted

Bibliography

- Cnossos-EU
- ISO 9613-1
- IMMI help document – Wölfel
- Le guide des systèmes thermiques et acoustiques Arval – Arcelor Mittal
- Sujet et correction de l'agrégation de Génie Civil 2004
- Acoustique : conception et mise en œuvre - Bruxelles Environnement


CERN