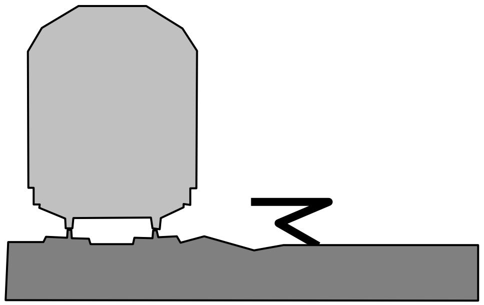
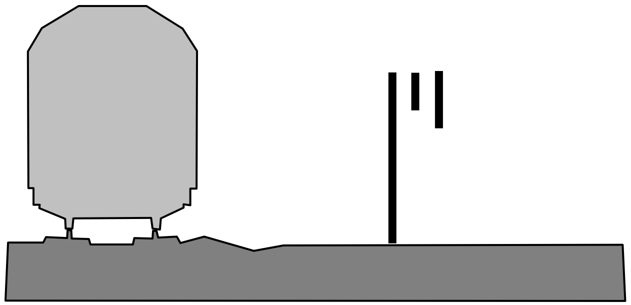
IMPACT

| DEUFRAKO Seminar | 27/10/2010

INTRODUCTION

- **Project : IMPACT** (complex noise protections' impact on goods transportation by railway in urban areas)
- **Partners : CSTB** and **SNCF**, & partly funded by **ADEME** (French Environment and Energy Management Agency).
- **Main objective** : to offer optimized solutions dedicated to reduce noise from rail freight transport.
- **Context** :In very dense urban areas, conventional noise protection cannot be considered for many reasons (aesthetic aspects, building constraints …).





⇒ Low height noise protections (for dense urban areas) and Multiple edge noise barrier (for peri-urban areas)

CONTENTS

NUMERICAL APPROACH

- **First step : parametric study with advanced numerical code MICADO, based on the boundary element method**

- **2nd step : use an optimization method (Genetic Algorithms and Nelder Mead algorithm coupled) to directly determine the optimal forms and impedances to build a noise barrier with a maximum efficiency.**

    - **function to be optimized is the average pressure field in a zone to be protected**
    - **optimization variables : shape and surface impedance of the acoustical protection.**

NUMERICAL APPROACH : MICADO

- **Boundary Integral Equation theory**

Direct formulation : Helmholtz integral equation (unknown functions : pressure and velocity)

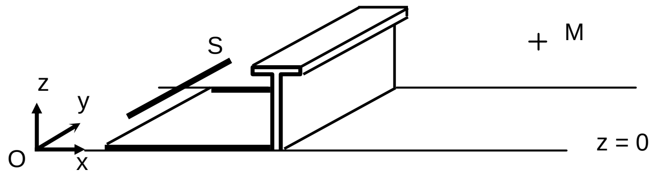
$$p(M) = p_0(M) + \int_\sigma \left[p(M) \frac{\partial G}{\partial n_S}(S, M) - G(S, M) \frac{\partial p}{\partial n_S}(M) \right] dS \,, M \in \Omega$$

$$G(M, N) = -\frac{i}{4} H_0(kr) - \frac{i}{4} H_0(kr') + P_\beta(M, N)$$

Use of a variational approach for solving the BIE

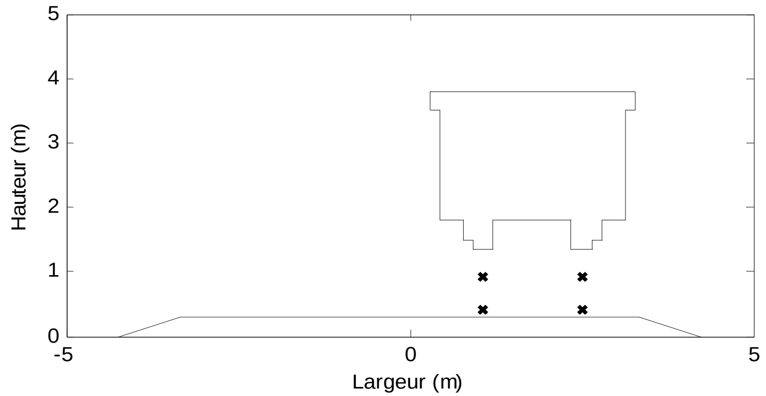
↓

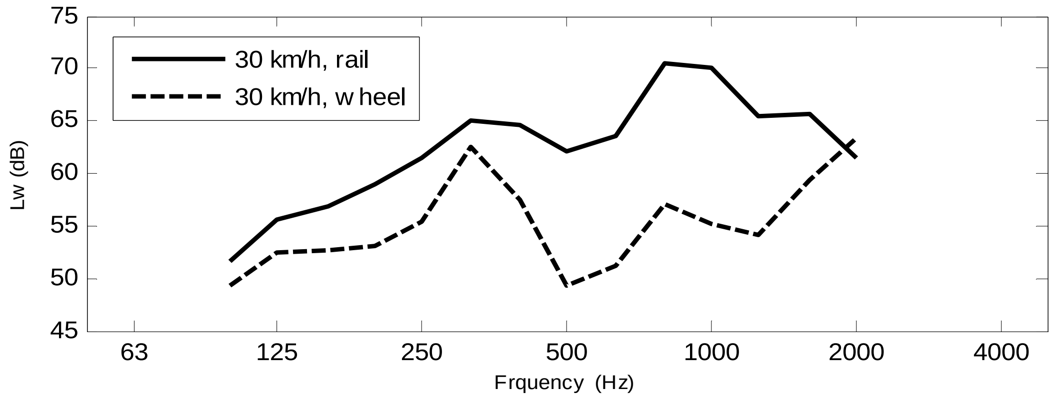
MICADO-BEM code



CONFIGURATIONS

- Output of the numerical code MICADO = efficiency of the acoustical protection
- Calculations with a typical freight train power spectrum running at 30 km/h
- General configuration and variable parameters for the calculations :
  - main noise source of freight train is the rolling noise,
  - four point sources are defined: two for the rail noise and two for the wheel noise
  - Specific noise spectrums are considered for those sources, for several speeds

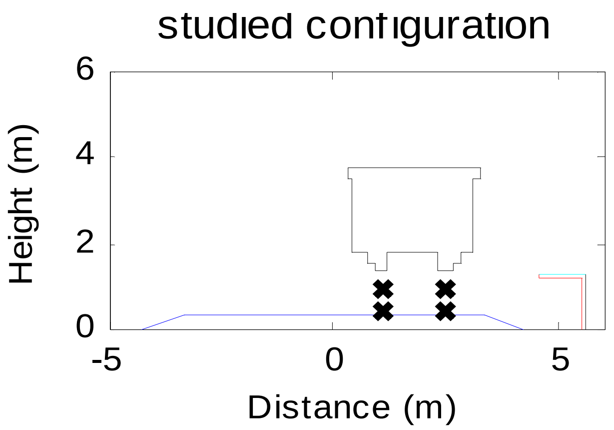


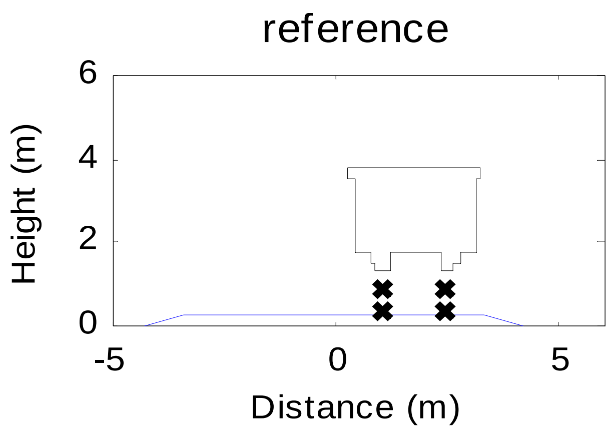


⇒ The parametric study concerns many variable parameters

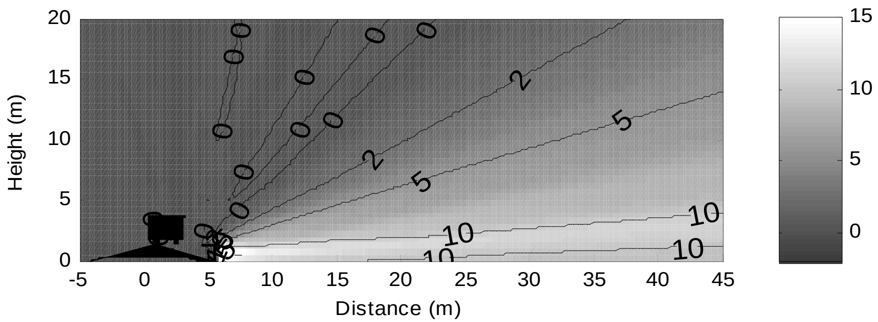
NUMERICAL APPROACH :
Calculation of efficiency

⇒ **Results are given as efficiency maps in dB(A) with details on the reference configuration and studied configuration**



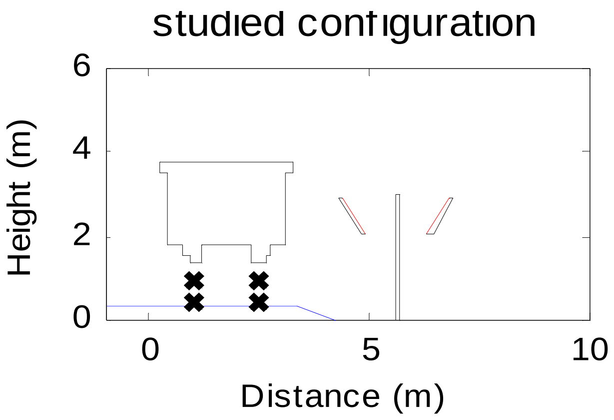


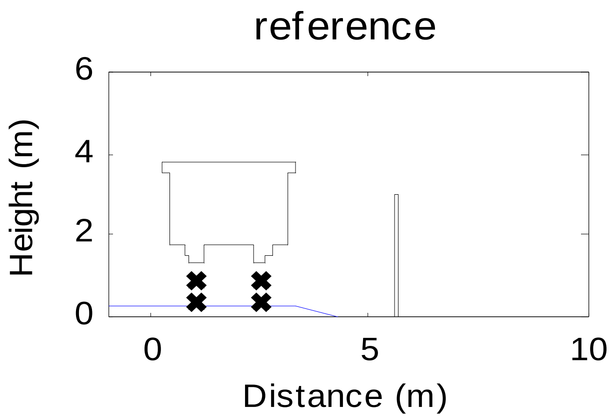
<u>Studied configuration :</u>
Low height noise protection with mineral-wool-like material on sides facing the noise sources and grass on the top of the protection.
<u>Reference configuration :</u>
No protection



⇒ **Efficiency of low height noise protections of 5 to 10 dB(A) in a large area / configuration with no protection**

NUMERICAL APPROACH :
Calculation of efficiency



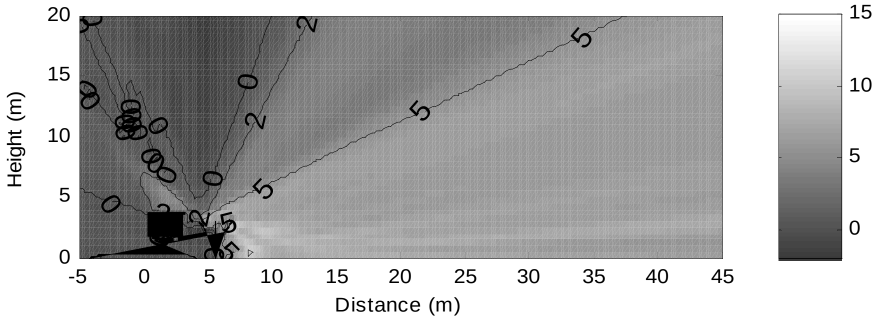


Studied configuration :

A multiple edge protection with the central barrier located like the barrier of the reference configuration and with two lateral panels (1m long), tilted (30°) and with mineral-wool-like material on the side facing the central barrier

Reference configuration :

A 3m-high straight noise protection

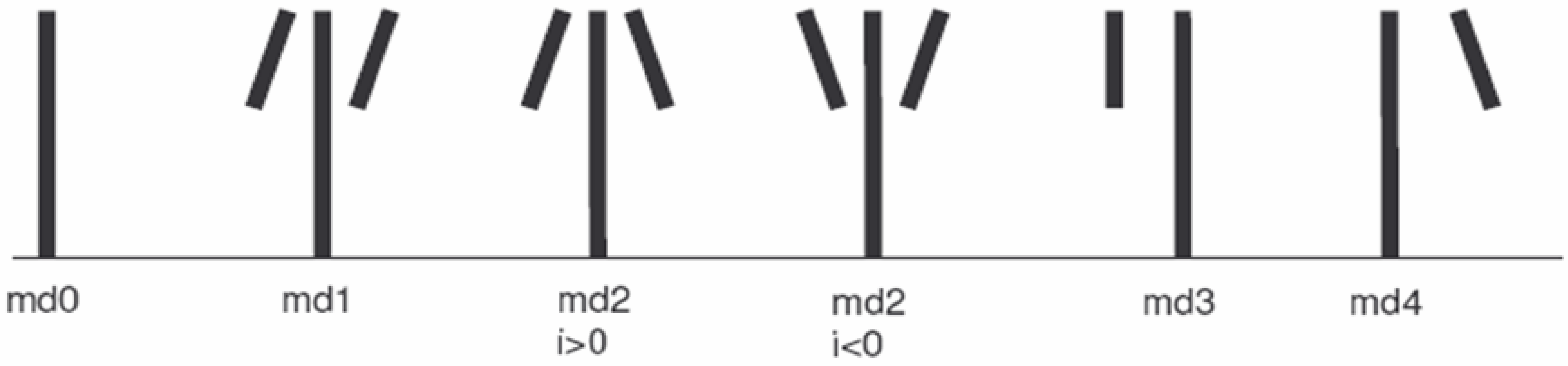


⇒ Impact of the shape of the multiple edge noise protection more than 5 dB(A) more efficient than the straight noise protection in a large area.

NUMERICAL APPROACH :
Results of parametric study

6 main parameters to be optimised for multiple edge barriers :

- design (c)
- distance between barrier and vehicule (d)
- barrier height (h)
- baffles spacing (e)
- baffles size (t)
- baffles slope (i)



NUMERICAL APPROACH :
Results of parametric study

4 main parameters to be optimised for low barriers :

- design (c)
- distance between barrier and vehicule (d)
- barrier height (h)
- barrier width (p)

NUMERICAL APPROACH :
Optimisation study

- **Multiple edge barriers : first results of the optimisation by genetic algorithms- 6 variable parameters, (h = 4 m ; t = 1 m)**

	c	d	h	p	t	i	Eff
lower limit	0	4.4	fixe	0.2	fixe	-80	
higher limit	4	6.7		1.5		80	
Précision	1	0.1		0.1		1	0.5
	2	6.1	4	1.3	1	-46	-15
	2	6.1		1.2		-46	
	2	6.1		1.3		-39	
	2	6.1		1.3		-45	
	2	5.6		0.8		-38	
	2	5.6		0.9		-38	
	2	5.6		1		-26	
	2	5.6		0.9		-36	

NUMERICAL APPROACH : Optimisation study

- **Low barriers : first results of the optimisation by genetic algorithms- 4 variable parameters, (c=1)**

	c	d	h	p	Eff
lower limit		4.4	0.8	0.2	
higher limit	fixe	6.7	1.5	1.5	
Précision		0.1	0.1	0.1	0.5
		4.5	1.5	0.4	
		4.6	1.5	1.2	
		4.6	1.5	0.8	
		4.5	1.5	0.8	
		4.4	1.5	0.8	
		4.6	1.5	0.2	
		4.6	1.5	1.1	
	1	4.6	1.5	0.3	-7
		4.6	1.5	1.5	
		4.4	1.5	1.1	
		4.5	1.5	0.7	
		4.6	1.5	0.5	
		4.6	1.5	1	
		4.5	1.5	1	
		4.6	1.5	0.6	

Experiments
Railway constraints of exploitation

▪ Two kinds of noise protections : low-height noise barriers for dense urban areas and multiple edge noise protections for more rural areas.

▪ Compromise between results of optimisation study and :

⇒ side clearance of the railways,
⇒ train body shape,
⇒ constraints of exploitation and of security
⇒ maintenance activities,

is not easy to find and depending of each site and application.

▪ For the moment optimisation were carried out on typical configuration.

▪ After finalizing experimentation sites, we will process the optimisation part again.

Measurements

- **The two optimised prototypes will be characterized in experiments in situ, in two different ways:**

SNCF will perform acoustic measurements with commercial trains:

- behind barriers and in “free field”,
- with various heights,

todetermine the average attenuation brought by the device and to analyze for each waveband the gain obtained compared to a conventional straight and reflective barrier.

CSTB will measure the efficiency of reflexion and transmission according to standards EN 1793-4 and -5.

⇒ Main aim of this measurement campaign will be to validate the acoustic performances of the barriers and to obtain an acoustic characterization of these new products.

CONCLUSION

- Parametric study has shown a significant efficiency of both kinds of protections.
- Work is still in progress for the numerical part and the experimental part.
- Numerical optimization calculations are still running in order to obtain optimal barriers for given configurations.
- For the experimental part, work is also in progress to find test sites to build prototypes with a design that would be determined by the optimization part.