



DEUFRAKO seminar Railway Noise workshop



FRET Locomotives Acoustic of Electrical Traction Systems

PROSODIE_PREDIT project_OG 8

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Münich, 27/10/2010

TRANSPORT |

ALSTOM

Summary

1st topic Acoustics & Freight Electrical Locomotives

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Railway Noise_Acoustics & Freight Electrical Locomotives

Acoustics & Freight Electrical Locomotives

Railway Noise_Acoustics & Freight Electrical Locomotives

Nowadays, ALSTOM Transport FRET Locomotives design has to satisfy more and more constraints:

- High traction power efficiency
- High interoperability
- High flexibility
- High level of reliability and maintainability
- High degree of safety and comfort
- High respect of environment



Railway Noise_Acoustics & Freight Electrical Locomotives

New generation electrical locomotive made by ALSTOM



Loco PRIMA EL II: BoBo architecture_4U_6400KW

Transport



Loco CHINE: CoCo architecture_1U_9600KW, One of the most powerful electrical locomotive in the world

TSI Noise>>>OK

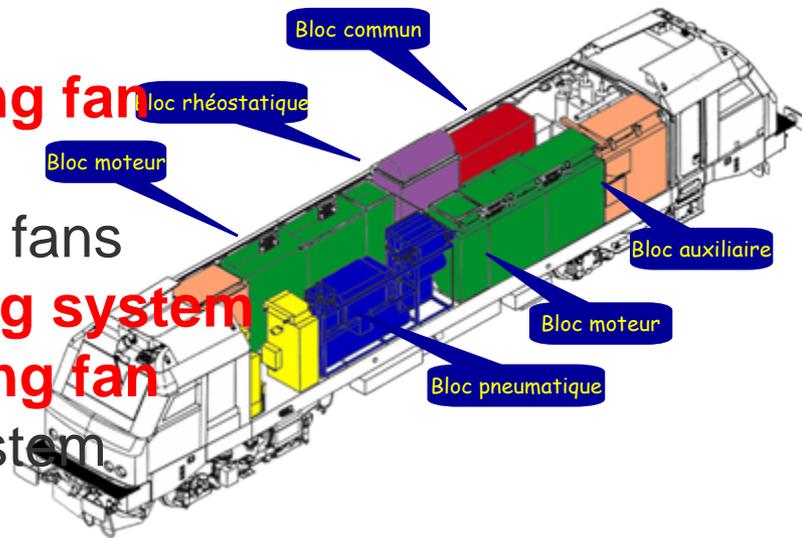
	Heavy duty freight	Freight	Passenger
Bogie configuration	CoCo	BoBo	BoBo
Traction power	9 600 kW	6 400 kW	6 000 kW
Speed	120 km/h	140 km/h	200 km/h
Power supply	25 kV - 15 kV - 1 500 V - 3 000 V		

>>OK

Railway Noise_Acoustics & Freight Electrical Locomotives

Noise sources of loco PRIMA EL II BoBo

- Rolling noise
 - ✓ Contact rail/wheels (2 bogies with 2 axles for PRIMA EL II_BoBo)
- **Traction** and auxiliaries equipments
 - ✓ **4 tractions motors with 1 cooling fan per bogie**
 - ✓ 4 gearboxes
 - ✓ **2 tractions boxes with their cooling fan**
 - ✓ 2 fans to refresh machines room
 - ✓ 2 auxiliaries boxes with their cooling fans
 - ✓ **1 main transformer with its cooling system**
 - ✓ **2 braking resistor with their cooling fan**
 - ✓ 1 air compressor with pneumatic system
 - ✓ 1 HVAC system for driver's cab

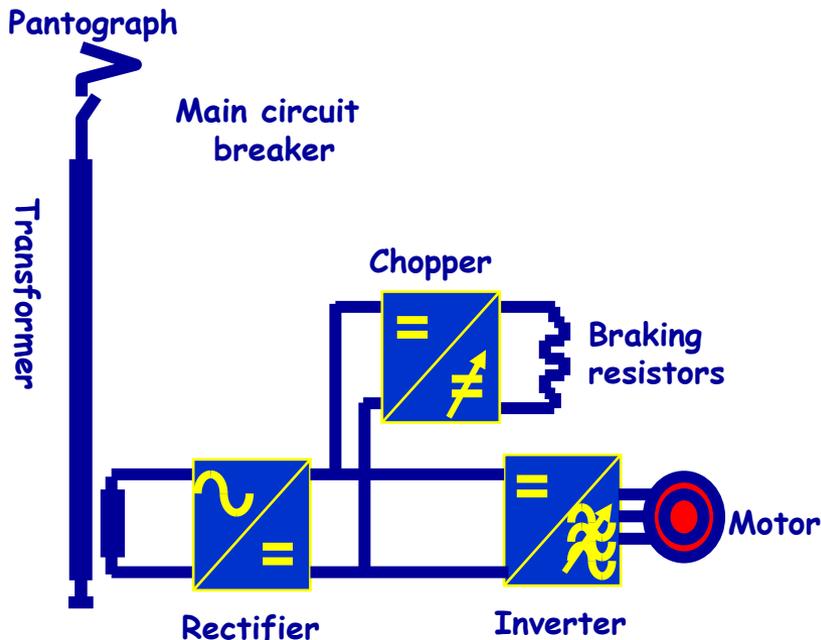


Comment: within CoCo architecture, there are 2 bogies with 3 axles, so 2 motors, 2 gearboxes,
1 traction box and 1 compressor are added (compared to BoBo configuration)

Railway Noise_Acoustics & Freight Electrical Locomotives

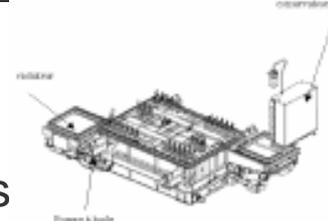
From catenary to traction motor

Main Traction equipments and noise



Main Transformer:

- Cooling unit with fan noise
- Magnetic core with electrical noise



Intermittent braking resistors:

- Cooling unit with fan noise
- Resistors with electrical noises



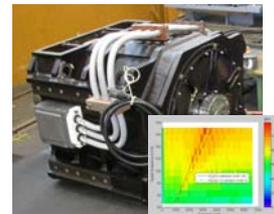
Traction converter:

- Cooling unit with fan noise
- Coils/inductors with electrical noise



Traction motor (PROSODIE project):

- Fan noise with forced cooling system



- Electrical noises due to magnetic forces



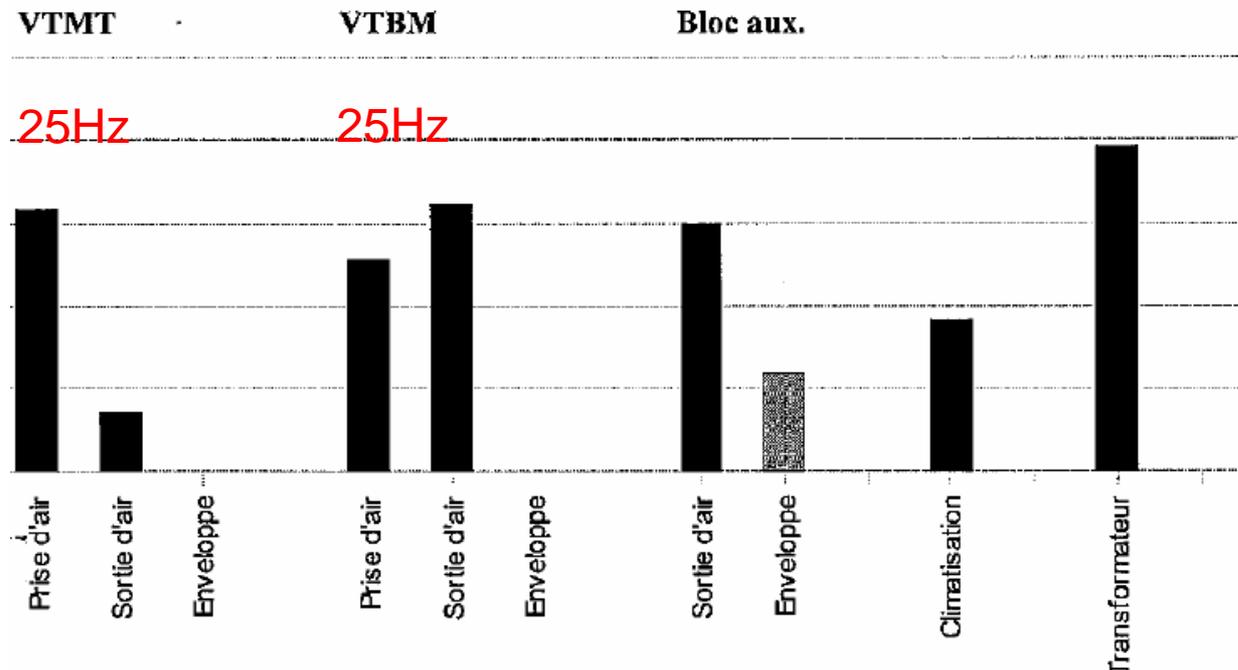
Railway Noise_Acoustics & Freight Electrical Locomotives

Electrical traction systems are well-known for being noise sources

(ranking from SITARE ALSTOM tool:

external noise prediction for loco PRIMA EL II_BoBo)

➤ at standstill_STI limit $L_{pAeq,T} < 75\text{dBA}$ is respected



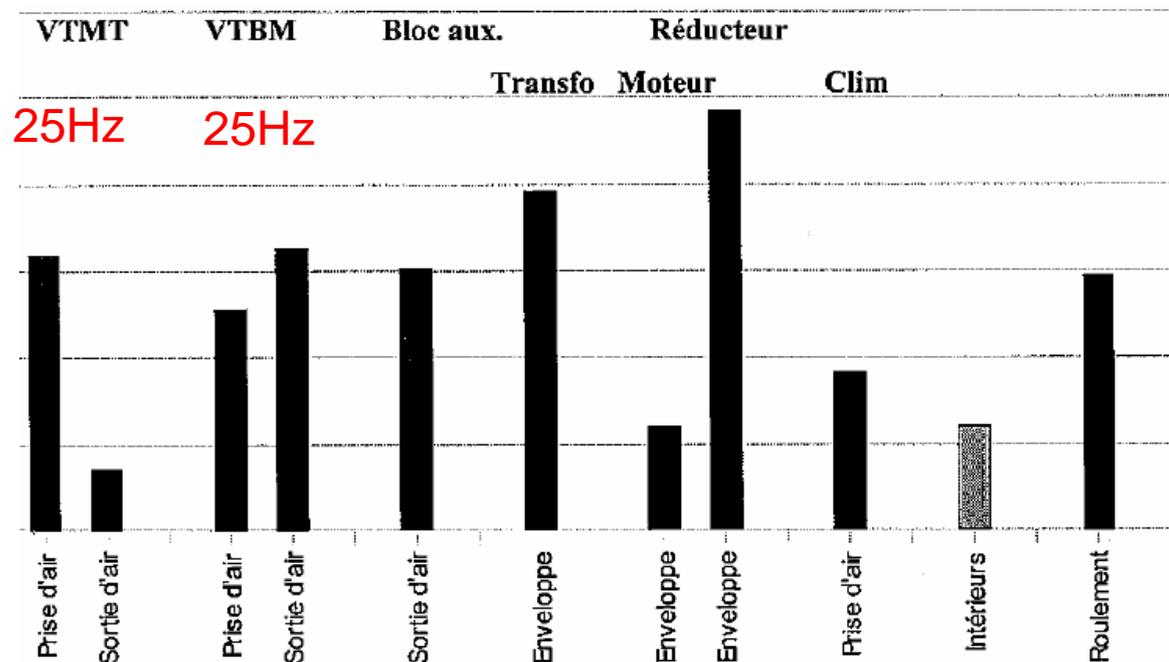
Railway Noise_Acoustics & Freight Electrical Locomotives

Electrical traction systems are well-known for being noise sources

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➤ at starting (0->20Km/h)_ **STI limit $L_{pAFmax} < 85\text{dBA}$ is respected**



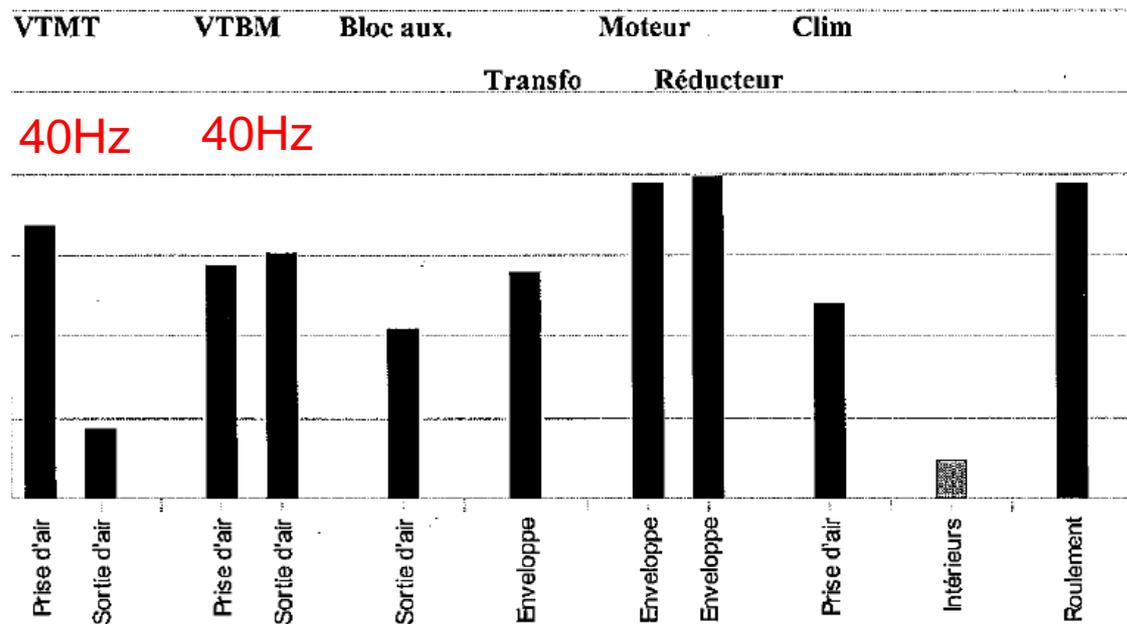
Railway Noise_Acoustics & Freight Electrical Locomotives

Electrical traction systems are well-known for being noise sources

(ranking from SITARE ALSTOM tool:

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➤ at low speeds (80Km/h)_ **STI limit $LpAeq,Tp < 85dBA$ is respected**



Railway Noise_Acoustics & Freight Electrical Locomotives

Acoustics & global environment for Freight Locomotives

Electrical traction systems contribute to noise pollution.

Development of components with high efficiency lead to important harmonic losses that can create **electrical noises** with high annoying pure tones and require an important cooling airflow (**aeraulic noises** can increase).

So more power needs more cooling and it can mean more NOISE !

Railway Noise_Acoustics & Freight Electrical Locomotives

ALSTOM Transport Eco-Design policy

For ALSTOM Transport, to reduce the environmental impact of rail transports and to improve passenger's comfort are very important objectives.

Environmental parameters are strongly incorporated into ALSTOM products from design phases.

Actions against noise pollution (PROSODIE project evidence) are real strategy points and research efforts enable ALSTOM Transport to:

- satisfy a stronger society's requirements,
- answer in easier way to standards, European directives (TSI Noise), and customers requirements that are more and more restricting,
- increase technology advances compared to competitors,

Railway Noise_PROSODIE project

PROSODIE project
Focus on electrical noises from traction
motor

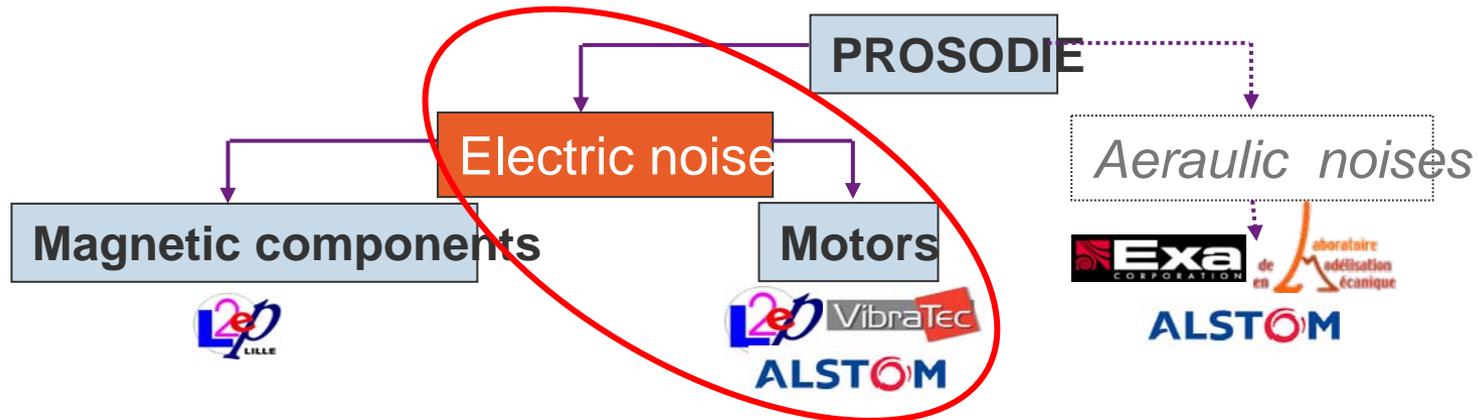
Railway Noise_PROSODIE project



PROSODIE is a R&D **PREDIT 3 project_ OG 8**

PROSODIE means in french: “**PRO**ulsion **Silencieuse** **Optimisée** et **Dimensionnée** pour l’**Environnement**”

2 research axis: Electrical and Aeraulic Noises



- ✓ To improve again the acoustic performances of traction equipments (traction motors, traction & auxiliaries converters)
- ✓ To develop new tools and new methodologies to progress in acoustic design
- ✓ To find solutions, new technologies to reduce electrical noises and aeraulic noises
- ✓ To validate improvements in real conditions with prototypes scale 1:1



Railway Noise_PROSODIE project

Acoustics of traction motors



The main noise sources on a **traction motor** are:

✓ **Aeraulic noise** due to cooling systems (very annoying at medium and high speeds for self-cooled motor)

✓ **Electrical noises** (very perceptible at low speeds and during acceleration phases) characterized by unpleasant high tonalities and audible by travelers (inside and outside) and by the people who live along the track

✓ ***Mechanical noises*** from gears and bearings

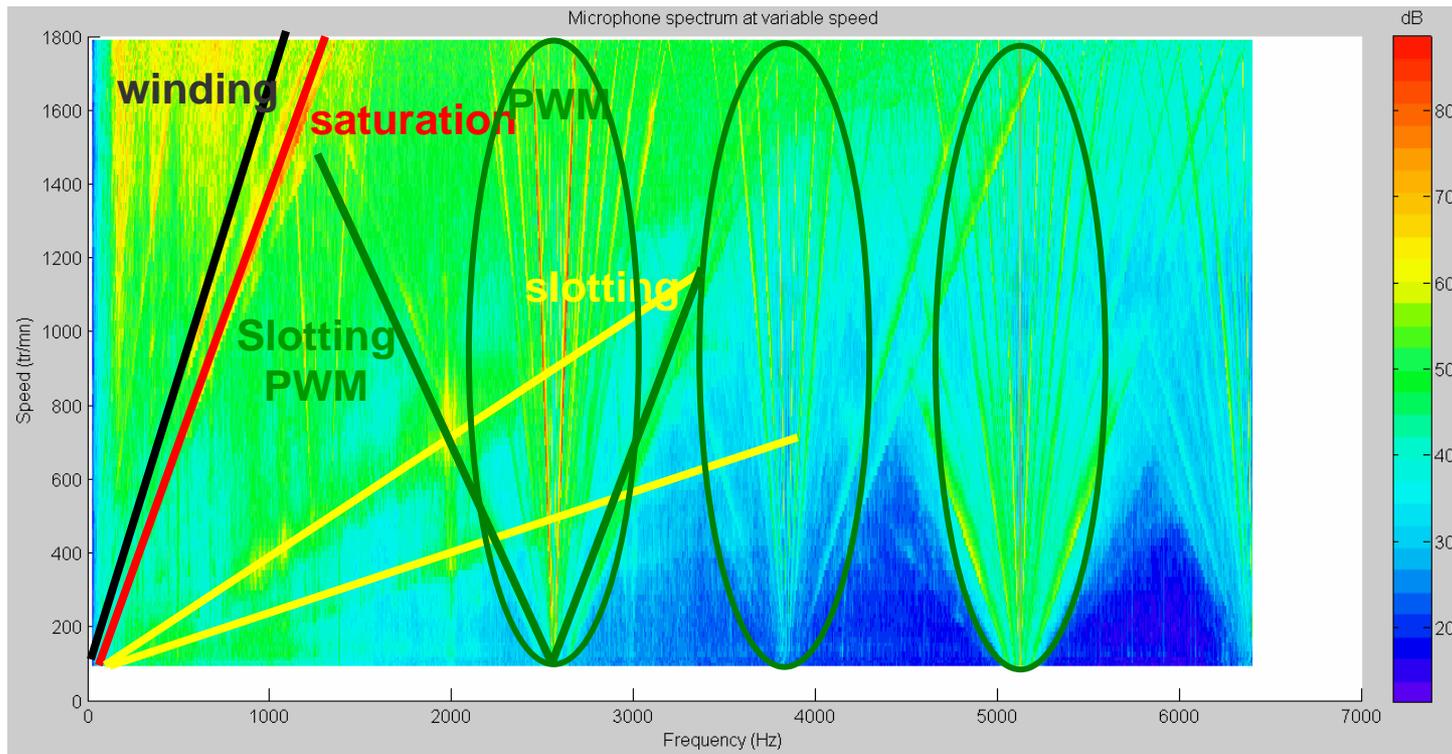
Electrical noises come from magnetic vibrations due to magnetic forces.

For traction motor, **air-gap Maxwell forces** are the main contributor of audible magnetic noises.

Railway Noise_PROSODIE project

Electrical noise motor analysis

To understand the audible magnetic noises radiated by the association motor+inverter



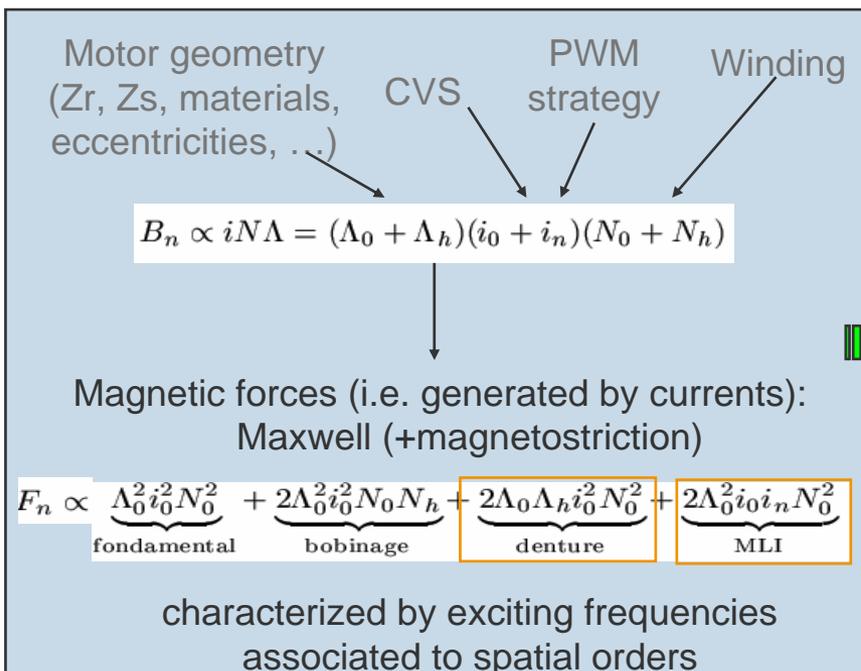
ALSTOM Traction motor (250KW) asynchronous PWM at 1280 Hz ($Z_r=36$,
 $Z_s=48$, $p=2$)

Railway Noise_PROSODIE project

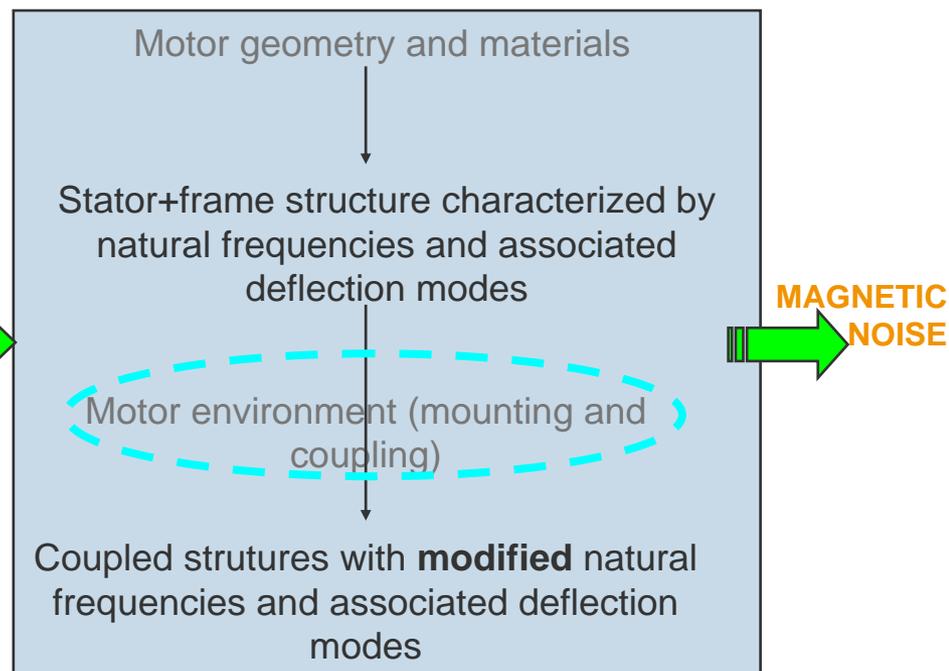
Electrical noise motor analysis

To understand the audible magnetic noises radiated by the association motor+inverter

EXCITING FORCES



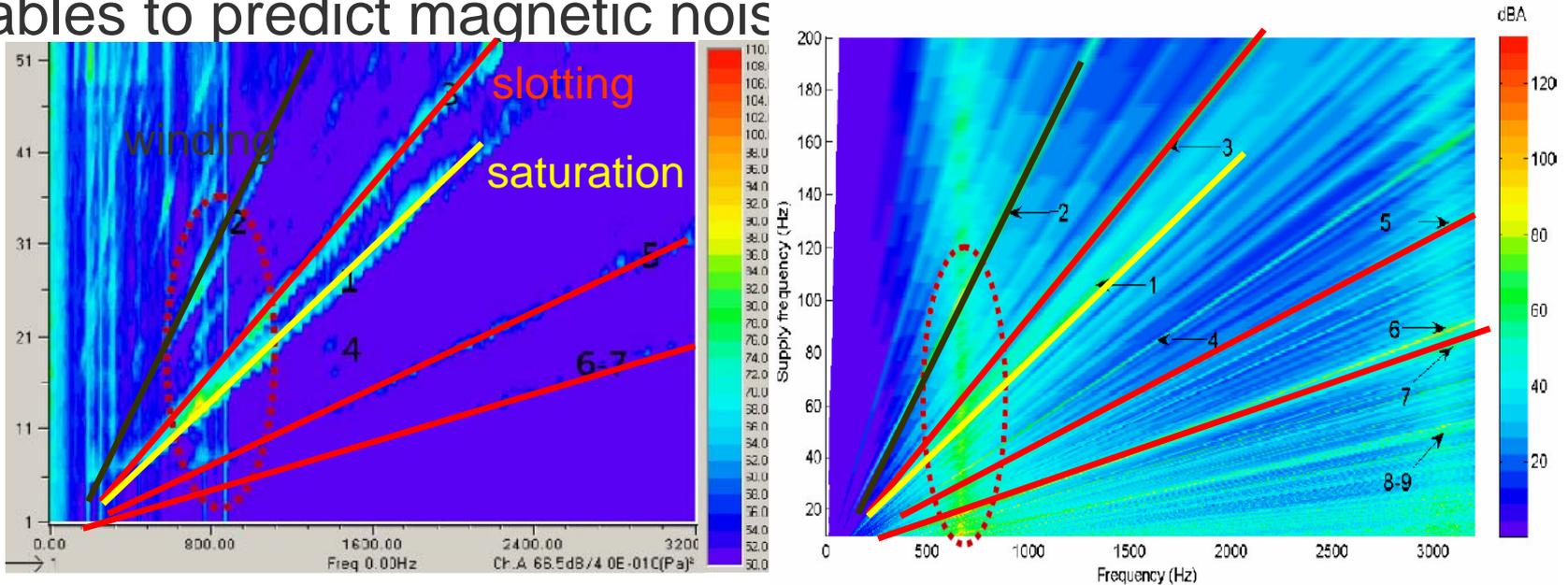
EXCITED STRUCTURE



Railway Noise_PROSODIE project

Electrical noise motor analysis

To develop and to validate at different stages (electrical, mechanical and acoustics field) a numerical tool that enables to predict magnetic noise

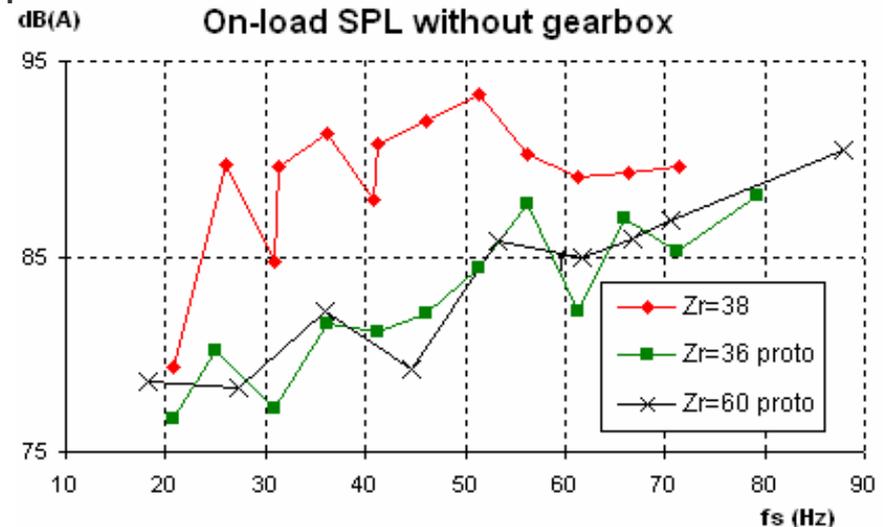
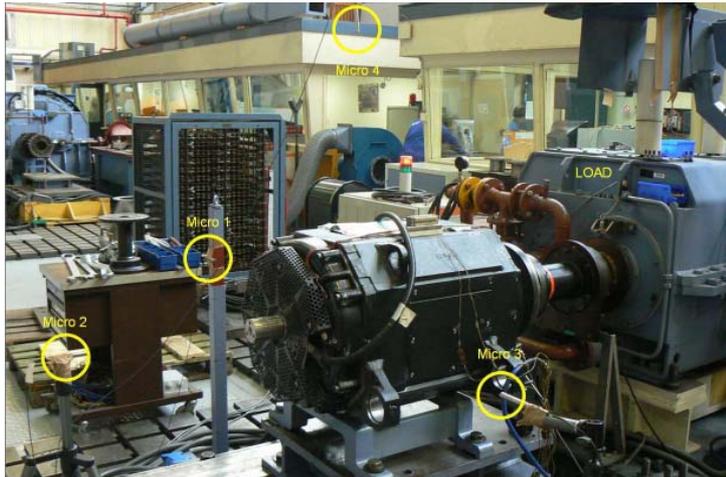


Railway Noise_PROSODIE project

Electrical noise motor analysis

To design low-noise motors fulfilling specified traction characteristics

Slotting phenomena



Sound pressure level at 1m from initial motor and 2 prototypes in on-load case (with resistive effort on rotor shaft)

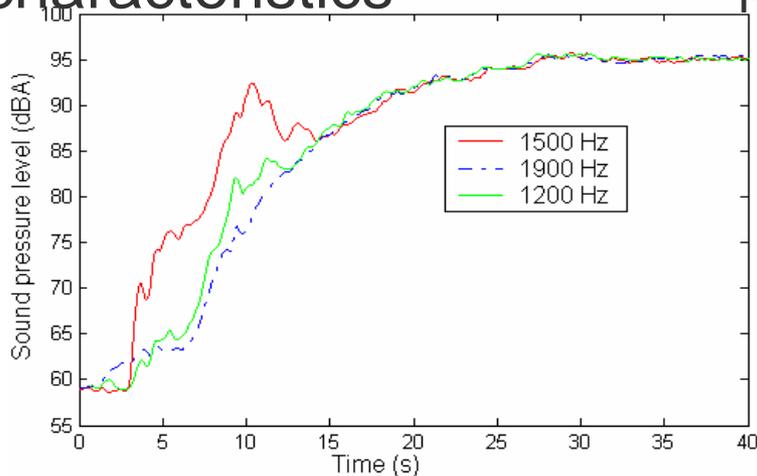
New motors are 15 dB quieter than the actual motor at some speeds

No significant resonance due to slotting or saturation occurred with new 2 rotor prototypes

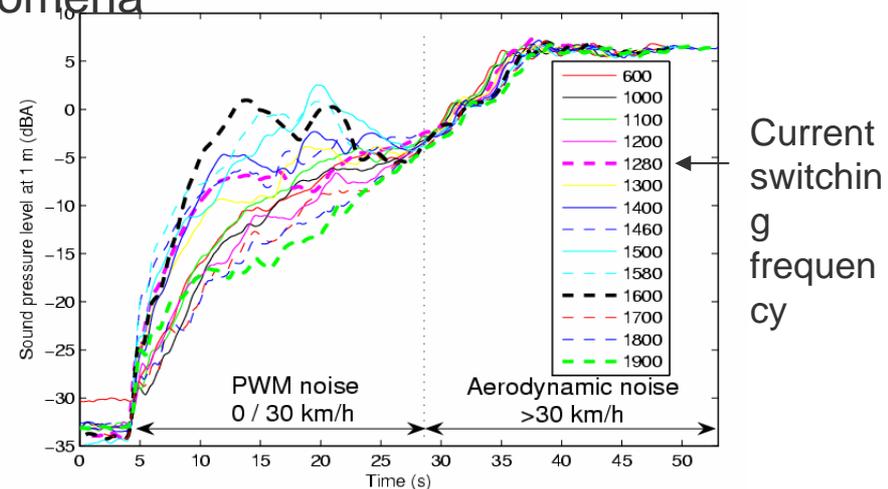
Railway Noise_PROSODIE project

Electrical noise motor analysis

To design low-noise motors fulfilling specified traction characteristics



Experimental sound pressure level measured at 1m during Zr=60 runup with different PWM asynchronous frequencies



Experimental sound pressure level measured at 1m during Zr=36 runup with different PWM asynchronous frequencies

The maximum sound pressure level is obtained when the PWM vibrations near twice the switching frequency enter in resonance with 0 and 2p stator modes near to 3000Hz, that's to say for $f_c=1500\text{Hz}$

Switching frequency has a 15 dB impact on starting noise

Railway Noise_PROSODIE project

Electrical noise motor analysis

Within PROSODIE project, ALSTOM Transport has developed a vibro-acoustic simulation tool that predicts correctly main magnetic noises, and helps ALSTOM engineers to design low-noise motors, and diagnosing magnetic noise problems

ALSTOM Transport continues to launch R&D projects in acoustics field to reduce more noise levels of its products.

Thank you for your attention

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