UNIVERSITY OF TORONTO INSTITUTE FOR AEROSPACE STUDIES
Faculty of Applied Science and Engineering

Noise reduction through mechanical damping in composite sandwich structures

Prof. Annie Ross

Colloquium on Sustainable Aviation, May 16, 2013

POLYTECHNIQUE MONTRÉAL

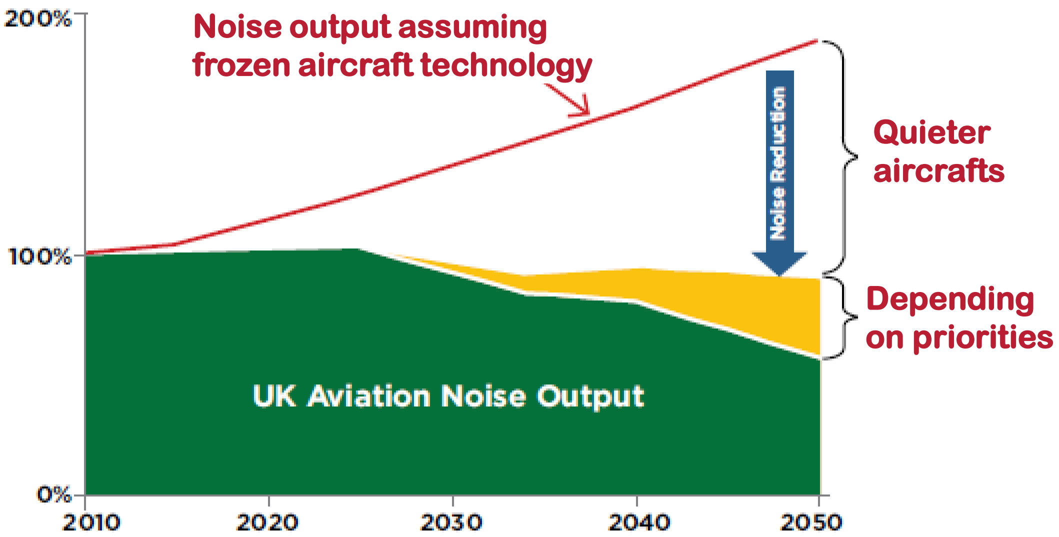
LE GÉNIE EN PREMIÈRE CLASSE

CRIAQ

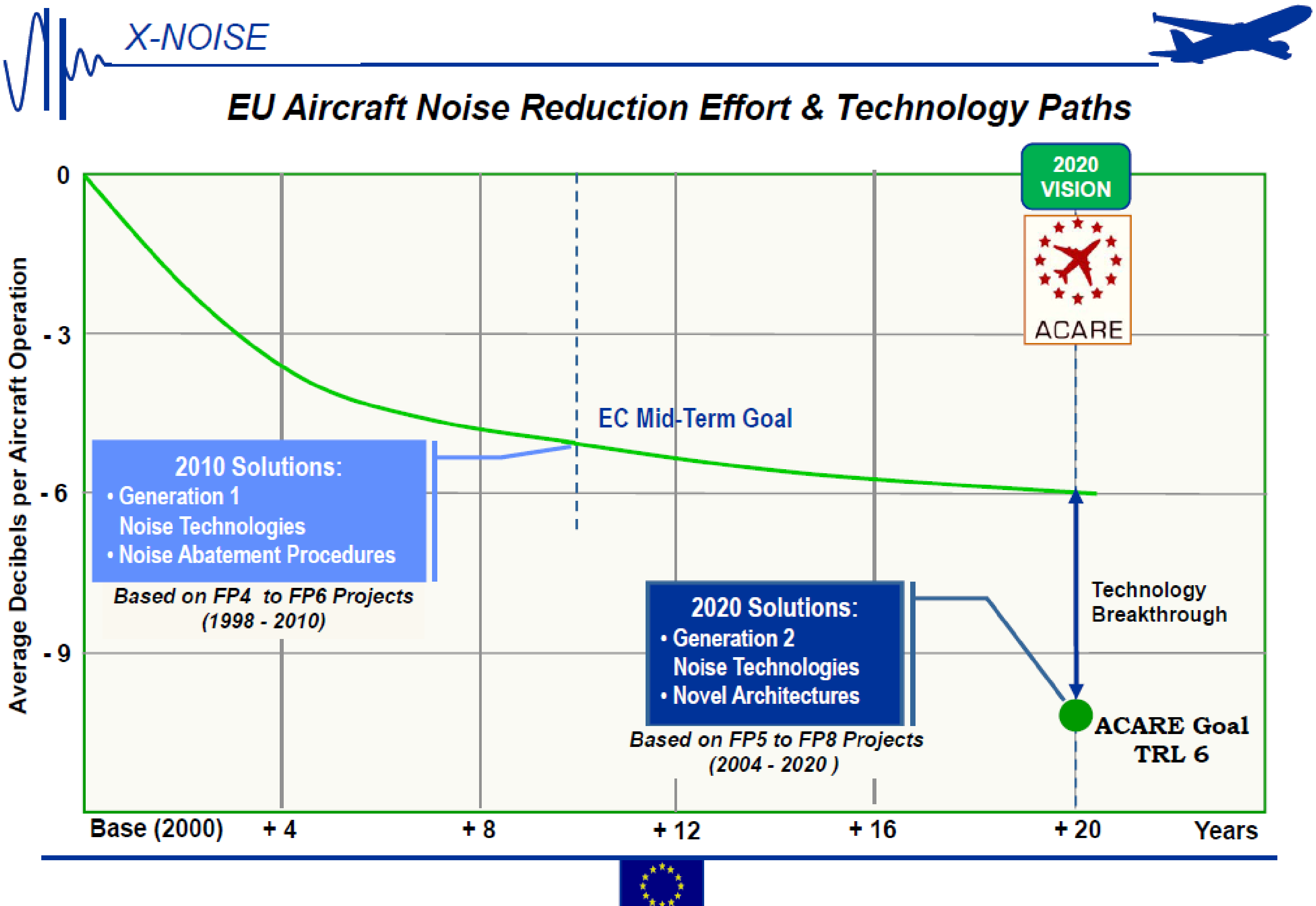
Consortium de recherche et d'innovation en aérospatiale au Québec
Consortium for Research and Innovation in Aerospace in Quebec

Sustainable aviation ??

www.sustainableaviation.co.uk

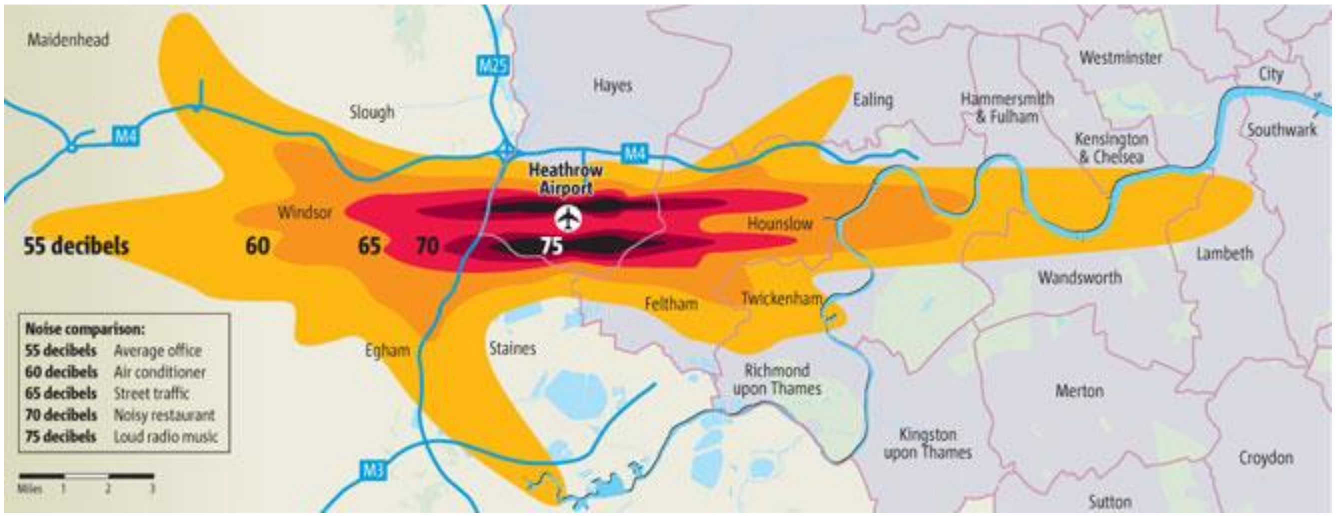


Sustainable noise ?



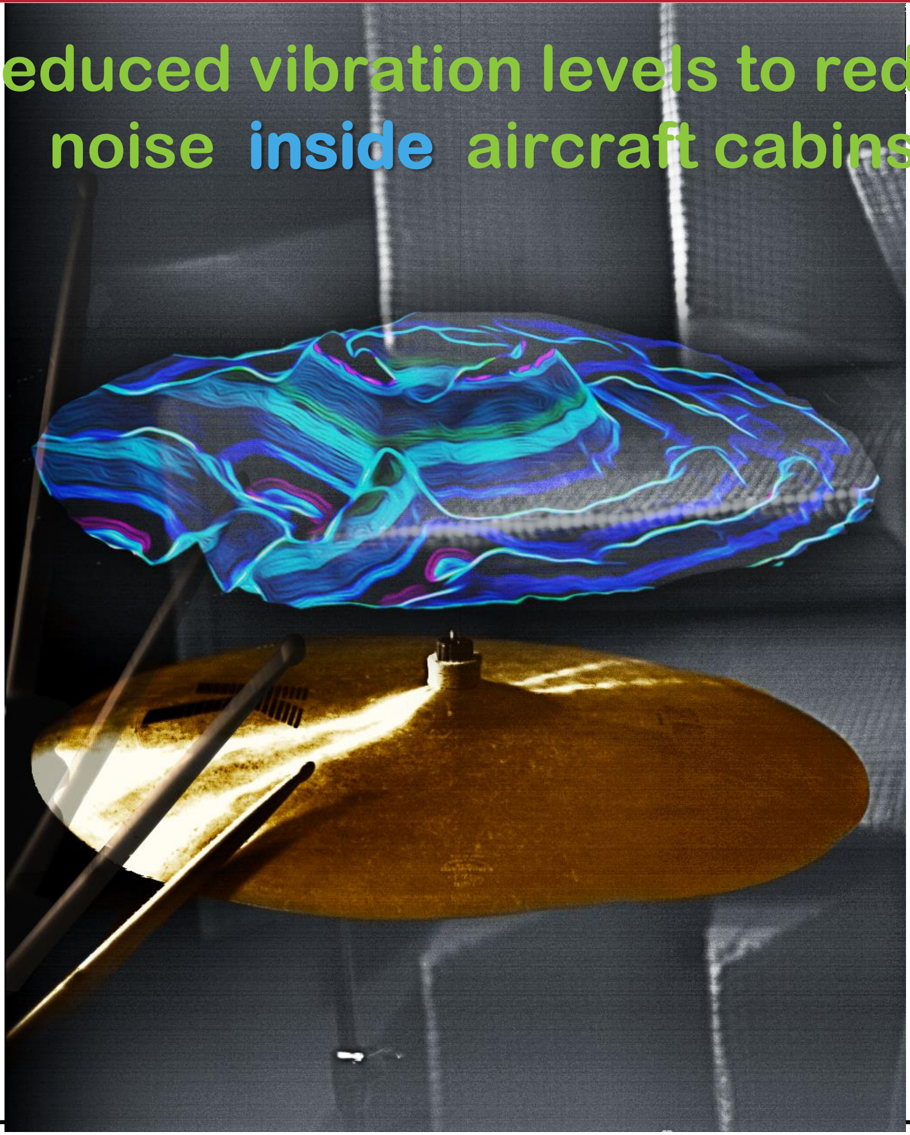
http://www.cdti.es/recursos/doc/eventosCDTI/Aerodays2011/6E1.pdf

Sustainable cabin noise !



Sustainable vibration

Reduced vibration levels to reduce noise **inside** aircraft cabins.



Embedded Damping Elements in Composites

- 4 research laboratories

LAVA – Laboratoire d'analyse vibratoire et acoustique

CCHP – Chaire sur les Composites à Haute Performance

GAUS – GROUPE D'ACOUSTIQUE DE L'UNIVERSITÉ DE SHERBROOKE

CDCQ – Centre de développement des composites du Québec

- 4 companies

Bell Helicopter – Une société de Textron

BOMBARDIER

Pratt & Whitney Canada – A United Technologies Company

ARTEC TECHNOLOGIES

- Supporting organizations

CRIAQ

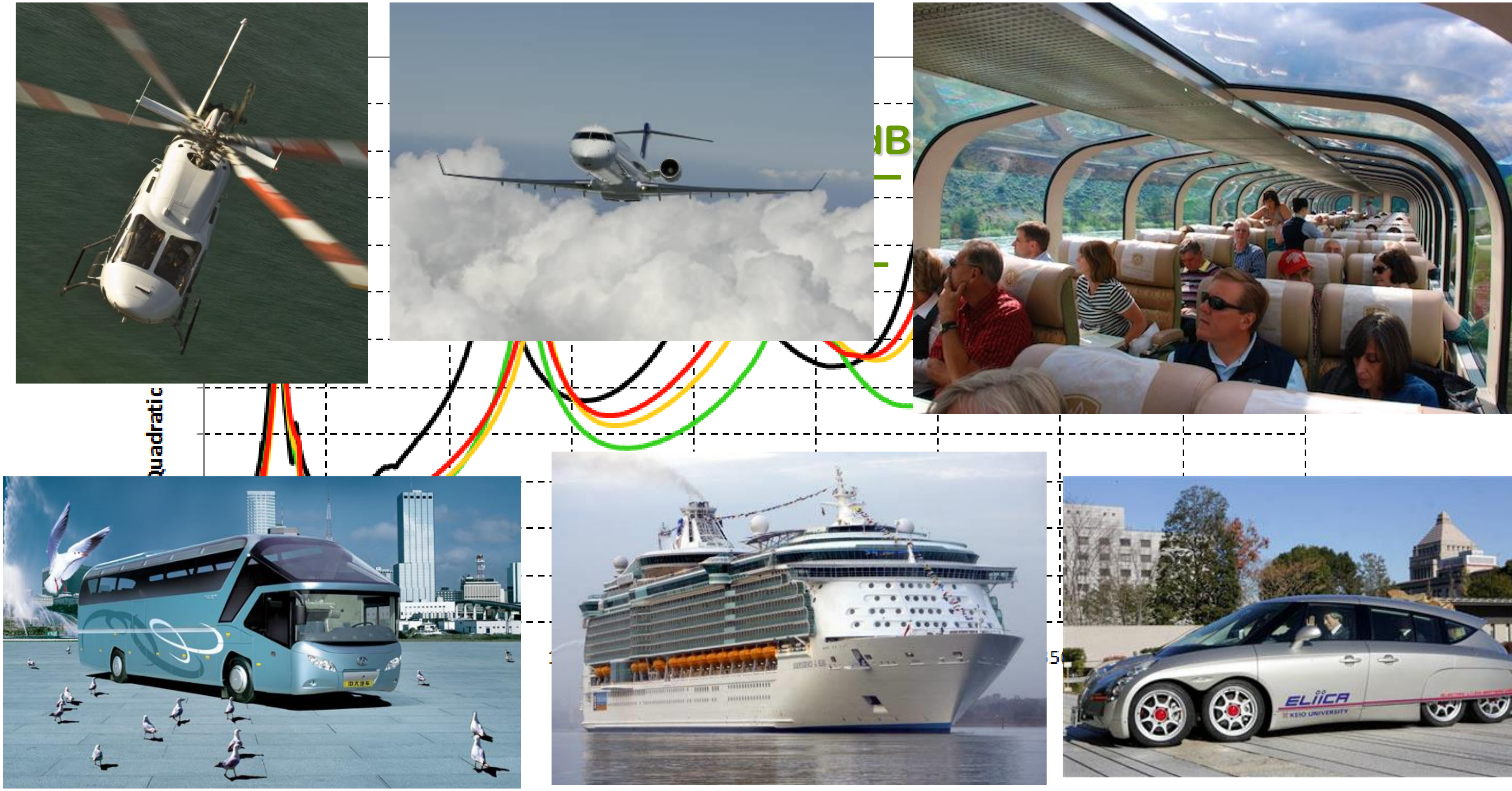
CRSNG NSERC

Finances et Économie Québec

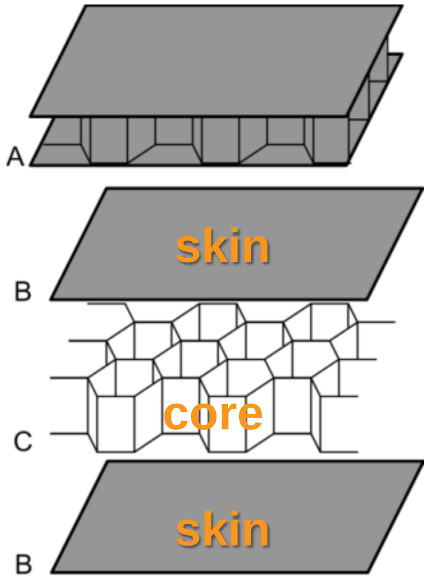
Fonds de recherche Nature et technologies Québec

crepec – Centre de recherche en plasturgie et composites / Center for Applied Research on Polymers and Composites

Results



Context – new design and manufacturing



Sandwich structure

Advantages :

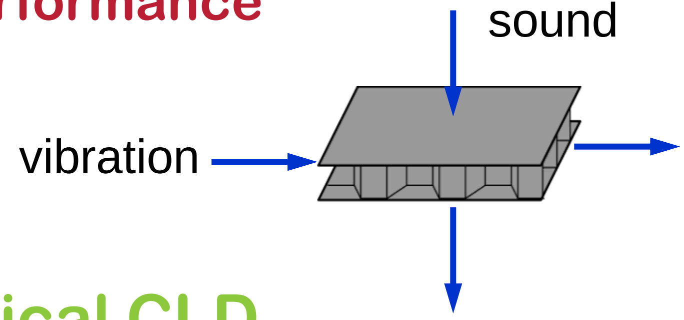
+ High flexural stiffness
+ High stiffness/mass ratio
+ Ability to manufacture complex shaped parts
+ Increasing use in all transportation industries

Disadvantages :

- Easy propagation of mechanical and acoustic vibration
- Risk of mechanical damage and passenger discomfort
- Initial damping not enough to reduce vibration
- Standard surface damping too weighty

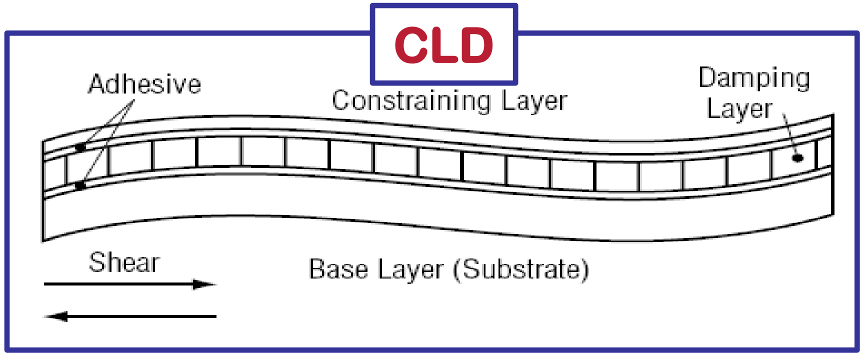
Objective – Proof of concept

- Define design and implementation strategies for low weight viscoelastic damping treatment
  - ✓ To reduce vibration and radiated noise
  - ✓ To deduce acoustic transmission
- Treatment should be embedded within composite sandwich, to have
  - ✓ Minimal impact on mechanical performance
  - ✓ Minimal added mass
  - ✓ Minimal impact on production



- Solution to be compared to typical CLD

Approach

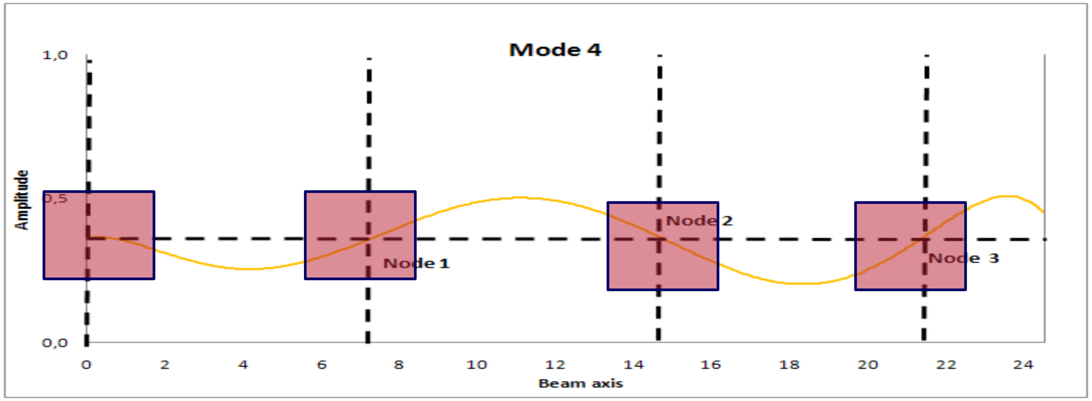


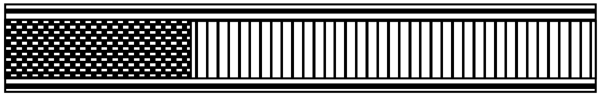
Use of CLD (Constrained Layer damping) concept

\+

Thin film of viscoelatic materials

\+





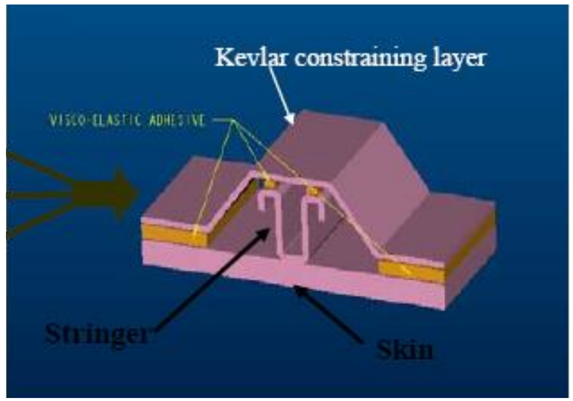
Targeting areas of maximal shearing deformation

= High damping with very low added mass

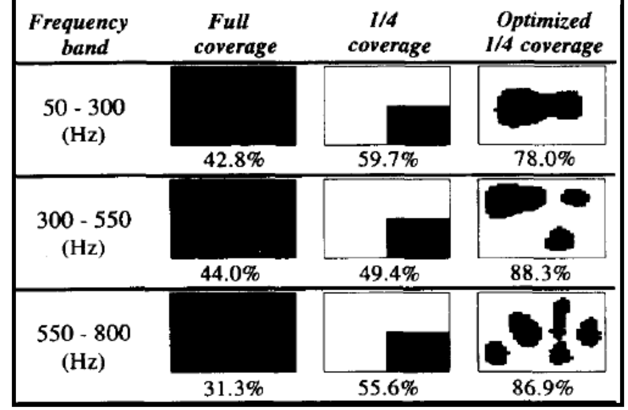
Development steps

Select appropriate viscoelatic material

Determine general shape of device[a]

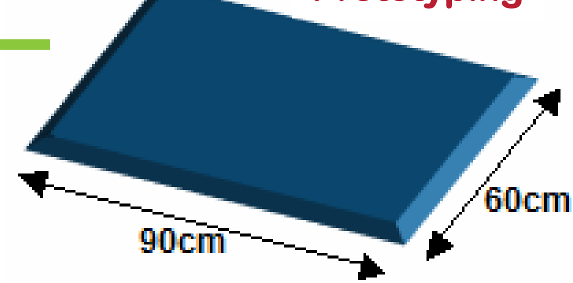


Determine number, size and locations of devices[b]



Design manufacturing procedures

Prototyping



Experimental testing : velocity, transmission

(a) Rao (2003). *Journal of Sound and Vibration, Vol. 262, (3), pp. 457-474.*
(b) Cheng, Lapointe (1995). *Thin- Walled Structures 21 307-326*

Viscoelastic materials

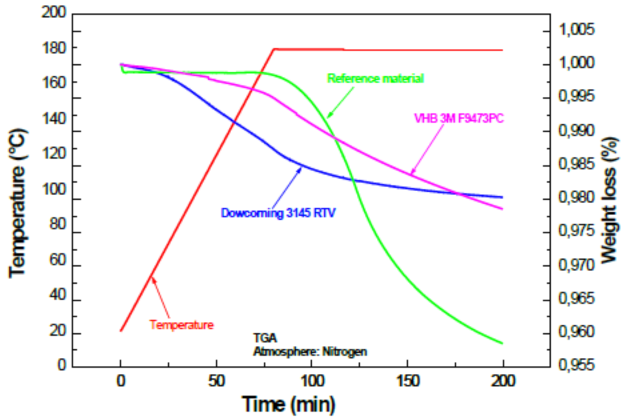
Select appropriate consistency

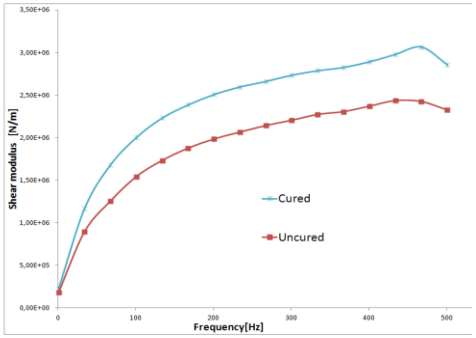
paste

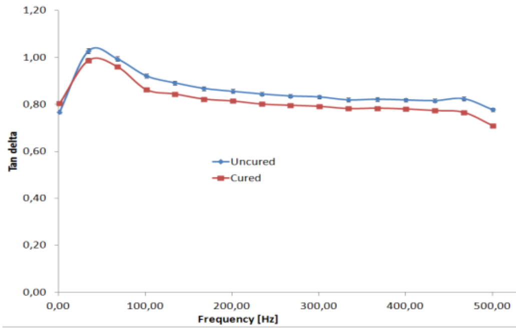
film

Test for temperature resistance

TGA weight loss



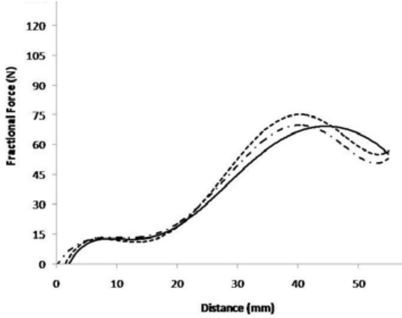




DMA shear modulus & loss factor

Test for bonding resistance

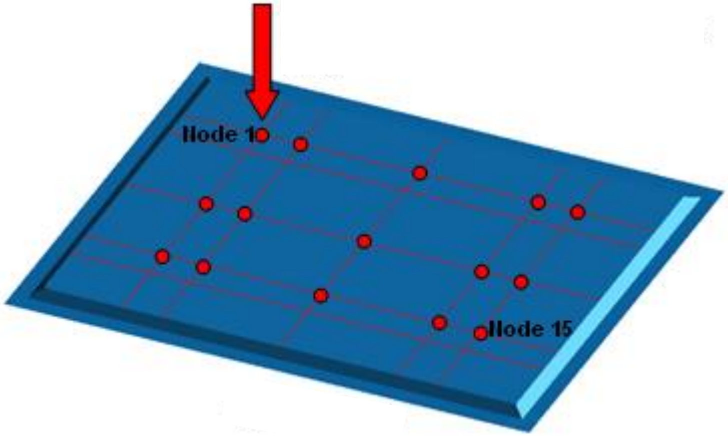
Wedge test



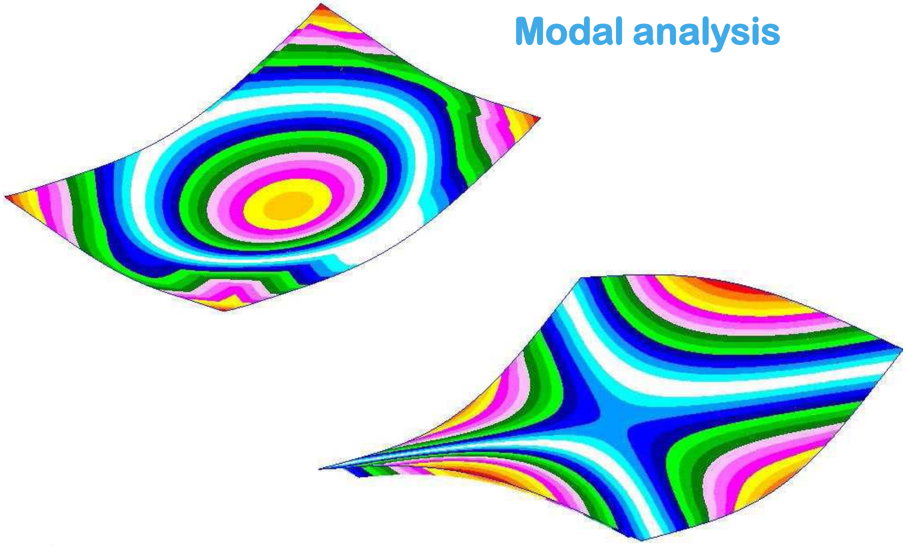
Seperatation force

Numerical vibration analysis

Mecanical loading at different locations
Various measurement points on plate surface

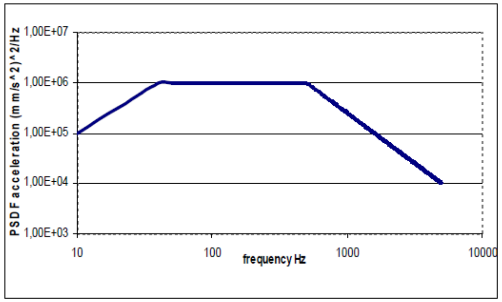


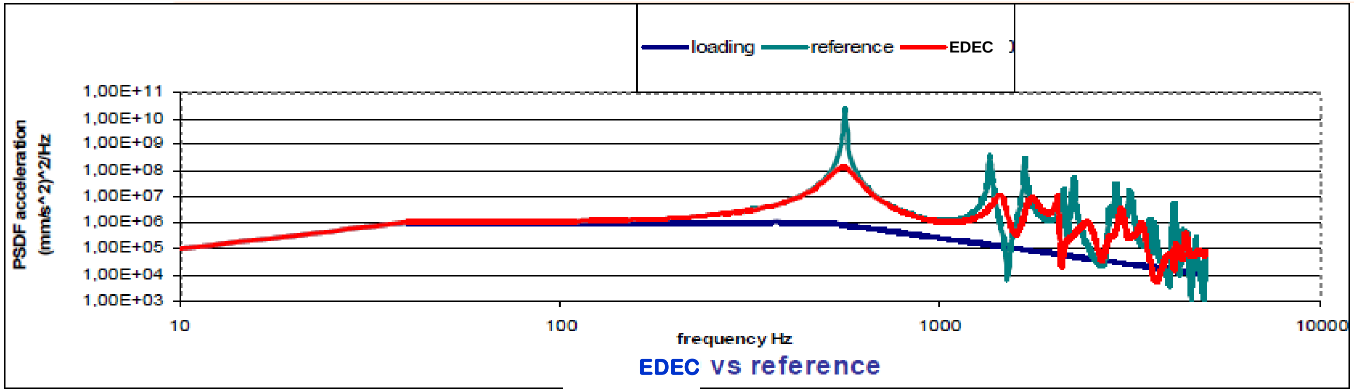
Modal analysis



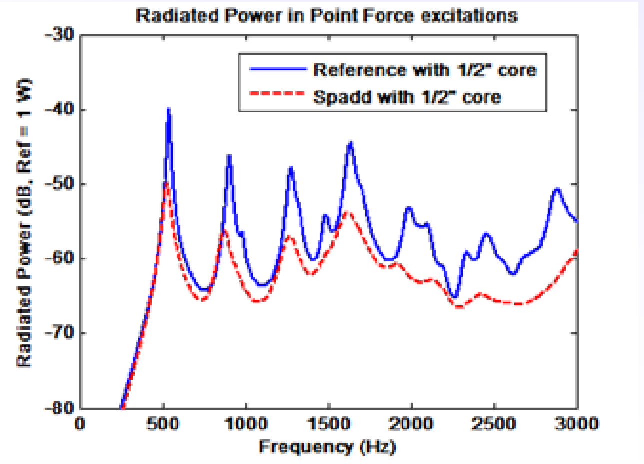
PSDF acceleration response

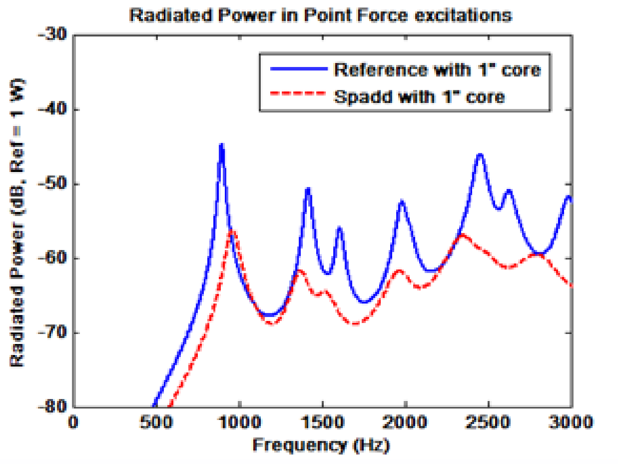
Acceleration loading



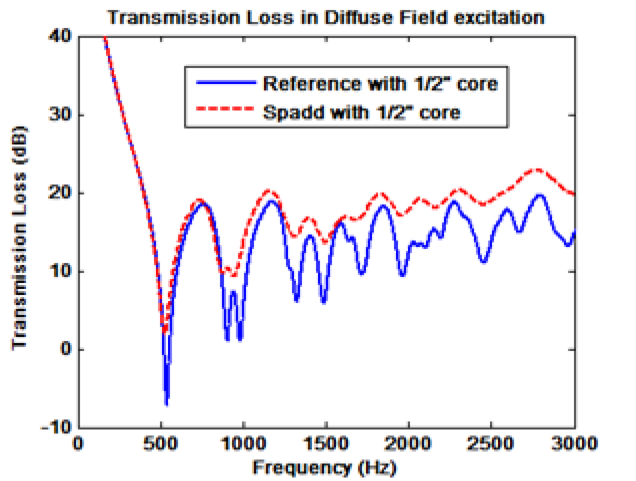


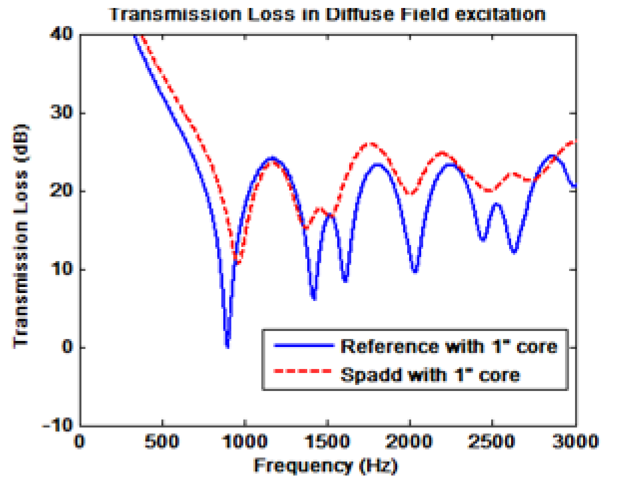
Numerical acoustic analysis





Acoustic power radiated due to mechanical loading

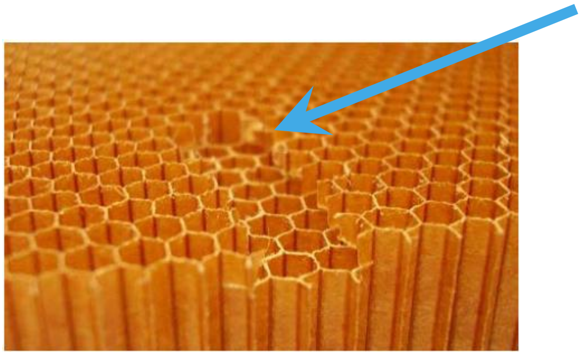


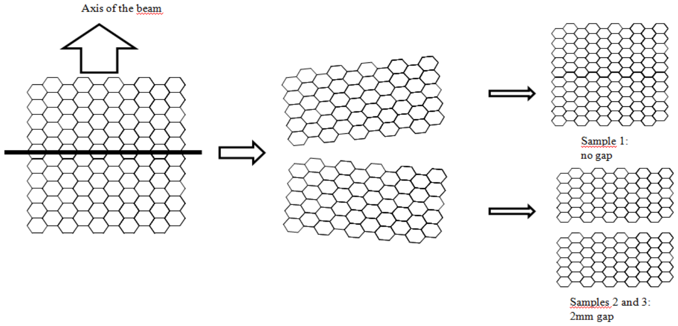


Acoustic transmission loss

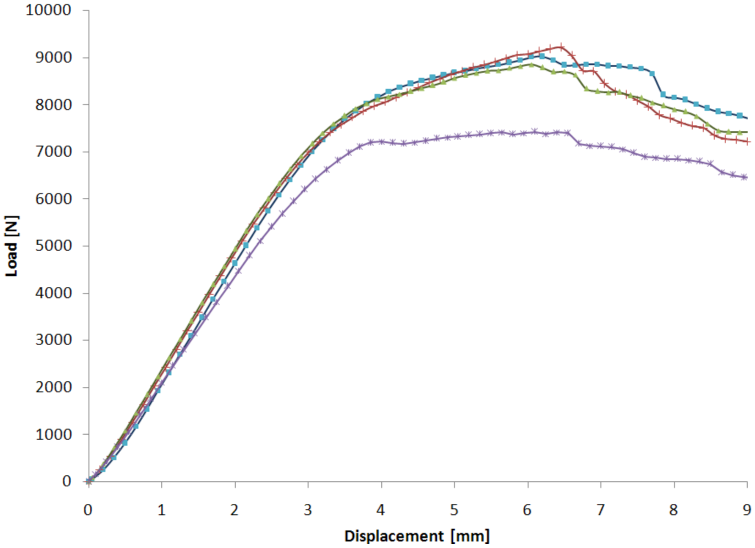
Fabrication and mechanical testing

Core cutting



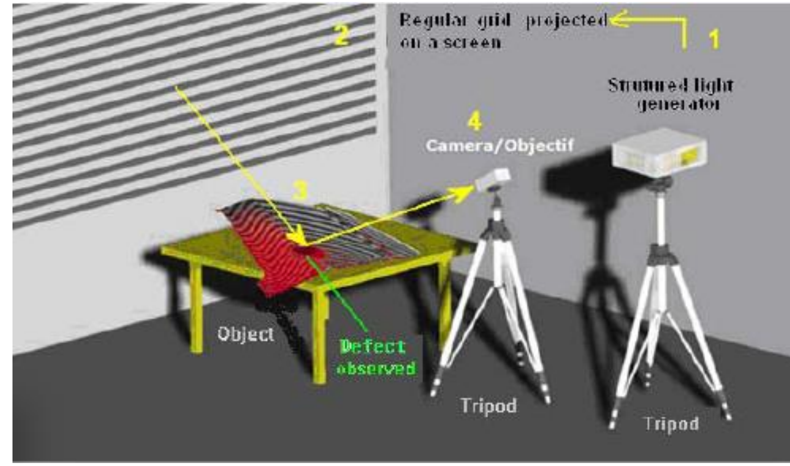


Mechanical testing
Four-point bending

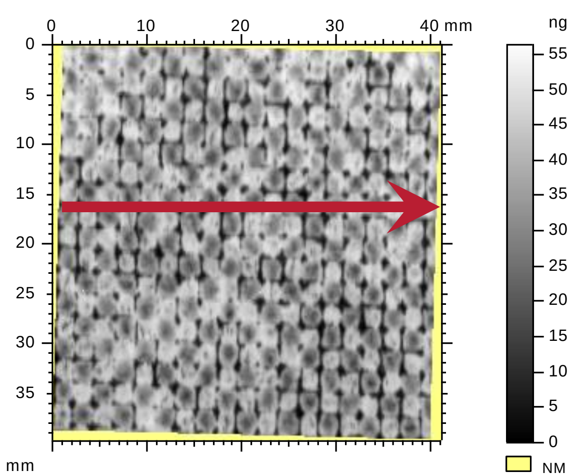


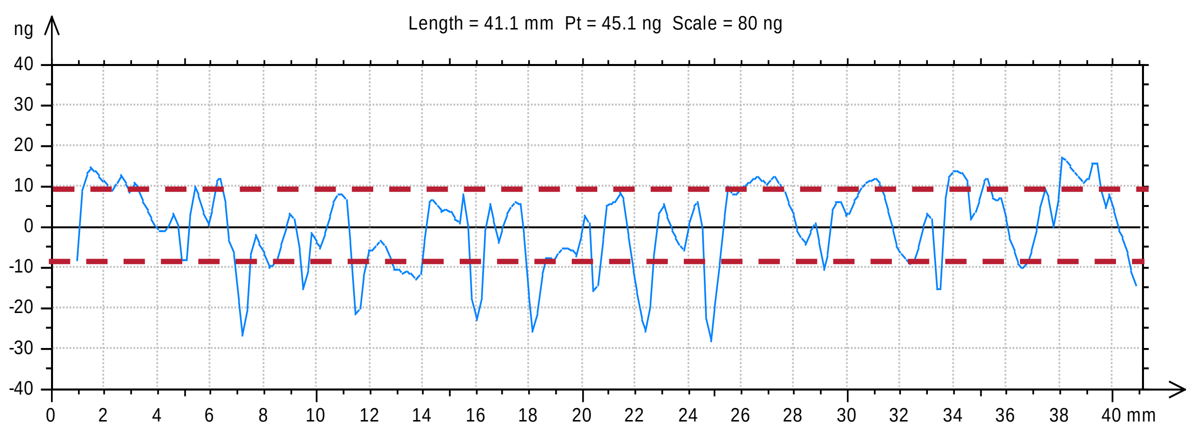
Fabrication and surface quality testing

Autoclave curing



Optical device

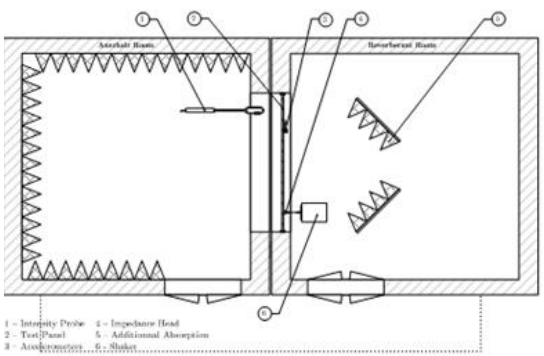




Experimental testing

Gains (dB) w/r baseline	Airborne (500-2500 Hz)	Structure-borne (100-2500 Hz)	
	TL	V2	AMCE
CLD	0,81	1,28	0,89
EDEC	1,57	4,37	1,52

- Airborn excitation by diffuse acoustic field
- Transmission Loss from sound pressure level and intensity level



- Structure-borne excitation at several points
- Panel acceleration measured at 25 locations
- Radiated sound measured at 25 locations

Reverberant room

Anechoic room

Publications

1. E.R. Fotsing, F. Miron, Y. Eury, A. Ross, Edu Ruiz (2012). Bonding analysis of carbon/epoxy composites with viscoelasticacrylic adhesive. *Composite part B 43 (2012) 2087–2093.* DOI:10.1016/j.compositesb.2012.03.009.

2. E.R. Fotsing, M. Sola, A. Ross, Edu Ruiz (2012). Lightweight viscoelastic damping treatment of composite sandwich beams: Experimental analysis. *Journal of composite materials, on-line*. DOI: 10.1177/0021998312449027.

3. M. Sola, E.R. Fotsing, A. Ross, Edu Ruiz. Mechanical properties of composites sandwich structure with core discontinuities. In preparation.

4. M. Sola, E.R. Fotsing, A. Ross, Edu Ruiz. Mechanical properties of composites sandwich structure with partial interleaved viscoelaticlayer. In preparation.

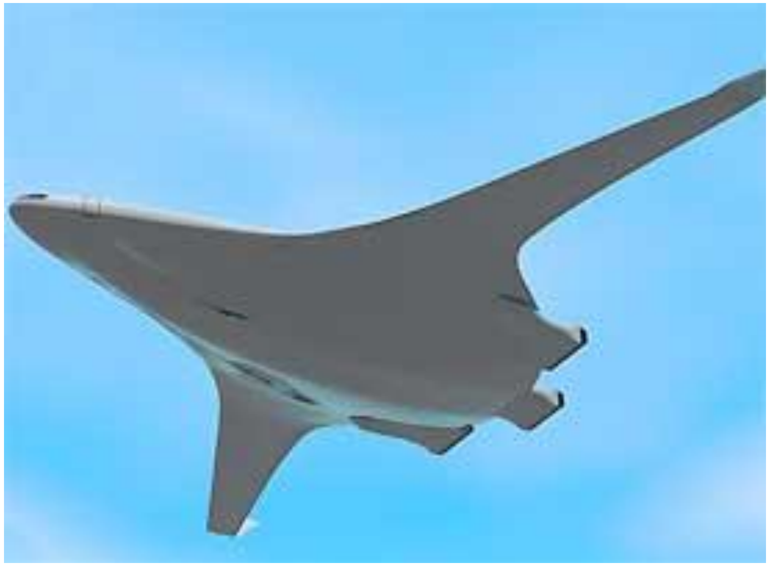
5. M. Sola, E.R. Fotsing, A. Ross, Edu Ruiz. Dynamic characterization of viscoelastic materials used in the composite industry, In preparation.

6. M. Sola, Marc-André Jetté, E. R. Fotsing, M. Cimmino, A. Ross and Edu Ruiz (2009). Analytical and experimental study of embedded damping element in composite. *Proceedings of ICSV 16, Krakow, July 2009*.

7. E.R. Fotsing, M. Sola, A. Ross, Edu Ruiz (2011). Lightweight viscoelastic damping treatment of composite sandwich beams. *Proceedings of ICSV 18, Rio de Janeiro, July 2011*.

Quieter airplanes ...

from the outside **and the inside !!**



Thank you.