

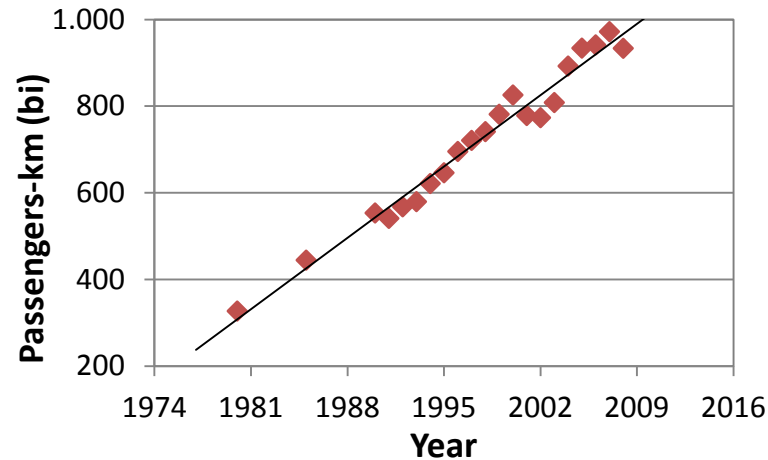
PRELIMINARY RESULTS ON THE MODELING OF AIRCRAFT VIBROACOUSTIC COMFORT



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- Introduction
- The aircraft cabin simulator
- Methodology
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THE FLYING BUSINESS



Source: Bureau of Transportation Statistics, EUA

Air passenger traffic increase and the development of new markets will create a demand for 31,000 new aircrafts in the next 2 decades

Due to the efficiency of aircraft operators being already close to optimal...

...this market will be disputed in areas only scarcely explored up to now, such as passenger **comfort**

AIRCRAFT COMFORT

Main factors:

- Noise and vibration;
- Seat;
- Temperature;
- *Expectation.*

Traditionally, research on civil aircraft cabins was limited to airworthiness aspects (aircrew fatigue, safety, work proficiency...)

Studies on the factors that affect comfort perception of aircraft passengers, were only pursued recently (e.g. IdEA-PACI, FACE, HEACE)

Standards limitations and sparseness of studies involving passengers in general and Brazilian consumers in particular, strongly motivate this research

THE AIRCRAFT CABIN SIMULATOR

Developed at the Federal University of Santa Catarina, Brazil.

Represents the typical cross section of a medium-sized aircraft and a standard economic class seat.

Acoustic reproduction:

Noise-cancelling headphones characterized using a dummy head

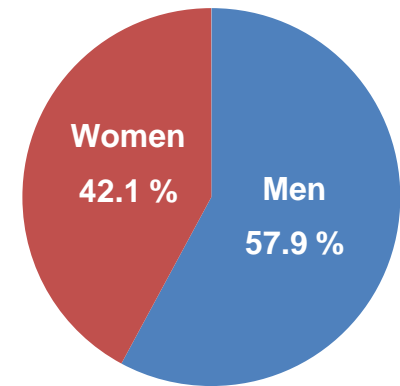
Vibration reproduction:

Electromagnetic shakers measured in real-time using a tri-axial accelerometer



SUBJECTS AND STIMULI

- Sample: 38 volunteers that had already traveled by plane
- Ages: 18 – 37 (avg: 24.18, sd: 4.13)
- Stimuli: 28 combinations of noise and vibration with different levels
- Signals: In-flight recordings during cruise (no turbulence)
- Experimental design: Signals were divided in blocks and the evaluations were spread over different days.



SUBJECTIVE EVALUATION

- i. Explanatory video on how to use touch-screen interface and proceed during the evaluation
- ii. Presentation of the signals
- iii. Evaluation of the perceived comfort on an ungraded straight line



Subjects were allowed to freely switch between stimuli to confirm their answers.

STATISTICAL MODELING

Outlier detection:

- Mahalanobis distance (compared to χ^2 for $\alpha = 0.05$)

Normality test:

- Q-Q plots
- K-S test

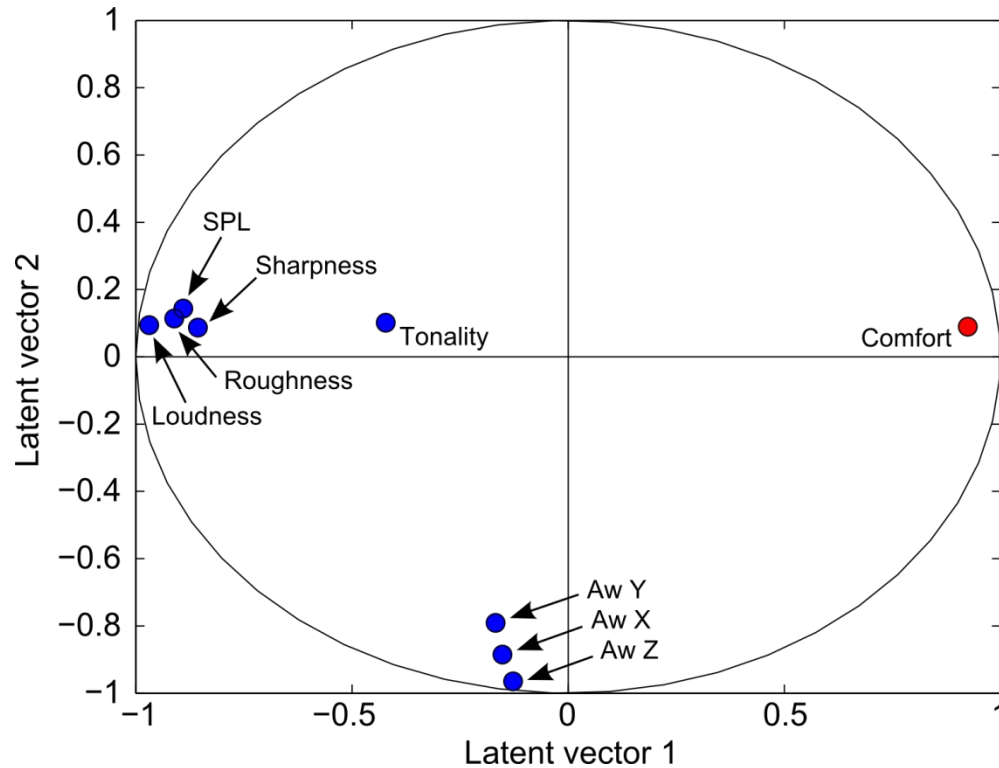
Regression model:

- *Regressors*: loudness, roughness, sharpness, tonality, global SPL, and resultant vibration levels weighted by the ISO 2631.
- *Partial Least Squares*
- Jackknife validation

Sensitivity analysis:

- Normalized (*studentized*) regression coefficients

PLS MODEL



Number of LVs: 2

Variance decomposition:

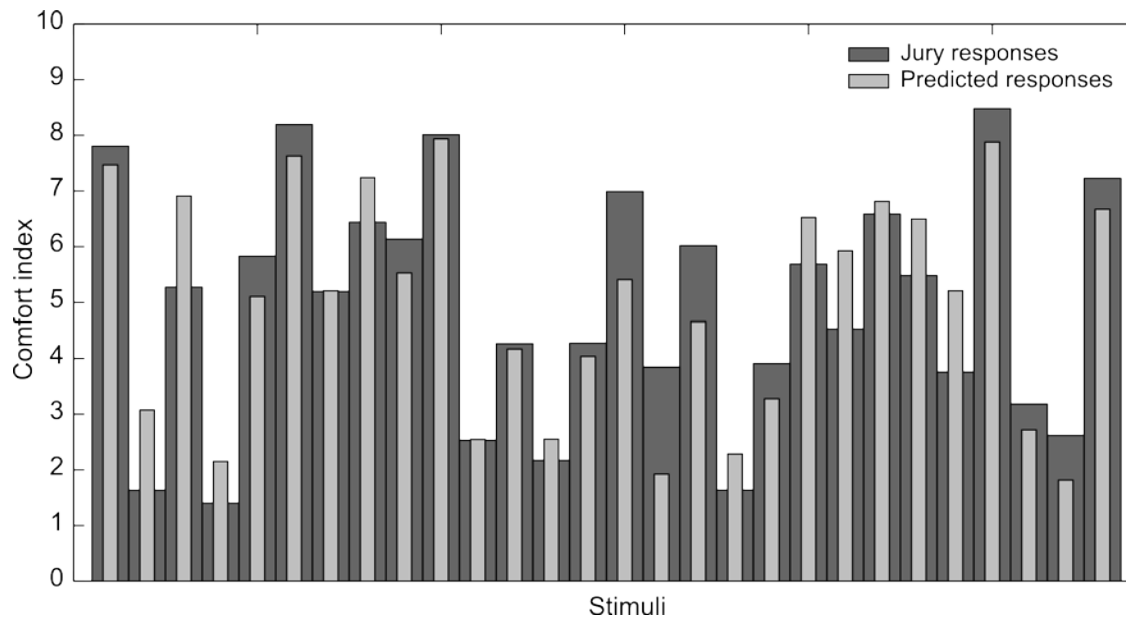
- IV: 74 %
- DV: 86 %

LV interpretations:

- LV 1: Acoustic
- LV 2: Vibration

The lower influence of vibration on comfort is already suggested by this analysis

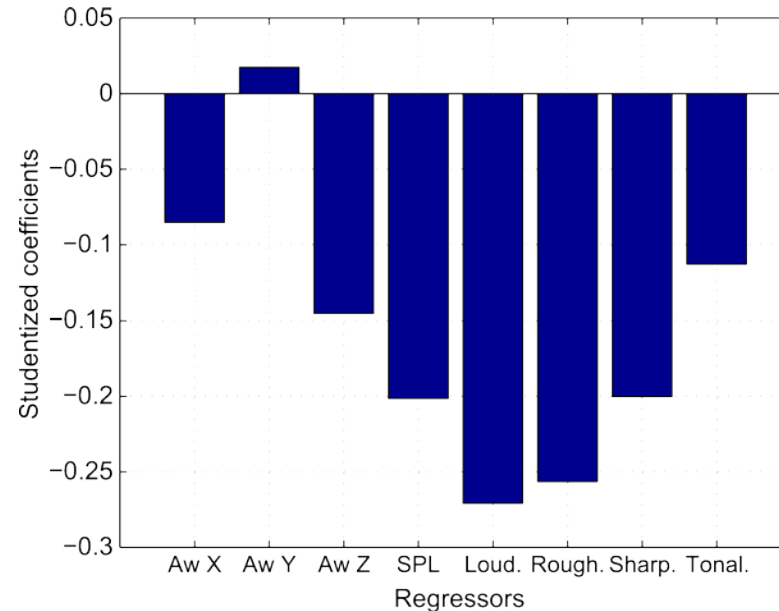
JACKKNIFE VALIDATION



Residuals SS: 16.73 (RMS = 0.77)

Prediction residuals SS (jackknife): 23.77 (RMS = 0.92)

SENSITIVITY ANALYSIS



Predominant factors: *loudness* and *roughness*, followed by *SPL* and *sharpness*

Tonality is less important due to the atonal nature of aircraft cabin noise.

Vibration has a small influence, although the Z axis contribution cannot be neglected.

CONCLUSIONS

An cabin simulator was developed to study the vibroacoustic comfort of aircraft passengers

A model for the perceived vibroacoustic comfort was proposed based on standard objective quantities

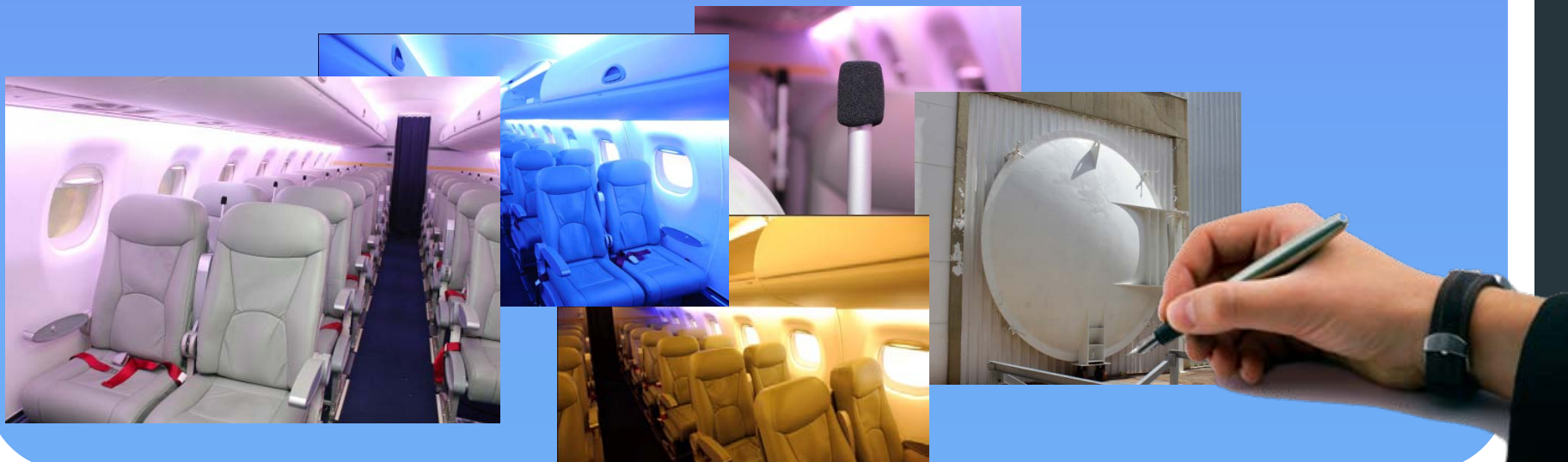
The model was validated and showed good agreement with observed comfort indices



FUTURE WORKS

An improved real-size simulator was constructed, allowing more control over environmental variables (lighting, temperature, pressure, sound and vibration)

New models involving different IVs, larger samples and integrated comfort with thermal, ergonomic and lighting are currently under study.



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