SYNTHESIS OF MULTIAXIS STATIONARY NON-GAUSSIAN SHAPED VIBRATION

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MOTIVATION

Road vibration is **random** in nature and **non-Gaussian**, although it is usually approximated through stationary Gaussian processes with prescribed PSD.
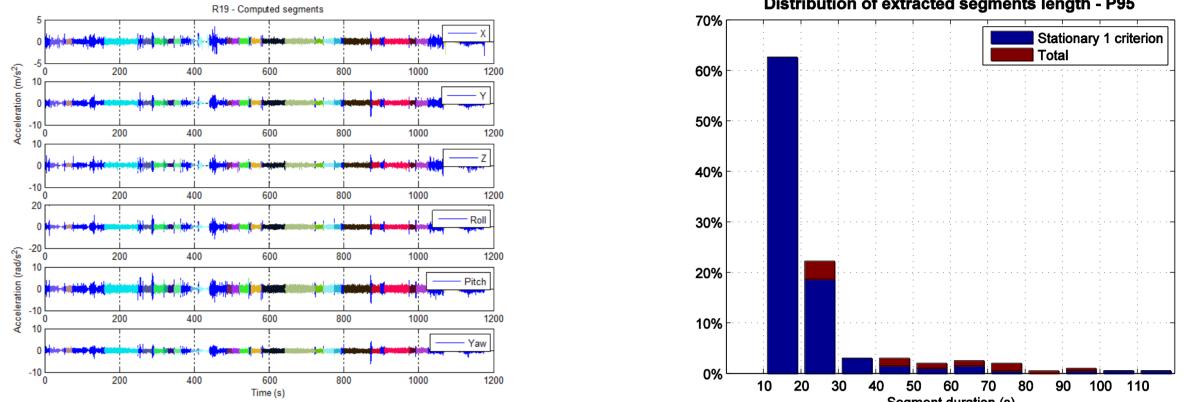
Since objects move in a 3D space, vibration is also a **multidimensional** physical process, but is usually simplified to a single dimension.
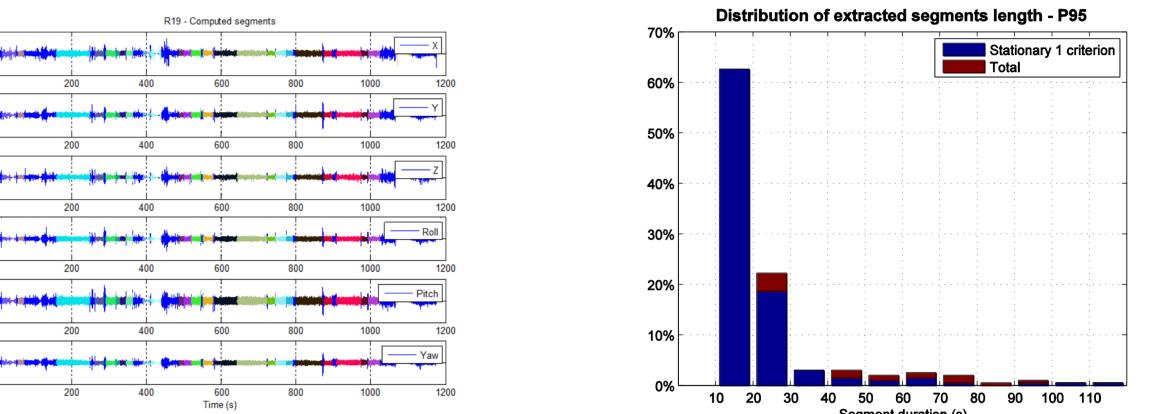
The unambiguous definition of a non-Gaussian multivariate process requires in general a complex specification in terms of its higher order **statistics**.

OBJECTIVE

The objective of this thesis is the development of a method for the **synthesis of non-Gaussian multiaxis road vibration**, with a prescribed PSD, *pdf* and cross-correlation. The goal of the first phase is the determination of the main characteristics of the process and the definition of a simplified model for the synthesis.

METHODOLOGY

The methodology for the characterization of the process includes four main steps.

Definition of the field measurement campaign
• Selection of the vehicle, component and measurement routes.
• Definition of the measurement points for 6DOF characterization.

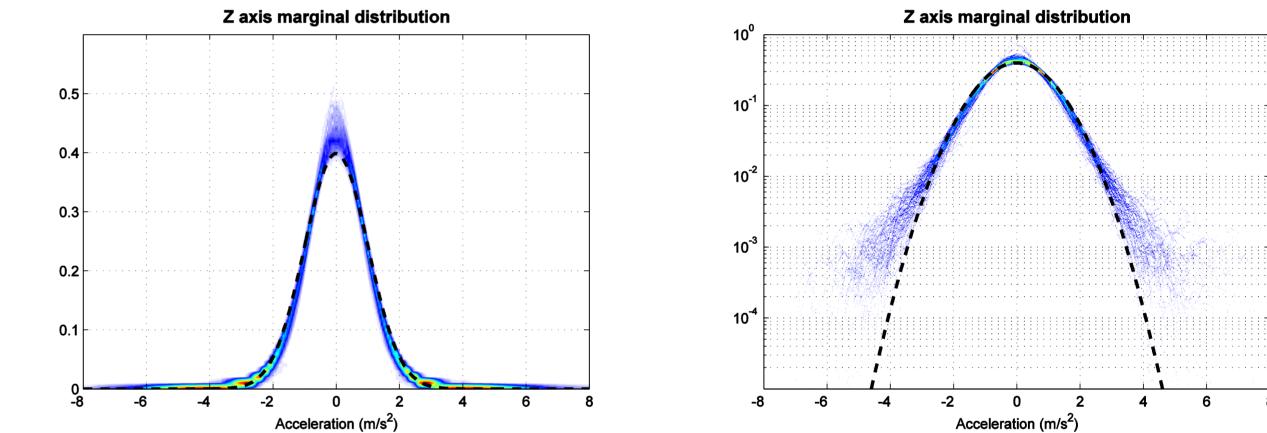**Vehicle instrumentation and data recording**
• Sensor positioning and configuration of the data acquisition system.
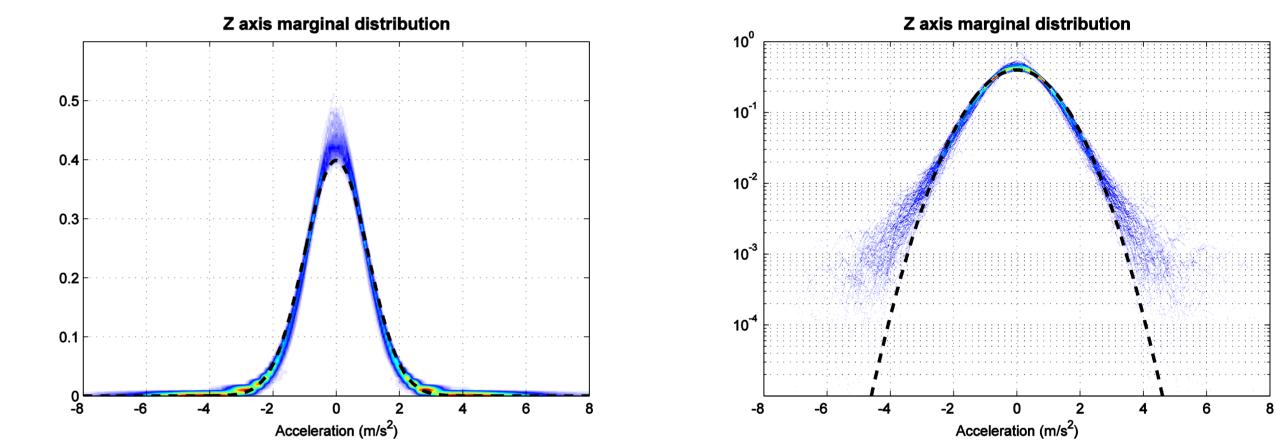• Signal recording.

Signal post-processing
• Process filtering and transformation.
• Signal segmentation.
• Spectral and *pdf* estimation.

Data analysis
• Stationarity and Gaussianity testing.
• Evaluation of the departure from Gaussianity.
• Determination of symmetries in the process.

INSTRUMENTATION AND DATA ACQUISITION

Instrumentation

12 DOF

6 DOF

Locations

REFERENCES

[1] Acoustical Society of America. *Specification for octave-band and fractional-octave-band analog and digital filters.* ANSI S1.11-2004, American National Standards Institute, 2004.
[2] David L. Davies and Donald W. Bouldin. *A cluster separation measure.* Pattern Analysis and Machine Intelligence, IEEE Transactions on, PAMI-1(2):224-227, April 1979.
[3] Bernard W Silverman. *Density estimation for statistics and data analysis*, volume 26. CRC press, 1986.
[4] Norbert Henze. *Invariant tests for multivariate normality: a critical review.* Statistical papers, 43(4):467-506, 2002

RESULTS AND DISCUSSION

Signal segmentation

The raw multivariate data is segmented based on a stationarity criterion, using an algorithm based on the **k-means** clustering of a **Constant Percentage Bandwidth** time-frequency spectrum.

• 33% of the measured signal duration is extracted by the algorithm.
• 80% of the extracted segments pass **stationarity** tests.
• > 80% of the extracted segments have less than 30 seconds duration.
• 0% of the extracted segments pass univariate **Gaussianity** tests for all DOFs.
• 0% of the extracted segments pass the BHEP multivariate Gaussianity test.

Statistical analysis

The process **marginals** are different for each DOF and in general close to Gaussianity, with zero skewness and higher tails. Better fitting is obtained using a t-Student distribution.
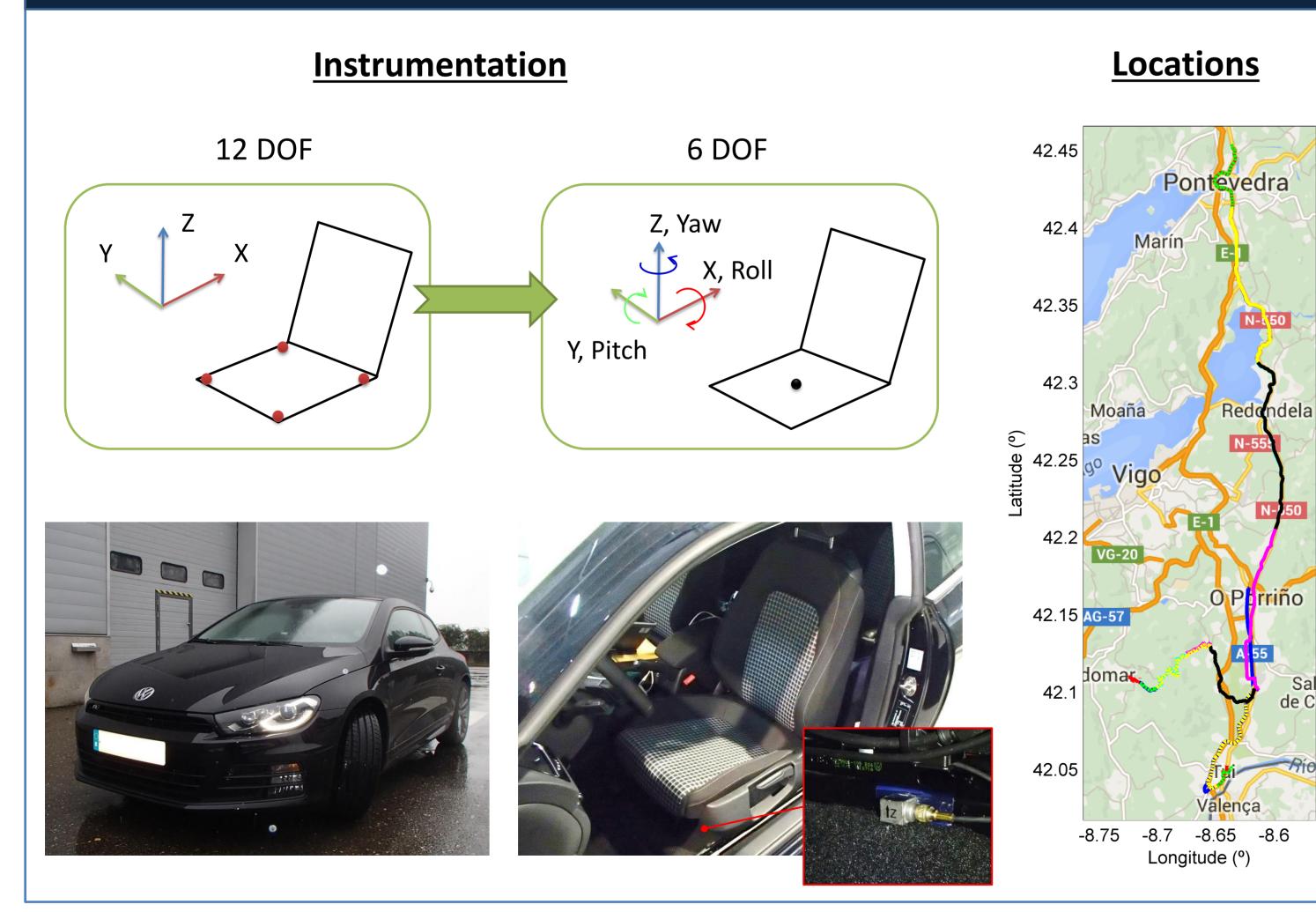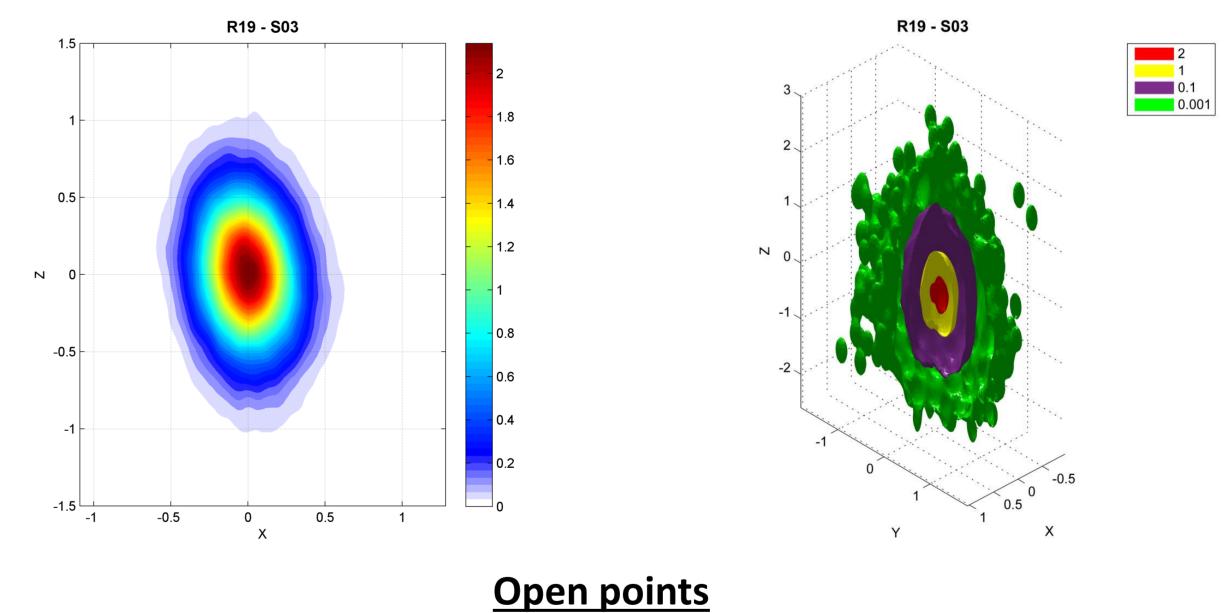

Joint densities up to dimension 3 reveal elliptical symmetry of the process.

Open points

• Evaluation of the process symmetry for higher dimensions.
• Definition of a simple model for unambiguous specification of the non-Gaussian multivariate *pdf* of the process (multivariate t-Student distribution, copula, …).

PLANNING FOR 2015-2016

Tasks for 2015-2016 include completing the analysis for process characterization, further investigation of single axis non-Gaussian and multiaxis Gaussian vibration synthesis.

Task	Description	2014				2015				2016			
		T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
1	Literature review												
2.a	Definition of the measurement conditions												
2.b	Field measurements												
2.c	Signal analysis						R						
3	Single axis non-Gaussian random vibration synthesis							C					
4	Multiaxial Gaussian random vibration synthesis								R				
5	Multiaxial non-Gaussian random vibration synthesis												