

# Partnerships Program

## Joint Applied Research Projects (PCCA)

### Summary of the Research Report

<b>Work package:</b>	IV
<b>Phase title:</b>	<i>Experiments</i>
<b>Project title:</b>	<i>Experimental model for change detection and diagnosis of vibrational processes using advanced measuring and analysis model-based techniques.</i>
<b>Cod:</b>	PN-II-PT-PCCA-2013-4-0044
<b>Acronym:</b>	VIBROCHANGE
<b>Main authority:</b>	<i>(UEFISCDI) – Executive Unit for Financing Education Higher, Research and Development and Innovations and Creativity.</i>
<b>Contractor:</b>	<i>“Dunărea de Jos” University of Galați</i>
<b>Contract no:</b>	224 / 01.07.2014
<b>Phase deadline:</b>	30.09.2017

#### Consortium:

CO - Dunărea de Jos University of Galați, Aiordăchioaie Dorel, Project manager  
P1 - INCD în Informatică Bucharest, Popescu Dan Theodor, Team Lider P1  
P2 - INCDMTM Bucharest, Cioboată Daniela, Team Lider P2  
P3 - TeamNet Engineering SRL Bucharest, Roman Nicu, Team Lider P3

## Phase #4: The summary of the Research Report

### 1. Introduction

The project considers the *Change Detection and Diagnosis problem* (CDD) in vibrational processes using advanced measuring and analysis techniques model-based. The vibrational processes are characterized by vibrational phenomena, which include mainly, as effect, mechanical vibration signals, resulting in normal or abnormal operating.

It is an important trend concerning the replacement of the systematic procedure of maintenance of machinery and equipment's by conditional maintenance strategies, based on continuously or selective monitoring of the process, with the scope of detection of abnormal behavior and to avoid catastrophic events of economic or ecological nature. In this context, early time detection of abnormal behavior of systems seems to be a necessary solution, possible and efficient, in rapport with a right working mode description, without artificial excitation, change of the working regime or breaks.

The general objective of the project is to build an experimental model for CDD with application in vibrational process monitoring, using advanced measuring and analysis techniques model-based. The specific objectives are: (O1) Development, implementation and validation of new methods, techniques and algorithms for CDD; (O2) Optimization of classical algorithms for CDD; (O3) CDD information fusion coming from and in time of process monitoring; (O4) Development of a CDD software library, which will implement both classical (known) methods and optimized and new developed ones during the project running; (O5) Development and testing of an experimental model for CDD, with commercial features, hardware and software, which will use the results obtained during the project, under all aspects: theoretic, algorithmic and methodological.

The monitoring of the vibrational processes will consider, in project, another two waves, which are naturally generated and accompanying, partial or complete, continuously or discontinuously, the mechanical vibrations: (1) acoustic waves, inside the audio spectrum; (2) ultrasound waves, with frequencies up to 100 kHz. The project looks on information analysis and processing generated by the set of three presented sources, and to information fusion, for the best decision. The approach will allow the improvement of the process monitoring, more efficient and matched to the considered scope, in rapport with non-fusion, and will be a novelty on national level and one of the few approaches in international area.

The project is sustained by the following consortium: "Dunarea de Jos" University of Galati (Coordinator); National Institute of Research and Development in Informatics, Bucharest (Partner 1); National Institute of Research and Development in Mechatronics and Measurement Technique, Bucharest (Partner 2); Teamnet Engineering SRL of Galati (Partner 3).

The project will build two products, both new, original and international competitive, which will provide solutions to CDD problems of vibrational processes. P1: A program library, as Toolbox of Matlab, which will implement the best algorithms for CDD, using both classical and advanced techniques, as those based on multiresolution analysis, information fusion and soft computing. The product will build a reference for CDD problem and will allow the performance evaluation of new algorithms to the old ones. By using real data from vibrational processes, CDD benchmarks will be proposed; P2: an experimental model, having a CDD software application as basis, to be used in monitoring of some pilot processes, in laboratory, and of a complex industrial process. The physical model will be the basis to launch full commercial products for various processes and markets.

## 2. Objectives

Figure 1 presents the links among the main modules of the experimental model VIBROCHANGE. It is about VIBROTOOL (Toolbox for CDD under Matlab) and VIBROMOD (hardware module for CDD, which implements some algorithms of VIBROTOOL). For testing in laboratory conditions a test module called VIBROGEN was built, which will generate vibrations waves under controlled conditions.

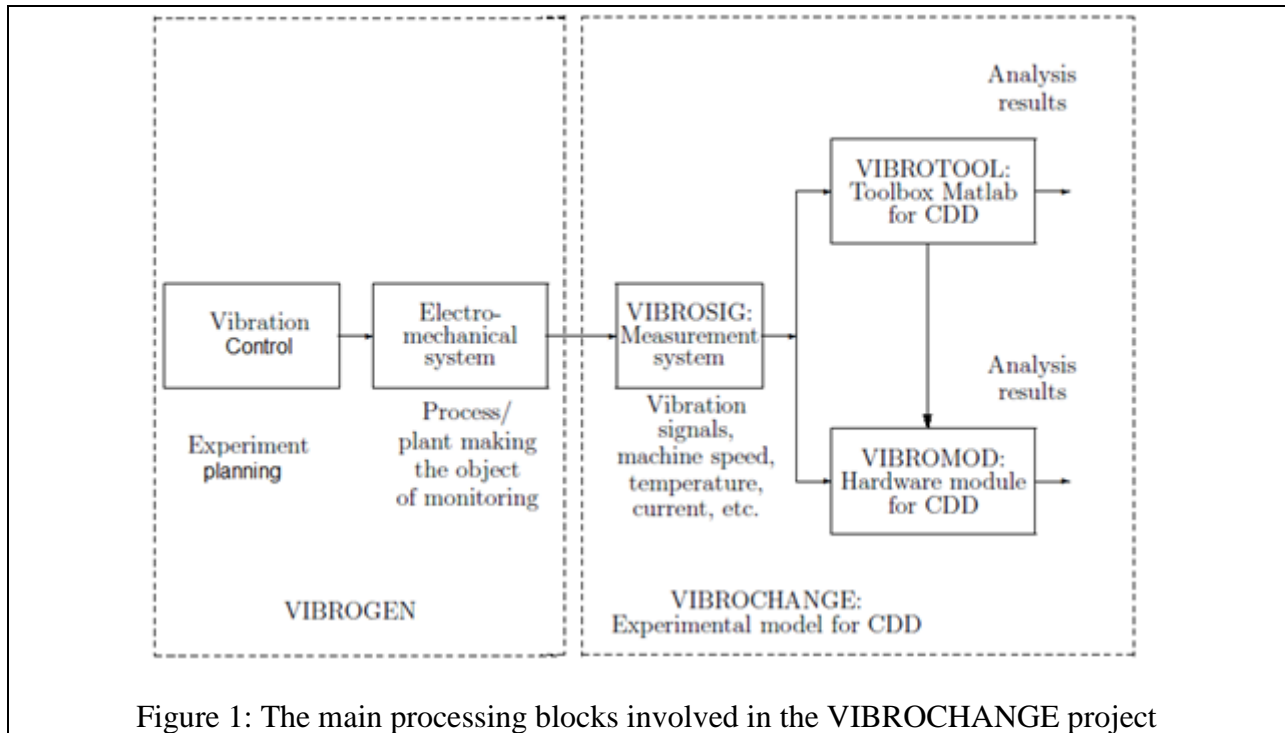


Figure 1: The main processing blocks involved in the VIBROCHANGE project

The 4<sup>th</sup> phase had the objective to make experiments to evaluate the performance of the experimental system VIBROCHANGE, as a whole, and of the individual components. The second objective was to design some technical and user manuals for the end users of the next products:

- VIBROGEN – vibrations generator;
- VIBROTOOL – Matlab toolbox for change detection and diagnosis of processes;
- VIBROMOD – Electric equipment for on-line monitoring of the vibrations;
- VIBROCHANGE – Experimental system for change detection.

## 3. The main results of the phase

- The experimental system VIBROCHANGE is ready to use, together with the following components: VIBROGEN, VIBROTOOL and VIBROMOD ;
- The functions of the VIBROTOOL toolbox were tested with data from industrial processes;
- The performances of the VIBROMOD products was established;
- For all products (VIBROGEN, VIBROTOOL, VIBROMOD and VIBROCHANGE) the user manuals are finished;
- A number of 12 papers were published at various international symposia;

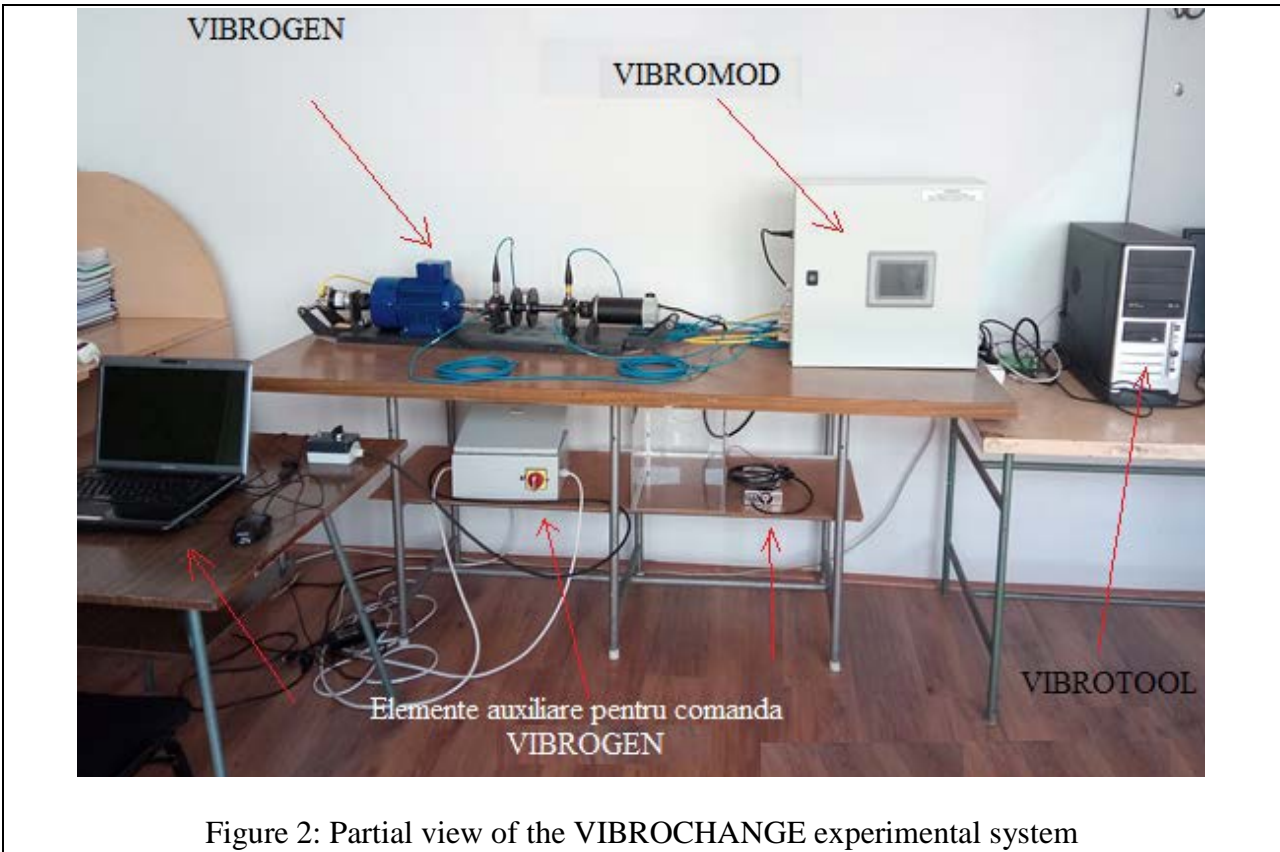


Figure 2: Partial view of the VIBROCHANGE experimental system

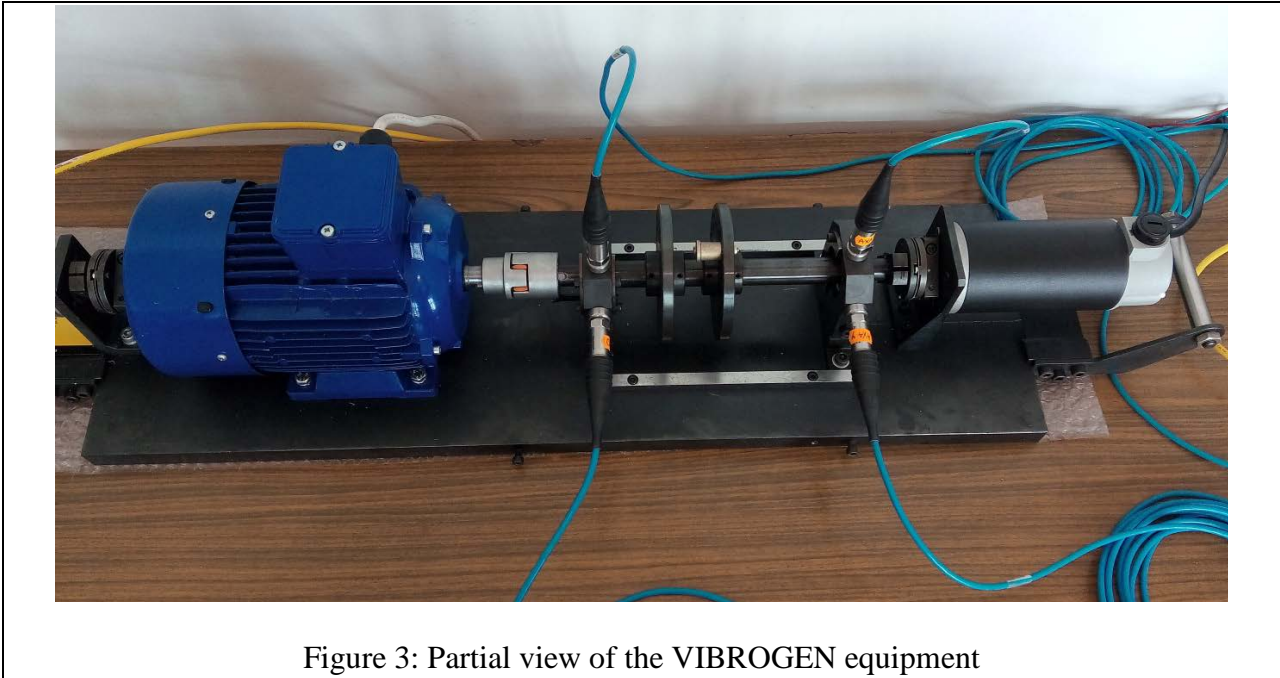


Figure 3: Partial view of the VIBROGEN equipment

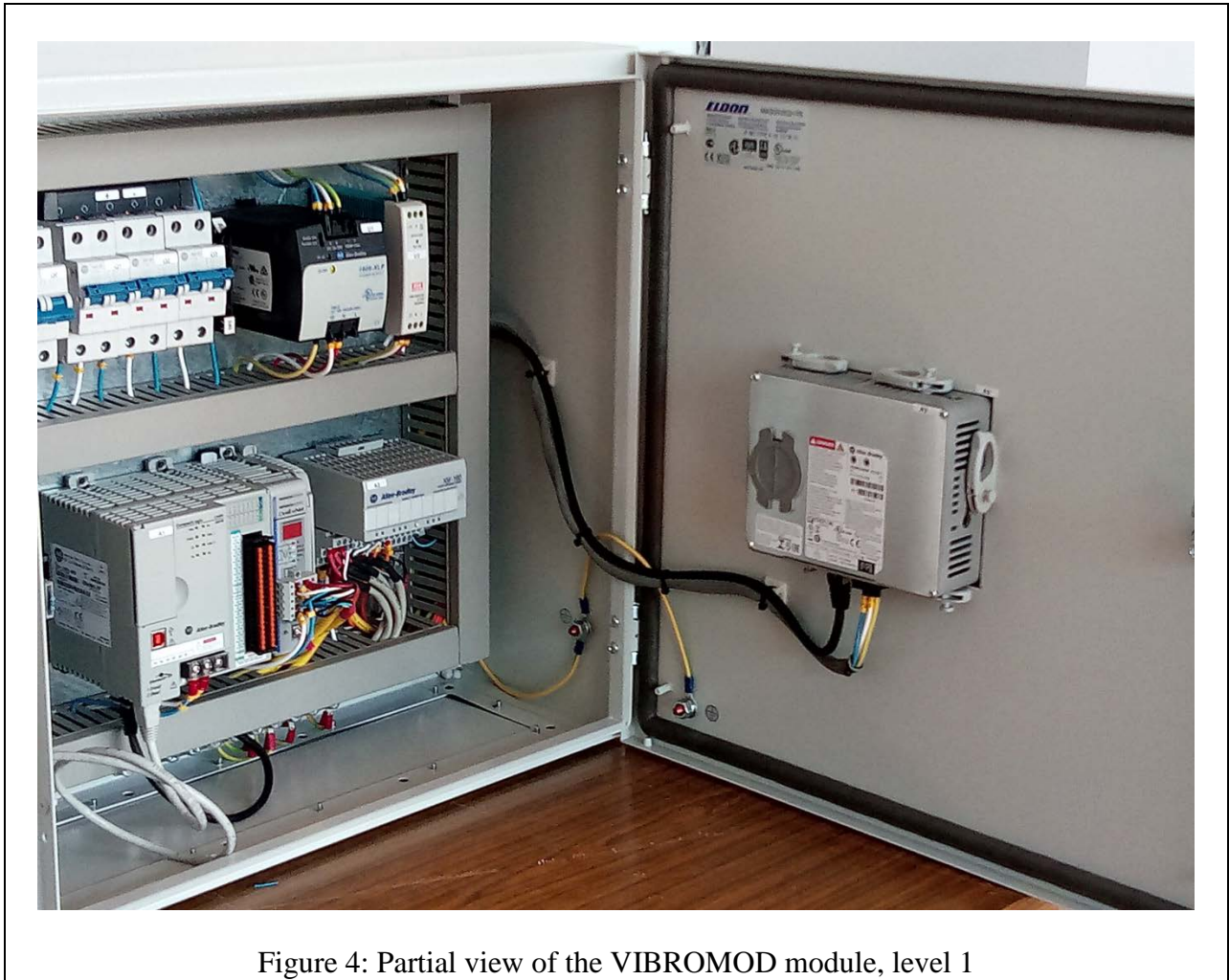


Figure 4: Partial view of the VIBROMOD module, level 1

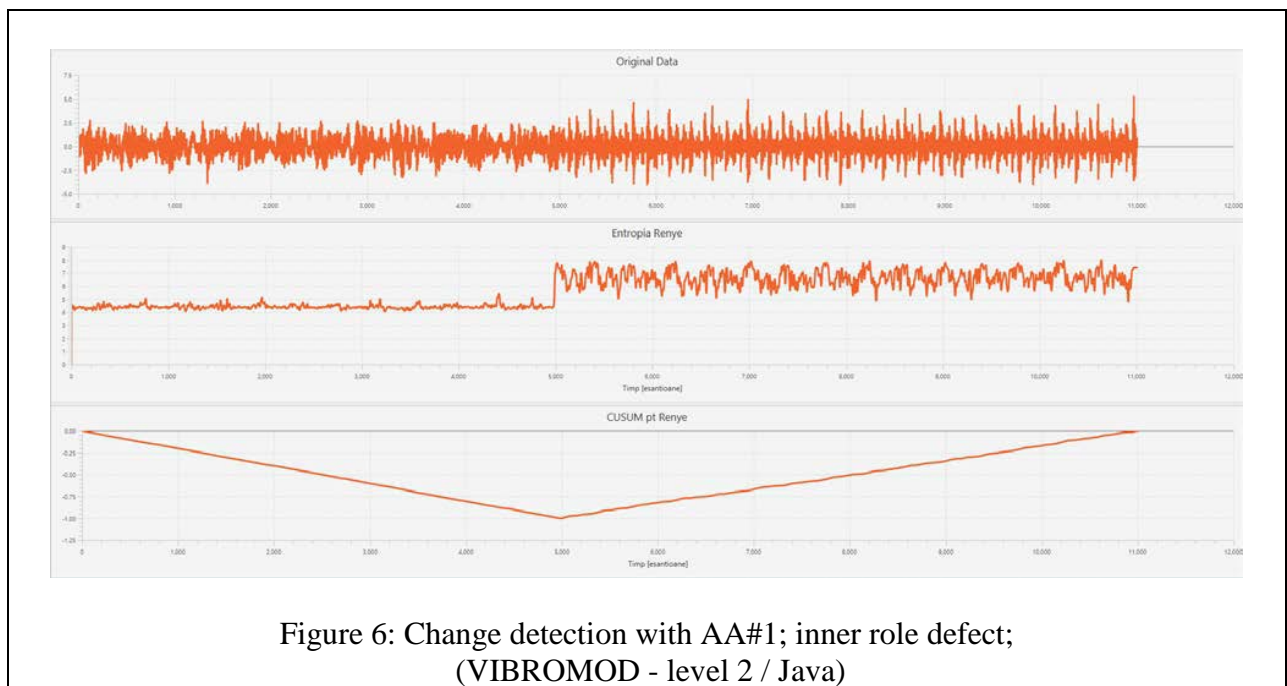
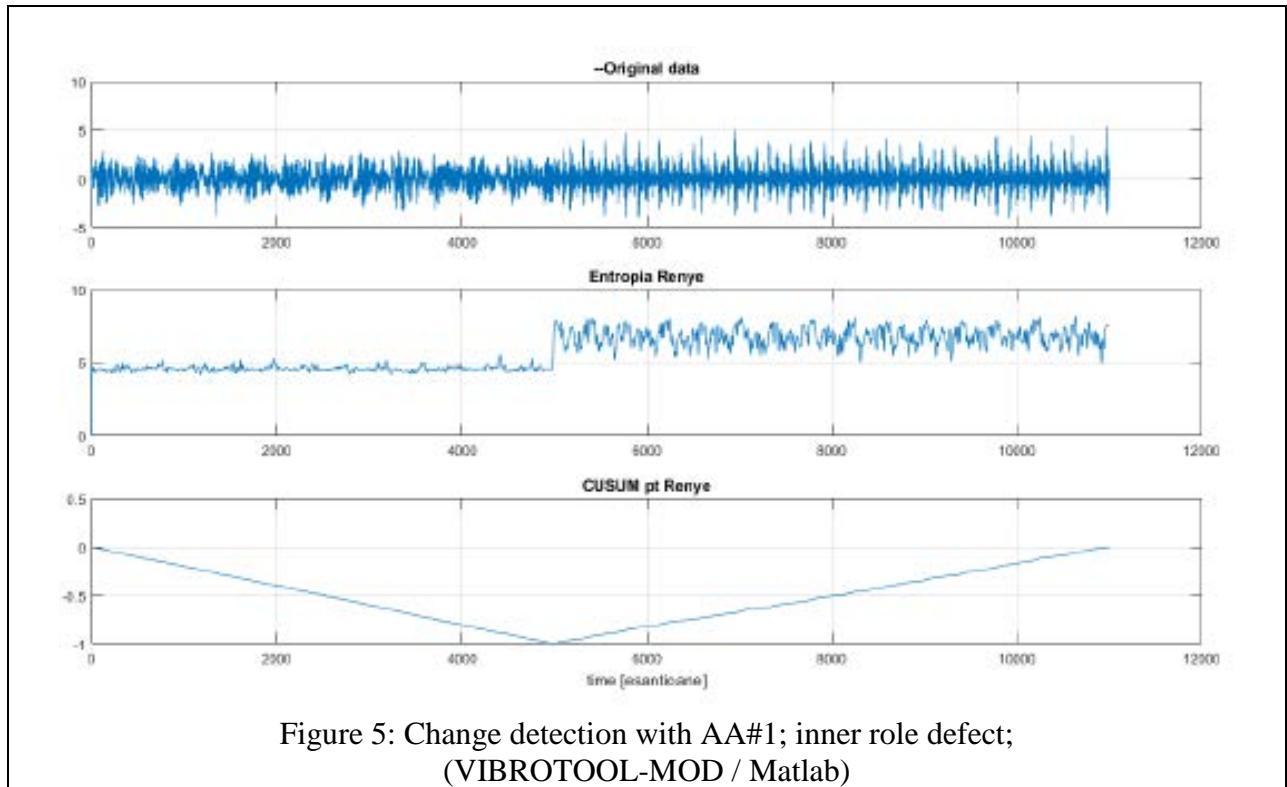
The base component of the VIBROCHANGE system is the VIBROTOOL toolbox. It implements some algorithms to solve the change detection and diagnosis problem (CDD). Some of them are original, developed during the research and others are from the available literature.

The structure of the VIBROTOOL is composed of

1. PRO – programs for raw data processing;
2. CDS – programs for detection and segmentation (CDS) ;
3. BSS - programs for blind separating sources;
4. TFR – programs for time-frequency analysis;
5. AUX – programs for auxiliary tasks.

The next figures present some results of the change detection algorithms with VIBROTOOL-MOD and VIBROMOD implemented algorithms.





#### 4. Published papers

1. Popescu, Th.D, Aiordachioaie, D., *New Procedure for Change Detection Operating on Renyi Entropy with Application in Seismic Signals Processing, Circuit Systems and Signal*

- Processing, vol. 36, no. 9, 2017, pp. 3778-3798, WOS = 000404650200017.
2. Dorel Aiordachioaie, *An Analysis System of Sonar Signals Based on Time-Frequency Representation*, ECAI 2017 - International Conference – The 9th Edition Electronics, Computers and Artificial Intelligence, 29 June -01 July, 2017, Targoviste, Romania.
  3. Dorel Aiordachioaie, Theodor D. Popescu, *A Method to Detect and Filter the Cross Terms in the Wigner-Ville Distribution*. ISSCS 2017 (IEEE 13-th International Symposium on Signals, Circuits and Systems), 13-14 July 2017, Iasi, Romania.
  4. Th. D. Popescu, M. Manolescu, *Blind Source Separation - A Tool for Multivariate Time Series Forecasting*, Proc. The 9th International Conference on Modelling, Identification and Control (ICMIC 2017), July 10-12, 2017, Kunming, P.R. China.
  5. Th. D. Popescu, Aiordachioaie Dorel, M. Manolescu, *Change detection. A review of problems and solutions*, The 5th International Symposium On Electrical And Electronics Engineering (ISEEE-2017), 20-22 October. Galati ROMANIA, Special Session “Change Detection In Vibrational Processes”, Paper No. 1.
  6. M. Electra, C. Resteanu, *Learning with OREL Software*, Proc. The 9th Annual International Conference on Education and New Learning Technologies, EDULEARN17, Barcelona, Spain, July 3-5, 2017.
  7. Dorel Aiordachioaie, *Aspects Of Change Detection In Vibrational Processes Based On Time-Frequency Transforms*, The 5th International Symposium On Electrical And Electronics Engineering (ISEEE-2017), 20-22 October. Galati ROMANIA, Special Session “Change Detection In Vibrational Processes”, Paper No. 2.
  8. Anisia Culea-Florescu, Mihai Culea, *Sparse paradigm for change detection applications*, The 5th International Symposium On Electrical And Electronics Engineering (ISEEE-2017), 20- 22 October. Galati Romania, Special Ssesion “Change Detection In Vibrational Processes”, Paper No. 3.
  9. Daniela Cioboata, Aurel Abalaru, Dănuț Stanciu, Logofătu Cristian, *Advanced measurement systems for vibration signals*, The 5th International Symposium On Electrical And Electronics Engineering (ISEEE-2017), 20-22 October. Galati Romania, Special Session “Change Detection In Vibrational Processes”, Paper No. 4.
  10. Bogdan Theodor, Anamaria Tiron, George Marinescu, Iulian Nacu, Laurentiu Luca, Nicu Roman, *A multi-level software solution for process monitoring*, The 5th International Symposium On Electrical and Electronics Engineering (ISEEE-2017), 20-22 October. Galati Romania, Special Session “Change Detection In Vibrational Processes”, Paper No. 5.
  11. Bogdan Dumitrașcu, Nicușor Nistor, Dorel Aiordăchioaie, *Analysis of Transient Signals by Feature Extraction from Time-Frequency Images*, 2017 IEEE 23<sup>rd</sup> International Symposium for Design and Technology in Electronic Packaging (SIITME), 26-29 Oct 2017, Constanța, Romania.
  12. N. Nistor, B. Dumitrascu, D. Aiordachioaie, *Smart Data Acquisition Board with Software Calibration of the Nonlinear Sensors*, 2017 IEEE 23<sup>rd</sup> International Symposium for Design and Technology in Electronic Packaging (SIITME), 26-29 Oct 2017, Constanța, Romania.

Galați, 20.09.2017

The VIBROGEN Project Manager,

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