# International Symposium on SHM and NDT, INSA Lyon, November 29, 2013

***PROGRAMME***

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| 9h | Registration-Coffee |
| 9h30 | Welcoming address<br>**Michel Lagarde**, *INSA Vice-president* |
| 9h45 | Presentation of INSA activities in the field of NDT and SHM,<br>**Jérôme Antoni**, *WATSON team, Laboratoire Vibrations et Acoustique* |
| 10h | Manual Ultrasonic Testing vs permanently installed sensors<br>**Frederic Cegla**, *Department of Mechanical Engineering, Imperial College of London, UK* |
| 10h40 | Infrared Thermography for NDT: Potentials and Applications<br>**Xavier Maldague**, *Computer Vision and systems laboratory, Electrical and Computing engineering department, Laval University, Quebec, Canada* |
| 11h20 | Needs and trends for NDT and SHM in the aerospace industry<br>**Hervé Trétout,** *Dassault Aviation, France* |
| 12h-14h00 | Lunch, coffee, exhibition |
| 14h00 | Monitoring of wind turbines – bridging industry and research<br>**Tomasz Barszcz,** *President of EC Systems, AGH University of Science & Technology, Krakow, Poland* |
| 14h40 | Novel Signal Processing Techniques for Condition Monitoring<br>**Leonid Gelman,** *Chair in Vibro-Acoustic Monitoring, Department of Applied Mathematics and Computing, Cranfield University, UK* |
| 15h20 | NDT for nuclear industry : needs and trends for the future<br>**Etienne Martin**, *EDF, Direction Production Ingénierie, CEIDRE, France* |
| 16h00 | Coffee break-Exhibition |
| 16h40 | Increasing the robustness in damage imaging<br>**Patrice Masson**, *Groupe d'Acoustique de l'Université de Sherbrooke (GAUS), Québec, Canada* |
| 17h20 | On-line monitoring of material degradation due to fatigue by using sensor principles based on micromagnetic and ultrasonic NDT<br>**Gerd Dobmann,** *Fraunhofer Institut für Zerstörungsfreie Prüfverfahren (IZFP), Germany* |
| 18h00 | End of symposium |

INSA LYON — CeLyA Centre Lyonnais d'Acoustique, UNIVERSITE DE LYON — NDT UALOR

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***ABSTRACTS***

**Frederic Cegla : Manual Ultrasonic Testing vs permanently installed sensors**
*Department of Mechanical Engineering, Imperial College of London, UK*

The quantification of a complex system's reliability is extremely difficult. The reliability of NDE techniques is strongly influenced by the physics of the measurement technique, the procedure with which the NDE technique is applied and human factors that can lead to differences between actual and desired outcomes. The NDE group at Imperial College London has developed permanently installed ultrasonic thickness monitoring tools which allow frequent acquisition as well as automatic evaluation of ultrasonic wall thickness estimates. Several thousand sensors have been deployed in field and some of the outcomes from site data will be presented. The factors that influence the system's performance will be discussed in this paper with a view to giving an indication of the different aspects that are important when trying to evaluate the reliability of a monitoring system compared to discrete manually collected conventional inspections.

**Xavier Maldague : Infrared Thermography for NDT: Potentials and Applications**
*Computer Vision and systems laboratory, Electrical and Computing engineering department, Laval University, Quebec, Canada*

In this presentation, we are going to present the fundamentals of Infrared Thermography aimed at NonDestructive Testing. We will see how image processing enables to significatively enhance the potential of this - still emerging - technique. Both passive and active techniques will be reviewed. Among the active techniques: pulsed, lockin thermography will be discussed along various deployments such as point, line and surface heating. Following this, NDT applications will be presented in various contexts such as aircraft industry, civil engineering, artwork conservation and history among other applications.

**Tomasz Barszcz : Monitoring of wind turbines – bridging industry and research**
*President of EC Systems, AGH University of Science & Technology, Krakow, Poland*

Wind turbines become widespread not only in Europe, but in the world. Due to the cost structure, knowledge about the technical state is crucial for the profitable operation much more than in any other power generation business. The most important component of the wind turbines, which should be monitored is the gearbox.
Several years of experience have shown that the "off-the-shelf" methods and monitoring systems are not fit to the very specific requirements of the wind turbines. The most important ones are: non-stationary operating conditions, large number of monitored units and the need for automation of the monitoring and diagnostic process. This was the trigger for a large number of research, where several novel data processing methods were developed. The lecture includes examples of cases from real wind turbines.

**Leonid Gelman : Novel Signal Processing Techniques for Condition Monitoring**
*Chair in Vibro-Acoustic Monitoring, Department of Applied Mathematics and Computing, Cranfield University, UK*

The current status and novel future directions in signal processing for condition monitoring will be presented. The classical second order and higher order spectral techniques that currently widely employed for condition monitoring in stationary conditions will be discussed. However, for some important practical applications in rotating machinery (e.g. change of the shaft frequency and load during machinery operation etc.), it is necessary to perform diagnosis in conditions of any known a priori or from measurement polynomial and non-polynomial variation of the instantaneous shaft frequency. The classical techniques and simple non-adaptive non-stationary techniques are not suitable for those conditions. Important future directions of signal processing for condition monitoring will be presented for condition monitoring in stationary and non-stationary conditions based on :
- new class of non-stationary adaptive second order and higher order spectral transforms
- new class of non-adaptive and adaptive higher order spectral frequency response functions
- new techniques for complete amplitude-phase extraction from second order and higher order stationary and non-stationary transforms for condition monitoring in stationary and non-stationary conditions.

Validation of these novel techniques by simulation and experiments in laboratory and field conditions will also be presented. It is shown that the proposed techniques offer an essential improvement (up to 70%-150%) in effectiveness of damage diagnosis in comparison to the traditional techniques.

**Etienne Martin : NDT for nuclear industry : needs and trends for the future**
*EDF, Direction Production Ingénierie, CEIDRE, France*

EDF, the first standardised fleet of nuclear power plants : 58 rectors, with a average plant age of 30 years, must be required to be exemplary in terms of nuclear safety and transparency. In the objective preparing for the future with a lifetime extended up to 60 years, we will be preparing a major overhaul taking into account a recovery of industrial performance. This performance is based on improved equipment reliability, organizational reliability and improved reliability of human activities. To achieve this objective, it is necessary to be able to apply Non Destructive Examinations on areas or facilities that were not designed at the beginning by integrating this aspect. The EDF NDT technologies toolbox available can meet in large part to these issues. The traditional NDT methods such as routine ultrasonics, visual inspection and radiography can be highly sensitive but the rate of coverage is often slow, so that full coverage can be prohibitively expensive, and extensive preparation for inspection may be required (eg access for internal visual inspection, removal of insulation for external inspection etc.) There are also many situations where geometry or access prevents the use of conventional inspection methods. In fact, several parts of these pipelines are shielded within rigid steel or concrete supports making the outside surface completely inaccessible to conventional UT transducers. Our objective is to develop an alternative NDT method that is capable of giving reliable wall thickness measurement on the feeder components as well as the circular welding joints between the components which are inaccessible by conventional UT transducers. Nevertheless, the introduction of new END (guided wave, EMAT, digital radiography ...) or the structural health monitoring (SHM) could give rise at a "little" revolution at principal issues of EDF nuclear power plants in operation but also reduce the response time of historical NDT processes. As such, EDF is attentive to any new technological development that has reached a sufficient level of maturity for its implementation on the ground. Objective for EDF is to preserve the chain of excellence in preventive maintenance.

**Patrice Masson : Increasing the robustness in damage imaging**
*Groupe d'Acoustique de l'Université de Sherbrooke (GAUS), Québec, Canada*

Damage imaging approaches have been developed for structural health monitoring (SHM) strategies. These approaches rely on the knowledge of wave velocity and the measurement of time-of-flight to localize defects within an inspected area. The knowledge of the wave velocity is however impaired by variations in material properties due to variations in the manufacturing process, or due to temperature variations. Moreover, transducers degradation can affect the measurement of the time-of-flight, leading to improper localization of the defects in the structure. In this work, a correlation-based imaging technique called « Excitelet » is first presented for the monitoring of defects in structures. The principle is based on guided wave generation and sensing using a compact micro-machined piezoceramic array and measurement of reflections induced by potential damages. The method uses a propagation model to correlate measured signals with a bank of signals and imaging is performed using a round-robin procedure (Full-Matrix Capture). Then, approaches are proposed to perform in situ characterization of material properties and correct for transducers degradation in damage imaging. Techniques are also discussed to compensate for temperature variations in measured signals. These approaches are implemented prio to damage imaging using Excitelet and improved robustness is demonstrated.

**Gerd Dobmann** : **On-line monitoring of material degradation due to fatigue by using sensor principles based on micromagnetic and ultrasonic NDT**
*Fraunhofer Institut für Zerstörungsfreie Prüfverfahren (IZFP), Germany*

So far materials are ferromagnetic - as most of the structural steels – micromagnetic material properties are sensitive to monitor fatigue behavior. In the case of austenitic stainless steels we have to separate materials which are prone to phase transformation under cyclic deformation or not. If a phase transformation to the body centered a'-martensite phase can be observed the ferromagnetic properties can be utilized. In all other cases, and when the material is fatigued at elevated service temperatures, e.g. when temperatures are greater equal 300°C, ultrasonic properties are of interest. A reasonable approach is based on the use of electromagnetic acoustic transducers (EMAT) which insonify a material without the need of a coupling media.
The contribution summarizes results obtained in R&D programs in the last decade as well as in the LCF- as well as in the HCF fatigue regime. Actual fatigue investigations concentrate on CFR-composites where the cyclic deformation is due to applied high power ultrasound in 3-point-bending machine, which can be used as an intrinsic NDT sensor.

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***Industrial partners/exhibitors***