

## **Resume of André PREUMONT**

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### **Position:**

**Professor of Mechanical Engineering and Robotics (Professeur Ordinaire)**  
**Université Libre de Bruxelles (ULB)**

### **Part-time Professor (Chargé de cours) at the University of Liège (LTAS)**

(Courses: -Random Vibrations and Spectral Analysis  
-Active Structures)

**Scientific Adviser at MICROMEGA Dynamics S.A. (Angleur, Liège)**

### **Education:**

M.Sc. Ingénieur Civil des Constructions Aéronautiques (University of Liège 1973)

Ph.D. Docteur en Sciences Appliquées (University of Liège ,1981)  
Dissertation:"Analyse Sismique du Coeur d'un Réacteur Nucléaire PWR".  
(Supervisor Prof. M.Geradin)

### **Previous Positions:**

1974/1975: Design Engineer at Coppee-Rust Engineering,  
1976/1985: Consultant for Belgonucleaire,  
1985/1986: Visiting Professor at the Aerospace and Ocean Engineering Department of  
Virginia Polytechnic Institute and State University,  
1986/1987: Consultant for Belgonucléaire and Lecturer at the University of Liège,  
1987/1992: Associate Professor (Chargé de cours) at ULB

### **Scientific Prizes:**

1981 *AILg* Prize for his Ph.D. Dissertation.

1983 International *Vinçotte* Prize for "his contribution to the seismic analysis of Nuclear Power Plants"

1987 *Louis BAES* Prize from the Belgian Academy for his work in Random Vibration.

2000 *Five-year FNRS Scientific Prize in Applied Exact Sciences* ( period 1996-2000)  
(*Dr A.DeLeeuw-Damry-Bourlart* Prize) "for his fundamental scientific contribution and numerous industrial applications in modelling and active control of complex mechanical structures"

### **Books (single author):**

- (1) *Vibrations Aléatoires et Analyse Spectrale*  
Presses Polytechniques Romandes, Lausanne, Suisse, 1990
- (2) *Random Vibrations and Spectral Analysis*, Kluwer 1994
- (3) *Vibration Control of Active Structures, An Introduction* , Kluwer 1997  
(second edition in 2002)

### **Books (as Editor):**

- (4) *Responsive Systems for Active Vibration Control*,  
Kluwer, NATO Science Series, Vol.85, 2002.

### **National and International Committees :**

Co-Editor-in-Chief of “Mathematics and Computers in Simulation” (Transactions of the IMACS: International Association for Mathematics and Computer in Simulation) (since 2002).

Member of the Editorial Board of “Journal of Systems and Control Engineering” (Proc. Of the Institution of Mechanical Engineers Part I) (since 2004).

Member of the Scientific Committee of the Nuclear Energy Division of the CEA (Commissariat à l’Energie Atomique, France) (since 2002).

Member of the Advisory Panel for Scientific Research of the University of Trento (Italy) (since 2001).

Member of the National Committee of Theoretical and Applied Mechanics of the Belgian Academy (effective from 1993 to 2000, then honorary).

Member of the CAPAS (Comité de l’Académie pour les Applications de la Science) (since 2001).

Member of the FWO (Fonds voor Wetenschappelijk Onderzoek-Vlaanderen) Commission for Mechanics, Electrotechnics and Electronics (since 1999).

Member of the IFAC Technical Committee on Intelligent Autonomous Vehicles (from 1994 to 2002).

### **Professional Societies:**

AIAA (American Institute of Aeronautics and Astronautics)  
ASME (American Society of Mechanical Engineers)  
IEEE (The Institute of Electrical and Electronics Engineers)  
SBM (Société Belge des Mécaniciens)  
SPIE (Society for Optical Engineering)  
SEM (Society for Experimental Mechanics)

### **Courses:**

- Theory of Structures
- Introduction to Composite Structures
- Structural Dynamics
- Random Vibrations
- Mechanical Engineering Design
- Kinematics and Dynamics of Robot Manipulators
- Mechatronics (created in 1992)

### **Fields of expertise and Scientific Interests:**

- Structural Dynamics (Nuclear and Aerospace structures)
- Random Vibration (Earthquake Engineering, Acoustic Fatigue)
- Robotics (Kinematics, Dynamics and Control of Manipulators, Walking robots)
- Structural Control, Active Isolation and Damping of Large Space Structures
- SMART materials
- Vibroacoustic control
- Active control of cable structures
- Nanomanipulation and nanomechanics

### **Career summary:**

I started my career in 1974 as mechanical engineer in an engineering company (Coppee-Rust) working for the steel industry in the Liege area (cold rolling mill). In 1976 I moved to the nuclear industry (Belgonucléaire) where I specialized in structural dynamics, earthquake engineering, and later in random vibrations. I was mainly concerned with the seismic behaviour of nuclear cores (both PWR and Fast Breeder). I did my Ph.D. from 1978 to 1981 under the supervision of Prof. M. Geradin, while working for Belgonucléaire ; the topic was the « Seismic analysis of pressure water reactor cores » ; it was mainly concerned with nonlinear structural dynamics with impact, but it was also the starting point of my research work in random vibrations. I created a course in Random Vibrations at the University of Liege at about that time. My work on the artificial earthquake generation and on the seismic behaviour of nuclear reactor cores was awarded the International Vinçotte Prize in 1983. Gradually, I got more interested in aerospace and, in 1985, I was offered to go to the USA as Visiting Professor at the Aerospace and Ocean Engineering Department of Virginia Polytechnic Institute and State University. At the time, there was a tremendous interest in large space structures in the USA, mainly because of the « strategic defence initiative » and the space station program. I stayed there for a year and was initiated to the control of large space structures by Profs. R.Haftka and W.Hallauer ; the former was a world renowned specialist in structural optimisation and the latter was, at the time, one of the few experimentalists trying to implement control systems that worked on actual structures. When I returned to Belgium I resumed my job for Belgonucléaire and looked for an academic position. In 1987, I was appointed at the chair of Mechanical Engineering and Robotics of the University of Brussels (ULB). From then on, I shared my time between teaching and research in Structural Dynamics, Control, Robotics, and Mechanical Engineering.

Since my appointment at ULB, my research activities have been divided into three themes :(i) Random vibrations, (ii) Active structures and (iii) Robotics ; they are briefly described below :

#### **(i) Random vibrations :**

My book « *Vibrations Aléatoires et Analyse Spectrale* » was published in 1991 by the « Presses Polytechniques et Universitaires Romandes ». A translated and revised edition was published by Kluwer in 1994 under the title « *Random Vibration and Spectral Analysis* ».

A software has been developed for spectral analysis of structures subjected to a random environment (both seismic and external loads); it has been integrated in a commercial finite element package (SAMCEF) since 1990 and is currently used by numerous industrial companies.

Subsequent developments have been made in the area of high-cycle fatigue life prediction of metallic structures under multi-axial random loading. An original frequency domain approach has been developed which extends the von Mises formalism to random stresses and allows to build damage maps much faster than current time domain methods (this was done with funding from EEC, ESA, SNECMA-SEP, ALENIA-SPAZIO, 1998-2001).

#### (ii) **Active Structures :**

When I was appointed at ULB, I decided to start some basic vibration control experiments on my own; at the same time, the « smart » materials (piezoelectric, magnetostrictive, shape memory alloys, ...) started to become widely available and offered completely new possibilities, particularly for precision structures. On the other hand, they also brought new difficulties in the modeling, due to the strong coupling in their constitutive equations, which requires a complete reformulation of the classical modeling techniques such as finite elements. We therefore started to work simultaneously on modeling, control and experiments. Initially, the projects were mainly related to space applications, with DORNIER, MATRA MARCONI SPACE (and next ASTRIUM), SPACEBEL and ESA as industrial partners. Amongst our early achievements, I would like to point out :

- The first active truss with piezoelectric actuators in Europe (1989),
- The development of a set of control techniques for active damping of flexible structures (1990-1995),
- An in-orbit experiment of active damping of a sandwich piezoelectric plate (successfully flown in September 1995)

The Active Structure Laboratory was inaugurated in November 1995 and my book « *Vibration Control of Active Structures, An Introduction* » was published by Kluwer in 1997. This book was very successful and a second, enlarged, edition was published in 2002; it is used as textbook in several universities.

Our more recent work covers the control of vibrations ranging from meter (flutter of bridges) to nanometer (precision structures for space telescopes) : I would like to point out

- The active tendon control technology for cable structures, with applications to large cable-stayed bridges (collaboration with BOUYGUES) and to large space trusses (future interferometry missions).
- The development of vibroacoustic control techniques for reducing the noise transmission through flat plates; this included the development of a real-time, broad-band noise radiation sensor for acoustic windows, based on a piezoelectric sensor array (collaboration with SAINT-GOBAIN/SAINT-ROCH), and later (still ongoing), distributed PVDF sensors with porous electrodes (collaboration with MICROMEGA).
- A software for the finite element modelling of piezoelectric composite shells (Mindlin shells) that we developed because such a software was not available; it was later integrated in the SAMCEF package.
- The development of a large stroke, high precision optical delay line for synthetic aperture telescopes, based on the magnetic bearing technology, which led to the creation of the spin-off MICROMEGA in 1999, which is pursuing this technology.
- The 6 degree-of-freedom Stewart platform isolator for payload isolation (parabolic flight tests were conducted in 2002).

#### (iii) **Robotics**

My main interests in robotics are new mobility concepts and new actuators. When I was appointed at ULB in 1987, I did not have specific skills in robotics. I started to work on the design and control of walking machines in 1989; several prototypes have been constructed and tested. In the mid 90's, a walking micro-rover was designed as a candidate for space exploration (Mars and comets); the concept was not selected because it was considered too complicated. A family of pipe inspection robots has recently been designed and tested (2002). Although the activity in mobile robotics is pursued with little external funding, it constitutes an excellent support for teaching mechatronics. NiTiNOL tendon actuators are being investigated in student projects.

Since 2002, we have started a research on nanomanipulation. The aim is to explore and develop expertise in nanomechanics. We use an Atomic Force Microscope (AFM) as nanomanipulator, and we have coupled it with a haptic interface, allowing the user to have a direct force feedback of the interaction force between the tip and the nano object. The project is still very much in an exploratory phase.

### **PhD dissertations**

1. **Paul Alexandre** : Contrôle hiérarchisé d'un robot marcheur hexapode (January 1997)
2. **Younes Achkire** : Active tendon control of cable-stayed bridges (June 1997)
3. **Nicolas Loix** : Amortissement actif des structures flexibles (September 1998)
4. **Xavier Pitoiset** : Méthodes spectrales pour une analyse en fatigue des structures métalliques sous chargements aléatoires multiaxiaux (March 2001)
5. **Vincent Piefort** : Finite element modelling of piezoelectric active structures (June 2001)
6. **Frederic Bossens** : Amortissement Actif des structures câblées : de la théorie à l'implémentation (Octobre 2001)
7. **Ahmed Abu Hanieh** : Active isolation and damping via Stewart platform (April 2003)

## Recent research contracts

- 2004 FW6 – InMAR: Intelligent Materials for Active Noise Reduction (coordinated by Fraunhofer LBF, Darmstadt)
- 2003 SSTC – Mandat de retour Arnaud Deraemaeker: Spatial filters for health monitoring, active control and vibroacoustic applications.
- 2003 ESA – ESTEC: *SMART* structures for payload and antenna (SSPA) (Collaboration with MICROMEGA, SAMTECH & VERHAERT in the GSTP program)
- 2003 ESA –ESTEC: Low stiffness 6 dof payload/disturbance isolator with steering capability (LSSP). (Collaboration with MICROMEGA in the GSTP program).
- 2002 FNRS: Haptic interface for a nanomanipulator
- 2002 EU-GROWTH: LAVINYA Thematic Network on Laser Vibrometry (systems and applications). Coordinator University of Ancona (G6Rt-CT-2002-05093).
- 2002 ESA-PRODEX: Parabolic flight test of a vibration isolator based on a Stewart platform.
- 2002 EC-FW5: CORRUGATION Wheel-Rail corrugation in urban transport (G3RD-CT-2002-00807) (research project, D2S International coordinator )
- 2002 SSTC: Inter University Attraction Pole IUAP5: Advanced Mechatronic Systems (Collaboration K.U.Leuven, U.C.Louvain)
- 2001 EC-GROWTH: SMARTTOOLS: Smart Devices for Machine Tools (G1RD-CT-2001-00551) (research project, SORALUCE project leader)
- 2001 EC-GROWTH: SAMCO: Structural Assessment, Monitoring and Control Thematic Network (CTG2-2000-33069) (VCE project leader)
- 2001 FNRS: Atomic force microscope and nano-manipulation
- 2001 NATO: Advanced Study Institute: Responsive systems for active vibration control (course held in Brussels in September 2001)
- 2000 ESA (ARCOP program) Amplified active tendon design for damping space trusses (collaboration with Micromega & CEDRAT)
- 2000 Région Wallonne : SAAB Active noise control of windows
- 2000 Région Wallonne : Interaction between the dynamics and control of non-linear mechanisms.
- 2000 INRS : Design of a semi-active suspension for the cabin of fork lift trucks. (collaboration with Micromega)
- 2000 FNRS : Active isolation based on a Stewart platform
- 2000 EEC/FW5 Consistent Semiactive System Control (CaSCo)

(Collaboration with Vienna Consulting Engineers, Mannesmann Rexroth, Univ. Vienna, JRC Ispra, Austrian Railways, Micromega)

- 1999 Région Wallonne, First Europe (F.Bossens) : Semi-active damping of vibration
- 1999 Région Wallonne-Micromega, Doctorat en entreprise (E.Mignon) : High precision mechanisms based on magnetic suspension
- 1999 FNRS : Sound radiation sensing and feedback control of a baffled plate
- 1999 ALENIA SPAZIO: Finite element evaluation of fatigue damage of multidimensional random stress fields
- 1999 SEP-SNECMA : Finite element evaluation of fatigue damage of multidimensional random stress fields
- 1999 Research in Brussels : Semi-active suspension of underground railways vehicle. (O.Vaculin)
- 1998 FNRS : Active control of sound radiation from a vibrating plate
- 1998 ESA/ESTEC Academic TRP: Multiaxial Fatigue Under Random Loading
- 1998 EEC-TMR: Multiaxial fatigue life prediction of metallic structures submitted to random vibrations (Marie Curie Fellowship, X.Pitoiset)
- 1998 ESA/ESTEC Microdynamics Active Control Systems  
(collaboration with MATRA MARCONI SPACE and DORNIER)
- 1997 Région Wallonne-Glacieries Saint Roch: Acoustic windows (convention 3512)
- 1997 Région Wallonne: Finite element modelling of composite piezoelectric shells  
(Collaboration with the University of Liege) (convention 9713549)
- 1997 EEC-BRITE/EURAM-BE96-3334: Active Control in civil Engineering (ACE)  
(Collaboration BOUYGUES, Mannesmann-Rexroth, DRA, MTS, Johns.Holt A.S., VSL, JRC Ispra, TU Dresden, Ecole Centrale Lyon)
- 1997 Ministry of Defence: Robotized Humanitarian Demining (Collaboration with the Royal Military Academy - ERM)
- 1997 SSTC: Inter University Attraction Pole IUAP4/24: Intelligent Mechatronic Systems  
(Collaboration K.U.Leuven, U.C.Louvain, U.Liège)
- 1996 FNRS: Flutter control of cable-stayed bridges
- 1996 SEP: Finite element fatigue damage evaluation under multidimensional random fields
- 1996 Région Wallonne: FIRST 3363: Active vibroacoustic control (noise isolation)  
(Collaboration Glacieries Saint Roch)
- 1995 European Union-Région Wallonne: EUCLID/RTP 9.2 (No 3183): Synthetic Aperture Telescopes (stabilization, pointing, delay line). (subcontract from SPACEBEL).

- 1995 Région Wallonne: Finite element modelling of piezoelectric structures (No 2792)
- 1995 FNRS: Active isolation of vibration sources in flexible structures
- 1995 Région Wallonne : FIRST-2272 (Extension) Active Suppression of Microvibration with Hybrid Controller (Feedback + Feedforward) (Collaboration SPACEBEL Instrumentation)
- 1994 ESA / ESTEC *Microgravity Payload Disturbance Study Extension Phase I* (subcontract from DORNIER)
- 1994 CEE / ESPRIT Basic research working group n°8474 *LEGRO* on walking machines (prime contractor : TECNOSPAZIO S.p.A.)
- 1994 ESA / ESTEC In-Orbit experiment *CFIE (Control Flexibility Interaction Experiment)* phase II (prime contractor : SPACEBEL)
- 1994 ULB / Action de Recherche Concertée : *Active Control of Structures and Walking Robots*
- 1993 FNRS : Active damping of cable stayed bridges
- 1993 CEE / TELEMAT 44 Kinematic Study of *ROBUG III* (walking machine) (subcontract from University of Portsmouth)
- 1993 ESA / ESTEC In-Orbit experiment *CFIE (Control Flexibility Interaction Experiment)* phase I (Laboratory demonstration model) (prime contractor : SPACEBEL)
- 1993 Région Wallonne : FIRST-2272 : Active Damping of an Optical Test Bench (Collab. SPACEBEL)
- 1993 ESA / ESTEC : *Damping and non-linear Structures* (subcontract from DORNIER)
- 1992 WESTINGHOUSE Energy System : Artificial generation of earthquake records