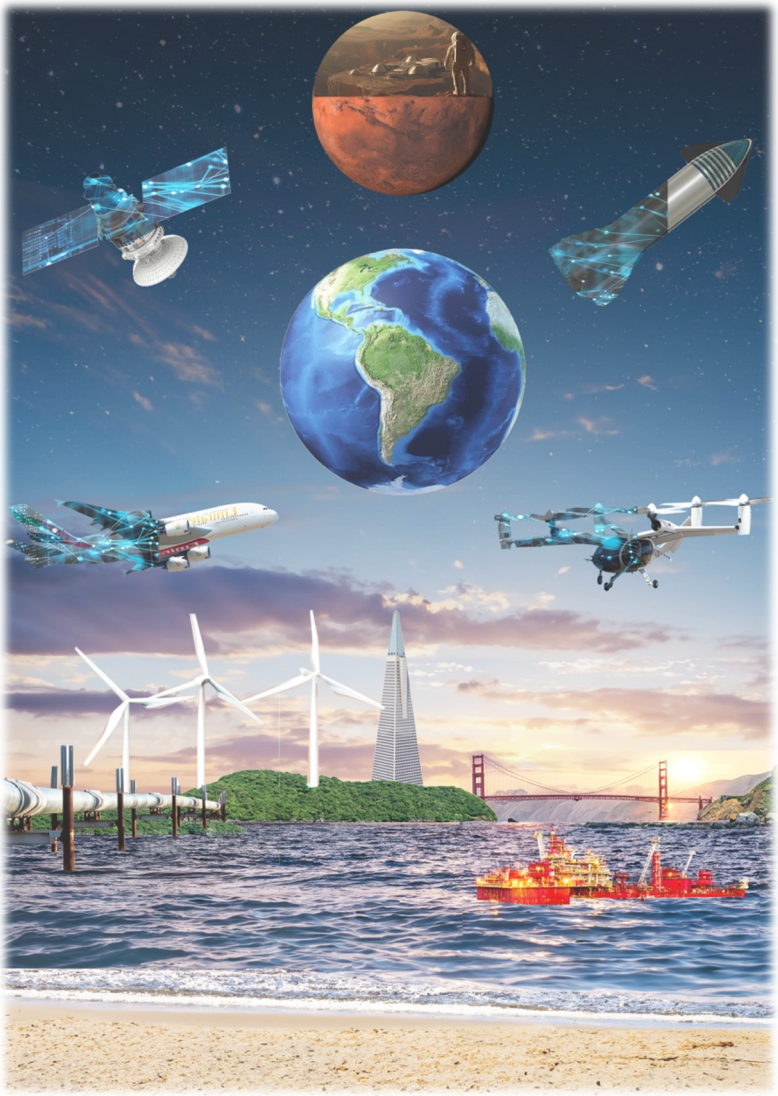
15th International Workshop on Structural Health Monitoring

IWSHM 2025



"SHM: Ensuring Mobility and Autonomy with Sustainability."

September 9 – 11, 2025
Stanford University

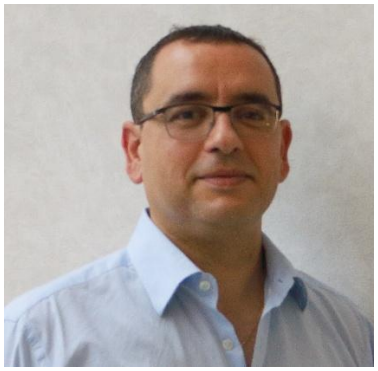
www.iwshm.org

AI-Enhanced SHM Using Tensor Decomposition and Sparse Atomistic Models for Damage Monitoring of aeronautical composite structures

Wednesday, Sept. 10th, (9:30 – 10:00 AM)

Nazih Mechbal

Full Professor and director of the Processes and Engineering in Mechanics and Materials Laboratory (PIMM – UMR CNRS) at Arts et Métiers Institute of Technology, Paris



The development of robust Structural Health Monitoring (SHM) solutions for large structures, particularly in the aerospace sector, is increasingly challenged by the volume, variability and complexity of the data. While extensive experimental data are available for healthy structural states, data for damaged states remain limited and often require computationally intensive simulations. In addition, environmental and operational variations - such as temperature and loading - add further complexity to signal interpretation and model reliability

This work presents a hybrid methodology that integrates physical knowledge and machine learning with advanced signal representations to improve SHM performance under realistic conditions. First, we exploit the intrinsic multi-dimensional nature of SHM data through tensor decomposition, enabling compact, interpretable representations that improve damage monitoring. Second, we couple it with the Single Atom Convolutional Matching Pursuit framework, which redefines classical sparse decomposition techniques to construct accurate and efficient wave propagation models tailored to SHM applications.
These methods are validated in the PIMM laboratory using a hierarchical dataset ranging from lab-scale coupon experiments to full-scale flight tests, including a case study involving several months of in-flight data from an A380 nacelle. The proposed approach demonstrates strong potential for scalable, transferable and reliable SHM, bridging the gap between numerical simulation and real-world deployment.

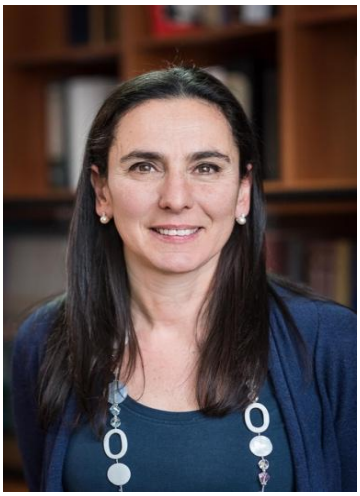
Bio: Nazih Mechbal is a full professor and the director of the laboratory at Paris. He has over 20 years' experience as a researcher, and his interests include developing and applying theoretical methods of automatic control and signal processing to smart structures, covering structural control, structural health monitoring and process control. He has managed and coordinated numerous industrial and public projects in this field.

September 11 – 8:30 - 9:30 AM

Spaceborne Interferometry for Bridge Monitoring: advancing Structural Integrity Management through Remote Sensing

Thursday, Sept. 11th, (8:30 – 9:00 AM)

Maria Pina Limongelli
Associate Professor of Structural and Seismic Engineering, Politecnico di Milano, Italy



Bridges are essential components of civil infrastructure, and ensuring their structural integrity is crucial for public safety and service continuity. Recent advancements in Synthetic Aperture Radar Interferometry (InSAR) have significantly enhanced our ability to remotely monitor structural behavior, offering a valuable complement to traditional inspection and sensor-based methods. While InSAR has been successfully applied in geohazard monitoring, its adaptation for civil structures - with smaller footprints and complex geometries - requires addressing specific technical challenges and aligning with engineering practices.

This keynote explores the use of spaceborne InSAR for structural health monitoring of bridges, focusing on data accessibility, resolution limits, uncertainty quantification and the interpretation of displacement data for damage identification. The European Ground Motion Service (EGMS), part of the Copernicus program, provides valuable ground motion data across Europe using Sentinel-1 imagery.

In addition to routine monitoring, InSAR holds substantial promise for post-event forensic analysis. It can help engineers investigate the underlying causes of bridge failures by revealing patterns of progressive displacement or subsidence leading up to collapse - critical information that traditional inspection and monitoring methods often miss.

The recently published Italian guidelines for InSAR monitoring of civil structures, developed under a project funded by the Italian Civil Protection, provide essential standards and best practices for integrating InSAR into infrastructure management.

The session concludes by discussing how InSAR can enhance asset management, early-warning systems, long-term resilience, and future research advancements in infrastructure maintenance, risk mitigation, and structural health monitoring.

Bio: Maria Pina Limongelli holds a PhD in Seismic Engineering from Politecnico di Milano, where she is currently an Associate Professor of Structural and Seismic Engineering. Her research focuses on Structural Health Monitoring (SHM) of civil structures, with particular emphasis on vibration-based and remote monitoring techniques, value of information, and SHM standardization.

Dr. Limongelli holds prominent roles in several committees and professional associations within the SHM and structural engineering fields. She is the Vice President of both IABSE and SCSHM, the President of EVACES, and a JCSS reporter. Additionally, she leads the Data Enhanced Infrastructure Management Committee of the Society of Civil Structural Health Monitoring.

She serves on the editorial boards of several international peer-reviewed journals, including *SHM Journal*, *Journal of Civil SHM*, *Engineering Structures*, and *Bulletin of Earthquake Engineering*. Dr. Limongelli also coordinates and participates in multiple national and international research projects focused on Structural Health Monitoring, digitalization, and the resilience of bridge integrity management.