

IOMAC2027



Tuesday, 18 May 2027 - Friday, 21 May 2027

Laško

Scientific Programme

General Tracks

Buildings

Experimental Testing

Fatigue and Damage Detection

Machine Learning and Bayesian Approaches

Measurement Techniques and Data Acquisition

Model Validation and Updating

Modelling and Computational Methods

New Methods for Structural Health Monitoring

OMA and Digital Twins

Signal Processing

Software for OMA and Structural Monitoring

Uncertainty Quantification

Wind Energy Structures

Special Tracks

Aerospace Engineering: Operational Modal Analysis

Operational Modal Analysis (OMA) is widely employed and became an industrial standard technique for identifying the modal parameters (i.e. resonance frequencies, damping ratios and mode shapes) of mechanical structures. The advantage, if compared with Experimental Modal Analysis (EMA), is that it is not necessary to stop the machine, but its modal characteristics can be estimated during its operating cycles. In other words, OMA does not rely on known and

deterministic excitation, but it uses exclusively the natural vibrations of the structure. It is very useful in cases in which the forces cannot be measured or when it is very difficult to excite a structure and it is more convenient to exploit the natural ambient excitation.

In the aerospace field many applications of OMA have been employed, for understanding the dynamic behaviour of light, flexible structures, for analysing data coming from flight testing, for predictive maintenance of systems, for safely operations for wind turbines and, broadly speaking, rotating machines.

This special session of IOMAC 2027 is collecting recent experiences on methods, measurements and simulations which employ OMA in aerospace applications and is bridging for future implementations of AI for improving data analysis, structural optimizations and certification requirements.

Keywords: Flight Testing, Light Structures, Wind Turbines, Numerical-Experimental Correlation, Structural Health Monitoring

Aerospace Engineering: Vibration-based Identification and Monitoring

Vibration-based techniques remain fundamental tools for assessing the dynamic behaviour, structural integrity, and operational reliability of aeronautical structures and systems. In the aerospace sector—where safety, performance, and lightweight design are paramount—accurate dynamic testing is essential not only for initial design validation, but also for continuous monitoring, in-service diagnostics, and life-cycle maintenance.

This Special Session focuses on recent advances and innovative applications of Experimental Modal Analysis (EMA, i.e., input-output, linear and nonlinear) and Operational Modal Analysis (OMA, i.e., output-only) in Aeronautics and Space.

Contributions of interest include, but are not limited to:

- Novel developments in automated modal analysis, with particular attention to approaches that enhance the identification of modal parameters in large and complex systems such as aircraft components or space structures. Studies on Automatic OMA tailored to aerospace applications are especially encouraged.
- Real-life applications, either on scaled-down laboratory specimens or field tests, including case studies that illustrate how modern modal analysis techniques support improved Structural Health Monitoring, real-time diagnostics, predictive maintenance, or similar.
- Interdisciplinary progress, including the integration of data-driven methods and artificial intelligence to increase the accuracy and efficiency of modal analysis in both aeronautics and astronautics.

The session welcomes original research papers, either experimental, numerical, or analytical, as well as review contributions. Both academic and industrial works are encouraged, with an emphasis on practical relevance and field applications of Structural Health Monitoring (SHM) and Non-Destructive Testing (NDT).

Keywords: Aeronautical Structures, Space Structures, Structural Health Monitoring, Experimental Modal Analysis, Operational Modal Analysis

Automated and Long-term Vibration-based Monitoring

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Bridges, Spatial and High-rise Structures: Dynamic Identification and Modal-based Monitoring

The structural assessment and continuous monitoring of bridges, spatial and high-rise structures play a fundamental role in guaranteeing safety, serviceability, and resilience. Within this framework, Operational Modal Analysis (OMA) and modal-based Structural Health Monitoring (SHM) have emerged as powerful approaches for the dynamic identification of large-scale civil structures, enabling both the characterization of their global dynamic behavior and the long-term tracking of their structural condition under operational conditions.

This session is intended to bring together recent advances, innovative methodologies, and real-world applications related to OMA and modal-based SHM of long-span bridges, high-rise and spatial structures, with particular emphasis on long-term monitoring strategies and dynamic identification in the presence of environmental and operational variability.

Suitable topics include, but are not limited to:

- Finite element model updating based on vibration data for improved structural identification and performance assessment
- Implementation of monitoring-informed digital twins for long-span bridges, high-rise buildings and spatial structures, supporting dynamic behavior replication, interpretation of monitoring data, and predictive maintenance decisions under variable operating conditions
- Long-term modal parameter tracking and uncertainty quantification under operational conditions

- Novel modal-based damage-sensitive features and indicators for early detection and localization of structural degradation
- Innovative procedures for modal feature identification and decision support
- Data normalization techniques to mitigate the influence of environmental and operational variability on modal parameters.

Keywords: Bridges, High-rise Buildings, Spatial Structures, Structural Identification, Structural Health Monitoring, Machine Learning, Digital Twin

Dynamic Substructuring and Transfer Path Analysis for Identification and Monitoring

This special session invites contributions on recent advances in dynamic substructuring and transfer path analysis (TPA) for structural dynamics identification and condition monitoring. The decomposition of complex systems into interacting substructures, combined with force and path reconstruction techniques, has emerged as a powerful framework for understanding, identifying, and monitoring the dynamic behaviour of assembled mechanical and civil structures. Recent developments in substructuring methodologies, inverse identification techniques, operational modal analysis, and hybrid experimental–numerical modelling have significantly expanded the applicability of these approaches under operational conditions. The session aims to bring together theoretical developments, methodological innovations, and practical applications demonstrating the potential of substructuring- and TPA-based approaches for system identification and structural health monitoring.

Topics of interest include, but are not limited to:

- Dynamic substructuring for identification of coupled structural systems
- Transfer Path Analysis for force reconstruction and source–path contribution analysis
- Operational and output-only identification within substructured systems
- Hybrid experimental–numerical substructuring
- Uncertainty quantification in substructuring and TPA
- Substructure-based damage detection and condition monitoring
- Data-driven and physics-informed approaches in dynamic substructuring

Keywords: Dynamic Substructuring, Transfer Path Analysis, Dynamics, System Identification

Operational Modal Analysis for Rotating Machinery

The modal identification of rotating machinery in operation remains a critical challenge relevant for transport, renewable energy, and many other mechanical engineering areas. The rotation superimposes the stochastic ambient excitation and harms the identification process if not properly identified. Traditional approaches struggle with harmonic interference from auxiliary systems, and time-varying operating conditions. These challenges become particularly acute when implementing real-time monitoring systems for predictive maintenance.

Despite these advances, a significant gap persists between laboratory validation and industrial implementation. This session bridges this divide by showcasing new approaches, techniques, and real-world applications that bring together the art of Operational Modal Analysis with the dynamic characterization of rotating machines in operation to ensure operation reliability.

Recent advancements in artificial intelligence and machine learning are revolutionizing our approach to these complex problems and are equally welcome in this session. AI-enhanced algorithms might be able to automatically distinguish between true modal responses and harmonic

interferences. The combination of classical operational modal analysis with machine-learning could contribute to the development of digital twins and thus the reliable estimation of an operating structure's health.

Structural health monitoring represents an ideal application for operational modal analysis. A reliable modal parameter identification of rotating machinery in operation is thus essential for effective structural health management. The derived dynamic models can then represent a crucial part of digital twin systems, providing the real-time structural performance data necessary for informed maintenance decisions.

Keywords: Rotating Machinery Diagnostics, Modal Parameter Identification, Structural Health Monitoring, Harmonic Interference Suppression, Machine Learning for OMA, New Sensor Technology

Operational Modal Analysis of Wind Turbines

This special session is dedicated to OMA of wind turbines, addressing a critical area for SHM and performance evaluation of modern wind energy systems.

OMA provides a non-intrusive methodology for assessing the dynamic behavior of wind turbines by analyzing vibrations induced by ambient excitations. As wind turbines continue to increase in scale and structural complexity while operating in demanding environmental conditions, robust OMA techniques are essential for accurate characterization of dynamic properties and long-term structural health assessment. This session welcomes contributions on advanced output-only identification methods, ambient vibration analysis, and operational modal parameter extraction techniques applied to wind turbine systems.

Objectives and Significance

This session highlights the strategic benefits of OMA for wind turbine applications, including:

- SHM for real-time assessments without operational interruption
- Early identification of structural anomalies, excessive vibrations, foundation issues, and component degradation
- Model validation through field data acquisition to refine numerical models and improve design accuracy
- Enhanced understanding of localized damage effects on modal characteristics and structural integrity

Addressed topics and challenges

Participants will examine the technical challenges specific to wind turbine OMA implementation, including:

- Modal parameter identification of wind turbine components with specialized techniques for both rotating and non-rotating element
- OMA methodologies and algorithms for addressing periodic behavior from rotor rotation
- Structural health monitoring and damage detection applications
- Environmental and operational effects on modal characteristics
- Model updating and digital twin development
- Advanced sensor systems and signal processing

Output-only Methods for Bridge Identification and Monitoring

This special session invites contributions on the latest advances in indirect or “drive-by” methods for bridge modal identification and structural health monitoring (SHM). Using instrumented vehicles as mobile sensors has emerged as a scalable and cost-effective alternative to traditional bridge SHM, enabling more continuous and network-level condition assessment. In recent years, advances in

machine learning and digital-twin technologies, among others, have further broadened the capabilities of drive-by approaches and improved their robustness under operational and environmental variability.

The session aims to bring together theoretical developments, algorithmic innovations, and practical case studies demonstrating the potential of drive-by SHM. Topics of interest include, but are not limited to:

- Bridge damage detection and condition monitoring using indirect methods
- Identification of modal properties from vehicle-sensing data
- Machine learning and physics-informed hybrid data models for drive-by SHM
- Building digital-twin platforms based on vehicle data
- Scalable monitoring strategies using fleets or crowdsourced vehicle measurements

Keywords: Drive-By, Bridge, Structural Health Monitoring, Machine Learning, Response Prediction

Physics-enhanced Machine Learning in Structural Monitoring

Physics-Enhanced machine learning refers to the fusion of sensing data, physical constraints and engineering knowledge within a common learning environment - also known as physics-informed ML, hybrid modelling, grey-box modelling, or scientific ML. More concretely, physics-enhanced schemes strive to integrate first-principles knowledge and physical biases with real-world observations and machine learning pipelines, thereby improving predictive accuracy, quantifying uncertainty, and enhancing computational efficiency and real-time feasibility. Such capabilities are critical for Structural Health Monitoring (SHM), Digital Twinning, and Engineering Decision Support.

This special session welcomes contributions on both fundamental research and industrial applications, including but not limited to:

- Physics-informed forecasting and anomaly detection in SHM,
- Methods for system identification, uncertainty quantification, and state estimation under incomplete or noisy sensing,
- Hybrid models for real-time inference and predictions in structural systems,
- Model adaptability under environmental and operational variability,
- Scalable and transferable architectures for digital twinning.

The session aims to foster dialogue between communities in mechanics, data science, and machine learning, showcasing advances that push structural engineering towards intelligent, self-adaptive, and resilient systems.

Keywords: Physics-enhanced, Physics-informed, Scientific Machine Learning

Railway Infrastructure Monitoring

Reliable and efficient monitoring of railway infrastructure is essential to ensure the safety, availability, and long-term sustainability of rail transportation systems. While numerous tools and methodologies have been developed to monitor assets such as bridges, tracks, sleepers, joints, switches, and vehicle fleets, increasing demands for cost-effective maintenance, higher traffic volumes, and resilience to ageing and climate-related effects continue to drive the need for more scalable and data-driven monitoring solutions.

This special session focuses on emerging technologies and methodologies for railway infrastructure monitoring, with emphasis on their practical application to predictive maintenance, early damage

detection, performance assessment, and system-level optimization. The session aims to bridge the gap between methodological advances and real-world implementation, highlighting approaches that support asset management and operational decision-making in railway systems.

- Contributions are invited on system identification and vibration-based structural health monitoring (SHM) methods for infrastructure and vehicles, including both direct sensing approaches (e.g., permanently installed sensor networks) and indirect or on-vehicle monitoring strategies. Topics of interest also include advanced data acquisition and analysis techniques, machine learning and AI-based methods, and their integration into railway monitoring frameworks.
- Relevant themes include operational modal analysis (OMA), statistical and stochastic system identification for parameter, state, and load estimation using physics-based or data-driven models, fault and anomaly detection, uncertainty quantification, optimal experimental design, and sensor placement. Contributions addressing structural prognosis and data-driven updating of performance and reliability predictions are also welcome.
- Submissions presenting experimental studies, field applications, or long-term monitoring data—particularly those demonstrating practical impact on maintenance planning and infrastructure management—are strongly encouraged. Advances in inspection and monitoring technologies such as ground-penetrating radar (GPR), laser-based systems, FBG-based sensors, inertial measurement units (IMUs), wireless sensing networks, and drone-based inspections are also within the scope of this session.

Keywords: Railway Infrastructure, Structural Health Monitoring, System Identification, Operational Modal Analysis, Data Driven Methods

Structural Health Monitoring for Wind Energy Structures

This special session deals with structural health monitoring (SHM) of wind turbines and farms. SHM can be employed for early-stage damage detection and to explore uncertainties in the design, provide early alerts for degradation, damage, and detect abnormal operations. It can also offer valuable insights for future design improvements and operational optimisation. This session focuses on the integration of sensing techniques for digital twinning, condition-based maintenance, population and fleet based monitoring and the assessment of life-cycle and remaining useful lifetime for wind energy structures and farms. SHM applications include, but are not limited to, measuring environmental inflow conditions, monitoring wind turbine performance, evaluating structural load impacts (both extreme and fatigue cycles), analysing system dynamics, assessing modal and physical properties.

Papers dealing with the following subjects are especially welcomed:

- Real-time schemes for efficient monitoring and diagnostics.
- Data-driven and physics-informed methods for virtual sensing and digital twinning.
- Physics-constrained machine learning applications.
- Experimental investigation and verification of analysis schemes.
- Population and fleet based monitoring of wind farms.
- Load and latent force estimation via system identification tools.

Keyword: Structural Health Monitoring, Wind Energy Structures, Wind Farms

Vibration-based Identification and Monitoring of Special Structures

An expanding range of applications and performance objectives has been driving Operational Modal Analysis into new problems and challenges. Therefore, this special session intends to bring together contributions addressing demanding case studies due to case-specific challenges in dams, bridges, buildings, offshore structures, and other special structures and construction equipment.

To better understand the structural behaviour of studied structures, operational modal analysis can be complemented by additional analytical and numerical approaches, enabling an integrated assessment of structural performance based either on individual experimental campaigns or on continuous condition monitoring.

By sharing experiences, methodologies, and solutions in this special session, researchers and practitioners can collectively tackle current challenges in vibration-based assessment and monitoring of special structures, ultimately contributing to safer and more reliable infrastructure for the benefit of society.

Keyword: Dams, Stadia, Offshore Structures, Construction Equipment, Special Buildings

Vision-based Techniques for Vibration Assessment and Monitoring

In recent years, computer vision and optical sensing have emerged as powerful, cost-effective, and non-contact technologies for vibration monitoring. They open up new possibilities in operational modal analysis and structural health monitoring, thanks to very dense spatial resolution and low instrumentation costs. Techniques such as digital image correlation, optical flow, motion magnification, and UAV-based photogrammetry enable accurate motion extraction, dynamic characterization, and early-stage damage detection, even under operational conditions.

This special session aims to showcase the latest developments and future directions in vision-based vibration assessment. Contributions are invited on novel methods, hybrid approaches combining video data with conventional sensing, and applications to real-world infrastructure such as bridges, buildings, and wind turbines.

Topics of interest include (but are not limited to):

- Motion extraction and vision-based modal analysis,
- Structural feature extraction for damage detection and diagnosis,
- Motion magnification and computational imaging techniques,
- UAV-based inspection and monitoring of hard-to-reach assets,
- Robust and efficient processing for real-world environments,
- Data fusion with conventional sensors,
- Benchmarking, validation campaigns, and comparisons with traditional sensing approaches.

Operational Modal Analysis for Vibration Serviceability and Human-Structure Interaction in Footbridges

Operational Modal Analysis has become an established tool for the dynamic identification and assessment of bridges and footbridges under operational conditions. Recent developments in sensing technologies, automated modal identification, data processing and structural modelling have expanded its use beyond conventional modal characterisation towards applications in vibration serviceability, structural sensitivity assessment, model updating, long-term monitoring and damage detection.

This special track aims to bring together recent experimental, numerical and field-based applications of Operational Modal Analysis to bridge and footbridge structures. Contributions addressing full-scale monitoring campaigns, controlled experiments, laboratory investigations and benchmark studies are particularly encouraged. Relevant topics include modal identification under ambient and operational excitation, assessment of environmental and operational variability, vibration serviceability of footbridges, human-structure interaction, sensitivity of modal parameters to structural and loading conditions, finite-element model calibration, automated modal tracking and vibration-based damage detection.

The track also welcomes studies dealing with practical challenges such as limited sensor availability, changing boundary conditions, non-stationary excitation, closely spaced modes, data uncertainty and the interpretation of small modal changes in the presence of environmental effects.

By presenting recent applications across different structural types and monitoring conditions, the session seeks to highlight the current capabilities and limitations of Operational Modal Analysis and to support the transfer of methodological developments into reliable engineering practice for bridges and footbridges.