Abstract: Continuous Online Monitoring of Aeroelastic Modal Parameters: A Comprehensive Study of Wind Tunnel and Flight Tests

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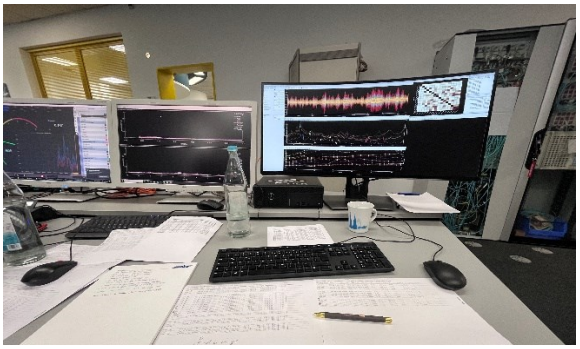
This paper presents a comprehensive overview of online monitoring of aeroelastic modal parameters, covering a diverse range of experimental setups including three wind tunnel tests and two flight test campaigns. The primary objective is to demonstrate the applicability and effectiveness of various techniques in real-world scenarios, thereby highlighting the broadness of applications and the value of the online monitoring system. Figure 1 illustrates, as an example, the integration of the online monitoring system at the European Transonic Wind Tunnel (ETW) and in a modified Dassault Falcon 2000 LX, i.e. the DLR research aircraft ISTAR.

The study begins by introducing the theoretical framework for operational modal parameter identification, emphasizing the advantages and disadvantages of continuous online monitoring over traditional offline methods. Subsequently, the wind tunnel tests are described, focusing on the experimental setup, data acquisition, and the implementation of online monitoring techniques. During these test campaigns different models are tested in different wind tunnels in Europe: a tilt rotor configuration in the DNW-LLF (Marknesse, Netherlands), a flexible wing at low speed in DNW-NWB (Brunswick, Germany) and a full aircraft model at transonic speed in ETW (Cologne, Germany). The results from these tests are analyzed to evaluate the accuracy, robustness, and real-time performance of the presented method.

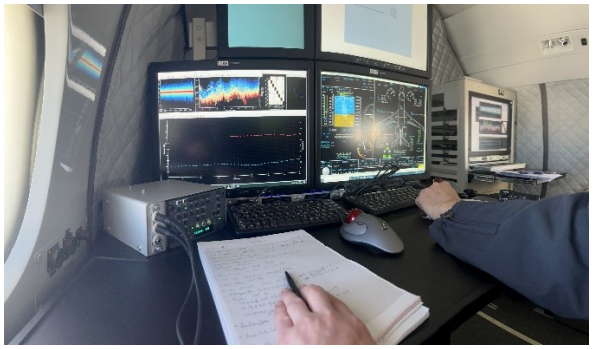
The paper then shifts its focus to the flight test campaigns, discussing the unique challenges and opportunities presented by these environments. One flight test campaign was conducted with the DLR research aircraft ISTAR, and the other flight test campaign was conducted with a fixed-wing UAV from the EU project FLIPASED. The implementation of online monitoring techniques into the flight test procedure is explained. The results from the flight tests are compared with those from the wind tunnel tests to assess the transferability of the techniques and to identify limitations.

Finally, the paper concludes by summarizing the key findings and discussing the implications for future research and practical applications. The study highlights the potential of online monitoring techniques to enhance flight test data exploitation, flight test safety, and performance, while also providing insights into the limitations and areas for improvement.

This paper contributes to the field of aeroelasticity by demonstrating the online monitoring techniques in a variety of real-world scenarios.



a) ETW Main Tunnel Control Room



b) DLR research aircraft ISTAR cabin

Figure 1: Example integrations of the online monitoring system in wind tunnel and flight tests.