EXPERIMENTAL AND OPERATIONAL MODAL ANALYSIS OF FULL-SCALE AIRCRAFT GVT: TOWARDS A HYBRID METHODOLOGY

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ABSTRACT

Experimental Modal Analysis (EMA) in the framework of Ground Vibration Tests (GVTs) is traditionally used to identify reliable normal modes with measured input excitation forces. In addition to this, Operational Modal Analysis (OMA) can be also used for a similar purpose when no input force control is available and a series of assumptions are met (e.g., time-resolved sensor data, broadband and stationary excitation). It is reasonable to ask whether these two approaches yield similar results for a certain structure, with the associate benefits that this might bring on. This paper seeks to assess the differences between EMA and OMA for a complete aircraft GVT.

Conveniently, a Full-Scale GVT was conducted at Airbus Defence and Space Spain facilities in a widebody military transport aircraft following a major structural modification to grant first flight clearance. The aim of the GVT was to obtain the modal parameters of the aircraft using EMA with a suitable sensor and excitations layout. Analysis and acquisition were performed by means of Siemens Simcenter™ Testlab™ software and associated hardware.

In addition, OMA was performed based on the available excitation datasets. This allowed quantifying differences in frequency and damping with respect to the modes obtained in the GVT results with EMA. The comparison, which is illustrated in *Figure 1*, shows an overall acceptable modal characterization and provides trends on which modal parameters remain robust and where deviations might occur. Acquisition of real time throughput data enabled this comparison taking advantage of computational and storage capability of current test means.

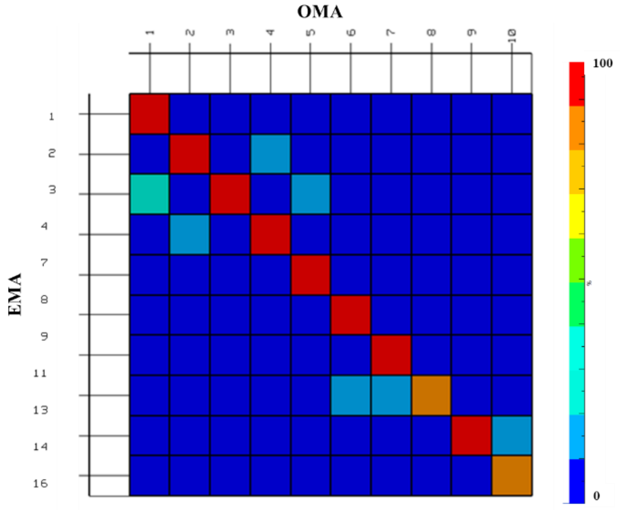

Figure 1.- Comparison of EMA vs OMA: Mean Assurance Criterion (MAC) matrix.

Then, the overall study was extended with an input source different from the GVT excitations. In this case, the aircraft was locally equipped with structure-integrated inertial shakers that did not provide direct force measurements. As a consequence, modal parameter extraction was enabled in configurations not accessible to EMA. A comparison was made between the excitation from the inertial shakers and the OMA performed previously with a similar force excitation level. *Figure 2* displays an example of this comparison through the sum of crosspower functions and MAC matrix.

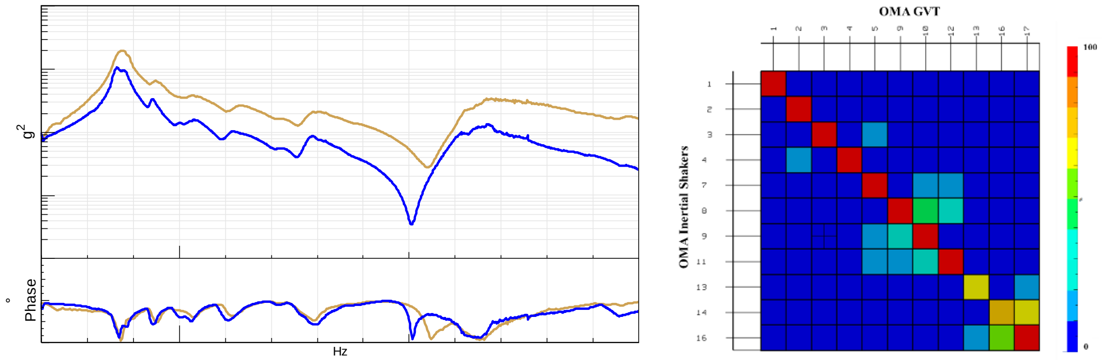

Figure 2.- Comparison of OMA: inertial shakers vs GVT.

The results support the practical use of OMA-based methods under non-ideal but realistic excitation conditions, and back up their extension to situations where unmeasured inputs are common such as in-flight events, engine-induced vibrations or aircraft ground handling.

In summary, a formal analysis of EMA-OMA consistency on full-scale aircraft can be highly relevant due to the lack of availability of large datasets of real aerospace structures. It could lead to a reduction in associated test efforts: use of auxiliary structure, number of excitations required, equipment involved, aircraft-disturbing activities; plus, synergies with Flight Test operations. This paves the way to an overall optimization in the Full-Scale aircraft GVT execution and analysis process in terms of time and cost, which is always a cornerstone in the certification path.