TASK 2.3.2 "TEST SIMULATION, PLANNING & MEASUREMENT" REVIEW OF CURRENT STATUS OF FULL-FIELD MEASUREMENT EQUIPMENT HARDWARE AND SOFTWARE, TEST PLANNING AND INTEGRATION TOOLS, SUGGESTIONS FOR FUTURE DEVELOPMENT

Executive Summary

This document describes a state-of-the-art review on full-field vibration measurement methods including laser Doppler vibrometer (LDV), holographic, and electronic speckle pattern interferometry (ESPI) techniques for structural dynamics analysis, together with further assessment of benefits of using these full-field measurements for the purpose of correlation and updating in model validation process. Further requirements for developments of test planning using full-field vibration measurement are also suggested.

The review shows a significant growth of laser-based techniques for vibration measurement in structural dynamics in the last decade. These techniques can be divided into two main categories: (i) laser Doppler vibrometry (LDV) and (ii) full-field techniques such as holography and electronic speckle pattern interferometry. The traditional LDV has led to development of the Scanning Laser Doppler Vibrometer (SLDV), a Continuously Scanning Laser Doppler Vibrometer (CSDLV), and a Tracking Laser Doppler Vibrometer (TDLV) etc., in order to measure vibrations of moving structures. Full-field measurement techniques can provide instantaneous maps of deformation of the vibrating structure by means of imaging techniques. Traditional holographic techniques based on a camera capture of patterns on photographic films have now developed to the Electronic Speckle Pattern Interferometry (ESPI) systems which enable us to provide the measured properties in a digital form and, further, to analysis using image processing tools. There are a range of ESPI techniques used in measurement of dynamic displacements: (i) time-averaged ESPI, (ii) stroboscopic ESPI (a.k.a. Vibro ESPI), and (iii) pulsed ESPI. The pulsed ESPI systems are currently the most exploited in the context of dynamic measurements. The current status and applications of laser-based measurement in the aerospace industry are mainly limited to ODS measurements and the use of measured results is mostly limited to visual comparison with numerical ones. Most

recently, the integration of full-field measurement results in model correlation has been considered and applied to practice.

The latest development in full-field measurement technology can provide measurements with a high spatial density of DOFs in a relative short period of time. Such a feature is very helpful for model correlation applications. The success of the model updating process depends on the number of updating parameters and the number of measured modal data (natural frequencies and mode shapes). The assessment of the benefits of using full-field measurement for model updating in this report is based on iterative updating methods and a plate structure is used as an example for all case studies. The following features can be noted:

- In cases where the number of updating parameters is smaller than the number of measured modes, the updating process can be successful using the natural frequency information only. It is unlikely that the extra information of detailed mode shapes can have many benefits for updating here. It can be explained that the updating equation, in this situation, is overdetermined when the number of natural frequencies selected for updating is greater than the number of updating parameters.
- In cases where the number of updating parameters is greater than the number of measured modes, the extra spatial information (mode shapes) can provide valuable help for model updating. It can be explained that the updating equation can be overdetermined when the extra spatial information from eigenvectors are considered together with natural frequencies. Otherwise, the updating equation is underdetermined if only natural frequencies are used for updating. Examples also demonstrate that modelling parameter errors can be located and corrected better when both natural frequencies and mode shapes represented by a large number of DOFs are used. The larger the density of measurements in the spatial domain, the greater the accuracy of updating that can be obtained. In addition, example studies show that the one-dimensional measurement taken from a particular direction to obtain the projection of all vibration modes of interest will provide more information which is helpful for model updating.

This report related to Subtask 2.3.2.2 “Test planning and integration applied to full-field measurement methods” (Originally ‘Support full-field measurement technology’) in Task 2.3.2 “Test simulation, planning and measurement”. This document is a Month-20 deliverable for the VIVACE project.