Wind Tunnel Model Design and Aeroelastic Measurements of the RIBES Wing

Ubaldo Cella, Ph.D.[1]; Pierluigi Della Vecchia, Ph.D.[2]; Corrado Groth, Ph.D.[3]; Stefano Porziani, Ph.D.[4]; Andrea Chiappa, Ph.D.[5]; Francesco Giorgetti, Ph.D.[6]; Fabrizio Nicolosi[7]; and Marco Evangelos Biancolini, Ph.D.[8]

Abstract: Several experimental databases of aeroelastic measurements performed on aircraft wing models are available for the validation of fluid–structure interaction (FSI) numerical methodologies. Most of these databases are used to model scaled systems focusing primarily on aerodynamic aspects, rather than on structural similitude with a full-scale model. To study flow regimes that replicate realistic operating conditions, wind tunnel test campaigns generate relatively high loads on models whose safe sizing forces the adoption of structural configurations that lose any similitude with typical wing box topologies. The aeroelastic measurements campaign conducted within the European Union "Radial basis functions at fluid Interface Boundaries to Envelope flow results for advanced Structural analysis" (RIBES) project was set up to shift attention to the structural similitude of aeroelastic mechanisms. The objective is to generate a database of loads, pressures, stresses, and deformations that is significant for a realistic aeronautical design problem. A wind tunnel model of a half wing that replicates a typical metallic wing box structure, instrumented with pressure taps and strain gauges, was designed and manufactured. This paper describes the experimental procedure and results by detailing the model design, its manufacture, and the measurements performed. All experimental data and numerical models are freely available online to the scientific community. **DOI: 10.1061/(ASCE)AS.1943-5525.0001199.** © *2020 American Society of Civil Engineers.*

Introduction

Several experimental static and dynamic aeroelastic test cases of wing geometries are available in the literature, e.g., Advisory Group for Aerospace Research and Development (AGARD) 445.6 (Yates 1988), High Reynolds Number Aerostructural Dynamics (HiReNASD) (Chwalowski et al. 2011), National Aeronautics and Space Administration (NASA) benchmark models program (BMP) (Bennett et al. 1991), and NASA common research model (CRM) (Keye et al. 2013). They can be used to test coupled computational fluid dynamics-computational structural mechanics (CFD-CSM) methodologies and to define guidelines regarding the applicability of simplifying assumptions as the modal approach. However, it is difficult to find test cases that model realistic aeronautical wing structures. The experimental design set up within the European Union (EU) "Radial basis functions at fluid Interface Boundaries to Envelope flow results for advanced Structural analysis" (RIBES) project had the objective of contributing to modeling such wing structures. Specifically, the aim of the project was to create a measurements database for the validation of aeroelastic numerical analysis tools, focusing on the verification of the fluid–structure interaction (FSI) methods' ability to accurately capture the structural response of a complex mechanical system, such as a wing box structure under steady aerodynamic loads. The accuracy of FSI analysis methodologies that couple CFD and finite-element method (FEM) solvers is related to the accuracy of the fluid dynamic solution, to the validity of the structural model, and to the proper transfer of information between the two physical models. Engineers have great confidence in the use of CFD codes to address typical aeronautical problems, and they are well aware of the accuracy of structural solvers. Within the RIBES project, a specific work package was addressed to the proper FEM-load mapping according to the CFD solution. The objective was to develop an algorithm able to minimize the error related to the interpolation involved when transferring the information between the common boundaries of the two physical models which are, in general, nonconformal. A procedure that introduces opportune correction functions that nullify the errors on net forces and significantly reduces the errors on moments was developed and implemented in a two-way FSI procedure based on a radial basis function (RBF) mesh morphing approach (Biancolini et al. 2018). In this scenario, some

[1]Researcher, Dept. of Enterprise Engineering, Univ. of Rome Tor Vergata, via Politecnico 1, Rome 00133, Italy (corresponding author). ORCID: https://orcid.org/0000-0002-9976-8540. Email: ubaldo.cella@uniroma2.it

[2]Assistant Professor, Dept. of Industrial Engineering, Univ. of Naples Federico II, via Claudio 21, Naples 80125, Italy. ORCID: https://orcid.org/0000-0003-1220-621X. Email: pierluigi.dellavecchia@unina.it

[3]Researcher, Dept. of Enterprise Engineering, Univ. of Rome Tor Vergata, via Politecnico 1, Rome 00133, Italy. Email: corrado.groth@uniroma2.it

[4]Researcher, Dept. of Enterprise Engineering, Univ. of Rome Tor Vergata, via Politecnico 1, Rome 00133, Italy. Email: porziani@ing.uniroma2.it

[5]Researcher, Dept. of Enterprise Engineering, Univ. of Rome Tor Vergata, via Politecnico 1, Rome 00133, Italy. Email: andrea.chiappa@uniroma2.it

[6]Researcher, Dept. of Enterprise Engineering, Univ. of Rome Tor Vergata, via Politecnico 1, Rome 00133, Italy. Email: francesco.giorgetti@uniroma2.it

[7]Professor, Dept. of Industrial Engineering, Univ. of Naples Federico II, via Claudio 21, Naples 80125, Italy. ORCID: https://orcid.org/0000-0003-4908-6194. Email: fabrnico@unina.it

[8]Professor, Dept. of Enterprise Engineering, Univ. of Rome Tor Vergata, via Politecnico 1, Rome 00133, Italy. ORCID: https://orcid.org/0000-0003-0865-5418. Email: biancolini@ing.uniroma2.it

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