High Fidelity Modeling of Involutionary Structures in IMOS

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ABSTRACT

A methodology is proposed for testing, modal identification and model correlation of structures which are assembled in an evolutionary manner. The methodology prescribes initial testing of a base structure without any attached components. The experimental modal properties are used to update the physical properties of the base structure finite element model using a Bayesian Estimation Technique (BET). The BET is implemented in MATLAB using IMOS functions.

As components are added onto the base structure, additional tests are performed. Three testing options are proposed, all of which enable estimation of the physical parameters of the components alone. Furthermore, improvements to the original BET implementation have been made, which contribute to higher fidelity models and more efficient computational times. These improvements include: a modal expansion technique (LSQI) which can expand the test mode shapes to the model degrees of freedom, but to a higher accuracy than predicted by the model; an error localization technique based on element modal strain energy errors (EMSEE) which can locate those elements within the model which are the most inaccurate, either because deficient model form or incorrect parameter values; a model reduction option based on Component Mode Synthesis (CMS) to increase the computational efficiency of the BET; and a Line Search Algorithm (LSA) which accelerates the convergence of the BET.

The proposed methodology has been successfully tested on the Micro-Precision Interferometry (MPI) Testbed Bare-Truss and Phase II configurations. Significant improvements in the updated model are observed.

1. INTRODUCTION

In 1993 an extensive modal test was performed on the Phase I configuration of the MPI Testbed (Fig. 1) which resulted in a high fidelity Finite Element (FE) model of the bare-truss, described by Carne, Mayes, and Levine-West (1993). The physical parameters of the FE model were updated using a Bayesian estimation method which minimizes the error between the measured modal properties and the predicted modal properties.

In the second phase of the MPI phased-delivery, several components were added to the bare truss. These components include two optics plates, an active optical delay line and its support structure (a.k.a., trolley), two siderostat mount structures, and a payload plate.

A high fidelity FE model being required for integrated controls-structures-optics performance prediction and design, it was decided that the physical parameters of the added components should be updated using newly obtained component dynamic test data. The resources were not available for an extensive modal test comparable to the 1993 effort. Instead, a method was conceived to minimize testing complexity and cost, reduce the impact of dynamic testing on the hardware delivery schedule, and allow for implementation of the identification and parameter estimation with more moderate computational capabilities.