SAND2008-7048C

Who is that Carne guy anyway?

David Epp, Todd Simmermacher
Session Organizers
Sandia National Laboratories
PO Box 5800
Albuquerque, NM, 87185

ABSTRACT
After recieving his B.A. in Physics from Pomona College, Thomas Carne received his M.S. and Ph.D. in Applied Mechanics from CalTech in 1972. After five years at the R&D Labs of General Motors, he joined Sandia National Laboratories in 1977 where he has performed research in finite element modeling of the structural dynamics of systems such as wind turbines, weapons, and automotive vehicles, and the Space Shuttle. In 1982 he transferred to the Experimental Structural Dynamics Department where he continued his research in the modeling of structural dynamic systems, with an emphasis on identification of uncertainties in analytical models by using experimentally measured modal parameters. In 1989 he was promoted to Distinguished Member of Technical Staff, a position which is limited to ten percent of the professional staff at Sandia National Laboratories.

Dr. Carne has been very involved in the modal analysis community, publishing over one hundred papers in conferences and journals, participating in every IMAC, and presenting five educational tutorials at IMAC. He is a member of the IMAC Advisory Board, the IOMAC Scientific Committee, the Scientific Advisory Board of the International Conference on Experimental Mechanics, and has served as an Associate Editor of The Modal Analysis Journal. He was honored by SEM with the D.J. DeMichele award in 2000. Following is a summary of the session where the papers presented were based upon Tom's career.

TESTING LARGE STRUCTURES IN THE FIELD (George James)

One the trajectories in Tom Carne's career that has had a major impact on the current state-of-the-art in modal testing is that of testing large-scale in-field structures. Three overlaping examples of his impact in such testing were discussed in the session. First, the testing of step relaxation testing of wind turbines was covered. This included testing of large-scale vertical axis wind turbines in parked and rotating conditions. The second example was the use of testing structures in the field using natural excitation. The verticle axis wind turbine was again the intiating structure for this work but the concept was applied to a wider variety of structures as the technology has matured. The final example was the development of a roll-out forcing function for the Space Shuttle stack during roll-out. This example has had to stretch beyond in-situ testing to include force reconstruction and hybrid analytical/experimental techniques. Throughout the chronological flow of these three examples, is the underlying theme that modal testing technology has grown as engineers like Tom Carne have attacked new and different problems with variations of the current technologies. As a result, this field is a growing, dynamic, and exciting field in experimental mechanics.

APPLICATIONS FROM MODEL VALIDATION AND COMPONENT MODE SYNTHESIS (David Martinez)

The second talk reviewed some contributions from Tom Carne's career in the areas of model validation and component mode synthesis. Some model validation methods utilize advanced nonlinear estimation methods to first identify unknown parameters in structural dynamics models. These identified parameters must subsequently be validated by comparison with other data and shown to provide predictive results, without further adjustment of the parameters. A general nonlinear estimation method was briefly reviewed. Results from composite shells, electronics packages, and other examples from Tom's career was presented using both simulated and measured data. Component Mode Synthesis (CMS) methods provide computational efficiency in structural dynamics analysis. They also provide a framework that is appropriate for problems involving physically separate subsystems and for combined experimental/analytical modeling techniques. A residual flexibility CMS formulation that is ideal for combined experimental/analytical modeling applications was briefly reviewed, and results from shell/payload structures was presented demonstrating the applicability of the method.

I'M JUST PRESENTING THIS PAPER FOR THE AUTHOR (Ralph Brillhart)

The third paper in the session was an overview of Tom's contributions to IMAC. Tom Carne has been a constant figure at these IMAC sessions for over 25 years. It is a rarity to find that consistency in almost anything these days. He has grown up through many of the developments that have brought modal testing and analysis to where it is today. He has also been a key contributor to IMAC helping assure its success. Not only has he had a paper at almost every IMAC, he has also been a session organizer and chairman in many. As a result of his availability and easy-going manner, he has often been asked to present papers at the last minute, with little or no time to prepare. Being in this position, of course, makes it difficult to have a full grasp of everything that the author may have intended. Nonetheless, Tom has never been one to shy away from this kind of challenge and will often start his presentation with "I'm just presenting this paper for the author, so you'll have to ask him your questions." Even so, Tom always is looking to understand what is presented and has done an admirable job of making clear and interesting presentations. A Tom Carne presentation can be the highlight of any IMAC.

FORCE RECONSTRUCTION AND THE SUM OF WEIGHTED ACCELERATIONS TECHNIQUE (Matt Allen)

The next paper discussed a variety of force reconstruction techniques that have been presented over the past few decades and how they relate to Tom's career. The basic premise is that if one knows the input-output model for a system, i.e. its natural frequencies, damping ratios and mode shapes, then one can find the forces (input) acting on the system from measurements of the response (output) caused by those forces . Force reconstruction is the only hope for determining the input loads needed for structural design in situations where those loads are impossible to measure directly, such as aerodynamic or acoustic loads on launch vehicles or aircraft, loads induced by the complex interaction between tires and the pavement, or loads induced on micro-scale systems by various physical phenomena.

Unfortunately, although force reconstruction is simple in principle, it is quite difficult to implement in practice for a few reasons. First, this inverse problem can be very sensitive to errors in the system's modal parameters, which may be poorly known or may change with time. Second, depending on the number and location of the response measurements and force locations, there may be several force patterns which could have caused the measured response, leading to ill-conditioning. Finally, the most common approach is based on inversion of the frequency response matrices, but they are inherently ill-conditioned at the natural frequencies of the structure. The Sum of Weighted Accelerations Technique (SWAT), developed by T. G. Carne and others beginning in the 1990s, provides a unique approach that may allow one to circumvent many of these difficulties. This presentation reviews the key features of the SWAT algorithm, compares it with other force reconstruction techniques, and highlights some promising directions for future research.

IMPROVING EXPERIMENTAL FREQUENCY RESPONSE FUNCTION MATRICES (Randy Mayes)

The final presentation discussed Tom's contributions in the area of admittance modeling. Admittance modeling is a process of coupling substructures using the Frequency Response Function (FRF) matrices associated with the individual substructures. These FRF matrices describe the structural dynamic character of the substructures at their interfaces and other points of interest. One desirable feature of admittance modeling is the FRF's can be derived from either measured data or analytical models. In this paper, we show that measurement-based FRF matrices can have small hidden anomalies, which are not readily observable until coupled to another system but can drastically affect the FRF's of the combined system. These anomalies arise due to measurement noise and subsequent mathematical processing of the FRF's. A filter has been developed which automatically removes these hidden anomalies, creating a well-behaved system, while minutely affecting the FRF matrices. This part of the session acknowledged the career accomplishments of Tom Carne and was a recap of one published by Carne and Dohrmann at IMAC in 2006.

ACKNOWLEDGEMENT

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy□s National Nuclear Security Administration under Contract DE-AC04-94AL85000.