BIOGRAPHICAL RESUMÉ

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CURRENT Vice President of Engineering**,** Blade Diagnostics Corporation

EDUCATION

Ph.D.	1973	California Institute of Technology
M.S., B.S.	1969	University of South Florida

EXPERIENCE

2005–present Blade Diagnostics Corporation
Founder and Vice President of Engineering
Technology Development and Services to Inspect and Control Engine Blade and IBR High Cycle Fatigue.

1980–2009 Carnegie Mellon University
William J. Brown Emeritus Professor
Director, Center for the **GUI**de Consortium Bladed Disk Structures Research

1977–1980 Pratt & Whitney Aircraft
Manager, Structure's Advanced Engine Fan Group
Technical Specialist, Life Prediction Technology Group
Senior Design Engineer, Vibration Group, Government Products
Senior Analytical Engineer, Commercial Products Division

Other Professional Experience

1974–1994
Senior Partner of Griffin Consulting
Visiting Faculty, Institute of Industrial Technologies, CSIRO, Australia
Visiting Senior Scientist, Air Force Wright Aeronautical Laboratories
Lecturer, Engineering Department, University of Auckland, New Zealand

PATENTS

2008 "Fundamental Mistuning Model for Determining System Properties and Predicting Vibratory Response of Bladed Disks" (Forced Response Prediction)

2007 "Determination of damping in bladed disk systems using the fundamental mistuning model" (Damping Identification)

2006 "Fundamental mistuning model for determining system properties and predicting vibratory response of bladed disks" (Mistuning Identification)

1982 Blade Damper

HONORS AND AWARDS

GUIde Consortium Award for Outstanding Service 2009
Best Paper Award, ASME Propulsion Technical Committee 2004
CMU Mechanical Engineering Professor of the Year Award 2002
CMU College of Engineering Outstanding Researcher Award 2001,2002
CMU College of Engineering Teare Teaching Award for Excellence in Engineering Education 1998
Fellow, American Society of Mechanical Engineering, awarded 1995
CMU Mechanical Engineering Professor of the Year Award 1995
Best Paper Award, ASME IGTI Structures & Dynamics Committee 1994

OVERVIEW OF RESEARCH RELATED ACTIVITIES

RESEARCH FOCUS

Professor Griffin's main research area is the development of methods for calculating the amplitude of response of vibrating structures. A significant portion of this work focuses on gas turbine engine components and systems. In order to predict resonant response it is necessary to predict the excitation forces, the system's structural characteristics, and the amount of damping.

MISTUNING RESEARCH

A turbine's structural characteristics are difficult to predict because turbine blade systems tend to have modes with closely spaced frequencies. When the natural frequencies are closely spaced, small changes in the structure, e.g., blade mistuning, can cause large changes in the mode shapes and the turbine's structural response. As a result, the amplitudes of blades can vary significantly from one blade to the next and from one engine to the next. Professor Griffin has worked extensively on the mistuning problem. Specifically, he has: promoted the use of statistical distributions to characterize the structural response of turbines; shown how to optimize the use of instrumentation in mistuned systems; developed computationally efficient methods for analyzing the response of systems with grouped blades; and developed reduced order models of bladed disks that have the structural fidelity of finite element models of the full bladed disk but that are far more computationally efficient. While at Carnegie Mellon, Professor Griffin's research group developed methods for solving the inverse problem, i.e. using the measured vibratory response to determine the frequencies of the individual blades. This work can provide the basis of inspection machines that can be used during the manufacturing process to determine if the parts meet specifications and during depot inspections to assess the effect of wear and damage. It also can be applied while the blades are rotating in the engine and may serve as the basis of monitoring engine health. A company was formed to complete the research and development of these concepts and to develop practical tools that have commercial applications.

Professor Griffin founded Blade Diagnostics Corporation (BDC) in 2005. The purpose of BDC is to develop practical experimental and analytical tools to identify and predict mistuned response of turbine blade systems. BDC has expanded the scope of the algorithms used to identify and predict vibratory response. In addition to identifying the frequencies of the blades, the algorithms can also identify damping, the forces that act on the blades, and the frequencies that the blades would vibrate at if all the blades were identical. This approach has been extended so that it can be used to understand and predict the vibratory response of multiple families of modes that interact with each other.

An example of a practical application of this technology is BDC's algorithm for sequencing turbine blades. BDC used its mistuning identification and prediction tools to develop a blade sequencing algorithm that uses the blades' frequencies from bench tests to determine

an optimum sequence around the disk. The blade sequence is chosen to minimize blade imbalance as well as minimize the vibratory response in two multiple modes. BDC's blade sequencing system is now being used to select blade sequences in a production military engine.

Experimentally, BDC has developed new, more precise methods of measuring the vibratory response of integrally bladed rotors. These improvements significantly increase the reproducibility of the measurements and are especially important when making higher frequency measurements above 10 KHz. In addition, BDC developed all of the control software used in their mistuning measurement machines. As a result, the BDC mistuning inspection machine is fully automated so that high precision measurements can be made by a technician using a simple graphical user interface.

While at Carnegie Mellon, Professor Griffin also studied a related problem: high variability in the forced response of low aspect ratio blades. In this problem, engineers observe high variability when individual blades are tested separately in the lab. The high variability occurs because low aspect ratio blades often have pairs of modes with closely spaced frequencies and these modes are highly sensitive to small differences that occur during the manufacturing process. An approach was developed at Carnegie Mellon for predicting which modes will have high variability and for optimizing the placement of strain gages to best measure and interpret their response. A new application for this technology has recently been developed and is being pursued at BDC – FAA certification of PMA blades. The FAA has recently updated their requirements for equivalency of PMA and OEM blades that involves showing that both blade sets have very similar modes of vibration. The technical challenge is that some of the mode shapes of the blades produced by the original manufacturer are highly variable because they have frequencies that are close together. BDC is in the process of applying their highly accurate measurement methods and their methods for dealing with modes that have closely spaced frequencies to the FAA single blade certification problem.

DAMPING RESEARCH

Professor Griffin's research has also explored damping in gas turbines. There are two primary sources of damping in turbines: aerodynamic and friction. Aerodynamic damping is typically calculated for the aerodynamic modes using computational fluid dynamic (CFD) codes. As mentioned in the last paragraph, Professor Griffin has developed reduced order models of the bladed disk that can be used for mistuning studies. The reduced order model represents the mistuned modes in terms of the aerodynamic modes. As a result, it is relatively easy to use these reduced order models to predict the effect of mistuning on aerodynamic damping. This approach is now used to investigate how mistuning can affect flutter in engines.

Professor Griffin's work at BDC has extended the mistuning identification algorithms so that they are also used to identify damping in bladed disks from their measured vibratory response. This is a difficult problem since mistuning and damping tend to cause resonant peaks to be close together where they lose their individual characteristics. BDC has successfully completed a research program on identifying damping in integrally bladed

rotors with damping coatings and also identifying damping from under-platform friction dampers.

Friction and other nonlinear constraints have also been a focus of study. The research seeks to improve the physical models of contact, improve the computational algorithms used to calculate forced response, and use them to improve design methodology. The work on modeling friction constraints includes studying: static and dynamic friction models, variable normal load, two dimensional motion, and microslip. Improvements in computational approaches include: the development of receptance methods for representing the linear substructures; the use of the Fast Fourier transform FFT for efficiently computing multiple harmonics of the nonlinear forces; and the development of harmonic balance methods for multi-dimensional contact. The resulting models and algorithms have been used to study the importance of friction in turbine design, e.g. optimizing damping to reduce resonant response, using friction to control flutter, the design of internal friction dampers, the design of shrouded stages, and the effect of friction on randomly excited blades. In addition, Professor Griffin's research has also focused on the development of more physical models of friction dampers that are based on first principles.

OTHER RESEARCH

Vibration: Professor Griffin has also directed other vibration research that is not related to turbines. For example, he has investigated the conditions related to high variability of viscous damping in composite and adhesively bonded structures. In addition, he has developed methods for predicting the torsional response of drive trains. Related work includes: new mathematical methods for analyzing the effect of periodically varying inertia and stiffness on drive train response; predictive models of damping due to microslip at friction interfaces in flanges and clutches; and an analytical and experimental program with the U.S. Navy for assessing and improving predictive methods. This last project has resulted in a computer code used by the Navy, Coast Guard and industry to predict torsional response of marine drive trains.

Solid Mechanics: Professor Griffin also has an interest in solid mechanics and has participated in research related to fracture mechanics and stress analysis. One project involved investigating the effect of thermal transients on crack tip stresses during thermal fatigue testing. A simple, analytical expression was developed that estimates the effect of electric current on stresses in specimens during tests that use direct resistance heating. Path independent integrals were developed and used to methodically study the effect of heating rate on crack tip stresses, and guidelines were developed for avoiding adverse effects. A recent project involved calculating the nonlinear contact stresses in a turbine blade attachment caused by cyclic loading.

GUIde CONSORTIUM DIRECTOR

While at Carnegie Mellon, Professor Griffin worked with industry and government to form the **GUI**de Consortium on the forced response of bladed disks. He was Director of the **GUI**de sponsored CMU Center for Bladed Disk Structures Research and Technology for 15 years (1991 – 2006).

The acronym **GUI**de stands for Government, University, and Industry working together to promote research and development and to expedite the transfer of new technologies to industry. The focus area is the development of methods for predicting the vibratory response on gas turbine engine components. The members of the **GUI**de Consortium included the US Air Force, NASA, the US Navy, all of the major US engine manufacturers, Carnegie Mellon University, and the other universities that had projects sponsored by **GUI**de, e.g. OSU, U. of Mich., Duke, ASU, MIT, Imperial College in London, UC Irvine, U. Virginia, and U. Kentucky. All administrative activities were carried out by Prof. Griffin at CMU.

The original agreement, **GUI**de I ended in 1996 and sponsored six, four year research projects. The **GUI**de I organizational structure and research projects were considered very successful by its Government and Industrial sponsors. **GUI**de research objectives are strongly aligned with DOD research initiatives on high cycle fatigue in jet engines. As a result, the Government and Industrial members endorsed the continuation of the **GUI**de program, and **GUI**de II started in 1996. **GUI**de III was initiated in 2002 and sponsors fourteen, four year projects.

REVIEWER

Journal of the Engineering Mechanics Division, ASCE; Journal of Sound and Vibration; AIAA Journal of Shock and Vibration; ASME Journal of Engineering for Gas Turbines and Power; ASME Journal of Vibration, Acoustics, Stress and Reliability in Design; National Science Foundation; International Gas Turbine and Aeroengine Congress and Exposition.

CONSULTANT

U.S. Air Force; U.S. Navy; NASA ; GE Aerospace; Rocketdyne; Pratt and Whitney Aircraft; United Technologies Corporation; Mitsubishi; Siemens Hamilton Turbines; Siemens Power Generation; TEXTRON Lycoming; and others.

FUNDED RESEARCH

Blade Diagnostics Corporation:

2008-2011	"Integrally Bladed Rotor (IBR) Maintenance and Life Management", SBIR I and II, US Air Force.
2006-2011	"Aerodynamic/Structural Mistuning Technologies for Assessing IBR/Blisk Repairs", STTR I and II, Office of Naval Research.
2006-2010	"Accurately Measuring the Damping of an IBR or Bladed Disk for Design and Maintenance of Aircraft Engines", SBIR I and SBIR II, US Air Force.

2005-2009 "A Field Inspection Mistuning Tool and a Systematic Approach for Assessing and Managing Mistuning in Integrally Bladed Rotors", SBIR I and II and Extension, US Air Force.

GUIde Consortium 1991 – 2006:

Professor Griffin was the administrator of all **GUI**de Consortium contracts with CMU and its participants. The total **GUI**de funding was $12M.

Major Contracts 1981-2004 while at Carnegie Mellon:

2002-2006	"A Coordinated Industry and University Research Program in Forced Response," US Air Force.
2002-2006	"Physical Models Of Friction Constraint And The Effect Of Friction On Bladed Disk Dynamics," US Navy.
2002-2004	"An Investigation into the Application of Advanced Probabilistic Methods to the Structural Mistuning of Bladed Disks," NASA Glenn.
2002-2004	"A Laboratory for System Identification of Mistuning in Integrally Bladed Disks," DURIP Instrumentation.
2002-2004	"Friction Test Specimens that will be Used to Measure Nonlinear Damping and Stiffness," AFOSR.
2001-2005	"**GUI**de Consortium Agreements with Industry," Rolls Royce, Honeywell, General Electric Aircraft Engines, Pratt & Whitney, Siemens-Westinghouse, Mitsubishi.
2000-2001	"Workshop on the Modeling, Analysis, and Measurement of Friction Constraints in Gas Turbine Components," AFOSR.
1999-2000	"Coupled Torsion/Bending Blade Disk Mode Interaction," Wright Laboratories and Battelle.
1996–2000	"**GUI**de Consortium Agreements with Industry," Rolls Royce-Allison, Allied Signal, General Electric Aircraft Engines, Pratt & Whitney, Siemens-Westinghouse.
1996-2001	"Blade Vibration Consortium Initiative," US Air Force.
1996-2000	"A Coordinated Approach to the Development and Validation of Aeroelastic Codes for Turbo-Machinery, NASA Lewis Research Center
1996-1999	"Calculating Finite Stress Concentrations in Dove Tail Attachments," General Electric.
1996-1997	"Enhanced Turbine Blade Damping, Pratt & Whitney Aircraft.
1996-2000	"Predicting Friction Damping in Shrouded Bladed Disk Assemblies, Naval Air Systems Command/**GUI**de.
1995-1997	"A Study of Shrouded Blade Dynamics," Pratt & Whitney Aircraft.
1992–1996	"Forced Response Consortium Initiative," US Air Force and NASA.
1991–1995	"**GUI**de Consortium Agreements with Industry," Allison Gas Turbine Division, Garrett Engineering Division, GE Aerospace, Pratt & Whitney, Textron Lycoming, Westinghouse Electric Corp.
1993	ATT Equipment Grant: Computers for Undergraduate Computing Laboratory.

1993–1997	"Torsional Vibration Consortium Agreements," ABS Americas, American Vulkan Corporation, Aquadrive Systems, Inc., Caterpillar Inc., Lord Corporation, Twin Disc,Inc.
1992	Hewlett Packard Equipment Grant for Undergraduate Vibration Laboratory.
1992-1996	"The Vibration of Low Aspect Ratio Airfoils", **GUI**de funded.
1991–1994	"Modeling the Effect of Shroud Contact and Friction Dampers on the Mistuned Response of Turbopumps," NASA Marshall Spaceflight Center.
1990–1992	"Torsional Vibration Analysis of Drive Trains," Office of Naval Research.
1988–1990	"Design Fusion," DARPA.
1988–1990	"The Use of Adhesives in Welded Joints," Ford Motor Company.
1988–1990	"Automating Methods for Performing Finite Element Analyses," NSF Engineering Design Research Center, Carnegie Mellon University.
1987–1991	"Torsional Vibration Analysis of Navy Small Craft Drive Trains," US Navy.
1987–1988	"Spectral Describing Functions for Nonlinear Dynamic Systems," National Science Foundation.
1986–1989	"The Effect of Transients on Crack Tip Stress Fields During Thermal Fatigue Loading," AFOSR.
1985–1986	"Bladed Disk Vibration and a Graduate Internship in Vibration," NASA.
1985–1986	"Response of Joint Dominated Space Structures," NASA.
1984–1985	"The Influence of Electric Current on Crack Propagation in Thermal Fatigue Tests," AFOSR.
1983–1987	"An Efficient Method for Predicting Vibratory Response of Linear Structures Containing Friction Interfaces," Air Force Aero Propulsion Laboratory.
1982–1984	"Analytical Evaluation of Turbine Blade Friction Damper Models," AFOSR.
1982–1983	"Internship for Graduate Education in Vibration," NASA.
1981–1985	"The Simulation of Aerodynamic Damping/Mistuning/Friction Interaction in Bladed Disk Vibration," NASA.
1981–1982	"A New Friction Damper Concept," Ford Motor Company Research Fund.

PRINCIPAL PUBLICATIONS & PRESENTATIONS

Professor Griffin is author of over 50 publications related to: friction damping, shrouded blades, bladed disk assemblies (mistuning), high frequency modes in low aspect ratio blades, torsional vibration in drive trains, viscoelastic damping, Consortia, stress analysis and fracture mechanics. In addition, he has given more than 100 presentations at conferences and seminars. Principal publications are listed here.

PUBLICATIONS RELATED TO FRICTION DAMPING:

"Friction Damping of Resonant Stresses in Gas Turbine Engine Airfoils," *ASME Journal of Engineering for Power*, Vol. 102, April 1980, pp. 329–333.

"Effects of Static Friction on the Forced Response of Frictionally Damped Turbine Blades," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 106, January 1984, pp. 65–69 (with A. Sinha).

"Friction Damping of Flutter in Gas Turbine Engine Airfoils," *AIAA Journal of Aircraft*, Vol. 20, April 1983, pp. 372–376 (with A. Sinha).

"Effects of Friction Dampers on Aerodynamically Unstable Rotor Stages," *AIAA Journal*, Vol. 23, February 1985, pp. 262–270 (with A. Sinha).

"A Comparison of Transient and Steady State Finite Element Analyses of the Forced Response of a Frictionally Damped Beam," *ASME Journal of Vibration, Acoustics, Stress, and Reliability in Design*, Vol. 107, January 1985, pp. 19–25 (with C.–H. Menq).

"Stability of Limit Cycles in Frictionally Damped and Aerodynamically Unstable Rotor Stages," *Journal of Sound and Vibration*, Vol. 103, December 1985, pp. 341–356 (with A. Sinha).

"The Influence of a Variable Normal Load on the Forced Vibration of a Frictionally Damped Structure," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 108, April 1986, pp. 300–305 (with C.–H. Menq and J. Bielak).

"Influence of Friction Dampers on Torsional Blade Flutter," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 108, April 1986, pp. 313–318 (with A. Sinha and R.E. Kielb).

"The Influence of Microslip on Vibratory Response; Part 1: A New Microslip Model," *Journal of Sound and Vibration*, Vol. 107, June 1986, pp. 279–293 (with C.–H. Menq and J. Bielak).

"The Influence of Microslip on Vibratory Response; Part 2: A Comparison with Experimental Results," *Journal of Sound and Vibration*, Vol. 107, June 1986, pp. 295–307 (with C.–H. Menq and J. Bielak).

"An Efficient Method for Predicting the Vibratory Response of Linear Structures with Friction Interfaces," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 108, 1986, pp. 633–640 (with E. Bazan and J. Bielak).

"Transient Response of Joint Dominated Space Structures: A New Linearization Technique," *AIAA Journal*, Vol. 26, 1988, pp. 1278–1285 (with G.A. Foelsche and J. Bielak).

"Evaluation of a Turbine Blade Damper Using an Integral Approach," in *Proceedings of the AIAA/ASME/ASCE/AHS Conference*, pp. 1495–1500, October 1988 (with R.E. Kielb and C.–H. Menq).

"A New Method for Optimizing Friction Damping in Randomly Excited Systems," presented at ASME Gas Turbine and Aeroengine Conference, Toronto, Ontario, Canada, 1989, Paper No. 89–GT–108 (with T.M. Cameron).

"An Alternating Frequency/Time Domain Method for Calculating the Steady–State Response of Nonlinear Dynamic Systems," *Journal of Applied Mechanics*, Vol. 56, 1989, pp. 149–154 (with T.M. Cameron).

"How Gravity and Joint Scaling Affect the Dynamic Response," *AIAA Journal*, Vol. 27, 1989, pp. 1280–1287 (with S.T. Hsu and J. Bielak).

"An Integrated Approach for Friction Damper Design," *ASME Journal of Vibration, Acoustics, Stress and Reliability in Design*, Vol. 112, 1990, pp. 175–182 (with T.M. Cameron, R.E. Kielb and T.M. Hoosac).

"A Review of Friction Damping of Turbine Blade Vibration," *International Journal of Turbo and Jet Engines*, Vol. 7, 1990, pp. 297–307.

"Friction Damping of Two–Dimensional Motion and Its Application in Vibration Control," *Journal of Sound and Vibration*, Vol. 144, 1991, pp. 427–447 (with C.–H. Menq and P. Chidamparam).

"Friction Damping of Circular Motion and Its Implications to Vibration Control," *ASME Journal of Vibration and Acoustics*, Vol. 113, 1991, pp. 225–229 (with C.–H. Menq).

"Friction Damping of Hollow Airfoils: Part I — Theoretical Development," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 120, 1998, pp. 120-125 (with W-T. Wu and Y. El-Aini).

"Characterization of Turbine Blade Friction Dampers," *ASME Journal of Engineering for Gas Turbines and Power*, **127**, pp. 856-862 (2005) (with K.H. Koh, J.H. Griffin, S. Fillipi, and A. Akay).

PUBLICATIONS RELATED TO SHROUDED BLADES:

"The Forced Response of Shrouded Fan Stages," *ASME Journal of Vibration, Acoustics, Stress, and Reliability in Design*, Vol. 108, January 1986, pp. 50–55 (with C.–H. Menq and J. Bielak).

"Blade Vibration with Nonlinear Tip Constraint: Model Development," *ASME Journal of Turbomachinery*, Vol. 112, 1990, pp. 778–785 (with L.F. Wagner).

"A Continuous Analog Model for Grouped–Blade Vibration," *Journal of Sound and Vibration*, Vol. 165, 1993, pp. 421–438 (with L.F. Wagner).

"Exploring How Shroud Constraints Can Affect Vibratory Response in Turbomachinery," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 117, 1995, pp. 198-206 (with M.–T. Yang).

"Forced Harmonic Response of Grouped Blade Systems: Part I — Discrete Theory," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 118, 1996, pp. 130-136 (with L. Wagner).

"Forced Harmonic Response of Grouped Blade Systems: Part II — Application," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 118, 1996, pp. 137-145 (with L. Wagner).

"A Rational Method for Optimizing Shroud Damping," in *Proceedings of the International Gas Turbine and Aeroengine Congress and Exposition*, Birmingham, England, Paper No. 96-GT-402, 1996 (with R. Labelle).

"Unstable Resonant Response of Shrouded Bladed Disks," in *Proceedings of the Third National Turbine Engine High Cycle Fatigue Conference*, San Antonio, TX, February 1998 (with Y.-C. Li and M.-T. Yang).

PUBLICATIONS RELATED TO BLADED DISK ASSEMBLIES (MISTUNING):

"Model Development and Statistical Investigation of Turbine Blade Mistuning," *ASME Journal of Vibration, Acoustics, Stress, and Reliability in Design*, Vol. 106, April 1984, pp. 204–210 (with T.M. Hoosac).

"The Interaction Between Mistuning and Friction in the Forced Response of Bladed Disk Assemblies," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 107, January 1985, pp. 205–211 (with A. Sinha).

"The Effect of Limiting Aerodynamic and Structural Coupling in Models of Mistuned Bladed Disk Vibration," *ASME Journal of Vibration, Acoustics, Stress, and Reliability in Design*, Vol. 108, April 1986, pp. 132–139 (with P. Basu).

"On Predicting the Resonant Response of Bladed Disk Assemblies," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 110, 1988, pp. 45–50.

"Optimizing Instrumentation When Measuring Jet Engine Blade Vibration," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 114, 1992, pp. 217–221.

"A Reduced Order Approach for the Vibration of Mistuned Bladed Disk Assemblies,"*ASME Journal of Engineering for Gas Turbines and Power*, Vol. 119, 1997, pp. 161-167 (with M.-T. Yang).

"A Normalized Modal Eigenvalue Approach for Resolving Modal Interaction," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 119, 1997, pp. 647-650 (with M.-T. Yang).

"A Reduced-Order Model of Mistuning Using a Subset of Nominal System Modes," *Journal of Engineering for Gas Turbines and Power*, Vol. 123, October 2001, pp. 893-900 (with M.-T. Yang).

"A State Space Approach for the Nonlinear Analysis of Frictionally Damped Turbines," presented at the *Fifth National Turbine Engine High Cycle Fatigue Conference*, Chandler, AZ, March 2000 (with N.E. Kim).

"A Fundamental Model of Mistuning for a Single Family of Modes, *ASME Journal of Turbomachinery*, Vol. 124, October 2002, pp. 597-605 (with D.M. Feiner).

"A Reduced Order Model for Evaluating the Effect of Rotational Speed on the Natural Frequencies and Mode Shapes of Blades," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 125, July 2003, pp. 772-776 (with P. Marugabandhu).

"Forced Response of Turbine Engine Bladed Disks and Sensitivity to Harmonic Mistuning," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 125, January 2003, pp. 113-120 (with J.A. Kenyon).

"Maximum Bladed Disk Forced Response from Distortion of a Structural Mode," *ASME Journal of Turbomachinery*, Vol. 125, April 2003, pp. 352-363 (with J.A. Kenyon and D.M. Feiner*).*

"Experimental Demonstration of Maximum Mistuned Bladed Disk Forced Response," *ASME Journal of Turbomachinery*, Vol. 125, October 2003, pp. 673-681 (with J.A. Kenyon).

"Mistuning Identification of Bladed Disks Using a Fundamental Model of Mistuning—Part I: Theory," *ASME Journal of Turbomachinery*, 2004, 126(1), pp. 150-158 (with D.M. Feiner).

"Mistuning Identification of Bladed Disks Using a Fundamental Model of Mistuning—Part II: Application," *ASME Journal of Turbomachinery*, 2004, 126(1), pp. 159-165 (with D.M. Feiner).

"Frequency Veering Effects on Mistuned Bladed Disk Forced Response," *ASME Journal of Propulsion and Power*, Vol. 20, September 2004, pp. 863-870 (with J.A. Kenyon and N.E. Kim).

"System Identification of Mistuned Bladed Disks from Traveling Wave Response Measurements," *Proceedings of the 2003 ASME Design Engineering Technical Conferences*, Chicago, IL, ASME Paper DETC 2003/VIB-48448 (with D.M. Feiner, K. Jones, J.A. Kenyon, O. Mehmed and A.P. Kurkov).

"Sensitivity of Tuned Bladed Disk Response to Frequency Veering," J. Eng. Gas Turbines Power, Oct. 2005, Vol. 127, Issue 4, 835-848 (with J.A. Kenyon and N.E. Kim).

"A Reduced-Order Model for Transient Analysis of Bladed Disk Forced Response," J. Turbomach, July 2006, Vol. 128, Issue 3, 474, (with J. P. Ayers, D. M. Feiner).

PUBLICATIONS RELATED TO HIGH FREQUENCY MODES IN LOW ASPECT RATIO BLADES:

"Resonant Response of a Tapered Beam and Its Implications to Blade Vibration," *ASME Journal of Engineering for Gas Turbines and Power,* Vol. 119, 1997, p. 147-152 (with G. Balaji).

"Theory and Methodology of Optimally Measuring Vibratory Strains in Closely Spaced Modes," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 120, 1998, pp. 801-807 (with M.-T. Yang).

PUBLICATIONS RELATED TO TORSIONAL VIBRATION IN DRIVE TRAINS:

"Improving Predictions of Boat Drive Train Vibrations," in *Proceedings of the 1993 Small Boats Symposium*, 1993 (with J.B. Brown Jr., W.-T. Wu and G. Meda).

"Torsional Vibration of Drive Trains," in *Proceedings of the International Off-Highway and Powerplant Congress and Exposition*, SAE Technical Paper #941697, 1994 (with W.-T. Wu, J.A. Wickert and J.B. Brown Jr.).

"Perturbation Method for the Floquet Eigenvalues and Stability Boundary of Periodic Linear Systems," *Journal of Sound and Vibration*, Vol. 182, 1995, pp. 245-257 (with W.–T. Wu and J.A. Wickert).

"Modal Analysis of the Steady State Response of a Driven Periodic Linear System," *Journal of Sound and Vibration*, Vol. 183, 1995, pp. 297 (with W.–T. Wu and J.A. Wickert).

PUBLICATIONS RELATED TO VISCOELASTIC DAMPING:

"A Special Element Approach for Calculating the Vibratory Response of Adhesively Bonded and Composite Structures," *Journal of Sound and Vibration*, Vol. 170, 1994, pp. 377–395 (with N. Kim).

"Sensitivity of Bonded and Composite Beams," *Journal of Sound and Vibration*, Vol. 177, 1994, pp. 71–92 (with N. Kim).

PUBLICATIONS RELATED TO CONSORTIA:

"The **GUI**de Consortium: Government, Universities, and Industry Working Together to Develop New Technologies," in *Proceedings of the 1995 International Gas Turbine and Aeroengine Congress and Exposition*, Houston, TX (with S.M. Richardson).

"A Consortium Approach to Torsional Vibration," in *Proceedings of the '97 Propellers/Shafting Symposium*, Virginia Beach, VA, September 1997, Society of Naval Architects and Marine Engineers, pp. 25-1–25-6.

PUBLICATIONS RELATED TO STRESS ANALYSIS AND FRACTURE MECHANICS:

"Path Independent Integrals for Computing Stress Intensity Factors at Sharp Notches in Elastic Plates," *International Journal for Numerical Methods in Engineering*, Vol. 20, 1984, pp. 999–1008 (with G.B. Sinclair and M. Okajima).

"On Stress Intensities Induced by Direct Resistance Heating," *International Journal of Fracture*, Vol. 33, 1987, pp. 135–144 (with S.E. Cunningham and G.B. Sinclair).

"On the Importance of Direct Resistance Heating in Thermo–mechanical Fatigue," *International Journal of Fracture*, Vol. 46, 1990, pp. 257–270 (with S.E. Cunningham).

"Estimating the Importance of Cyclic Thermal Loads in Thermo–mechanical Fatigue," *International Journal of Fracture*, Vol. 47, 1991, pp. 161–180 (with S.E. Cunningham).

"Contact Stresses in Dovetail Attachments: Finite Element Modeling," *ASME Journal of Engineering for Gas Turbines and Power*, Vol. 124, January 2002, pp. 182-189 (with G.B. Sinclair, N.G. Comier and G. Meda).

OTHER PUBLICATIONS:

"On the Dynamic Response of Suspended Cables," *International Journal of Earthquake Engineering and Structural Dynamics*, Vol. 4, April–June 1976, pp. 389–402 (with H.M. Irvine).

"Wave–Front Analysis of a Plane Compressional Pulse Scattered by a Cylindrical Elastic Inclusion," *Journal of Solids and Structures*, Vol. 10, December 1974, pp. 1333–1356 (with J. Miklowitz).

CONFERENCES, PRESENTATIONS, AND WORKSHOPS

"Wave–Front Analysis of a Plane Compressional Pulse Scattered by a Cylindrical Elastic Inclusion," International Congress of Applied Mechanics, Boulder, CO, June 1974.

"Friction Damping of Resonant Stresses in Gas Turbine Engine Airfoils," ASME Gas Turbine Conference, San Diego, CA, March 1979.

"Friction Damping of Resonant Stresses in Turbine Blades," Carnegie Mellon University, Pittsburgh, PA, August 1980.

"Turbine Blade Friction Dampers," Air Force Propulsion Laboratory, Dayton, OH, November 1980.

"Size Effects in Fracture Mechanics," Air Force Materials Laboratory, Dayton, OH, November 1980.

"An Analytical Evaluation of Turbine Blade Friction Damping Models," Carnegie Mellon University, Pittsburgh, PA, February 1981.

"An Analytical Comparison of Blade-to-Blade and Blade-to-Ground Dampers for Use in Gas Turbine Engines," Eighth Canadian Congress of Applied Mechanics, Moncton, NB, Canada, June 1981.

"Recent Work on Blade Dynamics," University of Dayton, Dayton, Ohio (August 1981).

"Understanding and Controlling Gas Turbine Engine Vibratory Stress," Carnegie Mellon University, Pittsburgh, PA, September 1981.

"The Effect of Blade–to–Blade Dampers on Aerodynamically Unstable Systems," 1982 NASA Dynamics Workshop, NASA Lewis Research Center, Cleveland, OH, June 1982.

"Recent Research on Friction Damping," CMU Workshop on Friction Damping, Carnegie Mellon University, Pittsburgh, PA, September 1982.

"Friction Damping of Gas Turbine Engine Blades," United Technologies Research Laboratories, East Hartford, CT, March 1983.

"Effects of Static Friction on the Forced Response of Frictionally Damped Turbine Blades," 28th International Gas Turbine Conference, Phoenix, AZ, March 1983.

"Effects of Friction Dampers on Aerodynamically Unstable Rotor Stages," 24th SDM Conference, New Orleans, LA, May 1983.

"A Comparison of Transient and Steady State Finite Element Analyses of the Forced Response of a Frictionally Damped Beam," 9th Biennial Design Conference on Mechanical Vibration and Noise, Detroit, MI, September 1983.

"Model Development and Statistical Investigation of Turbine Blade Mistuning," 9th Biennial Design Conference on Mechanical Vibration and Noise, Detroit, MI, September 1983.

"The Interaction between Mistuning and Friction in the Forced Response of Bladed Disk Assemblies," 29th International Gas Turbine Conference, Amsterdam, Holland, June 1984.

"Predicting Turbine Blade Vibration," Köngsberg Radial Turbomachinery Research, Köngsberg, Norway, June 1984.

"Current Work on Friction Damping at CMU," NASA Langley Research Center, Hampton, VA, August 1984.

"The Influence of Microslip on the Forced Response of Vibrating Systems," Massachusetts Institute of Technology, Cambridge, MA, October 1984.

"Research on Friction Damping in Jet Engines at Carnegie Mellon University," Vibration Damping 1984 Workshop, Long Beach, CA, November 1984.

"A New Model for Microslip in Vibrating Structures," Pennsylvania State University, University Park, PA, November 1984.

"The Influence of Microslip on Vibratory Response; Part 1: A New Microslip Model," ASME Winter Annual Meeting, New Orleans, LA, December 1984.

"The Influence of Microslip on Vibratory Response; Part 2: A Comparison with Experimental Results," ASME Winter Annual Meeting, New Orleans, LA, December 1984.

"The Forced Response of Systems Containing Friction Constraints," Princeton University, Princeton, NJ, February 1985.

"The Influence of a Variable Normal Load on the Forced Vibration of a Frictionally Damped Structure," 30th International Gas Turbine Conference, Houston, TX, March 1985.

"The Influence of Friction Dampers on Torsional Blade Flutter," 30th International Gas Turbine Conference, Houston, TX, March 1985.

"Structures with Tight Friction Constraints," NASA Lewis Research Center, Cleveland, OH, April 1985.

"Friction Damping in Gas Turbine Engines," Allison Gas Turbine Division, Indianapolis, IN, June 1985.

"A Review of Friction Effects in Gas Turbines," General Electric Corporation, Evandale, OH, June 1985.

"Torsional Vibration in Small Boat Drive Trains," NAVSEA, Washington, DC, July 1985.

"A Review of Friction Effects in Gas Turbines," NASA Marshall Space Flight Center, Huntsville, AL, July 1985.

"A Program to Develop Improved Friction Dampers for the Space Shuttle HPOTP," Rocketdyne Division, Canoga Park, CA, August 1985.

"The Forced Response of Shrouded Fan Stages," 10th ASME Biennial Design Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 1985.

"The Effect of Limiting Aerodynamic and Structural Coupling in Models of Mistuned Bladed Disk Vibration," 10th ASME Biennial Design Conference on Mechanical Vibration and Noise, Cincinnati, OH, September 1985.

"The Effect of Friction Constraints on the Forced Response of a Cantilevered Beam," Carnegie Mellon University, Pittsburgh, PA, October 1985.

"An Improved Method for Instrumenting Blades and Predicting Engine Durability," Pratt and Whitney Aircraft, West Palm Beach, FL, November 1985.

"Dynamic Response of Joint Dominated Space Structures," NASA Langley Research Center, Hampton, VA, January 1986.

"An Improved Method of Instrumenting Gas Turbine Engine Blades," Air Force Aeropropulsion Laboratory, Dayton, OH, March 1986.

"Optimizing Friction Damping in the Space Shuttle Main Engine Oxygen Turbo–Pump," NASA Marshall Space Flight Center, Huntsville, AL, March 1986.

"An Efficient Method for Predicting the Vibratory Response of Linear Structures with Friction Interfaces," Thirty–first International Gas Turbine Conference, Dusseldorf, Germany, June 1986.

"SSME Blade Damper Technology," NASA Conference on Structural Integrity and Durability of Reusable Space Propulsion Systems, NASA Lewis Research Center, Cleveland, OH, May 1987.

"On Predicting the Resonant Response of Bladed Disk Assemblies," Thirty–second International Gas Turbine Conference, Anaheim, CA, June 1987.

"An Integrated Approach for Friction Damper Design," ASME Eleventh Biennial Design Conference on Mechanical Vibration and Noise," Boston, MA, September 1987.

"SSME Blade Damper Technology," NASA Conference on Structural Integrity and Durability of Reusable Space Propulsion Systems, Cleveland, OH, May 1987.

"Evaluation of a Turbine Blade Damper Using an Integrated Approach," AIAA 29th Structures, Structural Dynamics and Materials Conference, Williamsburg, VA, April 1988.

"Transient Response of Joint Dominated Space Structures: A New Linearization Technique," AIAA 29th Structures, Structural Dynamics and Materials Conference, Williamsburg, VA, April 1988.

"Research on Bladed Disk Dynamics and Friction Damping at Carnegie Mellon University," Joint INDO–US Workshop on the Engineering Aspects of the Dynamics of Power Plants, Bangalore, India, February 1988.

"Vibratory Response of Adhesively Bonded, Welded Structures," Ford Research Labs., Detroit, MI, January 1989.

"Blade Vibration with Nonlinear Tip Constraint: Model Development," 34th International Gas Turbine Conference, Toronto, Ontario, Canada, June 1989.

"A New Method for Optimizing Friction Damping in Randomly Excited Systems," 34th International Gas Turbine Conference, Toronto, Ontario, Canada, June 1989.

"Friction Damping of Circular Motion," ASME 12th Biennial Design Conference on Mechanical Vibration and Noise, Montreal, Canada, September 1989.

"Forced Response of Structures with Nonlinear Constraints," Department of Mechanical Engineering, Ohio State University, Columbus, OH, November 1989.

"Torsional Vibration Analysis," Office of Naval Research, Washington, DC, March 1990.

"Analysis of Insert Damper," Pratt & Whitney Aircraft, West Palm Beach, FL, June 1990.

"Research on Bladed Disk Dynamics at CMU," Westinghouse Electric Corporation, Orlando, FL, June 1990.

"Torsional Vibration Test Requirements: History and Current Use," Navy Workshop on Vibration and Noise Test Procedures, Philadelphia, PA, May 1991 (invited panelist).

"Optimizing Instrumentation When Measuring Jet Engine Blade Vibration," 36th ASME International Gas Turbine and Aeroengine Conference, Orlando, FL, June 1991.

"Exploring How Shroud Tip Constraints Can Affect Resonant Response in the HPOTP," NASA Marshall Spaceflight Center, Huntsville, AL, October 1991.

"Friction Damping of Blade Vibration," Dresser–Rand, Wellsville, NY, February 1992.

"Exploring How Shroud Constraints Can Affect Vibratory Response in Turbomachinery," 1992 Conference on Advanced Earth–to–Orbit Propulsion Technology, Huntsville, AL, May 1992.

"Sensitivities of Frequencies and Damping to Geometric Perturbations," Ford Motor Company, Dearborn, MI, July 1992.

"The Sensitivity of the Natural Frequencies and Modal Damping of Adhesively Bonded and Composite Beams, Department of Mechanical Engineering, Carnegie Mellon University, Pittsburgh, PA, September 1992.

"Improving Predictions of Boat Drive Train Vibrations," U.S. Navy Small Craft Symposium, Virginia Beach, VA, May 1993.

"An Integrated Approach for Turbine Blade Friction Damper Design," Mechanical Systems Technology Branch, NASA Lewis Research Center, Cleveland, OH, June 1993.

"Forced Harmonic Response of Grouped Blade Systems—Discrete Theory," International Gas Turbine and Aeroengine Congress and Exposition, The Hague, Netherlands, June 1994.

"Forced Harmonic Response of Grouped Blade Systems—Application," International Gas Turbine and Aeroengine Congress and Exposition, The Hague, Netherlands, June 1994.

"Research Activities at Carnegie Mellon University," Manufacturing Technology Division, CSIRO, Melbourne, Australia, July 1994.

"Improving Prediction of Drive Train Torsional Vibration—a Torsional Vibration Consortium": *Comment:* The purpose of this presentation was to introduce the concept of the Torsional Vibration Consortium to as wide an audience as possible. MTU Motoren– und Turbinen–Union, Systemdynamik Torsionsschwingungen, Friedrichshafen, Germany, June 1994; ZF Friedrichshafen AG, Marine Transmission Systems (SW), Friedrichshafen, Germany, June 14, 1994; Austal Ships Pty. Ltd., Western Australia, Australia, July 1994; Transfield ASI Pty. Ltd., Western Australia, Australia, July 1994; WaveMaster International Pty. Ltd., Western Australia, Australia, July1994; Transfield Defence Systems Division, Transfield Shipbuilding Pty. Ltd., Victoria, Australia, July 1994; Phil Curran Design, Western Australia, Australia, July 1994; Department of Defence, DSTO Australia, Victoria, Australia, July 1994.

"Turbine Blade Mistuning," Aeronautical Research Laboratory, DSTO Australia, Victoria, Australia, July 1994.

"Friction Damping of Circular Motion," Department of Mechanical Engineering, University of Melbourne, Victoria, Australia, July 1994.

"Research Activities at Carnegie Mellon University," Division of Mathematics and Statistics, CSIRO, Sydney, Australia, July 1994.

"Solid Mechanics for Manufacturing," Division of Manufacturing Technology, CSIRO, Victoria, Australia, July 1994. Organized and co–chaired the workshop.

"Forced Response Consortium," Turbine Engine Technology Symposium, Dayton, OH, October 1994.

"The Resonant Response of a Tapered Beam and Its Implications to Blade Vibration," International Gas Turbine Congress and Exposition, Houston, TX, June 1995.

"A Reduced Order Approach for the Vibration of Mistuned Bladed Disk Assemblies," International Gas Turbine Congress and Exposition, Houston, TX, June 1995.

"High Frequency Modes in LAR Blades," Carnegie Mellon University, GUIde Technical Review Meeting, Pittsburgh, PA, November 1995.

"Utilizing Harmonic Mistuning to Optimize the Resonant Response of Turbine Blades," The Pennsylvania State University, State College, PA, November 1995.

"A Normalized Modal Eigenvalue Approach for Resolving Modal Interaction," International Gas Turbine and Aeroengine Congress and Exposition, Birmingham, England, June 1996.

"Friction Damping of Hollow Airfoils: Part I—Theoretical Development," International Gas Turbine and Aeroengine Congress and Exposition, Birmingham, England, June 1996.

"A Rational Method for Optimizing Shroud Damping," International Gas Turbine and Aeroengine Congress and Exposition, Birmingham, England, June 1996.

"Key Issues in the Structural Dynamics of Gas Turbines," Panel Session on High Cycle Fatigue, International Gas Turbine and Aeroengine Congress and Exposition, Birmingham, England, June 1996.

"Tip Modes in Low Aspect Ratio Blades," Second National Turbine Engine HCF Conference, Monterey, CA, December 1996.

"Vibration of Shrouded Bladed Disks with Friction Dampers (a Reduced Order Approach)," Second National Turbine Engine HCF Conference, Monterey, CA, December 1996.

"Mistuned Bladed Disk Vibration," Center for Nonlinear Analysis, Department of Mathematics, Carnegie Mellon University, Pittsburgh, PA, February 1997.

"A Normalized Modal Eigenvalue Approach for Resolving Modal Interaction," Department of Mechanical and Aerospace Engineering, Arizona State University, Phoenix, AZ, February 1997.

"Optimally Measuring Vibratory Strains in Closely Spaced Modes," Allied Signal Engines, Phoenix, AZ, February 1997.

"GUIde Update: 1997," Allied Signal Engines, Phoenix, AZ, February 1997.

"GUIde Consortium: Friction Constraints in Bladed Disk Systems," Air Force Science and Technology High Cycle Fatigue Program Kick-Off, Berkeley, CA, February 1997.

"Reduced Order Models of Mistuned Bladed Disk Vibration," Department of Mechanical Engineering, Ohio State University, Columbus, OH, April 1997.

"Predicting Friction Damping in Shrouded Bladed Disks," GUIde Consortium Review Meeting, Wright-Patterson AFB, OH, August 1997.

"A Consortium Approach to Torsional Vibration," Society of Naval Architects and Marine Engineers—Propellers/Shafting '97 Symposium, Virginia Beach, VA, September 1997.

"Theory and Methodology of Optimally Measuring Vibratory Strains in Closely Spaced Modes," 42nd ASME Gas Turbine and Aeroengine Congress, Exposition and Users Symposium, Orlando, Florida, June 1997.

"Unstable Resonant Response of Shrouded Bladed Disks," Third National Turbine Engine High Cycle Fatigue Conference, San Antonio, TX, February 1998.

"Predicting Friction Damping in Shrouded Bladed Disks," GUIde Consortium Review Meeting, Ohio State University, Columbus, OH, August 1998.

"A New Reduced Order Model for Predicting Bladed Disk Mistuning," Fourth National Turbine Engine High-Cycle Fatigue (HCF) Conference, Monterey, CA, February, 1999.

"Predicting Friction Damping in Shrouded Bladed Disks," GUIde Consortium Review Meeting, University of Michigan, Ann Arbor, MI, August 1999.

"A Reduced Order Model of Mistuning Using a Subset of Nominal System Modes," 1999 ASME 44th ASME Gas Turbine and Aeroengine Congress, Exposition and Users Symposium, Indianapolis, IN, June 1999.

Guest Lecture: "Some Implications of Structural Dynamics to HCF," Fifth National Turbine Engine High-Cycle Fatigue Conference, Chandler, AZ, March 2000.

"A State Space Approach for the Nonlinear Analysis of Frictionally Damped Turbines," Fifth National Turbine Engine High Cycle Fatigue Conference, Chandler, AZ, March 2000

"A Reduced Order Model for Evaluating the Effect of Rotational Speed on the Natural Frequencies and Mode Shapes of Blades," 2000 International Gas Turbine and Aeroengine Congress and Exposition, Munich, Germany, May 2000.

"Research on Friction Damping and Bladed Disk Vibration," NAVAIR Patuxent River, MD, March 2001.

"Mistuning in Bladed Disk Systems," Siemens Westinghouse Power, Orlando FL, July 2001; Hamilton, Ontario, Canada, August 2001.

"Predicting Friction Damping in Shrouded Bladed Disk Assemblies," GUIde Corsortium Annual Meeting, Carnegie Mellon University, Pittsburgh, PA, August 2001.

"Measuring and Predicting Mistuning in High Frequency Modes," GUIde Corsortium Annual Meeting, Carnegie Mellon University, Pittsburgh, PA, August 2001.

"CMU/Imperial College Fundamental Research Program on Mistuning," GUIde Corsortium Annual Meeting, Carnegie Mellon University, Pittsburgh, PA, August 2001.

"System Identification using a Fundamental Model of Mistuning," Pratt & Whitney, East Hartford, CT, October 2001.

"A Fundamental Model of Mistuning in Blade Disks," Purdue University, West Lafayette, IN, November 2001.

"A Simple, Accurate Model of Turbine Blade Mistuning," University of Connecticut, Storrs, CT, November 2001.

"Gas Turbine Vibrations," Carnegie Mellon University, Pittsburgh, PA, January 2002.

"Research on System Identification: Possible Joint Research," Air Force Wright Laboratories, Dayton, OH, May 2002.

"What is the Next Set of Technologies that We Need Beyond those being Developed in the HCF Initiative?" Seventh National Turbine Engine High Cycle Fatigue (HCF) Conference, Palm Beach Gardens, FL, May 2002.

"System Identification of Mistuning using a Fundamental Model," Rolls-Royce, United Kingdom, June 2002.

"System Identification of Mistuning," GUIde Corsortium, General Electric Aircraft Engines, Cincinnati, OH, July 2002.

"CMU/Imperial College Research on Mistuning Structural Dynamics," GUIde Corsortium, General Electric Aircraft Engines, Cincinnati, OH, July 2002.

"Contact Mechanics and Friction Damping," GUIde Corsortium, General Electric Aircraft Engines, Cincinnati, OH, August 2002.

"Research on Mistuning: Possible Joint Research," NASA Glenn, Cleveland, OH, August 2002.

"Experimental Demonstration of Maximum Mistuned Bladed Disk Forced Response", ASME International Gas Turbine and Aeroengine Congress and Exposition, Atlanta, Georgia, June 2003.

"Mistuning Identification Of Bladed Disks Using A Fundamental Mistuning Model – Part I: Theory", ASME International Gas Turbine and Aeroengine Congress and Exposition, Atlanta, Georgia, June 2003.

"Mistuning Identification Of Bladed Disks Using A Fundamental Mistuning Model – Part II: Application", ASME International Gas Turbine and Aeroengine Congress and Exposition, Atlanta, Georgia, June 2003.

"Characterization of Turbine Blade Friction Dampers," 8th National Turbine Engine HCF Conference, Monterey, CA, April 2003.

"System Identification in Higher Modal Density Regions of Bladed Disks," 8th National Turbine Engine HCF Conference, Monterey, CA, April 2003.

"A Completely Experimental Method of Mistuning Identification in Integrally Bladed Rotors," 8th National Turbine Engine HCF Conference, Monterey, CA, April 2003

"The GUIde Consortium (with Commentary)," invited seminar, United Technologies Fellows Speakers Program, May 2003.

"Sensitivity of Tuned bladed Disk Response to Frequency Veering," ASME Turbo Expo 2004 Power for Land, Sea, and Air, Vienna, Austria, June 2004.

"A Fundamental Model of Mistuning for Bladed Disks in Jet Engines," University of Akron College Lecture Series, Akron OH, October 2003.

"Frequency Veering Effects on Mistuned Bladed Disk Forced Response", 2003 AIAA/ ASME/SAE/ASEE Joint Propulsion Conference.

"A Fundamental Model of Mistuning for Bladed Disks," Mitsubishi Heavy Industries, Japan, December 2003.

"Tools for Vibration Analysis of Diaphragms," Siemens Westinghouse, Jupiter FL, February, 2004.

"Physical Models of Friction Constraint and the Effect of Friction on Bladed Disk Dynamics," GUIde Consortium Annual Review Meeting, Pittsburgh, PA, July, 2004.

"Improved Engine Durability," Siemens Westinghouse, Jupiter, FL, October, 2004.

"An Integrated System For Assessing Mistuning In Integrally Bladed Disks," RJLeeGroup, Monroeville, PA, November, 2004.

"Measuring mistuning in Integrally Bladed Disks," AF Research Laboratories, Dayton, OH, December 2004.

"Flutter of Mistuned Bladed Disks and Blisks with Aerodynamic and FMM Structural Coupling," ASME Turbo Expo 2004 Power for Land, Sea, and Air, Vienna, Austria, June 2004.

"Characterization of Turbine Blade Friction Dampers," ASME Turbo Expo 2004 Power for Land, Sea, and Air, Vienna, Austria, June 2004.

"A Reduced Order Model for Transient Analysis of Bladed Disk Forced Response." ASME Turbo Expo 2005 Power for Land, Sea, and Air; Reno, NV; June 2005 (with J.P. Ayers, D.M. Feiner).

"Experimental Study of the Fundamental Mistuning Model for Probabilistic Analysis," ASME Turbo Expo 2005 Power for Land, Sea and Air; June 2005, Reno, NV. (with M.R. Rossi, D.M. Feiner).

"Experimental Study of the Fundamental Mistuning Model for Probabilistic Analysis", National Turbine Engine High Cycle Fatigue Conference, March 2004; Pinehurst, N.C. (with M.R. Rossi and D.M. Feiner).

"Exploring the Use of FMM ID for Engine Health Monitoring", National Turbine Engine High Cycle Fatigue Conference, March 2004; Pinehurst, N.C. (with D.M. Feiner).

"A Reduced Order Model for Transient Analysis of Transient Analysis of Bladed Disk Forced Response", National Turbine Engine High Cycle Fatigue Conference, March 2004; Pinehurst, N.C. (with J.P. Ayers and D.M. Feiner).

"Probabilistic Analysis of Mistuned Bladed Disks and Blisks with Aerodynamic and FMM Structural Coupling", National Turbine Engine High Cycle Fatigue Conference, March 2004; Pinehurst, N.C., (with R.E. Kielb, D.M.Feiner, R. Miyakozawa).

"Dynamic Behavior of Spherical Friction Dampers and its Implication to Damper Contact Stiffness," ASME Turbo Expo 2006 Power for Land, Sea, and Air, May 2006, Barcelona, Spain (with K-H. Koh).

"Identification of Damping Variations in Mistuned Bladed Disks," 10th National Turbine Engine High Cycle Fatigue (HCF) Conference, March 2005, New Orleans, LA (with D.M. Feiner).

"The Dynamic Behavior of a Spherical Friction Damper," 10th National Turbine Engine High Cycle Fatigue (HCF) Conference, March 2005, New Orleans, LA (with K.H. Koh).

"Reducing Mistuning Effects by Optimally Switching Blades," 10th National Turbine Engine High Cycle Fatigue (HCF) Conference, March 2005, New Orleans, LA (with J.P. Ayers, D.M. Feiner).

"Aerodynamic and Structural Coupling Effects on Mistuned Bladed Disk Response," 10th National Turbine Engine High Cycle Fatigue (HCF) Conference, March 2005, New Orleans, LA (with R. Kielb, T. Miyakozawa, D. Feiner and S. Pai).

"The Concept of An Automated Field Mistuning Inspection System," DOD 2006 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2006, Jacksonville, FL (with D.M. Feiner).

"An Automated IBR Field Mistuning Inspection System," DOD 2006 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2006, Jacksonville, FL (with D.M. Feiner).

"Identifying Mistuning in Regions of High Modal Density," DOD 2006 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2006, Jacksonville, FL (with B.J.Staskowski, D.Feiner).

"Laser Shock Peening Changes the Frequencies of Compressor Blades," DOD 2006 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2006, Jacksonville, FL (with B.J.Staskowski and D.M.Feiner).

"The Dynamic Behavior of a Wedge-Type Spherical Friction Damper," DOD 2006 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2006, Jacksonville, FL (with K.H. Koh).

"Mistuning Identification in Bladed Disks," DOD 2007 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2007, San Diego, CA (with D.M. Feiner).

"Damping Identification in Mistuned Bladed Disks," DOD 2007 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2007, San Diego, CA (with D.M. Feiner).

"Aerodynamic and Structural Mistuning Technologies for Assessing Repairs of Integrally Bladed Rotors," DOD 2008 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2008, Myrtle Beach, SC (with D.M. Feiner, R. Kielb, and K.C. Hall).

"A Field Inspection Mistuning Tool and Systematic Approach for Assessing and Managing Mistuning in IBRs/Blisks," DOD 2008 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2008, Myrtle Beach, SC (with D.M. Feiner and B. Echols).

"Blade Inspection Technologies," DOD 2009 Propulsion, Safety and Affordable Readiness Conference, March 2009, Jacksonville, FL.

"Managing HCF Using SBIR Developed Vibration Testing and Analysis Technologies," DOD 2010 Propulsion, Safety and Affordable Readiness (P-SAR) Conference, March 2010, Jacksonville, FL.

EDUCATION ACTIVITIES

TEACHING

The Benjamin Richard Teare Teaching Award

Prof. Griffin received the 1997 Teare Teaching Award from the Carnegie Institute of Technology, the College of Engineering at CMU. The basis of the selection is excellence in engineering education in the areas of teaching, educational innovation, and educational leadership.

Professor of the Year Award

Prof. Griffin received from the Senior Class the Mechanical Engineering Professor of the Year Award in 1994, the first year it was awarded, and again in 2002. The award reads, "In recognition of outstanding contributions to the undergraduate experience in the Department of Mechanical Engineering at Carnegie Mellon University."

Faculty Course Evaluations

Prof. Griffin's average Faculty Course Evaluations scores while at CMU (1980-present) are:

Overall course: 4.46 out of a possible 5.0
Overall teaching: 4.54 out of a possible 5.0

Courses Taught at CMU

Undergraduate: Concepts of Engineering: Engineering Analysis, Dynamics, Dynamics and Vibration; Engineering Vibrations; Stress Analysis; Numerical Methods; Dynamic Systems and Controls.

Graduate: Advanced Topics in Solid Mechanics: Nonlinear Vibration; Introduction to Solid Mechanics; Mathematical Techniques in Mechanical Engineering; Numerical Methods in Mechanical Engineering; Advanced Topics in Solid Mechanics: Vibration of Turbomachinery.

COURSE AND LABORATORY DEVELOPMENT

Graduate Education: Course Development

Prof. Griffin developed two graduate mathematics courses at Carnegie Mellon that are an integral part of the graduate program. Also, he developed a new specialty course in his research area. The courses are:

- Mathematical Techniques in Mechanical Engineering

A course on analytical methods for solving ordinary and partial differential equations

- Numerical Methods in Mechanical Engineering

  The methods covered in this course introduce graduate students to the tools they need for using numerical methods in their research

- Vibration of Turbomachinery

  This course is an advanced graduate course in vibration which explores the unique vibratory characteristics and problems associated with gas turbine engines. This course presents the results of Prof. Griffin's twenty years of experience as a researcher into the causes of vibration induced failures of turbine components. The similarity of turbine systems to other important cyclic periodic structures is discussed so that students can understand the physical implications to a broader class of systems, e.g., brake systems, magnetic disk drives, etc.

Undergraduate Education: Course Development

Prof. Griffin updated and modernized two undergraduate courses:

- Engineering Vibrations

  The students first gain an understanding of how simple systems vibrate. Then they learn that complicated systems have "modes" of vibration that behave in a very similar way to simple systems. This understanding of modal response provides a fundamental way of viewing vibratory response in complex systems. Additional goals of the course are for the students to develop an understanding of some modern analytical and experimental techniques: computer simulation, finite element, spectral and modal analysis.

- Stress Analysis

  This course provides concepts and methods that are useful in mechanical design. It deals with why components break, especially from fatigue. It includes the following topics: buckling, Mohr's circle, two dimensional elasticity, finite element methods, stress concentrations, fatigue, singular problems in elasticity, and fracture mechanics.

Laboratory Development

Professor Griffin was instrumental in modernizing educational laboratories.

- Undergraduate Computer Laboratory

  Prof. Griffin was instrumental in introducing modern finite element methods (FEM) to the undergraduates. Prof. Griffin co-wrote the proposal for the AT&T grant of computers for an undergraduate computer laboratory and negotiated a grant for finite element software from ALGOR for use in the lab. He used the

finite element software as a computational laboratory that complements his experimental laboratories in both Stress Analysis and in Engineering Vibrations.

- Vibration Laboratory

  Prof. Griffin co-wrote a proposal to Hewlett Packard for an equipment grant of oscilloscopes, plotters, and spectral analyzers for use by students in the Engineering Vibrations lab.

UNDERGRADUATE COMMITTEE CHAIRMAN

Prof. Griffin was Chairman of the Mechanical Engineering Undergraduate Committee from 1995 to 1999 and from 2004 to 2005. During this time the UG Committee was very active. Some of the new initiatives were:

New Mechanical Engineering Curriculum

Prof. Griffin was a member of the Undergraduate Committee (Chaired by Prof. T. Shih) in 1994 that developed the initial plan for the new Mechanical Engineering curriculum. Prof. Griffin then became the Chairman of the Undergraduate Committee in 1995 and was responsible for its planning and final approval.

The key attribute of the new curriculum is that it provides Mech E students with more flexibility in tailoring their undergraduate education to their specific needs while maintaining a required core of key material.

Accelerated Graduate Program

Prof. Griffin introduced and developed the idea of an Accelerated Graduate Program for CMU undergraduates, which allows them to complete both BS and MS degrees in four and one half years.

Undergraduate Internship Program

Prof. Griffin initiated the idea of developing a formal undergraduate internship program for CMU Mechanical Engineering students. This program has now been completely transferred to the Career Center and has been expanded to include students from all Engineering Departments.

Hands-on Engineering Initiative

As Chairman of the Undergraduate Committee, Prof. Griffin met with the undergraduate Student Advisory Committee (SAC) on a regular basis. One result was a new faculty and student committee to develop and integrate additional hands-on learning experiences into the curriculum.

New Robotics Minor

A new Robotics Minor is now one of the most popular minors in the College of Engineering.

Undergraduate Handbook

A handbook was developed which provides information that helps the student have a better undergraduate experience, e.g. information about minors and areas of concentration, the student foreign exchange program, internships, as well as, the finer points of satisfying the degree requirements.

Town Meeting Initiative

Prof. Griffin proposed and organized the first "Town Meeting" of the Mechanical Engineering Faculty with the undergraduate students to discuss ways to improve the program. A number of specific suggestions were made and have either been implemented or are under consideration by the Department.

MEMBER, UNIVERSITY COMMITTEES

Chairman, Mechanical Engineering Undergraduate Committee (2004-2005)
Member, Mechanical Engineering Graduate Committee (2000-2001)
Chairman, Mechanical Engineering Undergraduate Committee (1995-1999)
Member, College of Engineering Ad Hoc Committee for Faculty Promotion (1989–1995, and 1997-1999)
Member, CIT Undergraduate Education Committee (1994–1995)
Member, University Review Committee for Tenured Promotion (1992–1993)
Member, Mechanical Engineering Visiting Committee Advisory Board (1991–1992)
Chairman, CIT Dean's Search Committee (1988)
Member, Mechanical Engineering Department Head Search Committee (1984–1985)
Member, University Review Committee For Reappointment and Non-tenured Promotions (1983–1985)
Represented Mechanical Engineering at CMU Planning Retreat (1984)
Member, Faculty Senate (1981–1983)
Chairman, Solid Mechanics Faculty Search Committee (1981–1982)

PROJECTS SUPERVISED

Advisor, Post Doctoral Fellows:

W. Wu, Technical Director for the Torsional Vibration Consortium (1993–1997).
M. Yang, Tip Mode Vibration in Low Aspect Ratio Blades (1994–1998).
N. Kim, Reduced Order Models of Frictionally Damped Bladed Disks (1999 – 2004).
D. Feiner, System Identification in Mistuned Bladed Disks (2003 – 2005).
K. Koh, Physical Models of Friction Damping (2005-2007).

Advisor, Ph.D. Projects:

Sinha, Friction Damping of Flutter in Gas Turbine Engines (1983).
Current Position: Professor of Mechanical Engineering, Penn State University.

C–H. Menq, The Vibratory Response of Frictionally Constrained Gas Turbine Engine Blades (1985).
Current Position: Professor of Mechanical Engineering, Ohio State University.

T. Cameron, Response of Frictionally Damped Systems Subjected to Multiple Discrete Frequencies and Random Excitations (1988).
Current Position: Professor of Mechanical Engineering, G.M. Institute, Flint, MI.

S. Cunningham, The Effect of Transients on Crack Tip Stress Fields During Thermal Fatigue Loading (1988).
Current Position: Florida Turbine Technologies

N. Kim, Analytical and Experimental Investigation of Vibratory Response in Adhesively Bonded and Composite Structures (1991).

L. Wagner, Vibration Analysis of Grouped Turbine Blades (1993).
Current Position: Westinghouse.

W. Wu, Stability Analysis and Steady State Response of Periodic Systems (1993).
Current Position: Pratt & Whitney Aircraft, UTC.

M. Yang, Modeling the Effect of Shroud Contact and Friction Dampers on the Mistuned Response of Turbopumps (1994).
Current Position: Pratt & Whitney Aircraft, UTC.

J. Kenyon, Air Force Palace Knights Fellow, Optimizing Mistuning for Robust Design (2003).
Current Position: Associate Director, Aerospace Technology, Office of the Deputy Undersecretary of Defense.

K. Koh, Physical Models of Friction Dampers (2005).
Current Position: Nanoprecision Products, Inc.

D. Feiner, DOD Fellow, System Identification in Bladed Disk Assemblies (2004).
Current Position: Blade Diagnostics Corporation.

B. Staskowski, A Reduced Order Model of Disk Mode/Blade Modes Interaction (2010)
Current Position: Blade Diagnostics Corporation.

Advisor, Master Degree Projects:

M. Okajima, Computation of Path–Independent Integrals for Elastic Notch Problems (1981) (with G. Sinclair).

J. Hahn, Analyses of Selected Vibration, Elasticity and Plasticity Problems Using the ANSYS General Purpose Finite Element Code (1982).

T. Hoosac, The Development of Efficient Computer Algorithms for the Statistical Simulation of the Forced Response of Mistuned Turbine Stages (1982–1983).

R. Knepper, Experimental Research in Nonlinear Vibrations: Amplitude Reduction Achieved Through Friction Damping (1983).

M. Maleck, Fatigue Testing of Specimens with Sharp Re–entrant Corners (1983–1984).

P. Basu, Aerodynamic and Structural Coupling of Gas Turbine Engine Bladed Disk Assemblies (1982–1984).

T. Cameron, The Development and Testing of a Magnetically Controlled, Frictionally Damped Bladed Disk (1983–1985).
S. Cunningham, The Influence of Electric Current on Crack Tip Stresses During Thermal Fatigue Testing (1984–1985).
G. Foelsche, Response of Joint Dominated Space Structures (1985–1986).
S. T. Hsu, How Gravity and Joint Scaling Affect the Dynamic Response of Space Structures (1987).
G. Meda, Torsional Vibration Analysis of Navy Small Craft Drive Trains (August 1986–August 1988).
W. Wu, Optimization of the Design of Boat Drive Trains (January 1988–August 1989).
B. Hsu, Automatic Methods for Performing Finite Element Analyses (August 1988–May 1990).
C. Shao, Design Fusion Project: Concurrent Design of Turbine Blades (October 1989–May 1991).
J. Bernhardt, Modelling Microslip in Friction Interfaces (May 1990–May 1991).
P. Mastilovic, Measuring the Properties of Flexible Couplings (August 1991–May 1992).
P. Choteborsky, Microslip in Flanges (August 1992–May 1993).
G. Balagi, Tip Modes in Low Aspect Ratio Blades (August 1992–August 1994).
K. Li, Continuum Model of Mistuning (January 1992–May 94).
K. Buttler, Friction Constraints in Shrouded Blades (August 95 - June 97)
P. Marugabandhu, System Identification in Integrally Bladed Disks (August 98 – August 00)
D. Feiner, Highly Sensitive Response in Shrouded Bladed Disks (August 98 – August 00)
M. Rossi, Experimental Study Of The Fundamental Mistuning Model (Fmm) For Probabilistic Analysis (December 03 – September 04)
J. Ayers, A Reduced Order Model For Transient Analysis Of Bladed Disk Forced Response (June 03 – present)

Advisor, Undergraduate Projects:

A. Field and J. Mullans, Design and Construction of an Experiment for Evaluating Friction Damping of Airfoil Flutter (Fall 1981).
H. Stoller, Development of Computer Codes for Predicting Subcritical Crack Growth (Summer 1982).
M. Davies, An Experimental Investigation of Instability in Vibrating Systems (1988–1989).
J. Sanders, Torsional Vibration of Boat Drive Trains (Fall 1989).
J. Saccani, Experimental Investigation of Friction Damping in Flanges (Fall 1992).
V. Hahn, Investigation into Experimental Techniques in Vibrations and Modeling the Damping Properties of Various Fiber Metal Alloys (Fall 1993–Spring 1994).
T. Libby, Dynamic Response of Buggies (Fall 1993–Spring 1994).
D. Kammerer, Magnetic Excitation of Turbine Blades (Spring 1994).
D. Chg, Torsional Response of Drive Trains (Fall 1994–Spring 1995).
P. J. Manautou, Development of a Torsional Test Machine (Spring 1996-Fall 1997).