

49th American Helicopter Society International Annual Forum 1993

**St. Louis, Missouri, USA
19 – 21 May 1993**

Volume 1 of 2

ISBN: 978-1-61782-944-4

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.
These proceedings were created from a scanned original document, and are the best quality available.**

Copyright© (1993) by the American Helicopter Society International
All rights reserved.

Printed by Curran Associates, Inc. (2011)

For permission requests, please contact the American Helicopter Society International
at the address below.

American Helicopter Society International
217 N. Washington Street
Alexandria, VA 22314-2538

Phone (703) 684-6777
Fax: (703) 739-9279

staff@vtol.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2634
Email: curran@proceedings.com
Web: www.proceedings.com

TABLE OF CONTENTS

Volume 1

ACOUSTICS

Noise Certification of Bell Model 412, 230, and 206L-4 Helicopters	1
<i>C. Cox, S. Shank, J. Brieger, T. Settle</i>	
Flight Measurements of Blade-vortex Interaction Noise Including Comparisons with Full-scale Wind Tunnel Data	26
<i>G. Yamauchi, D. Signor, M. Watts, F. Hernandez, P. Lemasurier</i>	
A Computational Study of the Aeroacoustics of Rotors in Hover	55
<i>J. Baeder, J. Gallman, Y. Yu</i>	
The Importance of Tail Rotor Interaction as an Acoustic Source	72
<i>J. Leverton, T. Pike</i>	
Helicopter Main Rotor/Tail Rotor Noise Radiation Characteristics from Scaled Model Rotor Experiments in the DNW	88
<i>K. Schultz, W. Splettstoesser</i>	

STRUCTURES & MATERIALS I

Structural Integrity of Composite Flexbeams	99
<i>A. Vizzini, S. Lee</i>	
Strength and Damage Tolerance Evaluation of Sandwich Structure Manufactured Utilizing the Automated Tow-Placement Process	110
<i>S. Llorente, R. Fay, L. Kitson</i>	
Performance of Composite Joints Utilizing Thermoplastic Fasteners	120
<i>A. Sawicki</i>	
Advanced Composite Main Rotor Flexbeam from Optimization to Full Scale Multicomponent and Whirl Tower Testing	131
<i>B. Hamilton, N. Bell, R. Murrill, S. Flores, L. Lucchetto</i>	
Injection Molded Notar® Fan Blade for Helicopter Dynamic Application	151
<i>S. Chen, R. Patel</i>	
Bearing Fatigue and Hole Elongation in Composite Bolted Joints	156
<i>P. Grant, N. Nguyen, A. Sawicki</i>	
Low Temperature Curing Adhesives for Repair	164
<i>D. Ruffner, R. Patel</i>	

HANDLING QUALITIES

Identification of UH-60 Stability Derivative Models in Hover from Flight Test Data	173
<i>J. Fletcher</i>	
V-22 Load Limiting Control Law Development	201
<i>D. King, C. Dabundo, R. Kisor, A. Agnihotri</i>	
The European ACT Programme: A Collaborative Approach to Handling Qualities Evaluation and Control Law Design	215
<i>M. Charlton, C. Guyomard, R. Lane, H. Modden, D. Schimke, A. Taghizad</i>	
Flight Evaluation of the New Handling Qualities Criteria Using the BO 105	237
<i>C. Ockier</i>	
Flight Simulation Model Application for AH-64A Apache Engine Integration	250
<i>P. Shanthakumaran, J. Harding, T. Thompson, M. Kuehn, D. Monroe</i>	
Helicopter Robust Nonlinear Controller Synthesis Using Approximate Linearization	272
<i>J. Leitner, J. Prasad</i>	

CREW STATIONS & HUMAN FACTORS

Active Man-machine Interface for Advanced Rotorcraft	286
<i>A. Zaklad, M. Weiland, W. Zachary, C. Fry</i>	
Inadvertent Helicopter Air Bag Deployment - Evaluation of the Effects in a Flight Simulator	295
<i>L. Bark, R. Zimmermann, K. Smith</i>	
Human Engineering Maintenance Analyses for the RAH-66 Comanche	305
<i>E. Wunsh, J. Grenell</i>	

AVIONICS & SYSTEMS

Fluidic Backup Flight Control and Integrated Pump-actuator for Advanced FBW Rotorcraft	323
<i>D. Muggeridge, J. Day, J. Berger</i>	
Integrated Fire, Flight and Propulsion Controls (IFFC) for a Rotorcraft Weapon System.....	337
<i>J. Edwards</i>	
Development of a Large AEW/Ground Target Radar for a Shipboard Compatible Tiltrotor Aircraft	347
<i>R. Pruyn, C. Lonroth</i>	

FLIGHT SIMULATION

An Aeroelastic Model Structure Investigation for a Manned Real-time Rotorcraft Simulation	357
<i>W. Lewis</i>	
Evaluation of Simulation Motion Fidelity Criteria in the Vertical and Directional Axis	385
<i>J. Schroeder</i>	
Application of Real-time Flight Simulation for Design of a Helicopter Obstacle Avoidance System	404
<i>C. Sullivan, E. Wood, J. Demaio</i>	
Real Time Implementation Aspects of a Rotorcraft Turbulence Simulation Method	423
<i>J. Prasad, G. Gaonkar, J. Riaz, D. Yingyi</i>	
Civil Tiltrotor: Flight Simulation Development of Instrument Procedures	429
<i>P. Klein, P. Wilkinson, L. Zmroczek</i>	
System Identificaiton Validation of an AH-64 Aeroelastic Simulation Model.....	444
<i>S. Sturisky, D. Schrage</i>	

MANUFACTURING & PRODUCT ASSURANCE I

Fabrication of the Notar[®] Tailboom for the MD Explorer.....	468
<i>P. Jouin, R. Kulesha, G. Schindler</i>	
Cost-effective Production of Helicopter Energy-absorbing Subfloor Structures with Advanced Thermoplastic Composites.....	479
<i>L. Bark, G. Yaniv, D. Orlino</i>	
Experiments and Modeling of Residual Deformations in the Manufacturing of Sandwich and Laminated Composite Structures.....	490
<i>P. Handel, P. Minguet</i>	
Laser Based Alignment, Advanced Manufacturing Techniques.....	500
<i>G. Confalone</i>	
Experimental Design Application: Udimet 720 Broaching Optimization	515
<i>D. Nowatney</i>	

AERODYNAMICS I

The Application of Computational Vorticity Confinement to Helicopter Rotor and Body Flows	518
<i>C. Wang, J. Bridgeman, J. Steinhoff, Y. Wenren</i>	
The Application of Vorticity Embedding to the Computation of Advancing Rotor Flows.....	532
<i>K. Ramachandran, S. Schlechtriem, F. Caradonna, J. Steinhoff</i>	
Vorticity Concentration at the Edge of the Inboard Vortex Sheet	545
<i>J. Kim, K. Komerath, S. Liou</i>	

A Consistent Approach for Modeling the Aerodynamics of Self-generated Rotor Blade-vortex Interactions	556
<i>A. Hassan, B. Charles, H. Tadghighi, C. Burley</i>	
A Fast Adaptive Resolution Method for Efficient Free Wake Calculations	575
<i>W. Miller</i>	
Unsteady Compressible Rotor Airfoil Aerodynamics Using an Automated Adaptive Finite Element Method.....	589
<i>B. Webster, M. Shephard, Z. Rusak</i>	
Dynamic Stall Correlation of a Rotor/Wing Navier-Stokes Solver on a Massively-Parallel Computer	607
<i>B. Wake, P. Lorber</i>	

MILITARY OPERATIONS

Scenario Analysis for VTOL Vehicles using an Interactive Environment.....	622
<i>T. Turpin, F. McQuillan</i>	
Apache Modernization - The User's Perspective	637
<i>D. Sale, G. Lund</i>	
Shipboard Suitability and the UAV	644
<i>B. Scholes</i>	
Development of a Realistic Combat Environment for Operational Testing	656
<i>L. Weidell</i>	
The OH-58D Kiowa Warrior: "The Spirit of the Cavalry" and "The Enemy's Worst Nightmare.....	662
<i>T. Cordrey, R. Cumbie</i>	
V-22 Osprey Survivability Tradeoff Studies	675
<i>B. Hegdahl</i>	

Volume 2

STRUCTURES & MATERIALS II

Rival Rotorcraft Water Impact Crash Simulation Using Program Krash	686
<i>G. Wittlin, M. Rapaport</i>	
Procedures Used to Ensure Strength, Endurance and Damage Tolerance of MIL Helicopter Fuselages (MI-26, MI-28, etc.)	697
<i>Z. Shnurov</i>	
Advanced Aluminum Alloys for Improved Rotorcraft Reliability	713
<i>G. Nanni</i>	
Flight Service Evaluation of Composite Components on the Bell Model 206L Helicopter.....	719
<i>S. Smith, H. Wilson</i>	
Systematic Application of Holometric Synthesis for Cost-effective Flight Load Monitoring.....	740
<i>B. Gustavson, W. Pellum, E. Robeson</i>	
Development of a Crashworthy Crewseat for the Kaman K-1200 Helicopter.....	760
<i>M. Richards</i>	

MANUFACTURING & PRODUCT ASSURANCE II

Flow Reduction Efforts Benefit from Computer Simulation	774
<i>S. Cooper</i>	
Rapid Prototyping for the Development of Gas Turbine Engines.....	781
<i>M. Hyduke, R. Chu</i>	
Automated Harness Design and Process Planning.....	792
<i>G. Geanuracos, J. Hollis</i>	
Small Diameter Wire Marking for Light Weight Electrical Interconnections Systems	798
<i>M. Rowland</i>	
Integration of Avionics Troubleshooting System with Interactive Electronic Technical Manuals.....	805
<i>J. Gulick, E. Kell</i>	

AIRCRAFT DESIGN I

The Design Evolution of the Canard Rotor/Wing	814
<i>J. Rutherford, S. Bass</i>	
Advanced Civil Tiltrotor Design Optimization and Issues	824
<i>D. Schleicher</i>	
Some European Considerations On Civil Tilt-Rotor Efficiency And Viability	841
<i>J. Renaud, J. Weisse, B. Allard, W. Muggli, D. Ingram</i>	
Analysis of Helicopter Air-to-Air Combat Tests, Design Implications	856
<i>K. Amer</i>	
Variable Design Criteria for Rotary Wing Aircraft Crash Resistance	880
<i>L. Burrows</i>	
The EH101 Helicopter - A Review of its Capabilities and Technology	891
<i>C. Battison</i>	
The Tilt Wing Design for a Family of High Speed VSTOL Aircraft	899
<i>W. Chana, T. Sullivan</i>	

DYNAMICS I

Stability of the Sikorsky S-76 Bearingless Main Rotor	917
<i>J. Wang, J. Duh, J. Fuh, S. Kottapalli</i>	
Correlation of Experimental Flap-lag-torsion Damping - A Case Study	944
<i>D. Andrade, D. Peters</i>	
Experimental Investigation of Main Rotor Wake Induced Empennage Vibratory Airloads for the RAH-66 Comanche Helicopter	961
<i>K. Frederickson, J. Lamb</i>	
Ground Vibrations Tests for the High Speed Dolphin Helicopter	972
<i>L. Girard, P. Lubrina</i>	
Full-scale Higher Harmonic Control Research to Reduce Hub Loads and Noise	985
<i>S. Kottapalli, S. Swanson, P. Lemasurier, J. Wang</i>	
Dynamics of a Rotor with Nonharmonic Control	997
<i>F. Straub, L. Robinson</i>	
The Practical Implentation of an Actively Controlled Flap to Reduce Vibrations in Helicopter Rotors	1009
<i>T. Millott, P. Friedmann</i>	

AERODYNAMICS II

Laser Velocimetry and Blade Pressure Measurements or a Blade-Vortex Interaction	1023
<i>S. Gorton, D. Poling, L. Dadone</i>	
Investigation of Empennage Airloads Induced by a Helicopter Main Rotor Wake	1050
<i>M. Torok, D. Ream</i>	
High Lift Concepts for Rotorcraft Applications	1067
<i>Y. Yu, S. Lee, K. McAlister, C. Tung, C. Wang</i>	
V-22 Flight Test Aerodynamic Refinements	1093
<i>M. Savage, M. Farrell, W. Grauer, M. McVeigh</i>	
Reduction of Tiltrotor Download	1102
<i>T. Wood, M. Peryea</i>	
Detailed Aerodynamic Design of the RAH-66 FANTAILTM Using CFD	1117
<i>R. Rajagopalan, C. Keys</i>	

PRODUCT SUPPORT

Integration of Publications, Training, and LSa to Support a Mature Fleet	1131
<i>M. Anderson III</i>	
Changing Role of the Contractor Field Technical Representative	1137
<i>V. Parziale</i>	
Supporting Mature Aircraft in a Decreasing Budget Environment	1140
<i>A. Conti, R. Crann, D. Gearhart</i>	

Smoothing the CH-47D With the Observe, an on Board Vibration Analyzer, Tracker, and Balancer	1148
<i>S. Crews, V. Berger</i>	

DYNAMICS II

Correlation of the LYNX-XZ170 Flight-test Results up to and Beyond the Stall Boundary.....	1154
<i>B. Lau, A. Louie, C. Sotiriou, N. Griffiths</i>	
High Speed Tiltrotors: Dynamics Methodology	1173
<i>M. Moore, M. Yablonski, B. Mathew, J. Liu</i>	
Bearingless Main Rotor Whirl Test: Design, Analysis And Test Results	1187
<i>R. Murrill, B. Hamilton, V. Anand, D. Lauson, B. Tuttle</i>	
Aeroelastic Stability Of The Mcdonnell Douglas Advanced Bearingless Rotor	1201
<i>K. Nguyen, M. McNulty, V. Anand, D. Lauzon</i>	
Measurements Of Unsteady Pressure On A Pitching Rotor Blade.....	1209
<i>M. Lal, S. Liou, G. Pierce, N. Komerath</i>	
Wind Thnnel Modeling of Higb Order Rotor Vibration	1223
<i>J. Staley, M. Mathew, F. Tarzanin Jr.</i>	

AIRCRAFT DESIGN II

A Feasibility Study Of Using Smart Materials For Rotor Control.....	1237
<i>F. Straub</i>	
Aeroelastic Optimization Of A Helicopter Rotor With Composite Tailoring.....	1250
<i>R. Ganguli, I. Chopra</i>	
The Combat Suitability Filter for the VECrR Project: (The Culmill4ltion of the Concept Analysis Process).....	1270
<i>J. Davis</i>	
Material Applications To A Light Helicopter	1283
<i>R. Taylor, K. Nunn, C. Rogers</i>	
Downwash Design Criteria for VTOL Aircraft	1294
<i>K. Stanzione, L. Oliver</i>	
Optimum Design Of High Speed Prop Rotors Including The Coupling Of Performance, Aeroelastic Stability And S1tructures.....	1310
<i>A. Chattopadhyay, T. McCarthy, J. Madden III</i>	
Applying Technology for Cost Effective Upgrades.....	1321
<i>T. Bartley</i>	

PROPULSION

Composite Inlet Housing for the T55 Engine	1328
<i>B. Pickett, A. Ben-Porat</i>	
Integrated Flight /Propulsion Control For Helicopters.....	1341
<i>S. Rock, W. Neighbors</i>	
Practical Application of Health and Usage Monitoring (HUMS) to Helicopter Rotor, Engine, and Drive Systems.....	1353
<i>J. Cronkhite</i>	
AH 64 Apache External Air Partic Le Separator (EAPS) Design And Performance	1364
<i>K. Boyd, R. Burgess</i>	
Seasprite Oil Out Transmission Testing	1387
<i>M. Abdelmaseh, C. Orkin, E. Sikorski</i>	
The Compound Helicopter - The Rotorcraft of the 21st Century?.....	1401
<i>T. Jordan, D. Humperson, B. Bengert</i>	

TEST & EVALUATION

Flight Research Of MI-26 Heucopter Transportation Of External Parallelepiped Cargo With Stabilizing And Aerodynamic Drag Reduction Means.....	1409
<i>V. Kozlovsky, N. Sumovsky, S. Barabesh, S. Isaev</i>	

Recent NOTAR® Anti-Torque System Research and Testing at MDHC.....	1412
<i>S. Dawson, T. Thompson</i>	
Certification Of Model 230 Helicopter For Category 'A' Elevated Helipad Operations	1424
<i>J. Goldenberge, L. Meslin, M. Blondino, D. Williams</i>	
Full-scale Wind Tunnel Evaluation of the Sikorsky Five-bladed Bearingless Main Rotor	1433
<i>T. Norman, C. Cooper, C. Fredrickson, J. Herter</i>	
Variable Diameter Tiltrotor Wind Tunnel Test Results.....	1450
<i>K. Studebaker, D. Matuska</i>	
A Full-scale Test of the McDonnell Douglas Advanced Bearingless Rotor in the NASA Ames 40- by 80-Ft Wind Tunnel	1459
<i>M. McNulty, S. Jacklin, B. Lau</i>	
Author Index	