

Multidisciplinary Design Optimization

Papers Presented at the AIAA Aviation Forum 2022

Chicago, Illinois, USA and Online
27 June – 1 July 2022

Volume 1 of 2

ISBN: 978-1-7138-5997-0

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.

The contents of this work are copyrighted and additional reproduction in whole or in part are expressly prohibited without the prior written permission of the Publisher or copyright holder. The resale of the entire proceeding as received from CURRAN is permitted.

For reprint permission, please contact AIAA's Business Manager, Technical Papers. Contact by phone at 703-264-7500; fax at 703-264-7551 or by mail at 34922 Uwptkug'Xcmg{ 'F tkxg."Uwkug"422, Reston, VA 20191, USA.

TABLE OF CONTENTS

VOLUME 1

AERODYNAMIC SHAPE OPTIMIZATION I

Active Flow Control Optimization with Stability Guarantees.....	1
<i>Luiz Victor R. Repolho Cagliari, Tucker Babcock, Jason E. Hicken, Sandipan Mishra</i>	
High-Fidelity Aerodynamic and Aeroacoustic Multi-Objective Bayesian Optimization.....	23
<i>Sihyeong Lim, Andrea Garbo, Philipp Bekemeyer, Christina Appel, Roland Ewert, Jan Delfs</i>	
Development of an Optimization Framework for a Circulation Control Morphing Wing	40
<i>Micajah Schweikert, Krishnakumar Patel, Konstantinos Kanistras</i>	
A Convex Optimization Approach to Thin Airfoil Design	58
<i>Daniel Berkenstock, Juan J. Alonso, Laurent Lessard</i>	

AEROELASTIC AND AEROSTRUCTURAL OPTIMIZATION I

Wing Aerodynamic Shape Optimization with Time Spectral Limit-Cycle Oscillation Adjoint	73
<i>Sicheng He, Eirikur Jonsson, Joaquim R. Martins</i>	
Aero-Structural Discrete Adjoint Sensitivities in SU2 Using Algorithmic Differentiation.....	96
<i>Harsh C. Patel, Alessandro A. Gastaldi, Christian Breitsamter, Fernass Daoud, Juan J. Alonso</i>	
Coupled Aerostructural Optimization Using High-Fidelity Aerodynamics and Surrogate Modeling for the Structure.....	114
<i>Joshua E. Fontana, Pat Piperni, Zhi Yang, Dimitri J. Mavriplis</i>	
Improved Surrogate-Based Design Optimization of Composite Rotor Blades	150
<i>Dawoon Lee, Yu-Eop Kang, Do-Hyung Kim, Kwanjung Yee</i>	

AERODYNAMIC DESIGN: ANALYSIS, METHODOLOGIES, AND OPTIMIZATION TECHNIQUES I

A Mathematical Method for Modelling Compliant Camber Morphing Airfoil Geometries	171
<i>Vijay Anand, Harshini Aich, Santanu Ghosh</i>	
Optimisation of Symmetrical Aerofoils for a Vertical Axis Wind Turbine.....	183
<i>Marcello Righi, David Anderegg, Leonardo Manfriani, Michael Ammann, Christian Oram, Anil Yildirim, Joaquim R. Martins, Oier Coretti</i>	
Managing the Vortices on the Aerostructures with Riblets Oscillating by Liquid Metal Actuators in the Laminar Flows.....	197
<i>Masoud Naghdi, Mostafa Hassanalian</i>	
Ground Effects on Mach Cutoff Phenomena of Sonic Boom.....	215
<i>Rei Yamashita, Yoshikazu Makino</i>	

Parametric Design and Investigation of Grid Fin Aerodynamics in Supersonic Flow Using Computational Fluid Dynamics.....	231
<i>Erdem Dincer, Nilay Sezer Uzol</i>	

AERODYNAMIC DESIGN: ANALYSIS, METHODOLOGIES, AND OPTIMIZATION TECHNIQUES II

Impact of Planform and Control Surfaces on the Vortical Flow Topology and Roll Stability of a Multi Delta Wing Configuration	246
<i>Andreas Schuette, Dietrich Hummel</i>	
Control Surface Effectiveness in Vortex-Dominated Flow Around Flying Wing Configurations.....	274
<i>Kerstin C. Huber</i>	
Preliminary Investigation of Hessian Approximation with an Orthogonal Modal Parameterisation for Accelerated Shape Optimisation	306
<i>Laurence Kedward, Christian B. Allen, T. Rendall, Daniel J. Poole</i>	

AIRCRAFT DESIGN OPTIMIZATION I

Integrated Vehicle-Propulsion-Control Design Architecture for Distributed Electric Propulsion-Enabled Aircraft	320
<i>Michael Cunningham, Nikhil Nigam, Sricharan K. Ayyalasomayajula, William Becker, Racheal M. Erhard, Juan J. Alonso, Nhan T. Nguyen</i>	
Exploring Vehicle and Fleet Design Spaces for Profitable Urban Air Mobility Operations	338
<i>Brandon E. Sells, William A. Crossley</i>	

METAMODELING, REDUCED-ORDER MODELS, AND APPROXIMATION METHODS

On Filtering in Non-Intrusive Data-driven Reduced-order Modeling	360
<i>Ionut Farcas, Ramakanth Munipalli, Karen E. Willcox</i>	
A Multi-Fidelity Approximation of the Active Subspace Method for Surrogate Models with High-Dimensional Inputs.....	376
<i>Bilal Mufti, Mengzhen Chen, Christian Perron, Dimitri N. Mavris</i>	
Prediction of Rotor Aerodynamic Force and Noise Using Reduced Order Model.....	402
<i>Kwon Soonmoung, Yu-Eop Kang, Yoonpyo Hong, Kwanjung Yee</i>	

AERODYNAMIC DESIGN: ANALYSIS, METHODOLOGIES, AND OPTIMIZATION TECHNIQUES III

A Parametrization Framework for Multi-Element Airfoil Systems Using Bézier Curves	418
<i>Matthew G. Lauer, Phillip J. Ansell</i>	
Multifidelity Data Fusion Applied to Aircraft Wing Pressure Distribution	432
<i>Mehdi Anhichem, Sebastian Timme, Jony Castagna, Andrew Peace, Moira Maina</i>	
Landing Gear Retraction Under Aerodynamic Loads	450
<i>Benjamin M. Duda, Andreas Deuring, Francisco Flores Alvarenga, Gregory M. Laskowski</i>	

Experimental Tests of Coanda Effect at the Aft Deck of a Frigate	466
<i>Juan Carlos Matias-Garcia, Rafael Bardera, Sebastián Franchini, Estela B. Barderas, María Jesus Casati</i>	

Improving Dynamic Stall Effects Using Leading Edge Tubercles.....	479
<i>Maurice N. Nayman, Ruben E. Perez</i>	

AERODYNAMIC DESIGN II

Rapid Design of a High-Lift Wing Using Potential Flow Methods	497
<i>Gabino Martinez-Rodriguez, Timothy T. Takahashi</i>	
Experimental Results of a Straight Tapered Flying Wing with Bell-Shaped Lift Distribution	512
<i>Jonathan Richter, Jason B. Woodring, Ramesh K. Agarwal</i>	
Design and Multi-Perspective Based Computational Analyses of Flying Wing UAV for Rescue Applications at Cryogenic Environments.....	544
<i>Vijayanandh Raja, Manikandan Prabhu, Karthikeyan Murugan, Senthil Kumar Solaiappan, Arul Prakash Raji, Raj Kumar Gnanasekaran, Manivel Ramaiah, Rajkumar Rajapandi, Vijayakumar Mathaiyan, Akshay Kumar Nandhan, Aswathama Kannan</i>	

An Investigation of Static Aeroelastic Effects on Aircraft Performance.....	579
<i>Benjamin D. Webb, Timothy T. Takahashi</i>	

Flight Control System Design and Sizing Methodology for Hypersonic Cruiser	601
<i>Roberta Fusaro, Davide Ferretto, Nicole Viola</i>	

AERODYNAMIC DESIGN: ANALYSIS, METHODOLOGIES, AND OPTIMIZATION TECHNIQUES IV

Aerodynamic Shape Optimization of a Transonic, Propulsion-Airframe-Integrated Airfoil System.....	615
<i>Matthew G. Lauer, Phillip J. Ansell</i>	
Comparison of Aerodynamic Characteristics of Circular and Noncircular Cross-Section Missile Configurations	628
<i>Mehdi Ghoreyshi, Pooneh Aref, Adam Jirasek, Jurgen Seidel</i>	
Numerical Investigation and Application of Riblets Within the Safety Analysis and Following Execution of the Stunt Tunnel Flight.....	657
<i>Mikel Lucas Garcia De Albeniz Martinez, Peter Adrian Leitl, Dario Costa, Andreas Flanschger, Barbara Forster</i>	

MULTI-FIDELITY METHODS AND PHYSICS-INFORMED MACHINE LEARNING

Non-Myopic Multifidelity Method for Multi-regime Constrained Aerodynamic Optimization	670
<i>Francesco Di Fiore, Laura Mainini</i>	
Aerodynamic Sensing for Hypersonics Via Scientific Machine Learning	685
<i>Julie Pham, Bryan J. Morreale, Noel Clemens, Karen E. Willcox</i>	
Efficient Inverse Design of Heterogeneous Locally Resonant Elastic Metamaterials for Targeted Vibration Suppression	703
<i>Manaswin Oddiraju, Mostafa Nouh, Souma Chowdhury</i>	

VOLUME 2

- A Multi-Fidelity Prediction with Convolutional Neural Networks Using High-Dimensional Data 715
Huseyin E. Tekaslan, Melike Nikbay

THE AGILE4.0 PROJECT I

- An MBSE Architectural Framework for the Agile Definition of Complex System Architectures 735
Luca Boggero, Pier Davide Ciampa, Björn Nagel
- Bringing Manufacturing into the MDO Domain Using MBSE 757
Ton Van Der Laan, Anne-Liza Bruggeman, Bas Van Manen, Zhijun Wang, Daniël Peeters, Jente Sonneveld, Huub Timmermans
- An MBSE-Based Requirement Verification Framework to Support the MDAO Process 770
Anne-Liza Bruggeman, Bas Van Manen, Ton Van Der Laan, Tobie Van Den Berg, Gianfranco La Rocca
- Aue-Driven Model-Based Optimization Coupling Design-Manufacturing-Supply Chain in the Early Stages of Aircraft Development: Strategy and Preliminary Results 787
Giuseppa Donelli, Pier Davide Ciampa, Thierry Lefebvre, Nathalie Bartoli, João M. Mello, Felipe I. Odaguil, Ton Van Der Laan

TOPOLOGY OPTIMIZATION FOR HIGH-PERFORMANCE STRUCTURES

- Multi-Material Topology Optimization for the Conceptual Design of an Additively Manufactured Aerospace Smart Table 804
Luke Crispo, Daniel Krsikapa, Kevin Chai, Melissa Young, Ilyong Kim
- 3D Topology Optimization of Aircraft Wings with Conventional and Non-Conventional Layouts: A Comparative Study 811
Ghanendra K. Das, Prateek Ranjan, Kai A. James
- Multi-Head Self-Attention GANs for Multiphysics Topology Optimization 830
Corey Parrott, Diab Abueidda, Kai A. James

IN MEMORIAM PROF. MANAV BHATIA

- Novel Airplane Design Configurations Using Truss-Braced Wing and Nature Stiffening Members 846
Rakesh K. Kapadia, Joseph A. Schetz, Wei Zhao
- Gradient Based Optimization of Chaotic Panel Flutter 908
Bret Stanford

AERODYNAMIC DESIGN III

- Design of a Rear BLI Non-Axisymmetric Propulsor for a Transonic Flight Experiment 916
Andrea Battiston, Rita Ponza, Ernesto Benini
- Performance Analysis and Optimization of Hybrid-Electric-propulsion Aircraft with Multidisciplinary Surrogate Models 931
Tianhong Jiang, Yaolong Liu, Yao Zheng

Propeller Design and Optimisation for Bi-Modal Operations	948
<i>Zhe Yang, Cees Bil, Piergiovanni Marzocca</i>	
Design Optimization of Bell Rocket Nozzle; Numerical Studies Using LES	962
<i>Marcel Ilie, Geoffrey Sullivan</i>	
Overall Systems Design Method for Evaluation of Electro-Hydraulic Power Supply Concepts for Modern Mid-Range Aircraft.....	971
<i>Marc Juenemann, Vivian Kriewall, Thimo Bielsky, Frank Thielecke</i>	

ASSORTED MDO TOPICS

Topology Optimization of Conjugate Heat Transfer Problems Considering Temperature-Dependent Thermal Properties	992
<i>Xinlei Li, Kun Wu, Linying Zhao, Xuejun Fan</i>	
Bayesian Learning of Dynamic Physical System Uncertainty	1006
<i>Zhenhua Jiang, Kelly Beigh</i>	
Non-Intrusive Polynomial Chaos Approach for Nonlinear Aeroelastic Uncertainty Quantification.....	1022
<i>Jeffrey Thomas, Earl H. Dowell</i>	
A General Square Exponential Kernel to Handle Mixed-Categorical Variables for Gaussian Process	1036
<i>Paul Saves, Youssef Diouane, Nathalie Bartoli, Thierry Lefebvre, Joseph Morlier</i>	

AERODYNAMIC SHAPE OPTIMIZATION III

Robust Design Optimisation of S-Ducts.....	1052
<i>Andrea Scaramuzzi, Ernesto Benini, Timoleon Kipouros</i>	
CFD-Based Shape Optimization of a Plate-fin Heat Exchanger	1085
<i>Josh L. Anibal, Joaquim R. Martins</i>	
Sensitivity-Based Geometric Parameterization for Aerodynamic Shape Optimization	1100
<i>Neil Wu, Charles Mader, Joaquim R. Martins</i>	

THE AGILE4.0 PROJECT II

Multidisciplinary Design of a More Electric Regional Aircraft Including Certification Constraints	1117
<i>Marco Fioriti, Carlos Cabaleiro De La Hoz, Thierry Lefebvre, Pierluigi Della Vecchia, Massimo Mandorino, Susan Liscouet-Hanke, Andrew K. Jeyaraj, Giuseppa Donelli, Aidan Jungo</i>	
Multidisciplinary Design and Optimization of Regional Jet Retrofitting Activity	1134
<i>Massimo Mandorino, Pierluigi Della Vecchia, Salvatore Corcione, Fabrizio Nicolosi, Vittorio Trifari, Giovanni Cerino, Marco Fioriti, Carlos Cabaleiro De La Hoz, Thierry Lefebvre, Dominique Charbonnier, Zhijun Wang, Daniël Peeters</i>	
Collaborative Design of a Business Jet Family Using the AGILE 4.0 MBSE Environment.....	1148
<i>Jasper H. Bussemaker, Pier Davide Ciampa, Jasveer Singh, Marco Fioriti, Carlos Cabaleiro De La Hoz, Zhijun Wang, Daniël Peeters, Philipp Hansmann, Pierluigi Della Vecchia, Massimo Mandorino</i>	

AIRCRAFT DESIGN OPTIMIZATION II

Mission and Shape Optimization of a HALE Aircraft Including Transient Power and Thermal Constraints.....	1167
<i>Christopher A. Lupp, Daniel L. Clark, Christopher T. Aksland, Andrew G. Alleyne</i>	
Free-Size Optimization of a Stiffened Panel Using Equivalent Radiated Power	1185
<i>Luke Crispo, Wesley Dossett, Adam McKenzie, Ilyong Kim</i>	
Core Components of an Optimization Framework for Engineering Systems Based on Automatic Differentiation	1195
<i>Peter Sharpe, R. John Hansman</i>	
Multi-Fidelity Aerodynamic Design Process for Moveables at DLR Virtual Product House.....	1220
<i>Alexander Zakrzewski, Fabian Lange, René Hollmann</i>	
Numerical Derivation of Necessary Conditions for Indirect Trajectory Optimization.....	1233
<i>Winston C. Levin, Sean M. Nolan, Daniel A. Delaurentis</i>	

NON-DETERMINISTIC DESIGN METHODS, EMERGING METHODS AND SOFTWARE

Efficient Uncertainty Propagation Through Computational Graph Modification and Automatic Code Generation.....	1244
<i>Bingran Wang, Mark Sperry, Victor E. Gandarillas, John T. Hwang</i>	
An Adaptive Sampling Method for Gradient-Enhanced Surrogate Modeling.....	1259
<i>Garo Bedonian, Jason E. Hicken</i>	
Mission-Oriented Trajectory Optimization for Search-and-Rescue Multirotor UAVs in Cluttered and GPS-Denied Environments.....	1284
<i>Pengcheng Cao, John T. Hwang, Thomas Bewley, Falko Kuester</i>	
A Consistent Fixed-Point Discrete Adjoint Method for Segregated Navier--Stokes Solvers.....	1305
<i>Lean Fang, Ping He</i>	

AEROELASTIC AND AEROSTRUCTURAL OPTIMIZATION II AND THE AGILE4.0 PROJECT III

Advancing Cross-Organizational Collaboration in Aircraft Development.....	1322
<i>Erik Baalbergen, Jos Vankan, Luca Boggero, Jasper H. Bussemaker, Thierry Lefebvre, Bastiaan Beijer, Anne-Liza Bruggeman, Massimo Mandorino</i>	
Constrained Multi-Objective Bayesian Optimization with Application to Aircraft Design	1344
<i>Robin Grapin, Youssef Diouane, Joseph Morlier, Nathalie Bartoli, Thierry Lefebvre, Paul Saves, Jasper H. Bussemaker</i>	
Parametric Wingbox Structural Weight Estimation of the CRM, PEGASUS and Truss-Braced Wing Concepts	1364
<i>Darshan Sarojini, Heriberto D. Solano, Jason A. Corman, Dimitri N. Mavris</i>	
Recycling Krylov Subspaces for Efficient Partitioned Solution of Aerostructural Coupled Adjoint Systems.....	1383
<i>Mehdi Jadoui, Christophe Blondeau, François-Xavier Roux</i>	

IMPROVED ROBUST DESIGNS USING MULTI-DISCIPLINARY DESIGN ANALYSIS AND OPTIMIZATION (MDAO)

- Lunar Coring Device for Microgravity Challenge 1405
David Kavalauskas, Jenna E. Stolzman, Sanjivan Manoharan

- Model-Driven Mission Dependability Design of Unmanned Aerial Systems 1424
Tuan Anh Nguyen, Kwonsu Jeon, Jae-Woo Lee, Iure Fe, Francisco Airton Silva

- Application of a Process-Oriented Build Tool to an INDI-Based Flight Control Algorithm 1436
Purav Panchal, Stephan Myschik, Konstantin Dmitriev, Florian Holzapfel

AERODYNAMIC SHAPE OPTIMIZATION II

- Stabilization and Acceleration of Coupled Discrete Adjoint Solvers in Multi-Disciplinary Optimization 1448
Ole Burghardt, Payam Dehpanah, Nicolas R. Gauger

- A Frequency-Domain-inspired Reformulation of the Unsteady Vortex Lattice Method 1457
Jiayao Yan, John T. Hwang

- Statistically Enhanced Evolutionary Algorithm for Aerospace Design Applications 1467
Grady Pastor, Roy Hartfield, Gerry Dozier, Mark Carpenter, Vivek Ahuja

Author Index