AeroBest 2021

ECCOMAS Thematic Conference on Multidisciplinary Design Optimization of Aerospace Systems

Programme and Abstracts

21-23 July 2021

André C. Marta & Afzal Suleman (chairs)

Last update: 13 July

Scientific Committee

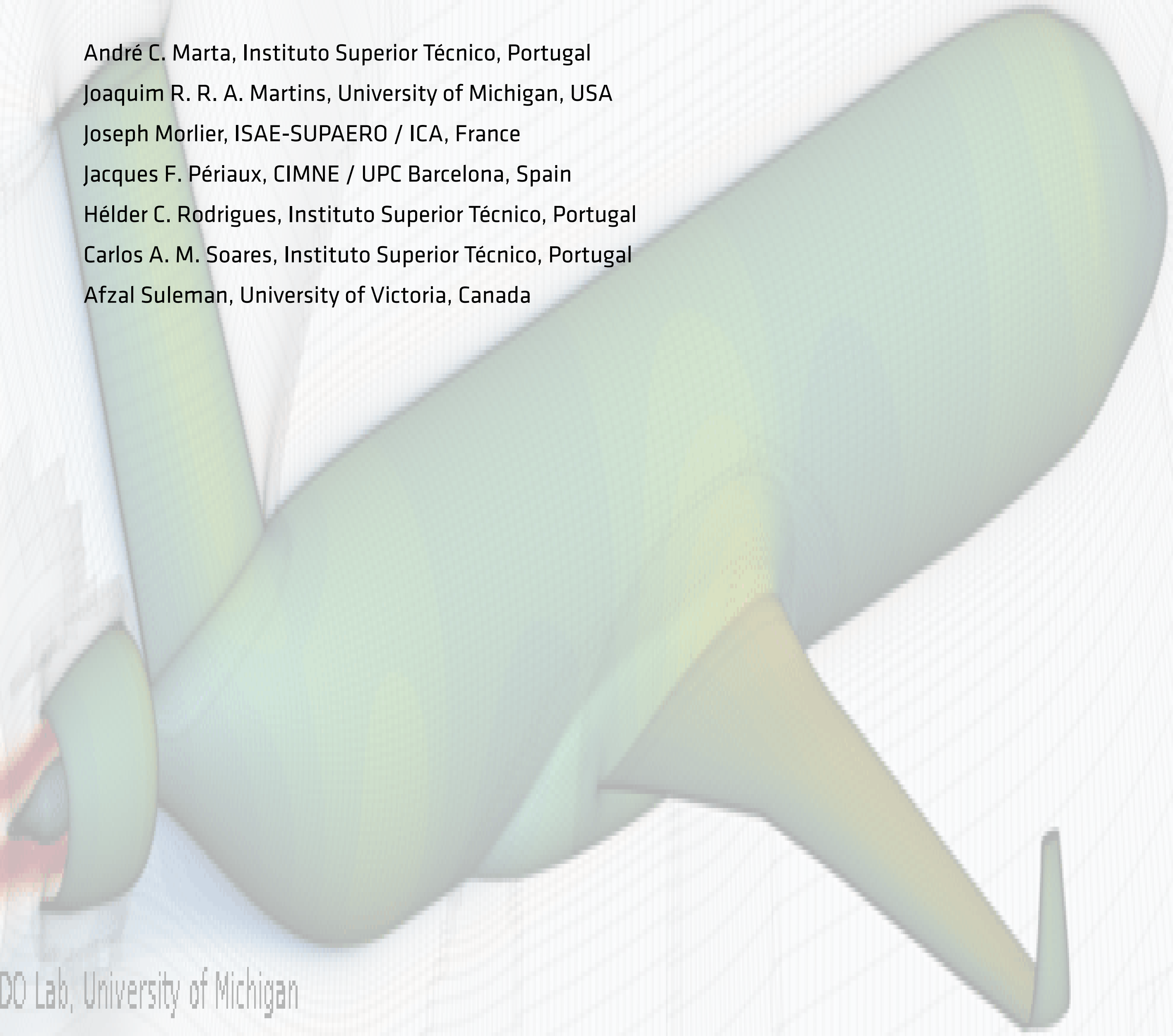

Image: MDO Lab, University of Michigan

https://aerobest2021.idmec.tecnico.ulisboa.pt

Programme Overview

(follow hyperlinks to session details)

UTC time (see next pages for your local time zone)

Wednesday, 21 July 2021		
13:00 - 13:10	Opening Ceremony (room A)	
13:10 - 13:55	Keynote Lecture I (room A) Prof. Jacques Périaux, CIMNE/UPC Barcelona	
13:55 - 14:00	Break	
14:00 - 15:00	SESSION 1A (room A)	SESSION 1B (room B)
15:00 - 15:20	Break	
15:20 - 17:20	SESSION 2A (room A)	SESSION 2B (room B)

Thursday, 22 July 2021		
13:00 - 13:50	Keynote Lecture II (room A) Prof. Joaquim Martins, University of Michigan	
13:50 - 14:00	Break	
14:00 - 15:20	SESSION 3A (room A)	SESSION 3B (room B)
15:20 - 15:40	Break	
15:40 - 17:20	SESSION 4A (room A)	SESSION 4B (room B)

Friday, 23 July 2021		
13:00 - 13:50	Keynote Lecture III (room A) Prof. Jonathan Cooper, University of Bristol	
13:50 - 14:00	Break	
14:00 - 15:00	SESSION 5A (room A)	SESSION 5B (room B)
15:00 - 15:20	Break	
15:20 - 17:00	SESSION 6A (room A)	SESSION 6B (room B)
17:00 - 17:10	Conference closure (room A)	

Conference Schedule in Different Time Zones

(follow hyperlinks to session details)

local time in Victoria/Canada (UTC-7)

Wednesday, 21 July 2021		
6:00-6:10	Opening Ceremony	
6:10-6:55	KL-I: Prof. Périaux	
6:55-7:00	Break	
7:00-8:00	Session 1A	Session 1B
8:00-8:20	Break	
8:20-10:20	Session 2A	Session 2B
Thursday, 22 July 2021		
6:00-6:50	KL-II: Prof. Martins	
6:50-7:00	Break	
7:00-8:20	Session 3A	Session 3B
8:20-8:40	Break	
8:40-10:20	Session 4A	Session 4B
Friday, 23 July 2021		
6:00-6:50	KL-III: Prof. Cooper	
6:50-7:00	Break	
7:00-8:00	Session 5A	Session 5B
8:00-8:20	Break	
8:20-10:00	Session 6A	Session 6B
10:00-10:10	Conference closure	

local time in Ontario/Canada, MI/USA and Amazonas/Brazil (UTC-4)

Wednesday, 21 July 2021		
9:00-9:10	Opening Ceremony	
9:10-9:55	KL-I: Prof. Jacques Périaux	
9:55-10:00	Break	
10:00-11:00	Session 1A	Session 1B
11:00-11:20	Break	
11:20-13:20	Session 2A	Session 2B)
Thursday, 22 July 2021		
9:00-9:50	KL-II: Prof. Martins	
9:50-10:00	Break	
10:00-11:20	Session 3A	Session 3B
11:20-11:40	Break	
11:40-13:20	Session 4A	Session 4B
Friday, 23 July 2021		
9:00-9:50	KL-III: Prof. Cooper	
9:50-10:00	Break	
10:00-11:00	Session 5A	Session 5B
11:00-11:20	Break	
11:20-13:00	Session 6A	Session 6B
13:00-13:10	Conference closure	

local time in Santa Catarina, Brazil (UTC-3)

Wednesday, 21 July 2021		
10:00-10:10	Opening Ceremony	
10:10-10:55	KL-I: Prof. Périaux	
10:55-11:00	Break	
11:00-12:00	Session 1A	Session 1B
12:00-12:20	Break	
12:20-14:20	Session 2A	Session 2B
Thursday, 22 July 2021		
10:00-10:50	KL-II: Prof. Martins	
10:50-11:00	Break	
11:00-12:20	Session 3A	Session 3B
12:20-12:40	Break	
12:40-14:20	Session 4A	Session 4B
Friday, 23 July 2021		
10:00-10:50	KL-III: Prof. Cooper	
10:50-11:00	Break	
11:00-12:00	Session 5A	Session 5B
12:00-12:20	Break	
12:20-14:00	Session 6A	Session 6B
14:00-14:10	Conference closure	

local time in Portugal and United Kingdom (UTC+1)

Wednesday, 21 July 2021		
14:00-14:10	Opening Ceremony	
14:10-14:55	KL-I: Prof. Jacques Périaux	
14:55-15:00	Break	
15:00-16:00	Session 1A	Session 1B
16:00-16:20	Break	
16:20-18:20	Session 2A	Session 2B)
Thursday, 22 July 2021		
14:00-14:50	KL-II: Prof. Martins	
14:50-15:00	Break	
15:00-16:20	Session 3A	Session 3B
16:20-16:40	Break	
16:40-18:20	Session 4A	Session 4B
Friday, 23 July 2021		
14:00-14:50	KL-III: Prof. Cooper	
14:50-15:00	Break	
15:00-16:00	Session 5A	Session 5B
16:00-16:20	Break	
16:20-18:00	Session 6A	Session 6B
18:00-18:10	Conference closure	

Conference Schedule in Different Time Zones

(follow hyperlinks to session details)

local time in Denmark,France,Germany, Italy,Netherlands,Poland,Spain (UTC+2)

Wednesday, 21 July 2021		
15:00-15:10	Opening Ceremony	
15:10-15:55	KL-I: Prof. Périaux	
15:55-16:00	Break	
16:00-17:00	Session 1A	Session 1B
17:00-17:20	Break	
17:20-19:20	Session 2A	Session 2B
Thursday, 22 July 2021		
15:00-15:50	KL-II: Prof. Martins	
15:50-16:00	Break	
16:00-17:20	Session 3A	Session 3B
17:20-17:40	Break	
17:40-19:20	Session 4A	Session 4B
Friday, 23 July 2021		
15:00-15:50	KL-III: Prof. Cooper	
15:50-16:00	Break	
16:00-17:00	Session 5A	Session 5B
17:00-17:20	Break	
17:20-19:00	Session 6A	Session 6B
19:00-19:10	Conference closure	

local time in Turkey (UTC+3)

Wednesday, 21 July 2021		
16:00-16:10	Opening Ceremony	
16:10-16:55	KL-I: Prof. Jacques Périaux	
16:55-17:00	Break	
17:00-18:00	Session 1A	Session 1B
18:00-18:20	Break	
18:20-20:20	Session 2A	Session 2B)
Thursday, 22 July 2021		
16:00-16:50	KL-II: Prof. Martins	
16:50-17:00	Break	
17:00-18:20	Session 3A	Session 3B
18:20-18:40	Break	
18:40-20:20	Session 4A	Session 4B
Friday, 23 July 2021		
16:00-16:50	KL-III: Prof. Cooper	
16:50-17:00	Break	
17:00-18:00	Session 5A	Session 5B
18:00-18:20	Break	
18:20-20:00	Session 6A	Session 6B
20:00-20:10	Conference closure	

local time in India (UTC+5.5)

Wednesday, 21 July 2021		
18:30-18:40	Opening Ceremony	
18:40-19:25	KL-I: Prof. Périaux	
19:25-19:30	Break	
19:30-20:30	Session 1A	Session 1B
20:30-20:50	Break	
20:50-22:50	Session 2A	Session 2B
Thursday, 22 July 2021		
18:30-19:20	KL-II: Prof. Martins	
19:20-19:30	Break	
19:30-20:50	Session 3A	Session 3B
20:50-21:10	Break	
21:10-22:50	Session 4A	Session 4B
Friday, 23 July 2021		
18:30-19:20	KL-III: Prof. Cooper	
19:20-19:30	Break	
19:30-20:30	Session 5A	Session 5B
20:30-20:50	Break	
20:50-22:30	Session 6A	Session 6B
22:30-22:40	Conference closure	

Keynote Speakers

Dr. Jacques Périaux

Dr. Jacques Périaux career started at Dassault Aviation (France), where he held the roles of Head of the Numerical Analysis Group in the Département d'Aérodynamique Théorique, High Scientific Adviser of the Advanced Studies Division, and later chair the Pôle Scientifique Dassault Aviation / University Pierre et Marie Curie.
From 2007 to 2010, he was selected by TEKES governmental Finnish Organization as Distinguished Professor at the Mathematical Information Technology Department at the University of Jyvaskyla, Finland. In 2010, he received a UNESCO Chair position on Numerical Methods in Engineering at CIMNE/UPC Barcelona, Spain. Dr. Périaux has built during the last two decades many scientific and technological cooperations, in Europe, USA, Australia and China. His research interests include Evolutionary Algorithms, Game Strategies and Multidisciplinary Design Optimization (MDO).

Presentation on Wednesday, 21 July, at 13:10 UTC

Hybridized Evolutionary Optimization with Game Strategies for Multi Objective / Multidisciplinary Design. Applications to Aeronautics and Aerospace.

Abstract: Drag reduction by laminarization, an innovative technology in aerodynamic design, remains a challenge to significantly improve the performance of aircraft and spacecraft. In this lecture two complex problems are considered: (1) the multi design optimization of transonic NLF airfoils/wings and (2) the multidisciplinary design integration of a supersonic combustion ramjet engine in an air breathing hypersonic vehicle, involving aerodynamics, thermodynamics and propulsion disciplines. Both associated complex physical modeling are non-differentiable and strongly suggest the use of evolutionary computing for MO/MDO problems. The two applications consider multi-objective design optimization (MO) solutions, the trade-offs decisions of which must be taken by the designer. Referring to the Game Theory foundations, there are three main game strategies to capture solutions of MO problems: Pareto solutions (cooperative game), Nash equilibrium solution (competitive game), and Stackelberg equilibrium solution (hierarchical game). Game strategies are hybridized with Evolutionary Algorithms (EA). Their implementation with additional speed ups (variable fidelity, games coalition,...) provides a reliable "core software" used to solve complex problems. Hybridized methods are successfully implemented to optimize aerodynamic shapes of NLF airfoils/wings and an hypersonic air breathing vehicle with an idealized supersonic combustor. Numerical results are presented and discussed; they illustrate the potential of the approach for optimizing aerodynamical configurations operating around complex physical flows. It is concluded that the hybridization of games strategies with EA is a computationally efficient design tool which can be used in 3D industrial design environments with large HPC facilities.

Prof. Joaquim R. R. A. Martins

Joaquim R. R. A. Martins is a Professor of Aerospace Engineering at the University of Michigan, where he heads the MDO Lab. He is a Fellow of the American Institute of Aeronautics and Astronautics and a Fellow of the Royal Aeronautical Society. His research involves the development and application of MDO methodologies to the design of aircraft configurations, with a focus on high-fidelity simulations that take advantage of high-performance parallel computing.

Before joining the University of Michigan faculty in 2009, he was an Associate Professor at the University of Toronto, where from 2002 he held a Tier II Canada Research Chair in MDO. Prof. Martins received his undergraduate degree in Aeronautical Engineering from Imperial College, London, with a British Aerospace Award. He obtained both his M.Sc. and Ph.D. degrees from Stanford University, where he was awarded the Ballhaus prize for best thesis in Aeronautics. He has served as Associate Editor for the AIAA Journal, Optimization and Engineering, and Structural and Multidisciplinary Optimization. He is currently an Associate Editor for the Journal of Aircraft.

Presentation on Thursday, 22 July, at 13:00 UTC

Multidisciplinary Design Optimization for the Next Generation of Aircraft

Abstract: Despite the progress in high-fidelity numerical simulations enabled by high-performance computing, challenges have remained in the use of these simulations for design optimization. This talk focuses on the developments that made it possible to perform high-fidelity design optimization of aircraft configurations. The challenges addressed include handling a large number of design variables, robust and efficient large-scale simulations, effective geometry and mesh handling, and efficient discipline coupling. To tackle these issues, we combine gradient-based optimization algorithms with adjoint gradient computation and develop an adaptive coupled Newton-Krylov approach to solve the coupled numerical simulations efficiently and robustly. The applications focus on aircraft design, including unconventional configurations. We first tackle wing design by coupling computational fluid dynamics to structural finite-element solvers and simultaneously optimizing the aerodynamic shape and structural sizing. The methods we developed to tackle this problem are generalized in the OpenMDAO framework, an open-source framework for multidisciplinary analysis and optimization. This and other open-source tools developed in this work open the door to further advances in algorithms and their application to aircraft design and beyond.

Prof. Jonathan Cooper

Prof. Jonathan Cooper holds the Airbus Royal Academy of Engineering Sir George White Chair of Aerospace Engineering at the University of Bristol. He has an international reputation for research in aeroelasticity, loads and structural dynamics, having published over 400 technical papers in leading journals and conferences, with 4 written paper prizes, and is the co-author of the Wiley textbook, Introduction to Aircraft Aeroelasticity and Loads.

Over the past 30 years he has worked closely with industry to develop solutions that enable aircraft designs to be more fuel efficient and environmentally friendly through exploitation of the interactions between the airflow and aircraft structures. His Airbus sponsored chair is one of only 7 in the UK.

Prof. Cooper is a Fellow of the Royal Academy of Engineering, a Fellow of the Royal Aeronautical Society (RAeS), a Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and has been a Chartered Engineer for over 25 years. He has currently just finished a two year term as President of the Royal Aeronautical Society.

Presentation on Friday, 23 July, at 13:00 UTC

Preliminary Aircraft Design Incorporating Structural Enablers

Abstract: Preliminary aircraft design is a key stage in the aircraft design process, where the conceptual configuration is optimised through consideration of the aerodynamics, structure and controls. Structural enablers are a broad range of technologies that can be used to facilitate improved aircraft performance through exploitation of the aeroelastic couplings and include morphing structures, aeroelastic tailoring, aeroservoelastic tailoring, folding wing-tips, vibration suppression devices, etc but there are few applications on current commercial jet aircraft. This presentation will show how incorporating structural enablers into a multi-disciplinary based approach can significantly improve preliminary aircraft designs in terms of the well-known Breguet Range Equation. The approach will be demonstrated upon high aspect ratio wing designs.

Conference Sessions

(follow hyperlinks to manuscript details)

Notice to presenters (underlined): 20-minute presentation slots, including Q&A

Wednesday, July 21st

Session 1A - 14:00-15:00 UTC

ID	Title	Authors	Affiliation
	Aerospace Design and Integrated Systems – UAV Chair: Prof. Miguel Silvestre		
12	THE CONCEPT OF SELF-DEPLOYABLE HELIUM-FILLED AEROSTATS BASED ON TENSEGRITY STRUCTURES	L. Knap, A. Świercz, C. Graczykowski and J. Holnicki-Szulc	Warsaw University of Technology, Polish Academy of Sciences
13	ADAPTIVE MORPHING OF TENSEGRITY-BASED HELIUM-FILLED AEROSTATS	L. Knap, A. Świercz, C. Graczykowski and J. Holnicki-Szulc	Warsaw University of Technology, Polish Academy of Sciences
19	DESIGN OF A SOLAR UAV FOR NIGHT SURVEILLANCE OPERATIONS	R.D.A. Santos, A. Regmi and P.V. Gamboa	C-MAST, Universidade da Beira Interior, Universidade do Porto

Session 1B - 14:00-15:00 UTC

ID	Title	Authors	Affiliation
	Discipline Analysis Models - Acoustics & Propulsion, Energy and Heat Transfer Chair: Dr. Amin Fereidooni		
17	SURROGATE MODELLING OF PROPELLER NOISE IN UNSTEADY LOAD CONDITIONS	P.M. Neto and P.V. Gamboa	C-MAST, Universidade da Beira Interior
41	APPLICATION OF THERMAL ENGINEERING SYSTEMS COMPUTATIONAL MODELS IN AIRCRAFT PASSENGER VIRTUAL CABIN	E.Z.E. Conceição, J.M. Gomes, M.M.J.R. Lúcio and H.B. Awbi	Universidade do Algarve, University of Reading

Session 2A - 15:20-17:20 UTC

MDO - Approximation and Surrogate Models Chair: Prof. Frederico Afonso			
ID	Title	Authors	Affiliation
8	SURROGATE-BASED MULTIDISCIPLINARY DESIGN OPTIMIZATION OF AN UAM-VTOL AIRCRAFT FOR ENERGY MINIMIZATION	C. Ribeiro, F. Afonso, M. Sohst and A. Suleman	Universidade de Lisboa, University of Victoria
18	MULTI-FIDELITY GAUSSIAN PROCESS MODEL FOR CFD AND WIND TUNNEL DATA FUSION	R. Conde Arenzana, A.F. López-Lopera, S. Mouton, N. Bartoli and T. Lefebvre	ONERA
32	EFFICIENT GLOBAL MULTIDISCIPLINARY DESIGN OPTIMIZATION TO SUPPORT AIRCRAFT CONCEPTUAL DESIGN	D. Maruyama, F. Schültke, E. Stumpf and A. Elham	Technical University of Braunschweig, RWTH Aachen University
33	DEVELOPMENT OF MDO FORMULATIONS BASED ON DISCIPLINARY SURROGATE MODELS BY GAUSSIAN PROCESSES	S. Dubreuil, N. Bartoli, G. Berthelin, O.C. Vila, C. Gogu, T. Lefebvre, J. Morlier and M. Salaün	ONERA, ICA, ISAE-SUPAERO, Université de Toulouse
49	PROPELLER BLADE OPTIMIZATION FOR UNMANNED AIR VEHICLES DESIGN APPLICATION	T.C. Kone, S. Ghinet, A. Grewal and V. Wickramasinghe	Canada National Research Council
53	A MULTIFIDELITY AERODYNAMIC SURROGATE MODEL IMPLEMENTATION FOR OPTIMIZATION OF A NONPLANAR LIFTING SURFACE	B. Pirlepeli, M. Nikbay and K. Kontis	Istanbul Technical University & University of Glasgow

Session 2B - 15:20-17:20 UTC

Design Optimization - Topology Optimization Chair: Prof. Hugo Policarpo			
ID	Title	Authors	Affiliation
15	TOPOLOGY OPTIMIZATION OF FULLY COUPLED AEROTHERMOELASTIC SYSTEM	P.N. Mishra and A. Gogulapati	Indian Institute of Technology Bombay
23	AEROSTRUCTURAL TOPOLOGY OPTIMIZATION USING HIGH FIDELITY MODELING	P. Gomes and R. Palacios	Imperial College London
28	TOWARDS MANUFACTURED LATTICE STRUCTURES: A COMPARISON BETWEEN LAYOUT AND TOPOLOGY OPTIMIZATION	E. Stragiotti, F.-X. Irisarri, C. Julien and J. Morlier	ONERA, ICA, ISAE-SUPAERO
30	TOPOLOGY OPTIMIZATION OF A SMALL UAV FUSELAGE FOR ADDITIVE MANUFACTURING	R. Costa, F. Afonso, J.C. Pereira, H. Policarpo and J. Lourenço	IDMEC, Universidade de Lisboa, Escola Naval, Althima
37	A DAMAGE-BASED FRAMEWORK TO IMPROVE THE STRENGTH OF STRAIN DRIVEN GENERATIVE DESIGNS	M.G. Marco, L.S. Mora, H.G. Modet, L. Saucedo, M.A. S. Gomez and F.J.M. Leal	GAMOSINOS, Universidad Politécnica de Madrid

Thursday, July 22nd

Session 3A - 14:00-15:20 UTC

Aerospace Design and Integration Systems – VSTOL Chair: Prof. Fernando Lau			
ID	Title	Authors	Affiliation
22	PRELIMINARY DESIGN OF THE PROPULSION SYSTEM OF A FIXED-WING TILT-ROTOR QUADCOPTER CLASS I MINI UNMANNED AIRCRAFT	P. Mendes, L. Félix, T. Oliveira and V. Franco	Academia da Força Aérea
43	DESIGN OF A HYDROGEN POWERED SMALL ELECTRIC FIXED-WING UAV WITH VTOL CAPABILITY	B.M. Alves, V.L. Coelho, P.A. Silva, A.C. Marta, F.J. Afonso, P.J. Sá, L.F. Félix and J.V. Caetano	Academia da Força Aérea, IDMEC, Universidade de Lisboa
50	DESIGN AND OPTIMIZATION OF A 3D PRINTED PROPELLER FOR A VTOL UAV	H. Rocha, P. Alves, A. Rodrigues and M. Silvestre	C-MAST, Universidade da Beira Interior

Session 3B - 14:00-15:20 UTC

Systems Engineering and Integration Chair: Prof. Pedro Gamboa			
ID	Title	Authors	Affiliation
1	MODELING AND OPTIMIZATION OF AN OBSTACLE DETECTION SYSTEM FOR SMALL FIXED-WING UAV	N.M.P. Alturas and A.C. Marta	IDMEC, Universidade de Lisboa
6	GLOBAL MODEL OF AIRCRAFT DESIGN: FROM PERFORMANCE REQUIREMENTS TOWARDS ARCHITECTURES OPTIMIZATION	C. García-Rubio, K. Thanissaranon, J.-C. Chaudemar, N. Bartoli and T. Lefebvre	ISAE-SUPAERO, ONERA/DTIS, Université de Toulouse
10	MULTIPLE UAV TRAJECTORY OPTIMISATION IN A FOREST FIRE DETECTION MISSION	J.V.R. Sousa and P.V. Gamboa	C-MAST, Universidade da Beira Interior
47	DESIGN OPTIMIZATION OF ACTIVE HELICOPTER SEAT SYSTEM FOR FLIGHT TESTING	Y. Chen, A. Fereidooni, R. Laliberte and V. Wickramasinghe	Canada National Research Council

Session 4A - 15:40-17:20 UTC

Design Optimization – Shape and Size Optimization Chair: Prof. José Chaves Pereira			
ID	Title	Authors	Affiliation
4	AUTOMATIC SHAPE OPTIMIZATION OF A NON-PLANAR WING BASED ON DISCRETE ADJOINT AND RADIAL BASIS FUNCTION MESH DEFORMATION	L. Abergo, M. Morelli and A. Guardone	Politecnico di Milano
16	SHAPE OPTIMIZATION OF NONPLANAR SOLID FOAM CORE WINGS WITH LARGE DEFORMATIONS	C. Conlan-Smith and C.S. Andreasen	Technical University of Denmark
29	MULTI-POINT AERODYNAMIC SHAPE OPTIMIZATION OF AEROFOILS USING MODIFIED XOPTFOIL	R.J.F. Palmeira and P.V. Gamboa	C-MAST, Universidade da Beira Interior
31	IMPACT OF THE DESIGN VARIABLES TYPE ON A FREEFORM WING OPTIMIZATION	D.B. Akel, P.T.S. Melo, R.E. Onety and T.P. Tancredi	Universidade do Estado do Amazonas, Universidade Federal de Santa Catarina

Session 4B - 15:40-17:20 UTC

Discipline Analysis and Models – Materials and Structures Chair: Prof. Sergio Ricci			
ID	Title	Authors	Affiliation
3	DESIGN OF PRE-TWISTED TAPERED BEAMLIKE STRUCTURES VIA EFFICIENT YET ACCURATE MODELS AND FORMULAS	G. Migliaccio	University of Pisa
25	MULTIFIDELITY AEROELASTIC OPTIMIZATION APPLIED TO HAR WINGS	Y. Le Lamer, G. Quaglia, E. Benard and J. Morlier	ISAE-SUPAERO, ICA, Université de Toulouse
35	AEROELASTIC IMPLICATIONS OF ACTIVE WINGLET CONCEPT AIMED TO IMPROVE CIVIL TRANSPORT AIRCRAFT PERFORMANCES	M. Delavenne, B. Barriety, F. Vetrano, V. Ferrand and M. Salaün	ISAE-SUPAERO, Airbus Operations SAS
45	COMPUTATIONALLY EFFICIENT APPROXIMATE BUCKLING AND POSTBUCKLING ANALYSIS OF PRISMATIC COMPOSITE STRUCTURES	J.C. Schilling and C. Mittelstedt	Technical University Darmstadt
48	WINGBOX META-MODEL AND AERO-SERVO-ELASTIC OPTIMIZATION WITH NEOPT	F. Toffol and S. Ricci	Politecnico di Milano

Friday, July 23rd

Session 5A - 14:00-15:00 UTC

ID	Title	Authors	Affiliation
Aerospace Design and Integr. Sys. – Sailplanes, Ultralight and Flexible Aircraft & Reusable Spacecraft Chair: Prof. Luis Félix			
40	A MULTI-OBJECTIVE OPTIMIZATION APPROACH TO THE DESIGN OF A FREE-FLYER SPACE ROBOT FOR IN-ORBIT MANUFACTURING AND ASSEMBLY	J. Vale, A. Rocha, M. Leite and R. Ventura	ISR, IDMEC, Universidade de Lisboa
55	SIZING OF HIGH ASPECT RATIO WINGS INCORPORATING FOLDING WINGTIP	H. Gu, F. Healy and J.E. Cooper	University of Bristol

Session 5B - 14:00-15:00 UTC

ID	Title	Authors	Affiliation
Design Optimization – Optimization Algorithms & Sensitivity Analysis Methods Chair: Prof. Rodrigo Ventura			
7	CONSTRAINED BAYESIAN OPTIMIZATION OVER MIXED CATEGORICAL VARIABLES, WITH APPLICATION TO AIRCRAFT DESIGN	P. Saves, N. Bartoli, Y. Diouane, T. Lefebvre, J. Morlier, C. David, E. Nguyen Van and S. Defoort	ISAE-SUPAERO, ONERA, Université de Toulouse,
27	INVESTIGATING THE INFLUENCE OF UNCERTAINTY IN NOVEL AIRFRAME TECHNOLOGIES ON REALIZING ULTRA-HIGH ASPECT RATIO WINGS	Y. Ma, E. Minisci and A. Elham	Technische Universität Braunschweig, University of Strathclyde
34	PERFORMANCE OF HYBRID OPTIMIZATION METHODS APPLIED TO ACTIVE FLOW CONTROL DEVICES	M. Coma, N.M. Tousi, J. Pons-Prats, J.M. Bergadà and G. Bugeda	Universitat Politècnica de Catalunya, CIMNE

Session 6A - 15:20-17:00 UTC

MDO – Design under Uncertainty & Decomposition Architectures Chair: Prof. Craig Steeves			
ID	Title	Authors	Affiliation
52	STUDY OF DISTRIBUTED ARCHITECTURES FOR MULTI-DISCIPLINARY OPTIMIZATION USING OPENMDAO	S.S. Gulawani, K.M.K. Babu and R.S. Pant	Indian Institute of Technology, Bombay
26	WING AEROSTRUCTURAL OPTIMIZATION WITH ACTIVE FLOW CONTROL AND ACTIVE LOAD ALLEVIATION	V. Mosca and A. Elham	Technische Universität Braunschweig
39	UNCERTAINTY QUANTIFICATION OF AEROELASTIC SYSTEMS USING ACTIVE LEARNING GAUSSIAN PROCESS	S. Yildiz, E. Cakmak, E. Kara and M. Nikbay	Istanbul Technical University
54	ROBUST DESIGN OF AIRCRAFT WING SIZING INCLUDING JIG TWIST SHAPE	L. Liu, C. Scarth and J.E. Cooper	University of Bristol, University of Bath
24	MODELLING VARIABILITY IN ADDITIVELY MANUFACTURED MATERIAL FOR TOPOLOGY OPTIMIZATION	D.D. Pepler and C.A. Steeves	UTIAS, University of Toronto

Session 6B - 15:20-17:00 UTC

Discipline Analysis Models – Aerodynamics Chair: Prof. Melike Nikbay			
ID	Title	Authors	Affiliation
2	ACTIVE CONTROL OF DIGITAL MORPHING AIRFOILS USING DEEP LEARNING	R. Carreira Rufato and J. Morlier	ISAE-SUPAERO, Université de Toulouse
14	A FINITE-ELEMENT TRANSONIC POTENTIAL SOLVER WITH AN EMBEDDED WAKE APPROACH FOR AIRCRAFT AEROELASTIC OPTIMIZATION	I. López, M. Núñez, A. Geiser, R. Rossi, R. Wüchner and K.-U. Bletzinger	Technical University of Munich, CIMNE
20	INTERACTIVE AIRFOIL DESIGN USING ARTIFICIAL INTELLIGENCE	M. Eizinger, M. Trenker and W. Toplak	ESA/ESTEC, Fachhochschule Wiener Neustadt, Toplak Laboratory eU
36	A COMPARATIVE STUDY ON MULTI-FIDELITY SONIC BOOM PREDICTION FOR A SUPERSONIC AIRCRAFT	Y. Demiroglu and M. Nikbay	Istanbul Technical University

Abstracts

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

MODELING AND OPTIMIZATION OF AN OBSTACLE DETECTION SYSTEM FOR SMALL FIXED-WING UAV

N. M. P. Alturas * and A. C. Marta

IDMEC
Instituto Superior Técnico
Universidade de Lisboa
Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal
{nuno.alturas,andre.marta}@tecnico.ulisboa.pt, https://www.idmec.tecnico.ulisboa.pt/

Abstract. *A solution for the enhancement of safety during the flight of small fixed-wing UAVs, regarding the detection of obstacles during flight, is presented. This was achieved by making a market study on available sensors to find the most suitable to equip a UAV and by modeling them, so that these models could be integrated into collision detection and avoidance simulations. Different tracking filters and sensor fusion techniques were studied, where the Converted Measurement Kalman Filter and the Weighted Filter technique were found to be the best to implement. In the simulations, the Potential Fields avoidance method was chosen for being computationally inexpensive and for providing feasible solutions in real time. Several parametric studies were conducted to test the performance of the selected sensors and to assess how their different parameters affect the success of the obstacle avoidance. An optimization study was also conducted, using a global optimizer, to find the orientation of sensors, for different sets of sensors, that results in the best performance for a set of randomly generated collision scenarios with both stationary and moving obstacles. Relatively simple detection configurations were found that still provide high collision avoidance success rate.*

Keywords: Potential Fields, Genetic Algorithm, Kalman Filter, Unbiased Conversion, Sensor Fusion

AeroBest 2021
Lisboa, 21-23 July 2021

ACTIVE CONTROL OF DIGITAL MORPHING AIRFOILS USING DEEP LEARNING

Raul Carreira Rufato [1*] and Joseph Morlier[2]

1: Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO)
Université de Toulouse
31055 Toulouse, FRANCE
raulc.rufato@hotmail.com

2: ICA, Université de Toulouse, ISAE-SUPAERO, MINES ALBI, UPS, INSA, CNRS, France
Université de Toulouse
31055 Toulouse, FRANCE
joseph.morlier@isae-supaero.fr

Abstract. *Detect and prevent an aircraft instability condition is extremely important, especially for flight control, and morphing airfoils can be used for this purpose. This work proposes the determination of a digital morphing airfoil, using a deep learning approach, to avoid an unstable aeroelastic condition in a 2D wing model. To parametrize the airfoil's geometry, Bezier – Parsec 3434 parametrization was used and some of the parameters were determined by an optimization process based on a Genetic Algorithm. The airfoil's geometric C_g position, c_l, c_d and c_m distributions for some angles of attack were used to train a deep neural network, capable to estimate the desired BP3434 parameters. Finally, this trained machine learning model was then coupled to the 2D aeroelastic model of a wing to change the airfoil's curvature when it faced an instability. The trained deep learning algorithm had an excellent Person's coefficient of 0.919 when predicting a new geometry. Our methodology permits to automatically detect and avoid instability using digital morphing techniques coupled with AI, using only one sensor, monitoring the dynamic behaviour of the airfoil.*

Keywords: Digital morphing airfoils, deep neural networks, Bezier-Parsec parameterization, 2D aeroelastic instabilities

AeroBest 2021
Lisboa, 21-23 July 2021

DESIGN OF PRE-TWISTED TAPERED BEAMLIKE STRUCTURES VIA EFFICIENT YET ACCURATE MODELS AND FORMULAS

Giovanni Migliaccio

Department of Civil and Industrial Engineering,
University of Pisa,
Largo Lucio Lazzarino 2, 56122, Pisa, Italy,
giovanni.migliaccio.it@gmail.com

Abstract *Beamlike elements with tapered and pre-twisted cross-sections are widespread in engineering applications as their peculiar shape has long been exploited to optimize the mechanical behavior of many engineering structures, e.g. blades of helicopters and wind turbines just to mention some examples. Unfortunately, engineering methods and formulas commonly used to evaluate the stress and stain fields in prismatic beams provide incorrect results in tapered and pre-twisted cases because of the variable dimensions and orientations of their cross-sections which yield non-trivial stress and stain distributions absent in the prismatic case. Not to speak of the large displacements such structures may undergo, which further complicate the derivation of closed-form formulas for engineering design purposes. However, the design and optimization of the mechanical behaviour of such tapered and pre-twisted elements can be addressed via a modelling approach that is computationally efficient and accurate (with respect to nonlinear 3D-FEM approaches) and enables evaluating even analytically the effects of taper and pre-twist design parameters on the stress and strain fields, as is discussed in the present work.*

Keywords: non-prismatic beams, analytical results, structural design.

AeroBest 2021
Lisboa, 21-23 July 2021

AUTOMATIC SHAPE OPTIMIZATION OF A NON-PLANAR WING BASED ON DISCRETE ADJOINT AND RADIAL BASIS FUNCTION MESH DEFORMATION

Luca Abergo[1*], Myles Morelli[2] and Alberto Guardone[3]

Department of Aerospace Science and Technologyr
Politecnico di Milano
Building B12, Via La Masa 34, Milano, MI 20156, Italy

1:Master Student, luca.abergo@mail.polimi.it
2: Postdoctoral Researcher, mylescarlo.morelli@polimi.it
3:Professor, alberto.guardone@polimi.it

Abstract. *The results obtained by an Automatic Shape Optimization tool are strongly effected by the mesh deformation method used. A computationally efficient Radial Basis Function (RBF) grid deformation is coded with two data reduction schemes: multi-level greedy surface point selection algorithms and volume point reduction methods. Following, it is combined with the discrete adjoint inside the open-source software SU2. The robustness of the method, the ability to handle complex shapes and apply large deformations makes possible to optimize also a non planar geometry like a wing provided with a winglet. The surface sensitivity, besides also the final value of the objective function, depends on how the grid is updated, since for the computation of the adjoint variables the process is differentiated by Automatic Differentiation. Finally, the gradient based algorithm "Sequential Least Squares Programming" drives the research of a new local minimum by gradually morphing the geometrical shape*

Keywords: discrete adjoint, design, optimization, mesh deformation, radial basis functions

AeroBest 2021
Lisboa, 21-23 July 2021

GLOBAL MODEL OF AIRCRAFT DESIGN: FROM PERFORMANCE REQUIREMENTS TOWARDS ARCHITECTURES OPTIMIZATION

Carlos GARCIA-RUBIO[1*], Kittinan THANISSARANON[1*], Jean-Charles CHAUDEMAR[2], Nathalie BARTOLI[3] and Thierry LEFEBVRE[3]

1: ISAE-SUPAERO, Université de Toulouse
Toulouse, France
{Carlos.Garcia-Rubio,Kittinan.Thanissaranon}@student.isae-supaero.fr

2: ISAE-SUPAERO, Université de Toulouse
Toulouse, France
jean-charles.chaudemar@isae-supaero.fr

3: ONERA/DTIS, Université de Toulouse
Toulouse, France
{Nathalie.Bartoli,Thierry.Lefebvre}@onera.fr

Abstract. *Systems engineering is a transdisciplinary approach that seeks the successful realisation of a system. In order to reach that, it is necessary to satisfy a series of needs and stakeholders, which have to be defined as a group of requirements to be fulfilled. Design approaches such as MDAO, MBSE, and MBSA have been created to help better designing aircraft in different aspects. However, there has never been an aircraft design method which combines all the mentioned design approaches and that, nowadays, has an increasing interest in the industry. Therefore, the paper aim is to produce aircraft design tools and methodology which link all the three design approaches together by using a surveillance UAV as a study case. As a part of the MDAO-MBSE global project, a MDAO model has been developed using a web application (WhatsOpt) and a MDAO platform (OpenMDAO) on Python, while the tool considered to develop the MBSE model is Eclipse Papyrus, a powerful tool that allows to use XML for export their models. Some promising results show the coupling between MDAO and MBSE based on XML file exchange.*

Keywords: MBSE, MDAO, SysML, XML

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

CONSTRAINED BAYESIAN OPTIMIZATION OVER MIXED CATEGORICAL VARIABLES, WITH APPLICATION TO AIRCRAFT DESIGN

Paul Saves[1,2], Nathalie Bartoli[2], Youssef Diouane[1], Thierry Lefebvre[2], Joseph Morlier[3], Christophe David[2], Eric Nguyen Van[2] and Sébastien Defoort[2]

1: ISAE-SUPAERO, Université de Toulouse, Toulouse, France
{paul.saves2,youssef.diouane}@isae-supaero.fr

2: ONERA/DTIS, Université de Toulouse Toulouse, France
{nathalie.bartoli,thierry.lefebvre,christophe.david,eric.nguyen_van,sebastien.defoort}@onera.fr

3: ICA, Université de Toulouse, ISAE-SUPAERO, MINES ALBI, UPS, INSA, CNRS, Toulouse, France
joseph.morlier@isae-supaero.fr

Abstract. *Multidisciplinary Design Optimization (MDO) methods aim at adapting numerical optimization techniques to the design of engineering systems involving multiple disciplines or components. Among MDO architectures, various ones are considering the resolution of the Multidisciplinary Design Analysis (MDA). In our study, the system of interest being an aircraft, the resolution of the MDA will be provided by the Future Aircraft Sizing Tool with Overall Aircraft Design (FAST-OAD), a point mass approach that estimates the required fuel and energy consumption for a given set of top-level aircraft requirements. In this context, a large number of mixed continuous, integer and categorical variables that arise from aircraft design has to be tackled by the optimization process.*

Recently, there has been a growing interest in mixed variables constrained Bayesian optimization based on Gaussian process surrogate models. In this setting, most existing approaches severely increase the dimension of the covariance matrix related to the surrogate. In fact, the construction of the Gaussian process model may not be scalable to practical applications involving a large number of mixed variables.

In this paper, we address this issue by constructing a covariance kernel for the surrogate model that depends on only a few hyperparameters. The new kernel is constructed based on the information obtained from the partial least squares method. The obtained numerical results lead to interesting results for the optimization of a baseline aircraft and to reduce the fuel consumption of "DRAGON", a new hybrid electric propulsion aircraft, with a high number of mixed variables and for a small budget of time-consuming evaluations.

Keywords: Green Aircraft, Future Aircraft, Multidisciplinary Design Optimization, Bayesian Optimization, Surrogate-based Optimization, Gaussian Process

AeroBest 2021
Lisboa, 21-23 July 2021

SURROGATE-BASED MULTIDISCIPLINARY DESIGN OPTIMIZATION OF AN UAM-VTOL AIRCRAFT FOR ENERGY MINIMIZATION

Catarina Ribeiro[1], Frederico Afonso[1], Martin Sohst[2] and Afzal Suleman[1,2]

1: IDMEC
Instituto Superior Técnico
Universidade de Lisboa
Av. Rovisco Pais, 1049-001, Lisboa, Portugal
{catarina.fonseca.ribeiro,frederico.afonso,suleman}@tecnico.ulisboa.pt,
https://www.idmec.tecnico.ulisboa.pt/

2: Department of Mechanical Engineering
University of Victoria
Victoria, BC, V8P 5C2 Canada
{msohst,suleman}@uvic.ca, https://www.uvic.ca/

Abstract. *This work aims at evaluating surrogate based Multidisciplinary Design Optimization (MDO) strategies for designing an Urban Air Mobility (UAM) Vertical Take-Off and Landing (VTOL) aircraft. During the conceptual stages, it is important to have a vast exploration of the design space, using models for several disciplines that need to be considered regarding the mission requirements. Surrogate models are a potentially good approach to rapidly explore the design space. Therefore, in this work, a comparison between the results of a MDO using real functions and the surrogate models of these functions is provided. Three major strategies for the aircraft optimization are carried out: an optimization using the real, analytical functions and their derivatives with the adjoint method; a surrogate-based optimization where Kriging-based surrogate models for both the objective function and constraints are built, using the Surrogate Modeling Toolbox (SMT); and an optimization based on adaptive sampling using the Watson and Barnes (WB2) infill criteria. To compare these MDO strategies, an energy minimization problem is established for the VTOL aircraft as a case study in OpenMDAO, where aerodynamics and structures are modeled using the low-fidelity models provided in the OpenAeroStruct (OAS) framework. Initially, only two design variables are considered. Then, more design variables are added to the problem, and therefore increasing the complexity of the optimization problem.*

Keywords: Multidisciplinary design optimization, surrogate models, adaptive sampling, aircraft design, aerostructural

AeroBest 2021
Lisboa, 21-23 July 2021

MULTIPLE UAV TRAJECTORY OPTIMISATION IN A FOREST FIRE DETECTION MISSION

Joaquim V.R. Sousa [1]*, and Pedro V. Gamboa [1]

1: Centre for Mechanical and Aerospace Science and Technologies (C-MAST-UBI)
Universidade da Beira Interior
6200-001 Covilhã
joaquim.sousa@ubi.pt, pgamboa@ubi.pt, http://www.ubi.pt

Abstract *This paper describes the work of UAVs trajectory optimisation in a possible fire detection mission context. The fire detection mission consists of using a team of UAVs to patrol a given search area here defined as a grid of equally spaced targets placed at a constant height above ground level. Each target is assigned with a score consisting of a count-up timer that starts from the mission beginning and resets every UAV visit. Each UAV is assumed to fly a 3D Dubins manoeuvre between two given targets and to have an electric propulsion system with a limited amount of onboard energy. The energy constraint prevents the entire search area from being covered in a single trip. The goal is to continuously optimise each new trajectory by determining the number and order of targets to visit that maximise the total trip score. The problem solution is found using the Variable Neighbourhood Search (VNS) metaheuristic, particularly the randomised variant of the VNS (RVNS). The trajectory optimisation algorithm is evaluated on a scenario where the team is composed of two fixed-wing aircraft and a multi-rotor. The proposed approach produces feasible results when generating optimised trajectories for a fire detection mission, ensuring the selection of targets that have not been visited more recently on future trajectories. The team was able to effectively patrol the search area with each target being visited every 550 seconds on average.*

Keywords: Fire detection, Trajectory optimisation, Unmanned Aerial Vehicle, Dubins airplane, Variable Neighbourhood Search, Remote Sensing

AeroBest 2021
Lisboa, 21-23 July 2021

THE CONCEPT OF SELF-DEPLOYABLE HELIUM-FILLED AEROSTATS BASED ON TENSEGRITY STRUCTURES

Lech Knap[1], Andrzej Świercz[2], Cezary Graczykowski[2*], Jan Holnicki-Szulc[2]

1: Institute of Vehicles and Construction Machinery
Warsaw University of Technology
Narbutta 84, 02-524 Warsaw, Poland
Lech.Knap@pw.edu.edu, http://www.simr.pw.edu.pl

2: Institute of Fundamental Technological Research
Polish Academy of Sciences
Pawinskiego 5B, 02-106 Warsaw, Poland
{aswiercz, cgraczyk, holnicki}@ippt.pan.pl, http://www.ippt.pan.pl

Abstract *In this contribution, the authors propose a concept of novel type of an ultra-light helium-filled aerostat. The internal construction of the proposed aerostat is based on a self-deployable tensegrity structure equipped with prestressed tensioned elements of controllable lengths. Such construction enables convenient transportation of the aerostat and its fast deployment at the required operational point at the atmosphere. The controllable tensegrity structure can be used for simultaneous changes of the aerostat volume and external shape during the flight. This enables modification of buoyancy and drag forces and obtaining a desired vertical and horizontal motion as well as a desired flight path. The authors propose a method of numerical modelling of self-deployable helium-filled aerostats based on the finite element method as well as CFD and FSI models presenting behaviour of aerostat during typical operational conditions. The presented results show the interaction of the internal tensegrity structure and aerostat envelope and positively verify the feasibility of the proposed concept of tensegrity-based aerostats.*

Keywords: tensegrity structure, internal construction, helium-filled aerostat, numerical modelling

AeroBest 2021
Lisboa, 21-23 July 2021

ADAPTIVE MORPHING OF TENSEGRITY-BASED HELIUM-FILLED AEROSTATS

Lech Knap[1], Andrzej Świercz[2*], Cezary Graczykowski[2], Jan Holnicki-Szulc[2]

1: Institute of Vehicles and Construction Machinery
Warsaw University of Technology
Narbutta 84, 02-524 Warsaw, Poland
Lech.Knap@pw.edu.pl, http://www.simr.pw.edu.pl

2: Institute of Fundamental Technological Research
Polish Academy of Sciences
Pawinskiego 5B, 02-106 Warsaw, Poland
{aswiercz, cgraczyk, holnicki}@ ippt.pan.pl, http://www.ippt.pan.pl

Abstract *In this contribution the authors propose and investigate the concept of adaptive morphing for recently introduced tensegrity-based helium-filled aerostats. The proposed aerostat is based on an ultra-light tensegrity structure equipped with prestressed tensioned elements of controllable lengths. Such internal structure allows for adaptive morphing of the aerostat defined as simultaneous controllable modifications of aerostat volume and external shape during the flight. The controlled volume changes enable influencing buoyancy forces acting on the envelope and obtaining desired vertical motion of the aerostat during the ascending and descending process ("vertical mobility"). In turn, the controlled changes of external shape of the aerostat can be used either for lowering the aerodynamic drag forces and reducing energy usage needed to maintain stable horizontal position or to follow the desired path of aerostat horizontal motion ("horizontal stability"). The authors effectively apply the previously introduced mechanical FEM model of the tensegrity-based aerostat and dynamic model of the aerostat's vertical and horizontal motion to conduct simulations of the process of adaptive morphing and maintain a proper position in the atmosphere. The obtained results positively verify the idea of adaptive morphing and its efficiency in controlling vertical and horizontal motion of the aerostat.*

Keywords: tensegrity structure, helium-filled aerostat, adaptive morphing, vertical mobility, horizontal stability

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

A FINITE-ELEMENT TRANSONIC POTENTIAL SOLVER WITH AN EMBEDDED WAKE APPROACH FOR AIRCRAFT AEROELASTIC OPTIMIZATION

Iñigo López[1*], Marc Núñez[2], Armin Geiser[1], Riccardo Rossi[2], Roland Wüchner[1] and Kai-Uwe Bletzinger[1]

1: Chair of Structural Analysis
Department of Civil, Geo and Environmental Engineering
Technical University of Munich
Arcisstr. 21, 80333, Munich, Germany
inigo.lopez@tum.de, armin.geiser@tum.de, wuechner@tum.de, kub@tum.de,
https://www.bgu.tum.de/en/st/forschung/

2: Kratos Multiphysics Group
International Center for Numerical Methods in Engineering
Polytecnic University of Catalonia
C/ Gran Capità s/n Campus Nord UPC, 08024, Barcelona, Spain
mnunez@cimne.upc.edu, rrossi@cimne.upc.edu, https://www.cimne.com

Abstract. *An embedded wake approach for the effective use of potential transonic solvers in the context of aircraft aeroelastic optimization is presented. To support a jump in the potential across the wake, cut elements are disconnected across wake surfaces by enriching the finite element space with additional degrees of freedom. The wake boundary conditions are then applied with the additional equations that stem from the discretization. Representing the wake implicitly within the domain saves modeling time and allows performing aircraft aeroelastic optimization, where the position of the wake may change due to the structural response or due to the geometry's evolutionary steps. Using embedding techniques can potentially lead to ill-conditioned systems due to the so-called small cut cell problem. To ensure robustness and avoid large condition numbers, a full-integration technique is presented. The wake surface can be automatically generated by shedding it from the trailing edge in the freestream velocity direction. A robust and accurate capturing of the potential jump across the wake is achieved by automatically refining the mesh with a metric-based technique. An artificial compressibility method is used to stabilize the problem in supersonic flow regions preventing the Jacobian from becoming singular and allowing to capture shock waves. To validate the method, the transonic flow solution over the ONERA M6 wing is compared with wind tunnel data and reference solutions from other codes. The solver is implemented in KRATOS Multiphysics and is available under a BSD license.*

Keywords: Embedded wake surfaces, full potential equation, finite element method, aeroelastic optimization, transonic flow

AeroBest 2021
Lisboa, 21-23 July 2021

TOPOLOGY OPTIMIZATION OF FULLY COUPLED AEROTHERMOELASTIC SYSTEM

Pankil N. Mishra[1] and Abhijit Gogulapati[2]

1: Ph.D. Candidate
Department of Aerospace Engineering
Indian Institute of Technology Bombay
IIT Bombay, Powai, Mumbai 400 076, Maharashtra, India
pankilmishra@iitb.ac.in

2: Assistant Professor
Department of Aerospace Engineering
Indian Institute of Technology Bombay
IIT Bombay, Powai, Mumbai 400 076, Maharashtra, India
abhijit@aero.iitb.ac.in

Abstract. *Topology optimization of a coupled aerothermoelastic system is of interest here. The aerothermoelastic system is a simplified model of the panel in a hypersonic flow. The aerothermal loads are computed using a combination of piston theory and Eckert's reference enthalpy approaches. A thermal buckling metric is developed which is used as the objective function for the optimization study. The topology optimization is performed using the Solid Isotropic Material with Penalization (SIMP) model. Results are shown for various types of admissible design domain with thermal boundary conditions on different surfaces of the panel.*

Keywords: Topology optimization, aerothermoelastic system, coupled aerothermal loads, SIMP, fluid-thermal-structural interaction

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

SHAPE OPTIMIZATION OF NONPLANAR SOLID FOAM CORE WINGS WITH LARGE DEFORMATIONS

Cian Conlan-Smith[1]* and Casper Schousboe Andreasen[1]

1: Department of Mechanical Engineering
Section of Solid Mechanics
Technical University of Denmark
2800, Lyngby, Denmark
*: cicosm@mek.dtu.dk

Abstract

This work applies gradient-based shape optimization methods to the design of nonplanar wings with a solid foam core such as those commonly used on drones or model aircraft. A coupled aeroelastic model is used to capture the physics where the aerodynamics is modelled using a constant source-doublet 3D panel method with approximations for viscous drag, and the structural deformations are modelled using nonlinear co-rotating beam finite elements. The wings are parameterized based on the definitions of NACA 4-digit airfoils from which the majority of cross-sectional stiffness properties can be derived analytically. Approximations are introduced for the torsional stiffness and shear center location, which then yields expressions for the full cross-sectional stiffness matrix of a solid homogenous airfoil section without the need to conduct any cross-sectional analysis. Results are first presented to compare the differences between linear and nonlinear finite element models, which highlight the importance of capturing nonlinear deformations for coupled aeroelastic optimization problems. Finally, the aeroelastic behaviour of raised and drooped wings is investigated, where drooped wings are found to be beneficial due to an effective increase in wingspan as the wing deforms leading to a larger reduction in induced drag.

Keywords: Aeroelastic shape optimization, panel methods, co-rotating beam finite elements, analytic cross-sectional properties, drooped wings.

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

SURROGATE MODELLING OF PROPELLER NOISE IN UNSTEADY LOAD CONDITIONS

Pedro M. Neto[1*] and Pedro V. Gamboa[1]

1: Centre for Mechanical and Aerospace Science and Technologies (C-MAST-UBI)
Faculdade de Engenharia
Universidade da Beira Interior
6200-001 Covilhã
pedro.matos.neto@ubi.pt, pgamboa@ubi.pt, http://www.ubi.pt

Abstract. *This paper presents the formulation and implementation of a numerical propeller noise analysis tool. The tool is capable of estimating the noise produced by a propeller under different inflow conditions and is designed to be used in propeller geometry optimization problems where the inflow conditions, observer position and velocity and the range of propeller geometric characteristics are specified. The code uses Latin Hypercube Sampling to select a space-filling set of propellers; Then, the overall sound pressure level (OASPL) for these samples is calculated using a formulation of the Ffowcs-Williams and Hawkings (FW-H) equation with loading data from a modified Blade Element Momentum (BEM) theory; A Kriging model is then produced and made available to the user for direct analysis or further implementation in optimization problems. Validation cases are presented for all modules of the tool and a study case with a propeller operating in a push configuration is analysed.*

Keywords: Propeller noise, Unsteady load, Disturbed airflow, Blade Element Momentum Theory, Farassat 1A, Surrogate models

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

MULTI-FIDELITY GAUSSIAN PROCESS MODEL FOR CFD AND WIND TUNNEL DATA FUSION

Rubén Conde Arenzana[1], Andrés F. López-Lopera[1], Sylvain Mouton[2], Nathalie Bartoli[1] and Thierry Lefebvre[1]

1: ONERA/DTIS, Université de Toulouse, F-31055 Toulouse, France
2: ONERA/DS, F-31410 Mauzac, France

Abstract. *In aerodynamic design, both Computational Fluid Dynamics (CFD) simulations and wind tunnel (WT) experiments deliver datasets that are complementary in terms of uncertainties and density of information. In many situations it is desirable to use methods that combine all available information while accounting for the strengths of both sources. In this paper, we combine the sources in a multi-fidelity Gaussian process (GP) model to foretell the aerodynamic forces and moments. The resulting model accounts for input-dependent error measurements in both experimental and simulated data. To validate the model, we construct a proper multi-source aerodynamic database containing CFD and WT data. This database is based on the NASA Common Reference Model. The CFD simulations are based on Reynolds-averaged Navier-Stokes (RANS) equations. We demonstrate in numerical settings that the suggested multi-fidelity GP framework outperforms the single-fidelity one in terms of prediction accuracy at the highest level of fidelity (i.e. WT data). The resulting model also allows to reconstruct common aerodynamic profiles (e.g. representations of longitudinal forces) with uncertainties.*

Keywords: CFD, wind tunnel tests, multi-fidelity databases, error measurements, surrogate models, Gaussian processes

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

DESIGN OF A SOLAR UAV FOR NIGHT SURVEILLANCE OPERATIONS

Rúben D.A. Santos[1*], Anuj Regmi[2] and Pedro V. Gamboa[1]

1: Center for Mechanical and Aerospace Science and Technologies (C-MAST-UBI)
Faculty of Engineering
Universidade da Beira Interior
6200-001 Covilhã
ruben.almeida.santos@ubi.pt, pgamboa@ubi.pt, http://www.ubi.pt

2: Department of Electrical and Computer Engineering
Faculty of Engineering
University of Porto
4200-465 Porto
anuj@fe.up.pt, https://sigarra.up.pt/feup

Abstract. *Since the beginning of human flight, one of the most desirable and difficult goals has been to make an airplane to stay aloft for very long periods of time. One of the solutions to this problem is to harvest solar power during flight to increase the flight time and ideally achieve perpetual flight. A solar plane has the advantage of not having to be refueled or recharged every start of the mission, instead it collects solar energy during day-time for flight and to recharge the battery for night flight. This process reduces the need for daily ground operations.*

This paper presents a methodology to design a solar Unmanned Aerial Vehicle (UAV) capable of flying for long periods of time which may be dedicated to performing night surveillance operations. The developed methodology builds on previous works by Noth by adding the possibility of analyzing several wing and tail airfoils as well as computing the respective aerodynamic characteristics to have more reliable results. It also includes a second phase where a more detailed analysis is performed to provide more reliable results for a given mission profile defined by a high-altitude daytime segment and a low altitude night flight.

A test case is presented to demonstrate the methodology. This test case represents a fixed wing UAV that flies at a latitude of 30ºN to monitor the night activity of nocturnal animals over a period of several days in a row. At this latitude, the winter solstice has 10.2 hours of daylight and 13.8 hours of night time. Since the solar UAV will have an endurance of at least 24 hours at the winter solstice, the aircraft is able to fly every day of the year. The design of a solar UAV capable of flying several days is a challenging, complex, and multidisciplinary problem. This work shows that even for a very light payload mass a relatively large wing aircraft is needed due to the very low wing loading required for high flight efficiency and flight overnight. Also, parameters such as battery energy density, solar panel area ratio, structural mass, mission profile, and mission location and time of the year have important effects on the final design size and mass.

Keywords: Aircraft design, Solar UAV, Design methodology, Perpetual flight

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

INTERACTIVE AIRFOIL DESIGN USING ARTIFICIAL INTELLIGENCE

Martin Eizinger[1], Markus Trenker[1] and Werner Toplak[2]

1: Aerospace Engineering
Fachhochschule Wiener Neustadt
Johannes-Gutenberg-Straße 3, 2700 Wiener Neustadt, Austria
martin.eizinger@gmx.at, markus.trenker@fhwn.ac.at

2: TopLab - Toplak Laboratory e.U.
dr.toplak@toplab.at

Abstract. *Aerodynamic shape design has a long history of extensive and detailed development, including different methods of optimization based on the various technologies that have been made available over the years, ranging from simple manual iteration to numerical inverse design. As artificial intelligence sees increasing popularity, it has also penetrated the field of fluid dynamics. We present a machine learning workflow for developing an artificial neural network that predicts the two-dimensional distribution of the coefficient of pressure along the perimeter of parameterized airfoils in variable steady-state subsonic high-Reynolds flow conditions. The data set is obtained from computational fluid dynamics simulations of pseudo-randomly generated parameter sets comprising of profile shape parameters and flow conditions. Several artificial neural networks are trained and ranked by performance, based on methods and quality metrics commonly used in machine learning. The highest-ranking network is further validated using several methods, including comparison to theory and experimental data. A software implementation of the neural network including a graphical user interface achieves real-time prediction and display of the distribution of the coefficient of pressure in response to variations of the shape and flow parameters. Other software features have been implemented, including interfaces to numeric solvers that can verify predicted results by executing the same automated workflow that has been used for creating the training data. The developed prototype toolbox has the potential to contribute in industry - in both optimization and conceptual design - as well as in education of professionals and students by providing a means to analyze in detail how the flow responds to a shape variation.*

Keywords: machine learning, airfoil optimization, computational fluid dynamics

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

PRELIMINARY DESIGN OF THE PROPULSION SYSTEM OF A FIXED-WING TILT-ROTOR QUADCOPTER CLASS I MINI UNMANNED AIRCRAFT

Pedro Mendes, Luís Félix, Tiago Oliveira, and Vasco Franco

Centro de Investigação da Academia da Força Aérea
Academia da Força Aérea
Instituto Universitário Militar
2715-311 Pêro Pinheiro
{pdmendes, lffelix, tmoliveira, vhfranco}@academiafa.edu.pt http://www.academiafa.edu.pt

Abstract *This paper presents the preliminary design of the propulsion system of a fixed wing quadcopter Tilt-Rotor Unmanned Aircraft (TRUA) with Vertical Take-Off and Landing, following the conceptual design made in a previous work. It is also a goal to determine if the TRUA configuration is more efficient than using a fixed-wing quadcopter with an extra motor for forward flight (Quad+1). Initially, the most appropriate components of the propulsion system (motors, controllers and batteries) are selected, based on thrust requirements. A sample of eight propellers is selected, for which two comparison methods are applied: one theoretical (Blade Element Theory) and another experimental (wind tunnel). From these, the HP (propellers with best performance in forward flight which can deliver the required thrust in vertical flight), and VP (propellers with best performance in vertical flight) are selected. From the performance data obtained in the wind tunnel tests, two comparisons are made for five different arrangements – the first based in the efficiency of the arrangements and the second based in the endurance of the aircraft with different arrangements considering weight limitations. It is shown that if the TRUA solution is to be used, the most efficient arrangement is B2 – different front and rear propellers asymmetrically distanced longitudinally from the CG. It is concluded that the Quad+1 solution is more efficient and simpler to integrate and control than the TRUA solution. It is also concluded that if the weight available for the power and energy supply system is less than 8.93 kg, the endurance may be higher with the TRUA solution, if a light and robust tilting system is attained.*

Keywords: Tilt Rotor, Propellers, Blade Element Theory, Aircraft Design, Unmanned Aircraft, Vertical Take-Off and Landing

AeroBest 2021
Lisboa, 21-23 July 2021

AEROSTRUCTURAL TOPOLOGY OPTIMIZATION USING HIGH FIDELITY MODELING

Pedro Gomes[1] and Rafael Palacios[1*]

1: Department of Aeronautics
Faculty of Engineering
Imperial College London
Exhibition Rd, South Kensington, London SW7 2BX
r.palacios@imperial.ac.uk

Abstract. *We investigate the use of topology optimization to design the aeroelastic response of a very flexible wing. A Reynolds-averaged Navier-Stokes finite volume solver is coupled to a geometrically nonlinear finite element structural solver to simulate the large displacement fluid-structure-interaction. A gradient-based approach is used with derivatives obtained via a coupled adjoint solver based on algorithmic differentiation. In the example problem, the optimization uses strong coupling effects and the internal topology of the wing to allow mass reduction while maintaining the lift. We propose a method to accelerate the convergence of the optimization to discrete topologies, which partially mitigates the computational expense of high-fidelity modelling approaches.*

Keywords: Topology optimization, Fluid-structure-interaction, MDO, Discrete adjoint, Multiphysics

AeroBest 2021
Lisboa, 21-23 July 2021

MODELLING VARIABILITY IN ADDITIVELY MANUFACTURED MATERIAL FOR TOPOLOGY OPTIMIZATION

Daniel D Pepler[1*] and Craig A Steeves[1]

1: Advanced Aerospace Structures Laboratory
Institute for Aerospace Studies
University of Toronto
4925 Dufferin St, North York, ON, Canada
d.pepler@mail.utoronto.ca, csteeves@utias.utoronto.ca

Abstract. *Topology optimization is a powerful optimization technique for efficiently generating optimal structures that can be very intricate, far beyond what a human designer could conceive. Additive manufacturing (AM) is one of the few manufacturing approaches that can be employed to construct such designs. However, the layering common to all additive manufacturing systems creates both anisotropic and stochastic material properties. If these material properties are not considered during the topology optimization, heavy manual post processing is required to ensure a robust design. This paper discusses the uncertainty expected in AM materials, and how the uncertainty can be measured using digital image correlation, quantified and incorporated in a numerical model. This employs a novel layered finite element that explicitly models the inherent morphology of AM materials. It is ideal for use in density-based topology optimization, because it enables modelling both the anisotropic and stochastic material properties simultaneously. The results indicate that the observable variation in the properties of AM materials can be modelled using layered elements.*

Keywords: Uncertainty, Quantification, Topology, Optimization, Additive, Manufacturing

AeroBest 2021
Lisboa, 21-23 July 2021

MULTIFIDELITY AEROELASTIC OPTIMIZATION APPLIED TO HAR WINGS

Yoann Le Lamer[1,2*], Giovanni Quaglia[1], Emmanuel Benard[1] and Joseph Morlier[2]

1: ISAE-Supaero
10 Avenue Edourd Belin, 31400 Toulouse, France
{yoann.le-lamer@isae-supaero.fr,giovanni.quaglia,
emmanuel.benard@isae-supaero.fr}@isae-supaero.fr

2: ICA, Université de Toulouse, ISAE-SUPAERO, MINES ALBI, UPS, INSA, CNRS, Toulouse, France
joseph.morlier@isae-supaero.fr

Abstract. *As part of a global effort toward the reduction of CO2 emissions, the study of High Aspect Ratio wings is a particularly promising avenue of research. Considering this type of configuration at preliminary design stage is thus critical for optimization purposes. The use of multifidelity can help reduce computational costs by mainly running low-fidelity computations and only resorting to high-fidelity computations when necessary. The goal of this study is to develop a sufficiently accurate aero-structural model in order to fully exploit the drag reduction potential of HAR wings. The first step is to develop and apply a multifidelity approach on the CRM wing by creating a low-fidelity model. It is made sure that there is an adequate correlation between the structural modes of both high-fidelity and low-fidelity models. The so obtained low-fidelity structural model is then implemented within a in-house aeroelastic analysis and optimization framework. Afterwards, a modified version of the CRM wing with a higher aspect ratio (AR=13.5) is considered in order to apply the same methodology with the goal to reduce significantly computational costs.*

Keywords: Multifidelity, High Aspect Ratio wings, Aeroelasticity, Multidisciplinary Design Optimization

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

WING AEROSTRUCTURAL OPTIMIZATION WITH ACTIVE FLOW CONTROL AND ACTIVE LOAD ALLEVIATION

Valerio Mosca[1*], Ali Elham[2]

1: Cluster of Excellence SE^{2}A – Sustainable and Energy-Efficient Aviation
Institute of Aircraft Design and Lightweight Structures
Technische Universität Braunschweig
Braunschweig, Germany, 38108
v.mosca@tu-braunschweig.de, https://www.tu-braunschweig.de/ifl/cad

2: Cluster of Excellence SE^{2}A – Sustainable and Energy-Efficient Aviation
Institute of Aircraft Design and Lightweight Structures
Technische Universität Braunschweig
Braunschweig, Germany, 38108
a.elham@tu-braunschweig.de, https://www.tu-braunschweig.de/ifl/cad

Abstract. *A medium-fidelity but physics-based analysis is performed to investigate advantages of novel technologies on the energy efficiency of a mid-range passenger aircraft. The framework intends to obtain accurate results, while keeping the computational cost lower than high-fidelity analysis and optimization. For this purpose, the coupled-adjoint aerostructural analysis and optimization tool FEMWET is modified to consider the effect of active flow control and active load alleviation on the outcome of a wing aerostructural optimization and consequently, on the overall aircraft fuel efficiency. Different test cases were studied, varying the maximum load factors reachable during flight and portion of laminar flow on the wing. Both technologies are found to be beneficial for fuel weight reduction. Best results are obtained considering the use of load alleviation, hence for* n_{max} *2 and 1.5 and for a wing with 80% laminar flow. The reduction is about 8.3% of the fuel weight while the wing drag may be reduced up to 22.5%.*

Keywords: Sustainable aviation, novel technologies, aircraft design, medium-fidelity analysis, aerostructural optimization

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

INVESTIGATING THE INFLUENCE OF UNCERTAINTY IN NOVEL AIRFRAME TECHNOLOGIES ON REALIZING ULTRA-HIGH ASPECT RATIO WINGS

Yiyuan Ma[1]*, Edmondo Minisci[2] and Ali Elham[1]

1: Institute of Aircraft Design and Lightweight Structures
Faculty of Mechanical Engineering
Technische Universität Braunschweig
35 Hermann-Blenk Street, 38108, Braunschweig, Germany
{Yiyuan.Ma, a.elham}@tu-braunschweig.de, https://www.tu-braunschweig.de/ifl

2: Intelligent Computational Engineering Laboratory
Faculty of Engineering
University of Strathclyde
75 Montrose Street, G1 1XJ, Glasgow, UK
edmondo.minisci@strath.ac.uk https://www.strath.ac.uk/staff/minisciedmondodr/

Abstract *This work studies the influence of uncertainty analysis on the unconventional aircraft conceptual design outcomes. The SBW and TF configurations are considered for the Short-Range (SR), Mid-Range (MR) and Long-Range (LR) missions, respectively. Conceptual design and analysis methodologies for the SBW and TF configurations are developed. Besides, the uncertainty analysis, constrained optimisation and global sensitivity analysis methodologies are presented. The proposed conceptual design methods are used to design an SBW and a TF aircraft for each mission, respectively, and the best-in-class configuration for each mission is initially obtained. Then the main uncertainties of each aircraft are identified and constrained optimisation is applied to find the best-case configuration with the objective function of the fuel weight. Moreover, a surrogate-based cut-HDMR method is used for the global sensitivity analysis to identify the most critical uncertainties and quantify their influences on the objective function. The results showed that according to the conceptual design results, the SBW configuration is the best-case for the SR mission, while the TF configuration is the best-case configuration for the MR and LR missions. Six main uncertainties, including four technologies-related and two mission-related parameters, are identified. The performed uncertainty analyses point out that, while there is not appreciable difference in terms of robustness against the operative and technology uncertainties for the SR mission configurations, the TF configuration is also more robust for MR and LR missions. Moreover, the sensitivity analyses assists in understanding which are the main uncertain drivers for each configuration and mission.*

Keywords: Uncertainty analysis, conceptual design, constrained optimisation, global sensitivity analysis, configuration comparative study

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

TOWARDS MANUFACTURED LATTICE STRUCTURES: A COMPARISON BETWEEN LAYOUT AND TOPOLOGY OPTIMIZATION

Enrico Stragiotti[1], François-Xavier Irisarri[1], Cédric Julien[1] and Joseph Morlier[2]

1: ONERA - The French Aerospace Lab
DMAS - Département matériaux et structures
92320 Châtillon, France
{enrico.stragiotti, francois-xavier.irisarri, cedric.julien}@onera.fr

2: ICA - Institut Clément Ader
ISAE - SUPAERO
31400 Toulouse, France
joseph.morlier@isae-supaero.fr

Abstract. *The repetitive nature of cellular lattice structures brings various interesting features among which fast assembly and repair time, reduced tooling, and manufacturing costs are major advantages. Additionally, as the mechanical performances of the structure are heavily influenced by the topology and materials of the cell, the designers can optimize the cell to tailor the structure for various scenarios. In this paper, we discuss and compare two relevant structural optimization methods for lattice structures: topology optimization and layout optimization. In the first part of the article, we presented an innovative cellular topology optimization formulation that minimizes the structural mass taking into account the internal stresses. The cellular implementation is based on the full-scale method called variable linking. In the second part, a qualitative comparison of topology and layout optimization is carried out, analysing the strength and the weakness of the two methods when applied to a lattice structure context.*

Keywords: Lattice Structures, Topology Optimization, Layout Optimization, Stress-Constrained Optimization, Structural Optimization

AeroBest 2021
Lisboa, 21-23 July 2021

MULTI-POINT AERODYNAMIC SHAPE OPTIMIZATION OF AEROFOILS USING MODIFIED XOPTFOIL

Ricardo J.F. Palmeira[1]*, and Pedro V. Gamboa[1]

1: Centre for Mechanical and Aerospace Science and Technologies (C-MAST-UBI)
Faculdade de Engenharia
Universidade da Beira Interior
6200-001 Covilhã
ricardo.palmeira@ubi.pt, pgamboa@ubi.pt, http://www.ubi.pt

Abstract

Aerofoil shape has a significant influence on aircraft performance. Multiple methodologies can be applied, such as direct design, inverse design or performance design. With the improvement of computer technology there has been a continuing trend of automating this process by using performance-based methods and formal optimization algorithms. Parametrization formulations of aerofoils have continually advanced, some examplesare B-Spline, Class Shape Functions, Hicks-Henne functions and Bezier-PARSEC 3333. Main comparisons of parametrizations have focussed on morphology, design space and aerodynamic consistency. The parametrizations mentioned are applied and its results compared for different numbers of design variables.

A multi-point approach is used with an aggregated objective function using weights that are determined using the aircraft design data, to maximize the score for the competition Air Cargo Challenge (ACC), using XFOIL for aerodynamic analysis and particle swarm optimization (PSO) under a modified version of the program XOPTFOIL. The initial aerofoil was obtained by iterative inverse design during previous works, the optimization includes the flap chord and deflection angle for the different selected lift coefficient conditions as design variables. The initial population is bounded between maximum and minimum limits set by the initial aerofoil design variables and an initial perturbation.

The aerofoil is constrained by minimum and maximum thicknesses, a minimum trailing edge angle and a specified trailing edge thickness. Several additional restrictions are also imposed on the aerofoil to avoid unneeded analysis of a geometry with an expected non converged solution in XFOIL. These include the angles' maximum, minimum and difference values of the two points closest to the leading edge, the maximum angle between any three consecutive points and the number of curvature sign reversals at the upper surface and lower surface of the aerofoil. To deal with the constraints and restrictions a penalty function is used, each penalty being normalized by a maximum set value. To ensure that these do not unduly constrain the domain exploration of the optimization, a dynamic limit to the penalties is used. During the optimization, this limit decreases linearly with the iterations.

Keywords: Aerofoil design, aerodynamic shape optimization, particle swarm optimization, aerofoil parametrization methods, multi-point optimization

AeroBest 2021
Lisboa, 21-23 July 2021

TOPOLOGY OPTIMIZATION OF A SMALL UAV FUSELAGE FOR ADDITIVE MANUFACTURING

Ricardo Costa[1], Frederico Afonso[1], José Chaves Pereira[1], Hugo Policarpo[1,2] and João Lourenço[1,3]

1: IDMEC
Instituto Superior Técnico
Universidade de Lisboa
Av. Rovisco Pais, 1049-001, Lisboa, Portugal
{ricardo.teixeira.costa, frederico.afonso, jose.chaves, hugo.policarpo}@tecnico.ulisboa.pt,
https://tecnico.ulisboa.pt/pt/

2: CINAV
Escola Naval, Instituto Universitário Militar
Base Naval de Lisboa - Alfeite
2810-001, Almada, Portugal

3: Althima - Engineering Software Solutions, Lda
Rua Dr. Ferreira Alves, 750 4405-936,Vila Nova de Gaia, Portugal
jlourenco@althima.com

Abstract. *Applications of Additive Manufacturing (AM) combined with Topology Optimization (TO) has grown over the past years for a multitude of engineering fields. One example is the design of tailored structures for Unmanned Aerial Vehicles (UAVs). TO is a powerful computational tool to devise these structures since it is able to provide a lightweight design that can handle the most critical aerodynamic loads in the flight envelope. The resulting design can be then post-processed for manufacturing, using an AM technology such as Fused Deposition Modeling (FDM). In this work, the aim is to topologically optimize the internal structure of the fuselage of a small UAV. For this purpose, the critical aerodynamic loads obtained from Computational Fluid Dynamic (CFD) simulations for the boundaries of the flight envelope will be considered. Furthermore, all the required onboard instrumentation, wiring and propulsive system must be accommodated inside the fuselage creating holes in the structure and increasing design complexity.*

Keywords: Topology Optimization; Additive Manufacturing; Computational Fluid Dynamics; Aircraft Design; Unmanned Aerial Vehicle

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

IMPACT OF THE DESIGN VARIABLES TYPE ON A FREEFORM WING OPTIMIZATION

Diego Bandeira de Melo Akel Thomaz[1], Pedro Tiago Silva Melo[1], Renata da Encarnacao Onety[2], Thiago Pontin Tancredi[3]

1: Mechanical Engineering / 2: Production Engineering
NEO - Nucleous of Engineering and Optimization / EST - Escola Superior de Tecnologia
UEA - Universidade do Estado do Amazonas
{dbdmat.eng16, ptsm.eng19, ronety}@uea.edu.br, http://www.uea.edu.br

3: TEG - Thermofluids Engineering Group / LabSin - Naval Simulation Lab
UFSC - Universidade Federal de Santa Catarina
thiago.tancredi@ufsc.br, http://ufsc.br/

Abstract. *This work discusses the impact of the variables choice on an optimization process. To exemplify this influence, the wing optimization of an aircraft is analyzed. Optimized geometry is defined by 3 sections that are described by 10 parameters. The first one refers to the section chord close to the aircraft fuselage. The other 9 parameters refer to the position, chord and offset of the three sections that control the wing geometry. In this model, the profile of each section is fixed and is not modified in the optimization. The aerodynamic performance is analyzed using the well-known AVL program. The objective function is the aircraft payload, which is calculated from the aerodynamic performance and an empirical model capable of estimating the aircraft weight. Once the work's focus is the influence of the choice of design variables on the optimization process, two optimization models are analyzed. The first model uses the absolute values of position, chord and offset for each section. The second one uses variations of these parameters as the design variables. The results showed that the model with relative variables had a considerably better performance for all evaluated metrics.*

Keywords: Optimization model, Wing, Shape optimization, Absolute variables, Relative variables.

AeroBest 2021
Lisboa, 21-23 July 2021

EFFICIENT GLOBAL MULTIDISCIPLINARY DESIGN OPTIMIZATION TO SUPPORT AIRCRAFT CONCEPTUAL DESIGN

Daigo Maruyama[1]*, Florian Schültke[2], Eike Stumpf[2] and Ali Elham[1]

1: Chair of Overall Aircraft Design
Institute of Aircraft Design and Lightweight Structures (IFL)
Technical University of Braunschweig
Hermann-Blenk-Straße 35, D-38108 Braunschweig
{d.maruyama, a.elham}@tu-braunschweig.de

2: The Institute of Aerospace Systems (ILR)
RWTH Aachen University
Wüllnerstraße 7, 52062 Aachen
{florian.schueltke, eike.stumpf}@ilr.rwth-aachen.de

Abstract *This paper presents an efficient global optimization (EGO) framework which is integrated into the UNICADO software to perform multidisciplinary design optimization (MDO). The EGO framework is based on surrogate modelling to efficiently predict cost functions and the constraints by the TALRs (Top-Level Aircraft Requirements). The MDO architecture is the multidisciplinary feasible (MDF) composed by the developed EGO framework and the multidisciplinary analysis (MDA) module available in the UNICADO workflow. The developed toolbox was demonstrated by using a test case using a short-range reference aircraft CSR-01as a conceptual aircraft design problem to perform its usability of efficiently exploiting the global optimum solution. The EGO framework was further developed by introducing an extended Gaussian process (GP) model to handle various conceivable application problems such as multi-fidelity analyses, cases of a large number of geometrical design variables, complicate cost functions, and an online EGO framework for further efficiency by offline database by treating the conventional EGO framework as an online process. It was demonstrated in this paper by using test functions that the extended GP model can provide more efficiency in finding the global optimum than the conventional EGO framework.*

Keywords: Efficient Global Optimization, Multidisciplinary Design Optimization, Gaussian Processes, Neural Networks, Adaptive Sampling, Multidisciplinary Feasible Architecture

1. INTRODUCTION

The conceptual aircraft design has been used for years to develop new aircraft configurations or evaluate new technologies in existing aircraft configurations. For this reason, there are many conceptual aircraft design environments worldwide, especially in universities, which are now all more or less at the same level. The UNICADO[i] project aims to develop and establish a university conceptual aircraft design environment to bundle the design and disciplinary competencies of German universities and make them usable in the long term. The fundamental goal is to exploit synergy potentials and shift the focus of research and teaching from code development to actual design work. The design environment will be validated together with industry and large-scale research. Please refer [1] for more details on the objective of the UNICADO project.

[i] UNICADO: Development and Establishment of a University Conceptual Aircraft Design and Optimization Environment – project is funded by the German government in "Luftfahrtforschungsprogramm VI-I"

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

DEVELOPMENT OF MDO FORMULATIONS BASED ON DISCIPLINARY SURROGATE MODELS BY GAUSSIAN PROCESSES

S. Dubreuil[1*], N. Bartoli[1], G. Berthelin[1], O. Chandre Vila[2], C. Gogu[2], T. Lefebvre[1], J. Morlier[2] and M. Salaün[2]

1: ONERA/DTIS
Université de Toulouse
Toulouse, France
{sylvain.dubreuil,nathalie.bartoli,gaspard.berthelin,thierry.lefebvre}@onera.fr

2: ICA, ISAE-SUPAERO, MINES ALBI, UPS, INSA, CNRS
Université de Toulouse
Toulouse, France
{oriol.chandre-vila,joseph.morlier,michel.salaun}@isae-supaero.fr
{christian.gogu}@gmail.com

Abstract. *Surrogate based optimization is now well established in the field of derivative free optimization. Among the various possible approaches, this study focuses on Bayesian optimization using Gaussian process interpolation as surrogate models. From the pioneering work on unconstrained optimization based on the expected improvement to the latest developments of enrichment criteria to deal with nonlinear constrained problems, the Bayesian framework has been extensively studied and used in many application fields. During the last few years a collaboration between the authors led to the publication of several contributions aiming at the development and the evaluation of MDO formulations based on disciplinary Gaussian process surrogate models. In these formulations each disciplinary solver is modeled by Gaussian processes that are coupled to solve the MDA. Hence, the formulation is uncoupled as only the disciplinary surrogate models are coupled and not the actual disciplinary solvers. It is proposed here to focus on two challenges raised by this formulation, to which the authors contributed in the past. The first one concerns the extension and application of the Bayesian framework to the case in which the objective function is not modelled by a Gaussian random field. To make progress with respect to this issue, an original representation of this random field using an adaptive discretization strategy has been proposed leading to the Efficient Global Multidisciplinary Optimization (EGMDO) formulation. The second one concerns the resolution of the interdisciplinary coupling in the case of large vector valued coupling variables. As an example, static aeroelasticity which couples a CFD solver and a FEM solver is studied. Some proposals, based on model order reduction (e.g. Proper Orthogonal Decomposition) and Gaussian process interpolation, have been evaluated by the authors. Objective of this paper is thus to sum up these various contributions while presenting the potential benefits and remaining challenges of these MDO formulation to the MDO researchers community.*

Keywords: Multidisciplinary Design and Optimization, Bayesian Optimization, Gaussian Process Interpolation, Model Order Reduction

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

PERFORMANCE OF HYBRID OPTIMIZATION METHODS APPLIED TO ACTIVE FLOW CONTROL DEVICES

Martí Coma[1,2*], Navid M. Tousi[1], Jordi Pons-Prats[1,2], Josep M. Bergadà[1] and Gabriel Bugeda[1,2]

1: Universitat Politècnica de Catalunya. Barcelona Tech (UPC)
Edificio C1, Gran Capitan, 08034
Gran Capitan, 08034, Barcelona, Spain
Tel. (+34) 934016494 / Fax. (+34) 934016894
e-mail:
marti.coma,navid.monshi.tousi,jordi.pons-prats,josep.m.bergada,gabriel.bugeda@upc.edu,
http://www.upc.edu

2: Centre Internacional de Mètodes Numèrics a l'Enginyeria (CIMNE)
Edificio C1, Gran Capitan, 08034
Barcelona, Spain. Tel. (+34) 932057016 / Fax. (+34) 934016517
e-mail: mcoma, jpons, bugeda@cimne.upc.edu, http://www.cimne.com

Abstract. *Genetic Algorithms (GA) are optimization methods that are usually very robust but have a slow convergence to the exact minimum. On the other hand, Gradient Based methods which converge better, are not so robust, and can get stuck in local minimums or flat areas. In this article a Hybrid optimization method is presented and its performance is compared against a Gradient Based method and a Genetic Algorithm. The comparison is established with a Gradient Based method, which is a Conjugate Gradient, and a Genetic Algorithm, based on a* $\mu + \lambda$ *strategy. The Hybrid methods combine the two above-mentioned methods. Each Hybrid implementation is composed of a GA and a Conjugate Gradient which share information at each iteration, to try overcome individual-method limitations and achieve a better performance. The strategy used for sharing information among each method is based on games theory, more specifically Nash Games. The use of a coupling based on competitive players enhances the overall performance of the method pushing each one with the improvements of the other one. This enables an efficient management of the individuals, and the optimum ones, ensuring a good balance when dealing with elite individuals. A performance comparison is done with the optimization of an Active Flow Control (AFC) over a 2D Selig-Donovan 7003 (SD7003) airfoil at Reynolds number* 6×10^4 *and 14 degrees of attack. Five design variables are considered: jet position, jet width, momentum coefficient, forcing frequency and jet inclination angle. The fluid flow problem is solved using Computational Fluid Dynamics (CFD) with the Spalart-Allmaras turbulent model. The motivation behind the current study is to evaluate the performance of the Hybrid methods in a physical problem with a computationally expensive objective function.*

Keywords: Hybrid Optimization Methods, Optimization, Population-based Methods, Gradient-based Methods, Evolutionary Techniques, Active Flow Control, Synthetic Jet

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

AEROELASTIC IMPLICATIONS OF ACTIVE WINGLET CONCEPT AIMED TO IMPROVE CIVIL TRANSPORT AIRCRAFT PERFORMANCES

Martin Delavenne[1*], Bernard Barriety[2], Fabio Vetrano[2], Valérie Ferrand[3] and Michel Salaün[4]

1: Aircraft Design Department
ISAE-Supaero
Univ. Toulouse
10 Av. Edouard Belin, Toulouse, France
martin.delavenne@isae-supaero.fr

2: Loads and Aeroelastic Department
Airbus Operations SAS
316 route de Bayonne, Toulouse, France

3: Aerodynamic and Propulsion Department
ISAE-Supaero

4: Structural Mechanics and Material Department
ISAE-Supaero

Abstract. *Reduction of aircraft environmental footprint has become over years a key objective for the industry. Particularly, for decades winglets have been proven to efficiently reduce drag and fuel consumption. However, the design of those wingtip extensions mainly relies on an aerodynamic shape optimisation for a given cruise condition resulting in suboptimal behaviour for the rest of the flight. Active winglet concept proposes to optimise the winglet cant angle along the flight to compensate the loss of efficiency inherent to fixed designs. The variation of winglet deflection impacts the lift distribution with repercussion on wing deformation that must be investigated. Besides, the presence of moving masses at the tip of the wing also has influence on dynamic response and particularly on flutter onset. This work proposes to evaluate those impacts through an aeroelastic analysis of both static and dynamic implications of active winglets combined with an aerodynamic performances optimisation. The XRF1, an Airbus provided industrial standard multi-disciplinary research test case representing a typical configuration for wide body long-range aircraft, is used as the baseline aircraft. Coupled CFD/CSM computations are performed to assess the evolution of wing shape with respect to winglets deflections and the consequences on mission performance optimisation. While a parametric flutter analysis is carried-out to highlight the dependence of critical flutter speed on winglet cant angle.*

Keywords: Active winglet, aeroelasticity, CFD/CSM, optimization

AeroBest 2021
Lisboa, 21-23 July 2021

A COMPARATIVE STUDY ON MULTI-FIDELITY SONIC BOOM PREDICTION FOR A SUPERSONIC AIRCRAFT

Yusuf Demiroglu[1] and Melike Nikbay[2]

1:Research Assistant, Faculty of Aeronautics and Astronautics
Istanbul Technical University, Maslak, Istanbul, 34469, Turkey
demirogluy@itu.edu.tr

2:Professor, Faculty of Aeronautics and Astronautics
Istanbul Technical University, Maslak, Istanbul, 34469, Turkey
nikbay@itu.edu.tr

Abstract. *Sonic boom signature prediction is a primary criteria for low-boom supersonic aircraft design and requires multidisciplinary analysis. Due to high computational time required in multidisciplinary optimization processes, we study sonic boom prediction within a multi-fidelity approach. In this study, sonic boom loudness is computed by employing multi-fidelity aerodynamic and acoustics solvers. First, PANAIR panel code is used to determine the aerodynamic characteristics and the near-field pressure signature with a low-fidelity. Meanwhile, at high-fidelity, SU2 multi-physics solver is employed to solve for the near-field flow region around the aircraft. As a high-fidelity acoustic solver, NASA's sBOOM code is coupled with SU2 code via a Python script to automate the aerodynamic and acoustic solution process sequentially. Various wing-body combinations and several test cases were analyzed with both low- and high-fidelity solvers in our former studies. Here, the near field pressure signature and sonic boom ground signature of a complete low-boom aircraft configuration are studied with more focus to get a better understanding of the physical and geometrical limitations of the combined low-fidelity solution methods. This study aims to address the low-fidelity sonic boom prediction methods with respect to high-fidelity solutions in support of multi-fidelity design exploration and multidisciplinary optimization studies for supersonic aircraft design.*

Keywords: Sonic Boom Prediction, CFD, Panel Methods, Supersonic Flight, Acoustics

AeroBest 2021
Lisboa, 21-23 July 2021

A DAMAGE-BASED FRAMEWORK TO IMPROVE THE STRENGTH OF STRAIN DRIVEN GENERATIVE DESIGNS

Gonzalez Marco, Miguel[1*], Saucedo Mora, Luis[2], Garcia Modet, Hugo[3], Sanz Gomez, Miguel Angel[4] and Montans Leal, Francisco Javier[5]

GAMOSINOS: Grupo Avanzado de MOdelado y SImulación NO-lineal de Sólidos
Escuela Tecnica Superior de Ingenieria Aeronáutica y del Espacio
Universidad Politécnica de Madrid
28040
miguel.gonzalez.marco@alumnos.upm.es
luis.saucedo@upm.es
hugo.garcia.modet@alumnos.upm.es
miguelangel.sanz@upm.es
fco.montans@upm.es

Abstract. *This dissertation aims to achieve a damaged-based framework of the study of generative design pieces by optimizing the structural behavior in strain. By putting the piece through a virtual traction test, the objective is to achieve the breakage point which will give the necessary information to enhance the structural properties of weak areas in strain behavior. This will change the form of the design reinforcing these zones, so if done iterative, it will give a full-optimized piece against traction, reinforced in those areas which could be critical in a real-case scenario.*

Keywords: Topological Optimization, Tension test, damage, Generative design, structures, aerospace

AeroBest 2021
Lisboa, 21-23 July 2021

UNCERTAINTY QUANTIFICATION OF AEROELASTIC SYSTEMS USING ACTIVE LEARNING GAUSSIAN PROCESS

Sihmehmet Yildiz[1], **Enes Cakmak**[2], **Emre Kara** [2] **and Melike Nikbay**[3]

1: Research Assistant, Faculty of Aeronautics and Astronautics
Istanbul Technical University, Maslak, Istanbul, 34469, Turkey
yildizsih@itu.edu.tr

2: Research Scholar, AeroMDO Lab, Faculty of Aeronautics and Astronautics
Istanbul Technical University, Maslak, Istanbul, 34469, Turkey
cakmake19@itu.edu.tr
karae16@itu.edu.tr

3: Professor, Faculty of Aeronautics and Astronautics
Istanbul Technical University, Maslak, Istanbul, 34469, Turkey
nikbay@itu.edu.tr

Abstract. *This paper presents an uncertainty quantification study for the aeroelastic analysis of the High Reynolds Number Aerostructural Dynamics (HIRENASD) wing. The computational aeroelastic analysis employs an open-source multi-physics suite SU2 with a fully-coupled fluid-structure interaction capability. The surrogate model which is used for the uncertainty quantification study is constructed by integrating an Active Learning procedure into the Gaussian Process Regression Method for improving efficiency and accuracy. The current Active Learning assisted uncertainty quantification approach is assessed with respect to the conventional uncertainty analyses which are based on surrogates generated with Polynomial Chaos Expansion, Kriging, and Polynomial Chaos-based Kriging Metamodel methods. The root mean square error and maximum absolute error test metrics demonstrated that the Active Learning assisted Gaussian Process method provided more successful results than other methods in capturing both global and local features during this aeroelastic uncertainty quantification study.*

Keywords: Aeroelasticity, Uncertainty Quantification, Gaussian Process, Active Learning, Adaptive Sampling, HIRENASD

AeroBest 2021
Lisboa, 21-23 July 2021

A MULTI-OBJECTIVE OPTIMIZATION APPROACH TO THE DESIGN OF A FREE-FLYER SPACE ROBOT FOR IN-ORBIT MANUFACTURING AND ASSEMBLY

João Vale[1*], Alexandre Rocha[1], Marco Leite[2] and Rodrigo Ventura[1]

1: Instituto de Sistemas e Robótica
Instituto Superior Técnico
Universidade de Lisboa
Av. Rovisco Pais 1, 1049-001 Lisboa
{joao.luis.bruno.vale,alexandre.rocha,rodrigo.ventura}@tecnico.ulisboa.pt,
https://www.tecnico.ulisboa.pt

2: Instituto de Engenharia Mecânica
Instituto Superior Técnico Universidade de Lisboa
Av. Rovisco Pais 1, 1049-001 Lisboa
marcoleite@tecnico.ulisboa.pt, https://www.tecnico.ulisboa.pt

Abstract. *The growing need for larger assets in Space, ranging from commercial space stations to exploration beyond Earth orbit, will require the capability of manufacturing and assembling large structures in micro-gravity. Considering the use of autonomous space robots to perform these tasks, this paper studies the optimal design of a free-flyer robot for mobile manipulation with an emphasis on assembly and additive manufacturing. We propose a robot architecture comprising a dexterous six DoF parallel manipulator attached to a free-flyer robot body endowed with six DoF propulsion. The design methodology decouples the parallel manipulator from the robot body: For the parallel manipulator, we define performance metrics for work-space volume and accuracy. We employ multi-criteria optimization to determine the geometric parameters which best tradeoff defined metrics. For the robot body propulsion, we find which geometries result in maximum thrust and torque along all directions, in both force and torque space, thus maximizing maneuverability.*

Keywords: Space robotics, In-orbit manufacturing and assembly, Mobile manipulation, Multi-objective optimization

AeroBest 2021
Lisboa, 21-23 July 2021

APPLICATION OF THERMAL ENGINEERING SYSTEMS COMPUTATIONAL MODELS IN AIRCRAFT PASSENGER VIRTUAL CABIN

Eusébio Z. E. Conceição[1]*, João M. Gomes[2], Mª Manuela J. R. Lúcio[1] and Hazim B. Awbi[3]

1: Faculdade de Ciências e Tecnologia
Universidade do Algarve,
Campus de Gambelas, 8005-139 Faro, Portugal
econcei@ualg.pt, maria.manuela.lucio@gmail, http://www.ualg.pt

2: CINTAL
Campus de Gambelas, 8005-139 Faro, Portugal
jgomes@ualg.pt http://www.ualg.pt

3: School of Built Environment,
University of Reading, Reading, RG6 6AW, United Kingdom
h.b.awbi@reading.ac.uk.com http://www.reading.ac.uk/

Abstract. *This numerical work presents a design of an indoor environment and comfort evaluation, namely the thermal comfort and the air quality, in aircraft passenger cabin simulated through a virtual chamber similar to a real experimental chamber. This work presents and applies a numerical model, that considers the coupling of the CFD (Computational Fluids Dynamics) and HTR (Human Thermo-Physiology Response) numerical models. The coupling system, itself, generates the occupation presence and transfers the inputs/output between the CFD and HTR numerical models. The input of the compartment, using the Computational Aid Design, the location of the occupants and the external environmental variables are introduced in the software, while the occupants' geometry is generated by empirical equations, based on the height and width dimensions. The study is made in a virtual chamber occupied by twenty-four virtual occupants and twenty-four seats and equipped with a ceiling-mounted air distribution system. The inlet airflow is located above the head level, while the outlet airflow is located in the aircraft passenger cabin central area at the ceiling level. In the present study, the thermal comfort level (using the Predicted Mean Vote and the Percentage of People Dissatisfied indexes), the air quality level (using the carbon dioxide concentration in the respiration area), the Draught Risk (using the Predicted percentage of dissatisfied people), ventilation effectiveness for heat removal and effectiveness for contaminant removal and the ADI (Air Distribution Index), that each occupant is subjected, are calculated. Four Cases studies, defined for different mean internal air temperature, with an external air temperature of -50ºC, were developed. In accordance with the obtained results the thermal comfort level and the air quality are acceptable and ADI index is highest for the highest internal air temperature.*

Keywords: CFD, Human Thermo-physiology, Thermal comfort, Air Quality, ADI

AeroBest 2021
Lisboa, 21-23 July 2021

DESIGN OF A HYDROGEN POWERED SMALL ELECTRIC FIXED-WING UAV WITH VTOL CAPABILITY

Bernardo M. Alves[1]*, Vasco L. Coelho[1], Pedro A. Silva[1], André C. Marta[2], Frederico J. Afonso[2], Paulo J. Sá[1], Luís F. Félix[1] and João V. Caetano[1]

1: Centro de Investigação da Academia da Força Aérea
Academia da Força Aérea
Instituto Universitário Militar
Granja do Marquês, 2715-021 Pêro Pinheiro, Portugal
{bmalves, vlcoelho, paasiva, pjsa, lffelix, jvcaetano}@academiafa.edu.pt,
http://www.academiafa.edu.pt

2: IDMEC
Instituto Superior Técnico
Universidade de Lisboa
Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal
{andre.marta, frederico.afonso}@tecnico.ulisboa.pt, http://www.tecnico.ulisboa.pt

Abstract. *Most electric small UAVs require large batteries, which lead to increased weight and low endurance. With the current development of new energy sources and emerging technologies, the present work aims to design a fixed-wing UAV with vertical take-off and landing (VTOL) capability using a fuel cell-based propulsion system. The design requirements made by the Portuguese Air Force include a maximum take-off mass of 25 kg and a minimum flight time of two hours. To accomplish these, a conceptual design framework was developed, supported by fast estimates for the disciplines of aerodynamics, structures, propulsion and controls, and a multi-objective optimisation approach led to the initial UAV configuration and sizing. The different discipline models were coupled and multidisciplinary optimisation was conducted to find the UAV optimal design. This process led to a 22 kg aircraft, having a maximum endurance over 3 hours with a 7.2L hydrogen tank, assisted with batteries for VTOL and climb. The results obtained suggest that the application of the hydrogen-powered fuel cell system meets the requirements set, while also proving to be a feasible alternative to conventional solutions.*

Keywords: Fuel cell, Green aircraft, MDO, Multi-objective optimisation, Multi-rotor, Pusher configuration

AeroBest 2021
Lisboa, 21-23 July 2021

COMPUTATIONALLY EFFICIENT APPROXIMATE BUCKLING AND POSTBUCKLING ANALYSIS OF PRISMATIC COMPOSITE STRUCTURES

Jakob C. Schilling[1*] and Christian Mittelstedt[1]

1: Institute for Lightweight Construction and Design
Department of Mechanical Engineering
Technical University of Darmstadt
Otto-Berndt-Str. 2, 64287 Darmstadt, Germany
jakob.schilling@klub.tu-darmstadt.de, https://www.klub.tu-darmstadt.de

Abstract. *In order to optimize the design of structures of aircraft and space vehicles in preliminary stages, highly computationally efficient analysis methods are needed. Therefore, a closed-form approximate model is proposed that describes the stability behavior of prismatic composite structures. An example for such a structural element is an omega-stringer-stiffened panel that is currently used in the design of aircraft fuselages. The closed-form analysis is achieved by energy methods and aims to describe the stability behavior in the region of the bifurcation point approximately. The loadcase is limited to uniaxial compression. The results are compared to numerical methods. The introduced computational model offers the opportunity to fully utilize the potential of optimization by a highly efficient approximate analysis method.*

Keywords: Buckling, Composites, Postbuckling, Analytical, Computational model

AeroBest 2021
Lisboa, 21-23 July 2021

DESIGN OPTIMIZATION OF ACTIVE HELICOPTER SEAT SYSTEM FOR FLIGHT TESTING

Yong Chen, Amin Fereidooni, Rene Laliberte, Viresh Wickramasinghe

Aerospace Research Centre
National Research Council Canada
K1A 0R6
Eric.Chen@nrc-cnrc.gc.ca, http://www.nrc.canada.ca

Abstract *Helicopter aircrew are exposed to high levels of whole-body vibration during fight, which can degrade their ride comfort and even contribute to health issues such as lower back pain and neck strain. A patented active seat mount technology has been developed to reduce aircrew whole-body vibration at the N/rev harmonic frequencies of the helicopter main rotor speed. This paper describes the prototype design that demonstrated significant whole body vibration reduction to the manikin occupant in mechanical shaker experiments. To demonstrate the performance through flight testing on the Bell-412 helicopter, re-design and optimization of the prototype active helicopter seat mount have been introduced. These include the structural modifications and improvements to the baseline actuation mechanism for integration within the helicopter cabin, as well as the need to satisfy airworthiness requirements for flight demonstration on the NRC Bell-412 helicopter testing platform.*

Keywords: helicopter seat mount, active vibration control, flight testing, design and testing

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

WINGBOX META-MODEL AND AERO-SERVO-ELASTIC OPTIMIZATION WITH NEOPT

Francesco Toffol[1]*, Sergio Ricci[1]

1: Department of Aerospace Science and Technology
Politecnico di Milano
Via La Masa 34, 20156, Milano, Italy
francesco.toffol@polimi.it, sergio.ricci@polimi.it
https://www.aero.polimi.it

Abstract *This work presents a new methodology for the description of the wingbox, suitable for the conceptual and preliminary design phases. Starting from few geometrical information, a semi-analytical model of the wingbox is realized. The wingbox is described with a stick model and its stiffness and mass properties are obtained with a cross-section finite element solver which manages isotropic and orthotropic materials. The beam properties are updated in the aero-elastic model (stick FE +VLM/DLM) which is used for the evaluation of dynamic and trim load envelopes. An optimization framework sizes the wingbox using as design variables its thicknesses, satisfying failure, buckling and flutter constraints.*
The framework is exploited to perform a sensitivity study on a long-haul aircraft, evaluating how different design choices affect the overall performances.

Keywords: Conceptual design, meta-model, multidisciplinary optimization, active control, aero-servo-elasticity

AeroBest 2021
Lisboa, 21-23 July 2021

PROPELLER BLADE OPTIMIZATION FOR UNMANNED AIR VEHICLES DESIGN APPLICATION

Tenon Charly Kone[1]*, Sebastian Ghinet[1], Anant Grewal[1] and Viresh Wickramasinghe[1]

National Research Council Canada,
Flight Research Laboratory
1200 Montreal Road, Ottawa, ON, K1A 0R6, Canada
TenonCharly.Kone@nrc-cnrc.gc.ca, https://nrc.canada.ca
Sebastian.Ghinet@nrc-cnrc.gc.ca, https://nrc.canada.ca
Anant.Grewal@nrc-cnrc.gc.ca, https://nrc.canada.ca
Viresh.Wickramasinghe@nrc-cnrc.gc.ca, https://nrc.canada.ca

Abstract *Due to their impact on vehicle performance, energy efficiency and noise, propeller design is important in aircraft design in general and in unmanned aerial systems (UAS) in particular. The design of appropriate propeller configuration with optimum number of blades, allows for improvements in aerodynamic performance while decreasing the UAS energy dependence and thus reducing the CO_2 emissions. Recent advances in numerical simulation has resulted in the implementation of multidisciplinary optimization for complex shape propeller blade designs a feasible and affordable option. However, the numerical simulation linked to the optimization of complex systems such as propeller blades is known as a task of considerable computational time and complexity. In addition, the cost associated with the required commercial software contribute to the increase in design costs. As a result metamodel techniques using open source algorithms as a mean to explore and support the initial design concepts have become standard practice as they reduce the computational time required and decrease the total design cost.*

This paper proposes an optimization approach based on metamodels. The approach adopted is to combine several open source codes such as Salomé for the design and development of the mesh, OpenFoam for aerodynamic modelling and finally Dakota for the generation of new design parameters and the optimization of the aerodynamic performance. Improved aerodynamic performance was demonstrated numerically for an optimized propeller blade configuration as compared to a baseline geometry configuration.

Keywords: multidisciplinary design, propeller blade, optimization, aerospace, metamodel

AeroBest 2021
Lisboa, 21-23 July 2021

DESIGN AND OPTIMIZATION OF A 3D PRINTED PROPELLER FOR A VTOL UAV

H. Rocha[1], P. Alves[1], A. Rodrigues[1], M. Silvestre[1]

1: C-MAST—Center for Mechanical and Aerospace Science and Technologies
Department of Aerospace Sciences
University of Beira Interior
Rua Marquês d'Ávila e Bolama, 6201-001 Covilhã, Portugal
hugo.rocha;ferreira.alves;andre.filipe.rodrigues;mars@ubi.pt

Abstract. *Propeller design and optimization is widely present in aircraft development. Generally, UAV propeller optimization lays in minimizing the consumed electrical power for certain flight condition. In the field of eVTOL aircraft, one type of mission segment in which the importance of propeller optimization is highlighted is in hovering flight. This is especially relevant to surveillance and monitoring UAVs. In this work, promoted by Tekever, an inverse design method was implemented in order to obtain an optimum propeller for an eVTOL UAV, with the objective to minimize the electric power consumption of the propulsion system in hovering flight. The algorithm, based on vortex theory, considered a Prandtl's root correction, which is usually not present in optimum propeller design algorithms. Two propellers were obtained using the method, one considering the Prandtl's root correction, and another without considering it. The propellers were then 3D printed and tested in a wind tunnel. The experimental results were also compared to results obtained with a Blade Element Momentum analysis code. The results suggest that the consideration of the Prandt'ls root correction in the inverse design of the propeller rendered a more optimized propeller, with a higher efficiency. This indicates that the corrections made to the Blade Element Momentum analysis models, such as 3D and stall delay corrections, might also be necessary to implement in Inverse Design methods, in order to obtain correctly optimized propellers.*

Keywords: Propeller, performance, inverse design, optimization, 3D printing, wind tunnel

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

STUDY OF DISTRIBUTED ARCHITECTURES FOR MULTI-DISCIPLINARY OPTIMIZATION USING OPENMDAO

Shantanu S. Gulawani[1]*, K. M. Kiran Babu[1] and Rajkumar S. Pant[1]

Department of Aerospace Engineering,
Indian Institute of Technology Bombay, Mumbai
{shantanusg, kiranbabu, rpant}@iitb.ac.in, http://www.aero.iitb.ac.in/

Abstract *Multidisciplinary Optimization (MDO) is the approach of solving a problem to arrive at an optimum solution by considering all the significant disciplines that simultaneously influence the design. Many opensource and commercial MDO architectures are available, each having its own unique capabilities and benefits, such as OpenMDAO, which is an open-source MDO framework developed by NASA. With the use of MDO architectures, a largescale multi-disciplinary optimization problem can be transformed into a series of optimization sub-problems. In this study, an attempt is made to study and implement Collaborative Optimization (CO), Enhanced Collaborative Optimization (ECO) and MDO of Independent system (MDOIS) in OpenMDAO framework. The two test problems implemented in this study are Sellar's analytical problem and a Two-bar truss problem. Sellar's problem is solved by CO; the results are then compared with monolithic architectures. The two-bar truss design problem is formulated as a multi-level structural optimization problem and solved with CO, ECO and MDOIS. The implementation of nested optimization problems allowed the formulation of various distributed architectures.*

Keywords: Multi-Level Optimization, Collaborative Optimization, Distributed Architectures, Gradient-Based Optimization, Multi-Disciplinary Analysis

AeroBest 2021
Lisboa, 21-23 July 2021
©ECCOMAS, Portugal

A MULTIFIDELITY AERODYNAMIC SURROGATE MODEL IMPLEMENTATION FOR OPTIMIZATION OF A NONPLANAR LIFTING SURFACE

Berkay Pirlepeli[1],Melike Nikbay[2] and Konstantinos Kontis[2]

1: Faculty of Computer and Informatics Engineering
Istanbul Technical University
34467
pirlepeli18@itu.edu.tr, http://www.itu.edu.tr

2: Professor of Aerospace Engineering
Faculty of Aeronautics and Astronautics
Istanbul Technical University
34467
nikbay@itu.edu.tr, http://www.itu.edu.tr

3: Professor of Aerospace Engineering
School of Engineering
James Watt South Building
Glasgow, G12 8qq
kostas.kontis@glasgow.ac.uk, https://www.gla.ac.uk

Abstract. *As the requirements for green aviation technologies emerge, improving aerodynamic and structural performance of the lifting surfaces is beneficial to reduce costs and environmental pollution. Novel wing shapes such as non-planar lifting system configurations promise a significant improvement of aerodynamic efficiency by reducing lift-induced drag and consequently increasing aerodynamic efficiency for low-speed flight conditions in aircraft design. In this study, an optimal design study for a non-planar wing based on the SACCON configuration has been performed using a multi-fidelity surrogate model. To investigate the design space thoroughly and capture the sensitivities of the design variables, aerodynamic analyses are conducted with a low fidelity vortex lattice method on a large set of samples which are generated by the Latin Hypercube Sampling method. High fidelity prediction of the induced drag is obtained with Reynolds Averaged Navier Stokes (RANS) equations by using OpenFOAM solver. As the number of optimization parameters is high and RANS simulations are computationally expensive, a remedy for the optimization process is needed. Thus, a co-Kriging aerodynamic surrogate model is generated with low fidelity and high fidelity analyses by reducing the number of high fidelity CFD analyses efficiently.*

Keywords: non-planar wings, induced drag, multifidelity, co-Kriging, surrogate model, SACCON

AeroBest 2021
Lisboa, 21-23 July 2021

ROBUST DESIGN OF AIRCRAFT WING SIZING INCLUDING JIG TWIST SHAPE

L. Liu[1]*, C. Scarth[2] and J.E. Cooper[1]

[1] Dept of Aerospace Engineering
Faculty of Engineering
University of Bristol
University Walk, Bristol, BS81TR
long.liu@bristol.ac.uk
[2] Dept of Mechanical Engineering
University of Bath

Abstract *The aim of aircraft structural design is to produce a structure that enables the aircraft to meet all of the design requirements - range, performance, payload - whilst meeting all structural and aeroelastic constraints. Recent optimization approaches to achieve this goal have considered robust and reliable designs whereby uncertainties in the manufacturing, material and operating conditions are taken into consideration. This work will consider the effect that uncertainties in the jig (i.e manufactured shape on the ground) twist shape have upon design aerodynamic and aeroelastic performance. Robust design strategy is evaluated on a simple wing box model and compared to deterministic (i.e. no uncertainty) solutions to minimize wing weight, maximize lift over drag and maximize flight range. It is shown how it is important to consider jig shape uncertainties in the design optimization in order to produce viable practical solutions.*

Keywords: Jig Twist Shape, Aeroelastic performance, MDO, Robust and Reliable Optimisation

AeroBest 2021
Lisboa, 21-23 July 2021

SIZING OF HIGH ASPECT RATIO WINGS INCORPORATING FOLDING WINGTIP

H. Gu[1*], F. Healy[1], and J.E.Cooper[1]

Dept of Aerospace Engineering
Faculty of Engineering
University of Bristol
Email address
huaiyuan.gu@bristol.ac.uk

Abstract. *There is currently much interest in the development of high Aspect Ratio Wings due to the inherent reduction in induced drag that they provide; however, there are a number of potential problems including the increased structural weight and the limits on the wingspan imposed by the airport gate sizes. The use of floating folding wingtips has been shown to not only enable the aircraft to meet with the operational conditions in the airports, but also to reduce loads imposed on the wing. In this work, a comprehensive sizing of aircraft models is performed for a range of aspect ratios and incorporating a folding wing tip device with semi-aeroelastic hinge. The hinge is locked during cruise allowing the optimum aerodynamic performance to be obtained, while releasing it during gust and manoeuvres to achieve effective load alleviation. It was found that the wing-box mass reduces linearly with increasing proportions of the folding wingtip. A 30% reduction in wing weight can be achieved by extending the folding wingtip up to 40% of the wingspan, leading to an improved performances at the overall system level.*

Keywords: High Aspect Ratio Wings, Folding Wing tips, Preliminary Aircraft Design


image: MDO Lab, University of Victoria