

# Aircraft Design

Papers Presented at the AIAA SciTech Forum and Exposition  
2020

Orlando, Florida, USA  
6-10 January 2020

Volume 1 of 2

ISBN: 978-1-7138-1076-6

**Printed from e-media with permission by:**

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



**Some format issues inherent in the e-media version may also appear in this print version.**

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

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

# TABLE OF CONTENTS

## VOLUME 1

### **AIRCRAFT CONFIGURATION DESIGN STUDIES - FLYING/BLENDED AND TRUSS-BRACED WINGS**

VEHICLE DESIGN STUDY OF A STRAIGHT FLYING-WING WITH BELL SHAPED SPANLOAD.....	1
<i>Kevin Hainline, Jonathan Richter, Ramesh K. Agarwal</i>	
CONCEPTUAL DESIGN AND OPTIMIZATION OF A SOLAR-ELECTRIC BLENDED WING BODY AIRCRAFT FOR GENERAL AVIATION .....	46
<i>Nils Kleemann, Stanislav Karpuk, Ali Elham</i>	
MULTI-FIDELITY DESIGN OPTIMIZATION OF A LONG RANGE BLENDED WING BODY AIRCRAFT WITH NEW AIRFRAME TECHNOLOGIES .....	69
<i>Yaolong Liu, Angu Praveen Muthu Swamy, Ali Elham</i>	
DEVELOPMENT OF AN EFFICIENT M=0.80 TRANSONIC TRUSS-BRACED WING AIRCRAFT .....	86
<i>Neal A. Harrison, Gregory M. Gatlin, Sally A. Viken, Michael Beyar, Eric D. Dickey, Krishna Hoffman, Eric Y. Reichenbach</i>	

### **AIRCRAFT SYSTEM/SUBSYSTEM DESIGN AND ARCHITECTURE**

CONCEPTUAL DESIGN OF AIRCRAFT SYSTEM ROUTING ARCHITECTURES USING A BIO-INSPIRED ALGORITHM .....	100
<i>Jumpei Taneichi, Kenichi Rinoie</i>	
A MULTI-DESIGN POINT SIZING METHODOLOGY FOR ENVIRONMENTAL CONTROL SYSTEMS .....	114
<i>Mingxuan Shi, Yu Cai, Jonathan C. Gladin, Dimitri N. Mavris</i>	
ELECTRICAL CABLE DESIGN FOR URBAN AIR MOBILITY .....	134
<i>Eliot Aretskin-Hariton, Maricela Lizcano, Janet Hurst, Eric S. Hendricks, Jeffryes W. Chapman, Anthony Goretski</i>	
PROPULSION SYSTEM COMPONENT MODELING FOR AN ALL-ELECTRIC COMMUTER AIRCRAFT MISSION .....	145
<i>Saakar Byahut, Alejandra Uranga</i>	

### **PROPELLER AND DUCTED FAN DESIGN**

PROPELLER DESIGN EDUCATION, SIZING AND ANALYSIS - BACK TO BASICS APPROACH II .....	166
<i>Armand J. Chaput</i>	
ELECTRIC DUCTED FAN DESIGN AND TESTING FOR HIGH PERFORMANCE UAV INTEGRATION .....	183
<i>Drew Darrah, Joel Eppler, Wanbo Liu, Willem A. Anemaat</i>	

AERODYNAMIC MODELING AND DESIGN PROCEDURES FOR UNMANNED AERIAL VEHICLE PROPELLER.....	194
<i>Mohamed Y. Zakaria, Omar E. Abdelhameed, Mahmoud Abdelghafaar, Mostafa Yassin</i>	

UNCERTAINTY MANAGEMENT IN TECHNOLOGIES PRIORITIZATION FOR FUTURE AIRCRAFT PROGRAM.....	210
<i>Christopher Jouannet, Kristian Amadori, Erik Bäckström, Davi Bianchi</i>	

### **AIRCRAFT CONFIGURATION DESIGN STUDIES**

PRELIMINARY DESIGN AND PERFORMANCE ANALYSIS OF A BOX-WING TRANSPORT AIRCRAFT .....	221
<i>Vittorio Cipolla, Karim Abu Salem, Marco Picchi Scardaoni, Vincenzo Binante</i>	

THE NASA DC-8 AIRBORNE SCIENCE PLATFORM BEYOND 2030 .....	245
<i>Thomas A. Ozoroski, James W. Fenbert, Nicholas K. Borer</i>	

ROBUST CONCEPTUAL DESIGN OF TRANSONIC AIRFOILS.....	263
<i>Erik D. Olson</i>	

OPTIMAL DESIGN OF AN N+1 NARROW-BODY TRANSPORT AIRCRAFT .....	275
<i>Hunter Halversen, Riley Mitchell, Matthew Spear, Bryan Vo, Timothy T. Takahashi</i>	

### **STRUCTURAL DESIGN, ANALYSIS, AND OPTIMIZATION**

ACTUATOR CONCEPTS FOR ACTIVE GUST ALLEVIATION ON TRANSPORT AIRCRAFT AT TRANSONIC SPEEDS .....	311
<i>Lorenz Klug, Rolf Radespiel, Junaïd Ullah, Ferdinand Seel, Thorsten Lutz, Jochen Wild, Ralf Heinrich, Thomas Streit</i>	

AN EFFICIENT METHOD TO DIMENSIONALLY REDUCE APERIODIC INHOMOGENEOUS 3-D STRUCTURES TO 1-D BEAM-LIKE STRUCTURES.....	326
<i>Darshan Sarojini, Mohit Gupta, Dewey H. Hodges, Dimitri N. Mavris</i>	

ADJOINT-BASED STRUCTURAL OPTIMIZATION FOR BEAM-LIKE STRUCTURES SUBJECTED TO DYNAMIC LOADS .....	345
<i>Darshan Sarojini, Dushhyanth Rajaram, David Solano, Dimitri N. Mavris</i>	

STRUCTURAL SIZING OF UNCONVENTIONAL AIRCRAFT UNDER STATIC AND DYNAMIC AEROELASTIC LOADING.....	362
<i>David Solano, Darshan Sarojini, Jason A. Corman, Dimitri N. Mavris</i>	

CONSTRUCTAL APPROACH TO DESIGN OF WING CROSS-SECTION FOR BETTER FLOW OF STRESSES.....	380
<i>Ehsan Izadpanahi, Mojtaba Moshtaghzadeh, Hamid Reza Radnezhad, Pezhman Mardanpour</i>	

### **AERODYNAMIC TOOLS, METHODS, AND ANALYSES FOR AIRCRAFT APPLICATIONS**

WHEN HIGHER FIDELITY MODELS DEGRADE OUR UNDERSTANDING OF INDUCED DRAG - THE TRAGEDY OF THE TREFFTZ PLANE INTEGRAL .....	397
<i>Timothy T. Takahashi, Che-Wei Ou</i>	

MINIMIZATION OF INDUCED AND PARASITIC DRAG ON VARIABLE-CAMBER MORPHING WINGS.....	415
<i>Ausitn J. Stewart, Douglas F. Hunsaker</i>	
THE EFFECTS OF LEADING EDGE FLAP AND TRAILING EDGE FLAPERON DEFLECTIONS ON HORIZONTAL TAIL OPTIMIZATION .....	436
<i>Fazil S. Gomec, Emre C. Unver, Mehmet Z. Arisoy</i>	
LIFTING-LINE ANALYSIS OF OPTIMUM AILERON SIZING TO MINIMIZE INDUCED DRAG DURING ROLL.....	452
<i>Joshua R. Brincklow, Douglas F. Hunsaker</i>	
BLUNTNESS EFFECTS ON THE LIFT TO DRAG RATIO OF SLENDER BODIES IN HYPERSONIC FLIGHT .....	470
<i>Pasquale M. Sforza</i>	

### **HYBRID ELECTRIC AIRCRAFT DESIGN UNDER CLEAN SKY 2 (LPA WP1.6.1.4)**

MULTIDISCIPLINARY DESIGN AND PERFORMANCE OF THE ONERA HYBRID ELECTRIC DISTRIBUTED PROPULSION CONCEPT (DRAGON).....	492
<i>Peter Schmollgruber, David Donjat, Michael Ridel, Italo Cafarelli, Olivier Atinault, Christophe François, Bernard Paluch</i>	
AERO-PROPULSIVE EFFICIENCY REQUIREMENTS FOR TURBOELECTRIC TRANSPORT AIRCRAFT .....	519
<i>Reynard de Vries, Maurice Hoogreef, Roelof Vos</i>	
SYNTHESIS OF AERO-PROPULSIVE INTERACTION STUDIES APPLIED TO CONCEPTUAL HYBRID-ELECTRIC AIRCRAFT DESIGN .....	535
<i>Maurice Hoogreef, Reynard de Vries, Tomas Sinnige, Roelof Vos</i>	
MULTIDISCIPLINARY INVESTIGATION OF PARTIALLY TURBOELECTRIC, BOUNDARY LAYER INGESTING AIRCRAFT CONCEPTS CLEANSKY2 LPA WP1.6.1 SPECIAL SESSION.....	560
<i>Daniel Silberhorn, Max J. Arzberger, Maximilian Mennicken, Florian Wolters, Carsten Hollmann, Michael Iwanizki</i>	
ENERGY OPTIMIZATION OF SINGLE AISLE AIRCRAFT WITH HYBRID ELECTRIC PROPULSION .....	575
<i>Wim Lammen, Jos Vankan</i>	
CONCEPTUAL DESIGN STUDIES OF “BOOSTED TURBOFAN” CONFIGURATION FOR SHORT RANGE .....	595
<i>Tobias Hecken, Xin Zhao, Michael Iwanizki, Max J. Arzberger, Daniel Silberhorn, Martin Plohr, Konstantinos Kyprianidis, Smruti Sahoo, Sharmila Sumsurooah, Giorgio Valente, Michael Sielemann, Clément Coïc, Andreas Bardenhagen, Annika Scheunemann, Claire Jacobs</i>	

### **AIRCRAFT OPERATIONS AND PERFORMANCE**

AIRCRAFT EN-ROUTE PERFORMANCE CONSIDERING WINDS-ALOFT .....	618
<i>Philip R. Thomas, Timothy T. Takahashi</i>	

## VOLUME 2

ON THE OPERATIONAL IMPLICATIONS OF TRADITIONAL DESIGN RULES FOR  
MINIMUM CONTROLLABLE AIRSPEED ..... 632

*Timothy T. Takahashi, Ruben E. Perez*

COMMERCIAL AIRCRAFT VALUE EVALUATION AND SENSITIVITY ANALYSIS FROM  
THE PERSPECTIVE OF CHINESE AIRLINES ..... 657

*Cheng Chen*

BUSEMANN-SEARS-HAACK HYBRID GEOMETRIES APPLIED TOWARD SUPERSONIC  
COMMERCIAL VEHICLES FOR IMPROVED WAVE DRAG PERFORMANCE ..... 676

*Andrew Sklar, Zvi Rusak*

HYBRID AIRCRAFT FOR IMPROVED OFF-DESIGN PERFORMANCE AND REDUCED  
EMISSIONS ..... 716

*Georgi Atanasov, Daniel Silberhorn*

### **APPLICATIONS AND AIRCRAFT FOR TRANSFORMATIONAL FLIGHT**

KOREA HUMAN POWERED AIRCRAFT COMPETITION LESSONS LEARNED ..... 746

*Ki Ju Kwon, Hak-Tae Lee*

### **FORMATION FLYING I**

FORMATION FLYING (AIR-WAKE-SURFING) FOR EFFICIENT OPERATIONS – NATO  
STO RESEARCH TASK AVT- 279 ..... 758

*R K. Nangia, Nelson Brown*

FLIGHT PHYSICS OF FUEL-SAVING FORMATION FLIGHT ..... 770

*Andre Koloschin, Nicolas Fezans*

FLIGHT CONTROL SYSTEMS FOR FUEL EFFICIENT WAKE SURFING ..... 782

*Michael A. Niestroy, Robert Luckner, Andre Koloschin, Nelson Brown, Curtis E. Hanson,  
Carsten Doll*

OPERATIONALIZING FLIGHT FORMATIONS FOR AERODYNAMIC BENEFITS ..... 792

*Donald Erbschloe, Dennis L. Carter, Gary A. Dale, Carsten Doll, Michael A. Niestroy,  
Tobias Marks*

DIGITAL ENGINEERING INFLUENCES ON FORMATION FLYING TECHNOLOGY  
DEVELOPMENT ..... 808

*Rick E. Graves*

### **VEHICLE AND PROPULSOR SIZING - METHODS AND TOOLS**

A COMPARISON OF HYBRID-ELECTRIC AIRCRAFT SIZING METHODS ..... 829

*D. Felix Finger, Reynard de Vries, Roelof Vos, Carsten Braun, Cees Bil*

FRAMEWORK FOR DESIGN SPACE EXPLORATION OF NOVEL PROPULSION SYSTEM  
ARCHITECTURES ..... 860

*Anusha Harish, Jonathan C. Gladin, Dimitri N. Mavris*

## **FORMATION FLYING II**

MANEUVERS DURING AUTOMATIC FORMATION FLIGHT OF TRANSPORT AIRCRAFT FOR FUEL SAVINGS .....	878
<i>André Kaden, Robert Luckner</i>	
OPTIMAL TIMING AND ARRANGEMENT FOR TWO-AIRCRAFT FORMATIONS ON NORTH ATLANTIC UNDER CONSIDERATION OF WIND.....	895
<i>Tobias Marks, Majed Swaid</i>	
ADVANCES IN COOPERATIVE TRAJECTORIES FOR COMMERCIAL APPLICATIONS .....	905
<i>Tristan C. Flanzer, Stefan R. Bieniawski, John A. Brown</i>	

## **AIRCRAFT DESIGN/ANALYSIS METHODS AND VALIDATION**

DEVELOPMENT OF SIMULATION TOOLS FOR HIGH FIDELITY ANALYSIS OF COMPOUND ROTORCRAFT .....	927
<i>Tao Zhang, George N. Barakos</i>	
AIRCRAFT DESIGN WEIGHT METHODS COMPARISON AND IMPROVEMENT .....	953
<i>Brandon Basgall, Wanbo Liu, Truman Cassady, Willem A. Anemaat</i>	
HIGH-LIFT ACTUATION WEIGHT ESTIMATION USING LOW-COST METHODS .....	968
<i>Benjamin R. Moss, Andrea Da Ronch, Neil Tyler</i>	
FLYING QUALITIES PREDICTION TOOL FOR AERIAL REFUELLING OPERATIONAL COMPATIBILITY ASSESSMENT .....	988
<i>Luke H. Peristy, Ruben E. Perez, Peter W. Jansen</i>	
VALIDATION AND REFINEMENT OF AN AIRCRAFT DESIGN AND OPTIMIZATION TOOL, ATLASS .....	1007
<i>Brenden A. Autry</i>	

## **HYBRID-ELECTRIC, ELECTRIC, AND ALTERNATIVE PROPULSION STUDIES**

FEASIBILITY STUDY OF A LIQUEFIED NATURAL GAS FUEL-COOLED SMALL SCALE HYBRID ELECTRIC FLIGHT VEHICLE.....	1020
<i>Jason W. Hartwig, Brian Niezgoda, Lee W. Kohlman</i>	
THE FEASIBILITY OF ELECTRIC PROPULSION FOR COMMUTER AIRCRAFT .....	1033
<i>Michael Kruger, Alejandra Uranga</i>	
FEASIBILITY OF A SOLID OXIDE FUEL CELL SYSTEM APPLIED TO HYBRID-ELECTRIC REGIONAL AIRCRAFT .....	1050
<i>Steven Geuther, Francisco M. Capristan</i>	
AN INTEGRATED DESIGN FRAMEWORK FOR AIRCRAFT WITH HYBRID ELECTRIC PROPULSION .....	1064
<i>Benedikt Aigner, Eike Stumpf, Arne Hinz, Rik W. De Doncker</i>	
COMPARATIVE ASSESSMENT OF PARALLEL-HYBRID-ELECTRIC PROPULSION SYSTEMS FOR FOUR DIFFERENT AIRCRAFT .....	1082
<i>D. Felix Finger, Carsten Braun, Cees Bil</i>	

CONCEPTUAL DESIGN OF A THIN-HAUL AIRCRAFT BY ENERGY SIZING OPTIMIZATION INCLUDING AERO-PROPULSIVE INTERACTIONS .....	1097
<i>Higor Luis Silva, Thiago A. Guimarães</i>	

## **DESIGN OF UNMANNED AERIAL SYSTEMS I**

DESIGN AND FABRICATION OF A BATTERY-POWERED UNMANNED AERIAL VEHICLE FOR PRECISION AGRICULTURAL MONITORING MISSIONS.....	1109
<i>Md Tofazzal Hossain, Sadab Bin Islam, Mustafa Muneer, Ahmad S. Tuba, Labib Hasan, Shahnewaz Siddique</i>	

CONCEPTUAL DESIGN OF A HIGHLY-MANEUVERABLE TRANSITIONAL VTOL UAV WITH NEW MANEUVER AND CONTROL CAPABILITIES .....	1122
<i>Ashraf Kamal, Alex Ramirez-Serrano</i>	

PARAMETRIC STUDY OF MARS HELICOPTER FOR PIT CRATER EXPLORATION .....	1136
<i>Koji Fujita, Hilal Karaca, Hiroki Nagai</i>	

AN INVESTIGATION OF QUAD-ROTOR AIRCRAFT PERFORMANCE UNDER GUST WIND AND HEAVY RAIN IMPACTS.....	1151
<i>Tung Wan</i>	

ON THE OPTIMIZATION PERFORMANCE STUDY OF FLAPPING AERIAL VEHICLE UNDER HEAVY RAIN CONDITION.....	1161
<i>Tung Wan</i>	

## **PROPULSION/AIRFRAME INTEGRATION AND NACELLE DESIGN**

THE EFFECT OF ENGINE LOCATION ON THE AERODYNAMIC EFFICIENCY OF A FLYING-V AIRCRAFT .....	1171
<i>Berta Rubio Pascual, Roelof Vos</i>	

BLENDED WING BODY WITH BOUNDARY LAYER INGESTION CONCEPTUAL DESIGN IN A MULTIDISCIPLINARY DESIGN ANALYSIS OPTIMIZATION ENVIRONMENT .....	1194
<i>Ziang Gao, Howard Smith</i>	

COMPUTATIONAL METHODS FOR THE PRELIMINARY DESIGN OF ENGINE-NACELLE PLACEMENT ON TRANSONIC AIRCRAFT .....	1207
<i>Kristofer C. Frede, Timothy T. Takahashi</i>	

## **DESIGN OF UNMANNED AERIAL SYSTEMS II**

AERODYNAMIC DESIGN OF A TACTICAL BLENDED-WING-BODY UAV FOR THE AERIAL DELIVERY OF CARGO AND LIFESAVING SUPPLIES.....	1222
<i>Pericles Panagiotou, Dimitrios Mitridis, Thomas Dimopoulos, Stavros Kapsalis, Stylianos Dimitriou, Kyriakos Yakinthos</i>	

GUIDED AIR-TO-AIR HARD-LAUNCH MUNITIONS: A CASE STUDY IN INCREASED MISSION EFFECTIVENESS.....	1242
<i>Lauren Schumacher, Ronald M. Barrett-Gonzalez</i>	

GUIDED HARD-LAUNCH MUNITIONS: ENABLING ADVANCED AIR TO GROUND COMBAT.....	1250
<i>Lauren Schumacher, Ronald M. Barrett-Gonzalez</i>	



MONITORING OF INACCESSIBLE AREAS IN GPS-DENIED UNDERGROUND MINES  
USING A FULLY AUTONOMOUS ENCASED SAFETY INSPECTION DRONE..... 1257  
*Javad Shahmoradi, Amir Mirzaeinia, Pedram Roghanchi, Mostafa Hassanalian*

**Author Index**