

# THE AERONAUTICAL JOURNAL

Covering all aspects of Aerospace

Volume 115 Number 1172

October 2011



# THE AERONAUTICAL JOURNAL

Editor-in-chief: Prof Peter Bearman

## Associate Editors

Chairman: Prof Mike Graham

**Professor Chris Atkin**  
City University, London

**Professor Holger Babinsky**  
University of Cambridge

**Professor Ken Badcock**  
University of Liverpool

**Professor Rene de Borst**  
Eindhoven University of Technology

**Dr Trevor Birch**  
DSTL

**Wg Cdr Mike Bratby**  
RAeS Air Power Group

**Professor Richard Brown**  
University of Strathclyde, Glasgow

**Professor Jonathan Cooper**  
University of Liverpool

**Mr Anthony Cross**  
BAE Systems, Warton

**Professor Laurent Dala**  
University of the Witwatersrand, Johannesburg

**Professor Glyn Davies**  
Imperial College, London

**Professor Dimitris Drikakis**  
Cranfield University

**Mr Chris Fielding**  
BAE Systems, Warton

**Professor Victor Giurgiutiu**  
University of South Carolina

**Professor Ismet Gursul**  
University of Bath

**Professor Keith Hayward**  
RAeS Head of Research

**Professor Michael J de C Henshaw**  
Loughborough University

**Professor Richard Hillier**  
Imperial College, London

**Dr John Loizou**  
VEGA Space

**Professor Ken Morgan**  
Swansea University

**Dr Ravi Nayak**  
National Aerospace Laboratories, India

**Professor Gareth Padfield**  
University of Liverpool

**Professor Shahrokh Shahpar**  
Rolls-Royce

**Dr Howard Smith**  
Cranfield University

**Professor Marilyn Smith**  
Georgia Institute of Technology

**Professor Constantinos Soutis**  
University of Sheffield

**Professor John Stollery**  
Cranfield University

**Professor Anthony Waas**  
University of Michigan

### Aims and scope

The aims and scope of *The Aeronautical Journal* are intended to reflect the objectives of the Royal Aeronautical Society as expressed in its Charter of Incorporation. Briefly, these are to encourage and foster the advancement of all aspects of aeronautical and space science. Thus the topics of *The Aeronautical Journal* include most of those covered by the various Specialist Groups of the Society, which include:

Aircraft design, aerodynamics, air law, air power, air transport, air navigation, airworthiness and maintenance, aviation medicine, avionics and systems, environmental issues, flight operations, flight simulation, fluid dynamics, fluid mechanics, general aviation, guided flight, human factors, human powered flight, light aviation, management studies, propulsion, rotorcraft, safety, space, structures and materials, structural mechanics, systems and test procedures and UAVs.

Papers are therefore solicited on all aspects of research, design and development, construction and operation of aircraft and space vehicles. Papers are also welcomed which review, comprehensively, the results of recent research developments in any of the above topics.

We recognise the inhibiting pressures of time and confidentiality and acknowledge that many of the design testing, manufacturing and operational problems that industry has to solve contain important information for the whole aerospace community. *The Aeronautical Journal* provides a platform for refereeing and presenting your work to an international audience.

Papers will be considered for publication in *The Aeronautical Journal* if they meet the terms and conditions listed in The Instructions for authors. If these are not met, the Editor reserves the right to withdraw the paper without redress, which may be at any time up to publication.

Papers should be sent to: Prof Peter Bearman, Royal Aeronautical Society, No. 4 Hamilton Place, London W1J 7BQ, United Kingdom or [wayne.davis@aerosociety.com](mailto:wayne.davis@aerosociety.com)

### Subscriptions

#### Non-members

Annual subscription (12 issues) £399, Single copies, including back issues £36; *Non-member subscription orders are available from*; Royal Aeronautical Society, Publications Subscriptions Department, Dovetail Services Ltd, 800 Guillat Avenue, Kent Science Park, Sittingbourne, Kent ME9 8GU, UK.

Tel: +44 (0)844 848 8426, Fax: +44 (0)844 856 0650, email: [ras@servicehelpline.co.uk](mailto:ras@servicehelpline.co.uk)

#### RAeS members

Annual subscription (12 issues) £69, Single copies, including back issues £6; *member subscription orders are available from*; Membership Department, Royal Aeronautical Society, No. 4 Hamilton Place, London W1J 7BQ, UK. Tel: +44 (0)20 7670 4300, Fax: +44 (0)20 7670 4309, email: [membership@aerosociety.com](mailto:membership@aerosociety.com)

#### RAeS Conference Proceedings

Details, price and availability of Royal Aeronautical Society Conference Proceedings can be obtained from; RAeS Conference and Events Department, No. 4 Hamilton Place, London W1J 7BQ, UK. Tel: +44 (0)20 7670 4300, email: [conference@aerosociety.com](mailto:conference@aerosociety.com) or via [www.aerosociety.com/proceedings](http://www.aerosociety.com/proceedings)

All papers are available to view free of charge for subscribers and to purchase by others at: [www.aerosociety.com](http://www.aerosociety.com)



# CONTENTS

Volume 115 Number 1172

Reproduction of any of the papers published in this journal is not permitted without the written consent of the Editor.

#### Editor-in-Chief

Professor P W Bearman FREng FCGI FRAeS

#### Managing Editor

C S C Male BSc(Eng) MRAeS

#### Production Editor

W J Davis BA ARaES

#### Publications Officer

A L Hallam BA ARaES

#### Production

W I I Read MA(Econ)  
T C Robinson BA

#### Book Review Editor

B L Riddle BLib

#### Publisher

Royal Aeronautical Society (RAeS)  
No.4 Hamilton Place  
London W1J 7BQ, UK  
Tel: +44 (0)20 7670 4300  
Fax: +44 (0)20 7670 4309  
e-mail: raes@aerosociety.com

<http://www.aerosociety.com>

The Royal Aeronautical Society  
is a registered charity: No 313708

#### RAeS Chief Executive

S C Luxmoore MBA FRAeS

The content does not necessarily express the  
opinion of the Council of the Royal  
Aeronautical Society.

#### Advertisement Sales

Ben David  
Pelusa Media  
Sweetlands Barn  
Couchman Green Lane  
Staplehurst  
Kent, TN12 0RR, UK  
Tel: +44 (0)20 8406 0820  
email: ben@pelusa.co.uk

#### Printer

Sunday Publishing  
Studio 2  
First Floor  
Enterprise House  
1 - 2 Hatfields  
London SE1 9P6, UK  
ISSN: 0001-9240

#### Published monthly



**Mixed Sources**  
Product group from well-managed  
forests and other controlled sources  
[www.fsc.org](http://www.fsc.org) Cert no. TT-COC-002794  
© 1996 Forest Stewardship Council

- T. Fitzgerald, M. Valdez, M. Vanella, E. Balaras and B. Balachandran**  
Flexible flapping systems: computational investigations  
into fluid-structure interactions 593
- A.P. Harris and N.M. Ratcliffe**  
Dimensional modelling of the fuel outgassing phenomenon:  
Improving flammability assessment of aircraft fuel tanks 605
- S. Shahpar**  
Challenges to overcome for routine usage of automatic  
optimisation in the propulsion industry 615
- S. Blakey, C.W. Wilson, M. Farmery and R. Midgley**  
Fuel effects on range versus payload for modern jet aircraft 627
- J. Hall and D. Anderson**  
*Technical Note*  
Reactive route selection from pre-calculated trajectories –  
application to micro-UAV path planning 635
- M.R. Ahmed, M.M. Abdelrahman, G.M. ElBAYoumi  
and M.M. ElNomrossy**  
Optimal wing twist distribution for roll control of MAVs 641
- Book Review** 650

Front Cover: Boeing 787 Dreamliner. (Boeing)