

THE AERONAUTICAL JOURNAL

Covering all aspects of Aerospace

Volume 113 Number 1149

November 2009



THE AERONAUTICAL JOURNAL

Editor-in-chief: Prof Peter Bearman

Associate Editors

Chairman: Prof Mike Graham

Dr Holger Babinsky
Cambridge University

Dr Trevor Birch
Dstl

Professor Rene de Borst
Eindhoven University of Technology

Wg Cdr Mike Bratby
RAeS Air Power Group

Professor Richard Brown
Glasgow University

Dr Jon Carrotte
Loughborough University

Dr Graham Coleman
Ex-Dstl

Professor Jonathan Cooper
University of Liverpool

Mr Anthony Cross
BAE Systems Warton

Professor Glyn Davies
Imperial College, London

Dr Olivier Dessens
Cambridge University

Professor Dimitris Drikakis
Cranfield University

Mr Chris Fielding
BAE Systems, Warton

Professor Nabil Gindy
University of Nottingham

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

Professor Howard Hodson
University of Cambridge

Mr Julian Lea-Jones
Systems Consultant

Dr John Loizou
SELEX Systems Integration

Professor Ken Morgan
University of Wales, Swansea

Dr Ravi Nayak
National Aerospace Laboratories, India

Professor Gareth Padfield
University of Liverpool

Dr Shahrokh Shahpar
Rolls-Royce

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.

Subscriptions

Non-members

Annual subscription (12 issues) £390, 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

RAeS members

Annual subscription (12 issues) £65, 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

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 or via www.aerosociety.com/proceedings

All papers are available to view free of charge for subscribers and to purchase by others at: www.aerosociety.com



CONTENTS

Volume 113 Number 1149

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 4359
e-mail: publications@aerosociety.com
raes@aerosociety.com

<http://www.aerosociety.com>

The Royal Aeronautical Society
is a registered charity: No 313708

RAeS Chief Executive

S Luxmoore MBA FRAeS

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

Advertisement Sales

Steve Forsdick
Ten Alps media
One New Oxford Street
London WC1A 1NU, UK
Tel: +44 (0)20 7878 2334
Fax: +44 (0)20 7379 7118
email: steve.forsdick@tenalps.com

Printer

Manor Creative Limited
7 and 8 Edison Road
Eastbourne
East Sussex
BN23 6PT
United Kingdom
ISSN: 0001-9240

Published monthly



Mixed Sources
Product group from well-managed
forests and other controlled sources
www.fsc.org Cert no. TI-COC-002794
© 1996 Forest Stewardship Council

S. Lee and E. Loth

Supersonic boundary-layer interactions with various micro-vortex
generator geometries 683

W.J. Crowther, P.I.A. Wilde, K. Gill and S.M. Michie

Towards Integrated design of fluidic flight controls for a flapless aircraft 699

**R. Hosman, J. Schuring, P. van der Geest, A. Belyavin, G. Robel,
J.M. Towler and H.J. Hormann**

The pilot model balked landing simulation project:
A government, industry and national research cooperation 715

D. Saban, J.F. Whidborne and A.K. Cooke

Simulation of wake vortex effects for UAVs in close formation flight 727

T. Cain

A correction to sonic boom theory 739

Book Reviews

746

Front cover: An imagined group of Northrop Grumman RQ-4 Block 20
Global Hawks.