#### THE ROYAL INSTITUTE OF NAVIGATION

### Aims and Objects

The objects of the Institute are to unite in one body those who are concerned with or who are interested in navigation and to further its development. Navigation is conceived as applying to locomotion of all kinds and is perceived as encompassing aspects of: command and control, psychology and zoology, operational research, risk analysis, theoretical physics, operation in hostile environments, instrumentation, ergonomics, financial planning and law as well as electronics, astronomy, mathematics, cartography and other subjects traditionally associated with navigation.

The aims of the Institute are to encourage the creation and dissemination of knowledge through research and development, to co-ordinate information from all the disciplines involved, to provide a forum in which new ideas and new products can have the benefit of informed and professional scrutiny and to further education and communication. The Institute initiates conferences and symposia on specific subjects and has a programme of meetings at which lectures are given and discussed. There are standing Special Interest Groups (SIGs), which keep under constant review pertinent aspects of navigation. The success of these Special Interest Groups is crucially dependent on the active involvement of members.

The SIGs include: Land Navigation and Location Group (LN&L), General Aviation Navigation Group (GANG), History of Air Navigation Group (HANG), Civil and Military Air Group (CMAG), Marine Traffic & Navigation Group (MT&NG), Small Craft Group (SCG), Space Group (Space), Animal Navigation Group (ANG) and Research & Development Group (R&D).

The Institute publishes *The Journal of Navigation* six times a year. It contains papers which have been presented at meetings, other original papers and selected papers and reports from Special Interest Groups. The Institute also publishes *Navigation News* six times a year which contains a full account of the Institute's proceedings and activities. This includes Branch News, a record of current navigational work, a diary of events, topical articles, news about Membership and advertising. A great deal of the Institute's work is international in character and is coordinated with that of similar organisations in other countries.

### Membership

There are nine classes of membership under which individuals or organisations may apply to join the Institute. Details of the various membership criteria and current subscriptions are available on the RIN website (Home / Join the RIN / Membership Types http://www.rin.org.uk/general.aspx?ID=59) and from the Membership Secretary (membership@rin.org.uk Tel: +44(0)20 7591 3130 Fax: 44(0)20 7591 3131).

- (1) Ordinary Membership
- (2) Associate Membership
- (3) Associate Fellow Membership
- (4) Student Membership
- (5) Junior Associate Membership
- (6) Corporate Membership
- (7) Small Business Membership
- (8) Affiliate College University Membership
- (9) Affiliate Club Membership

Additional membership classes of Fellowship, Honorary Fellowship, Retired Membership and Affiliate Membership also exist and details are available from the Membership Secretary.

The subscription price (excluding VAT) to The Journal (ISSN 0373–4633) for Volume 72, 2019, which includes print and electronic access, is £667 (USA, Canada and Mexico US \$1204) and includes delivery by air; single parts are available at £121 (USA, Canada and Mexico US \$218) plus postage. The electronic-only price available to institutional subscribers is £517 (USA, Canada and Mexico US \$942). EU subscribers (outside the UK) who are not registered for VAT should add VAT at their country's rate. VAT registered subscribers should provide their VAT registration number. The Journal is issued free to all Members of the Institute. Orders, which must be accompanied by payment, may be sent to any bookseller or subscription agent or direct to the publishers: Cambridge University Press, UPH, Shaftesbury Road, Cambridge CB2 8BS, or in the USA, Canada and Mexico to Cambridge University Press, Journals Fulfillment Department, 1 Liberty Plaza, Floor 20, New York, NY 10006, USA. Japanese prices for institutions are available from Kinokuniya Company Ltd, P.O. Box 55, Chitose, Tokyo 156, Japan.

© 2019 The Royal Institute of Navigation

This journal issue has been printed on FSC-certified paper and cover board. FSC is an independent, non-governmental, not-for-profit organization established to promote the responsible management of the world's forests. Please see www.fsc.org for information.

# THE JOURNAL OF NAVIGATION

VOLUME 72 • NUMBER 5 • SEPTEMBER 2019

## **CONTENTS**

Frequency of use – the First Step Toward Human-Centred Interfaces for Marine Navigation Systems	1089
Viet Dung Vu, Margareta Lützhöft and Gholam Reza Emad	1007
Maritime Cyber Risk Management: An Experimental Ship Assessment Boris Svilicic, Junzo Kamahara, Matthew Rooks and Yoshiji Yano	1108
A Bayesian-Network-based Approach to Risk Analysis in Runway Excursions Fernando Calle-Alonso, Carlos J. Pérez and Eduardo S. Ayra	1121
A Study on Geometric and Barometric Altitude Data in Automatic Dependent Surveillance Broadcast (ADS-B) Messages Busyairah Syd Ali and Nur Asheila Taib	1140
Airborne Pseudolite Distributed Positioning based on Real-time GNSS PPP Panpan Huang, Chris Rizos and Craig Roberts	1159
Separation Risk Evaluation Considering Positioning Uncertainties from the Automatic Dependent Surveillance-Broadcast (ADS-B) System Peng Zhao and Yongming Liu	1179
The Effect of Light Projections for Wayfinding Purposes within an Airport Context Petek Tezcan and Suzanne Hiemstra-van Mastrigt	1200
A New Algorithm for Navigation Trajectory Prediction of Land Vehicles Based on a Generalised Extended Extrapolation Model Junna Shang, Can Liu, Huli Shi, Tao Cheng and Keqiang Yue	1217
Underwater Terrain Positioning Method Using Maximum a Posteriori Estimation and PCNN Model Pengyun Chen, Pengfei Zhang, Teng Ma, Peng Shen, Ye Li, Rupeng Wang, Yue Han and Lizhou Li	1233
Multiple Robust High-degree Cubature Kalman Filter for Relative Position and Attitude Estimation of Satellite Formation  Ning Li, Wentao Ma, Weishi Man, Liu Cao and Hui Zhang	1254
Gaussian Message Passing-Based Cooperative Localisation with Bootstrap Percolation Scheme in Dense Networks	1275
Yangyang Liu, Baowang Lian, Lin Zhang and Taoyun Zhou  Optimal Solution to Multi-Frequency BDS Code-Multipath Combination Measurement  Tian Jin, Bingjie Hu, Yining Sun, Zhigang Huang, Qian Wang and Qiong Wu	1279
Switching Method for Long-Term Inertial Navigation System Based on Switched Control Zhihong Deng, Lei Shi, Tong Liu and Bo Wang	1315
Performance Evaluation of the CNAV Broadcast Ephemeris Ahao Wang, Junping Chen, Yize Zhang, Jiexian Wang and Bin Wang	1331

# Cambridge Core







