

THE JOURNAL OF
Navigation

VOLUME 66 NUMBER 3 MAY 2013



Royal Institute of Navigation
Science Technology Practice

CAMBRIDGE
UNIVERSITY PRESS

THE ROYAL INSTITUTE OF NAVIGATION

Patron

HRH THE PRINCE PHILIP DUKE OF EDINBURGH, KG, KT, OM

OFFICERS AND COUNCIL 2012–2013

<i>President</i>	C. M. D. Beatty
<i>Vice Presidents</i>	R. A. McKinlay Prof. A. P. Norris
<i>Honorary Treasurer</i>	D. Cockburn
<i>Chairman of the Technical Committee</i>	Dr. S. Basker
<i>Chairman of the Membership & Fellowship Committee</i>	Wg Cdr J. W. Lindsay
<i>Other Members of Council</i>	
I. C. Benham	Prof. T Moore
Lt. Cdr. A. Egelend-Jensen	R. D. Pike
Dr. R. Filjar	Capt. J. B. Taylor OBE
S. E. Gaskin	Ms M. M. G. M. von Wendland
Dr N. D. Hughes OBE	Capt R. J. Wild
<i>Director</i>	Capt P. C. Chapman-Andrews, LVO MBE

THE JOURNAL OF NAVIGATION

Editor Simon Gaskin, FRIN FNI

Assistant Editor Tony Fyler

Editorial Board. The Editorial Board (for administrative matters) consists of the members of the Royal Institute of Navigation's Technical Committee.

Editorial Advisory Board. The Chairman of the Editorial Advisory Board (for academic matters) is the Royal Institute of Navigation Director (Capt P. C. Chapman-Andrews, LVO MBE), the Secretary is the *Journal* Editor (Simon Gaskin, FRIN FNI) and it consists of the following members:

<i>Name</i>	<i>(Affiliation, Region)</i>	<i>Name</i>	<i>(Affiliation, Region)</i>
Professor S. Akesson	(Lund, Sweden)	Doctor X. Meng	(Nottingham, UK)
Professor C. Allen	(Washington, USA)	Professor S. Mills	(Staffordshire, UK)
Professor V. Ashkenazi	(NSL, UK)	Professor T. Moore	(Nottingham, UK)
Professor V. A. Braithwaite	(Penn State, USA)	Professor P. Newnam	(Oxford, UK)
Professor A. Dodson	(Nottingham, UK)	Professor A. Norris	(Consultant, UK)
Doctor A. V. Dunaev	(JSC 'RSS', Russia)	Professor W. Ochieng	(Imperial College, UK)
Doctor A. El-Mowafy	(Curtin, Australia)	Professor P. Ooninx	(Defence, Netherlands)
Professor A. El-Rabbany	(Ryerson, Canada)	Professor M. Pawlowski	(Gdansk, Poland)
Professor N. El-Sheimy	(Calgary, Canada)	Professor M. Pourzanjani	(Raffles, Malaysia)
Doctor R. Filjar	(Rijeka, Croatia)	Professor T. Ritz	(California, USA)
Doctor M. George	(Pacific Traditions, USA)	Doctor W. Schuster	(Imperial College, UK)
Professor D. Grejner-Brzezinska	(Ohio State, USA)	Professor Sir M. N. Sweeting	(SSTL, UK)
Doctor C. Hegarty	(MITRE, USA)	Professor P. J. G. Teunissen	(Curtin, Australia)
Professor D.-J. Jwo	(National Taiwan Ocean, Taiwan)	Professor G. Trommer	(Karlsruhe, Germany)
Professor I. Kale	(Westminster, UK)	Doctor M. Unwin	(SSTL, UK)
Doctor A. Kealy	(Melbourne, Australia)	Professor P. Vörsmann	(Braunschweig, Germany)
Professor C. Kee	(Seoul, S. Korea)	Professor C. Walcott	(Cornell, USA)
Professor Dr. S. Kos	(Rijeka, Croatia)	Professor M. Walker	(Auckland, New Zealand)
Professor T. Kos	(Zagreb, Croatia)	A/Professor J. Wang	(Sydney, Australia)
Professor J. Kirschvink	(Caltech, USA)	Professor A. Weintrit	(Gdynia, Poland)
Professor G. Lachapelle	(Calgary, Canada)	Professor J. N. Weng	(Beihang, China)
Professor R. B. Langley	(New Brunswick, Canada)	Professor R. Wiltschko	(Frankfurt, Germany)
Professor D. Last	(Consultant, UK)	Professor W. Wiltschko	(Frankfurt, Germany)
Professor J. N. Liu	(Wuhan, China)	Professor M. Winklhofer	(Munich, Germany)
Doctor S. Lo	(Stanford, USA)	Professor X. Yang	(Academy of Sciences, China)
Professor K. J. Lohmann	(North Carolina, USA)	Professor Y. Yang	(CNAGA, China)
Doctor G. McCall	(Los Alamos, USA)	Professor M. Ziebart	(UCL, UK)
		Professor N. I. Ziedan	(Zagazig, Egypt)

The *Journal* is published six times a year by Cambridge University Press. It contains original papers contributing to the science of navigation, including those presented at the meetings of the Institute. Papers should be submitted to the Assistant Editor (editor@rin.org.uk) for consideration. The current 'Instructions for Contributors' are available by e-mail. The views expressed in the *Journal* are not necessarily those of the Institute, or of any organization or department to which the authors may belong. Crown Copyright may be reserved. Any facts stated or opinions expressed in this *Journal* are the sole responsibility of the contributors. Neither the Royal Institute of Navigation, the Editor nor the Publishers can be held responsible for any injury or loss sustained in reliance thereon.

This journal is included in the Cambridge Journals Online service (<http://journals.cambridge.org>). For further information on other Press titles access <http://www.cambridge.org>

The address of the Institute is The Royal Institute of Navigation, at The Royal Geographical Society, 1 Kensington Gore, London SW7 2AT (Telephone: 020 7591 3130 Fax: 020 7591 3131), website (www.rin.org.uk) e-mail (editor@rin.org.uk).

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.