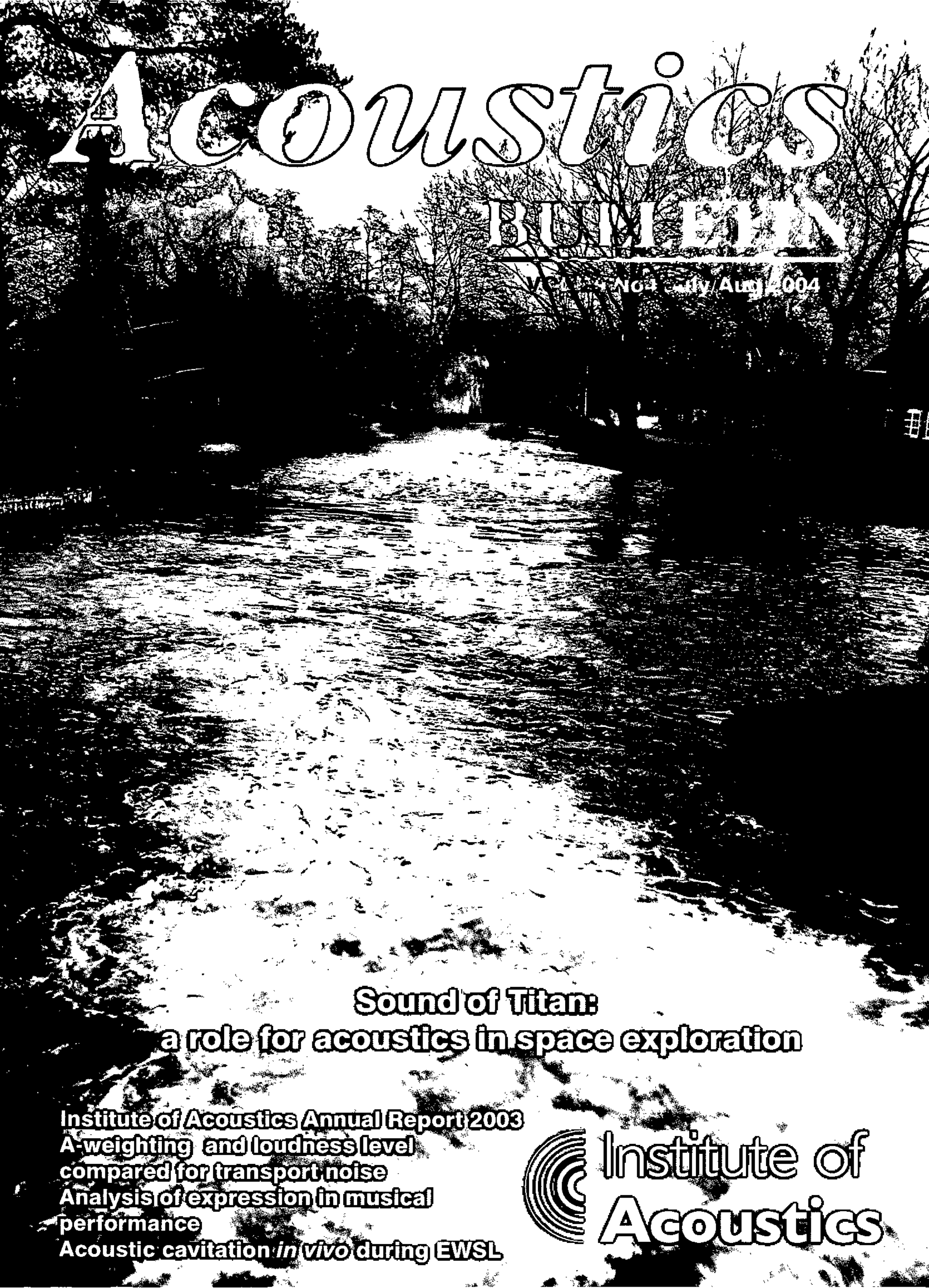


Acoustics BULLETIN

Vol [illegible] No4 July/Aug 2004

Sound of Titan: a role for acoustics in space exploration

Institute of Acoustics Annual Report 2003

A-weighting and loudness level compared for transport noise

Analysis of expression in musical performance

Acoustic cavitation *in vivo* during EWSL

Institute of Acoustics

Good advice is SOUND advice

Your vibration damping problems could be solved using our DEDPAN range of products

DEDPAN®

VIBRATION DAMPING MATERIALS

Dedpan products are available in self adhesive sheet form or spray on compound suitable for easy application.

Your noise insulation problems could be solved using our REVAC range of products

REVAC®

NOISE INSULATION MATERIALS

Highly specified polymeric acoustic barrier and foam composite materials for building, transport, industrial and commercial applications.

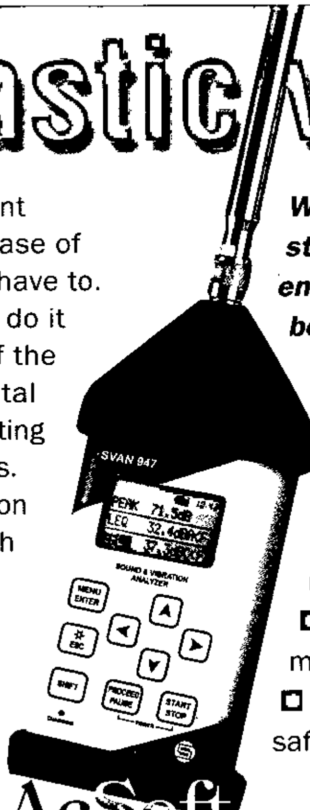
We welcome the opportunity to discuss new business development. Our specialist materials and knowledge can be applied effectively and economically to control many different noise and vibration problems.

If you buy, specify or supply Noise Control Materials and require further information please telephone the Wardle Storeys Sales Helpline on 01254 583825

Wardle Storeys Plc,
Durbar Mill, Hereford Road,
Blackburn BB1 3JU
Fax: 01254 681708

Svantastic value

We're not given to making extravagant claims for our products, and in the case of Svantek handheld meters, we don't have to. Plenty of Svantek users are ready to do it for us, and the price/performance of the latest release – the Type 947 all-digital handheld analyser – is literally extracting gasps of astonishment from early users. No wonder this Type 1 SLM and vibration meter, with mix-and-match options such as realtime octaves, third octaves, FFT, tonality, and built-in human vibration calculations, is already our stock in trade. The 947 starts at only 2400GBP, and the cost of options is equally ungrasping.



Whether you're looking for a standalone meter or PC front end with USB comms, you'll be amazed by the power that Svantek pack s into the 947. Call today for information about the value-for-money Svantek range.

- General acoustic measurements
- Environmental noise monitoring
- Occupational health and safety monitoring

AcSoft

AcSoft Limited, 8B Wingbury Courtyard, Leighton Road, Wingrave, Aylesbury HP22 4LW
Telephone: 01296 682686 Fax: 01296 682860 Email: sales@acsoft.co.uk www.acsoft.co.uk

CONTACTS

Editor:
I F Bennett BSc CEng MIOA

Associate Editor
J W Tyler FIOA

Contributions, letters and information on new products to:
Ian Bennett, Editor, 99 Wellington Road North, Stockport SK4 2LP
Tel 0161 476 0919 Fax 0161 476 0929
e-mail ian@acia-acoustics.co.uk

Books for review to:
S R Peliza MIOA, Institute of Acoustics, 77A St Peter's Street, St Albans, Herts AL1 3BN

Advertising:
Advertising enquiries to
Dennis Baylis MIOA, Peypouquet, 32320 Montesquiou, France
Tel/Fax 00 33 (0)5 62 70 99 25
e-mail dbioa@hotmail.com

Published and produced by:
The Institute of Acoustics, 77A St Peter's Street, St Albans, Herts AL1 3BN
Tel 01727 848195 Fax 01727 850553
e-mail ioa@ioa.org.uk
Web site http://www.ioa.org.uk

Designed and printed by:
International Labmate Ltd, Oak Court, Sandridge Business Park, Porters Wood, St Albans, Herts AL3 6PH

Production Editor:
Ann Satchell CamDipPR

Origination:
Norman Simpson

Views expressed in Acoustics Bulletin are not necessarily the official view of the Institute, nor do individual contributions reflect the opinions of the Editor. While every care has been taken in the preparation of this journal, the publishers cannot be held responsible for the accuracy of the information herein, or any consequence arising from them.
Multiple copying of the contents or parts thereof without permission is in breach of copyright. Permission is usually given upon written application to the Institute to copy illustrations or short extracts from the text or individual contributions, provided that the sources (and where appropriate the copyright) are acknowledged.

All rights reserved: ISSN: 0308-437X

Annual subscription (6 issues) £110.00
Single copy £20.00

© 2004 The Institute of Acoustics

Acoustics BULLETIN

Vol 29 No 4 July/Aug 2004

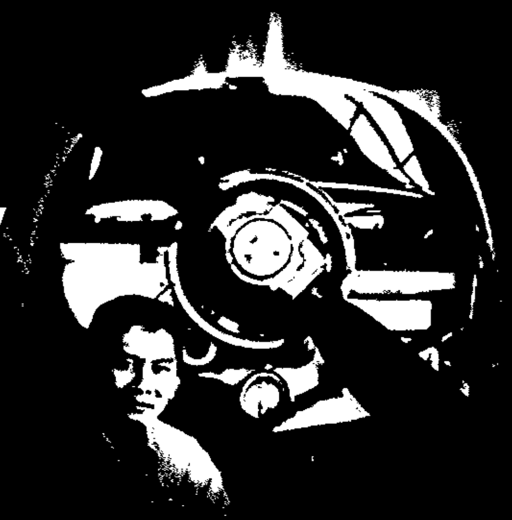
Contents

Institute of Acoustics

The Institute of Acoustics was formed in 1974 through the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society and is the premier organisation in the United Kingdom concerned with acoustics. The present membership is in excess of two thousand and since 1977 it has been a fully professional Institute. The Institute has representation in many major research, educational, planning and industrial establishments covering all aspects of acoustics including aerodynamic noise, environmental, industrial and architectural acoustics, audiology, building acoustics, hearing, electroacoustics, infrasonics, ultrasonics, noise, physical acoustics, speech, transportation noise, underwater acoustics and vibration. The Institute is a Registered Charity no 267026.

Wherever signal analysis takes you...

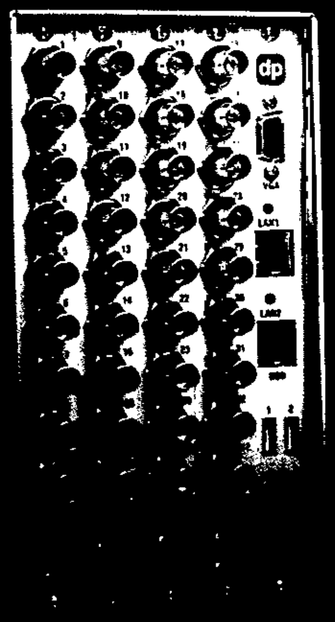
It's in the family



Experience scalable hardware and software designed to meet your challenges on the road or in the lab. An intuitive user interface makes sophisticated analysis easy. SignalCalc dynamic signal analysers are DSP powered to deliver precision and speed for all your noise and vibration applications:

- Structural dynamics analysis
- Rotating machinery diagnostics
- NVH and acoustic measurements
- Environmental vibration tests

Whatever your test, there is a SignalCalc analyser within your budget.



SignalCalc **ACE**

The world's smallest FFT analyser

- 2 input channels, 2 sources
- 100dB dynamic range
- 2kHz realtime bandwidth

SignalCalc **Mobilyzer**

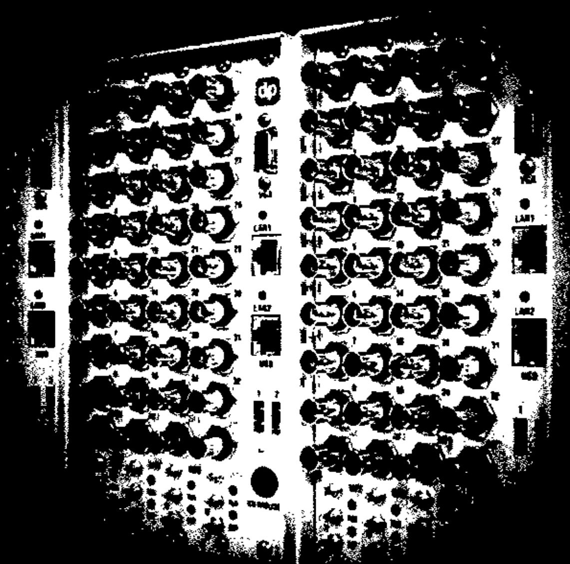
Powerful portable analysis

- 4–32 channels, up to 8 sources, 2–8 tachometer channels
- 120–150dB dynamic range
- 49kHz analysis bandwidth 97kHz optional

SignalCalc **Savant**

Power in numbers

- 40–1024 input channels
- Networked chassis with 1 Gigabit Ethernet to host
- 49kHz analysis bandwidth, all channels with simultaneous storage to disk



Discover more at www.dataphysics.co.uk

dp Data Physics

Contact us at Tel: +44 (0)1480 470345 Fax: +44 (0)1480 470456
E mail:sales@dataphysics.co.uk

ABACUS powered by

INSTITUTE COUNCIL

Honorary Officers

President
Dr A J Jones FIOA
AIRO Ltd

President Elect
C E English CEng FIOA
The English Cogger Partnership

Immediate Past President
G Kerry CEng FIOA
University of Salford

Hon Secretary
Dr R J Orlowski CEng FIOA
Arup Acoustics

Hon Treasurer
K A Broughton IEng MIOA
HSE

Vice Presidents
B F Berry FIOA
Berry Environmental Ltd
I J Campbell MIOA
Campbell Associates
Dr B McKell CEng MIOA
Hamilton + McGregor

Ordinary Members
Professor T J Cox MIOA
Salford University
Professor R J M Craik CEng FIOA
Heriot Watt University
Professor B M Gibbs FIOA
University of Liverpool
C J Grimwood MIOA
Casella Stanger
Professor T G Leighton FIOA
ISVR
Dr G C McCullagh MIOA
N Antonio MIOA
Arup Acoustics
Professor B M Shield FIOA
London South Bank University
A W M Somerville MIOA
City of Edinburgh Council

Chief Executive
R D Bratby

Dear Members

As I write this, the summer holiday period is on the horizon and Academe is in the throes of examination activity. The Institute of Acoustics plays a very important role in the field of education, and I'm very pleased to see that our Diploma and Certificate courses have been strongly supported again this year, with an increase in the number of candidates taking our examinations. Although by the time you read this letter their fate will have been determined, I wish all the candidates good fortune in their endeavours to improve their qualifications in the field of acoustics. I would also like to thank the tutors and examiners whose work makes our educational activities possible.

The Institute's meetings organisers from our network of Specialist Groups and Regional Branches have also been busy, enabling us to maintain an interesting programme of events again this year. As well as the successful Spring Conference at Southampton University there have been several topical one-day meetings. It was particularly gratifying to see a large attendance at the Aircraft Noise meeting at the Royal Society on 13 May which, apart from being an excellent meeting in itself, had the added benefit of providing a good turnout for the Annual General Meeting that followed it! All of our meetings are worthy of mention (and please do look at the Institute's Diary at the back of the Bulletin), but here I would draw your attention to the Underwater Acoustics Group's meetings in September on Sonar Signal Processing and on Bio-Sonar and Bioacoustics Systems to be held at Loughborough University, and to the Institute's Autumn Conference and Reproduced Sound 20 to be held in October. These should help you get your brains back into gear as your holiday memories fade!

Formal education and attendance at meetings, together with work experience and participation in the Institute's committees provide the building blocks for continuing professional development - and in parallel enable progress through the Institute's hierarchy of membership grades. Naturally, I would hope that all of you aspire to apply for the highest grade of membership commensurate with your career path and see the grades of MIOA and FIOA as an important symbol of your competence, to be recognised as such by other professionals and the public at large. Take a look and see whether you or someone you know is hiding their light under a bushel; application forms are readily available from the Institute office.

In the meantime, enjoy your holidays.

Tony Jones
President

Institute of **Acoustics**

Annual Report 2003

Summary

The Institute has continued to serve the interests of its members through its established programmes in the areas of education, professional development, meetings and publications, and by providing representation in areas such as the Engineering Council and International affairs

During the year

- **A high-level five day Mathematics for Acousticians course was held at ISVR, which attracted around 50 participants**
- **An ambitious programme of technical meetings and conferences was undertaken both at Branch level and nationally**
- **The Strategic Development Group presented an initial report to Council and future actions were being considered**
- **Following the creation of the Archive Fund last year, plans were being made for the archive to be housed at Southampton University**
- **Concern continued to be expressed about the level of recruitment into the acoustics profession and in conjunction with the Association of Noise Consultants an attempt was being made to promote education and careers in acoustics**
- **The Institute continued to respond to consultation documents produced by Government Departments**
- **The Good Practice Guide on the Control of Noise from Pubs and Clubs was published and over 600 copies were sold**
- **The Professional Development Committee merged with the Membership Committee**
- **Demand for the Diploma in Acoustics and Noise Control increased for the third year in succession, drawing students from the UK and abroad**
- **Liaison with EPSRC over the categorisation of research grants concerning Acoustics continued to be an important function of the Research Co-ordination Committee**
- **The Articles of Association and the By-laws were revised to include the new grade of Technician Members, and to rename Associates as Affiliates**
- **The Institute participated in a 'Chartership' day at Qinetiq, Farnborough, to promote membership and engineering registration**
- **A new Engineering Award was announced and nominations were sought for 2004**
- **Membership passed 2,500 for the first time**

Standing Committees

The operation of the Institute is guided by Council through standing committees concerned with education, medals and awards, meetings, membership, publications, and research co-ordination. There is also a committee of the Engineering Division

Education Committee

Education continued to be a valuable activity for the Institute throughout 2003. Through an extensive programme of diploma and certificate courses the committee exists to bring the activities of the Institute to the attention of many professionals working in acoustics and environmental health. Significant numbers of successful students then go on to join the Institute. In addition the considerable financial contribution of Education to the Institute's finances should not be forgotten. This year saw continued progress in our education plans due to the many unpaid hours put in by the members of the Education Committee. The committee work was yet again supported by excellent work by the permanent staff at Head Office and the efforts of the examiners and tutors at all levels.

The number of students enrolling for the *Diploma in Acoustics and Noise Control* rose for the third year in succession. This increase was the result of an increase in the number of distance learning students with the traditional day release centres enrolment remaining static. An increase in the number enrolling for the *Certificate of Competence in Workplace Noise Assessment* short course was expected in the coming year once the revised HSE guidelines to the new EU Physical Agents Directive had been issued. The Workplace Noise Committee was working hard to be ready for the anticipated demand.

The examinations for the *Diploma in Acoustics and Noise Control* were delivered in June without any major problems or significant numbers of appeals. For future examinations, the Institute was considering the need to issue guidelines for the consistent treatment of disabled students during examinations. Work on syllabus revision and assessment methods continued throughout the year with the new syllabus in Noise Control being ready for September 2004. An ongoing problem was posed by the small numbers of candidates for some specialist modules, and a review of the scope and number of specialist modules was planned for 2004. New tutorial notes for the Transportation Noise module were issued in March 2003. This was part of the continual revision of the teaching materials of the Distance Learning programme for the Diploma. A revised guide for the General Module was planned for autumn 2004.

A high-level five-day course in *Mathematics for Acousticians* was held at ISVR in July. Around 50 research and PhD students attended this interesting event which, it was hoped, marked a greater recognition of acoustics as a distinct discipline within UK research. The need for a short course or seminar in the skills needed to be a noise consultant was considered and it was planned that this would go forward in 2004 as a joint venture between the Institute of Acoustics and the Association of Noise Consultants.

Engineering Division Committee

The year 2003 saw the launch of the new Engineering Council UK-SPEC for registration of professional engineers, replacing SARTOR. The Institute's Engineering Division Committee contributed to the work of the Engineering Council during the

year and started to plan for the implementation of the new Standard.
The Committee met three times during the year. Paul Cariss, who replaced Frank Shaw as IMechE representative, provided valuable support and advice to the Committee throughout the year. Two internal audits were carried out, with no non-compliances identified. The Institute participated in a 'Chartership' day at Qinetiq, Farnborough, to promote membership and engineering registration. Although the number of enquiries for registration remained strong, some candidates still deferred or failed to complete their applications. It was hoped that the introduction of UK-SPEC would help rectify this. The Institute's five year Engineering Council licence would fall due for renewal in 2004. The Committee finalised the terms of reference for *The Institute of Acoustics Engineering Medal*, a new biennial award to be inaugurated in 2004.

Medals and Awards Committee

The 2003 Rayleigh Medal winner, Professor Hugo Fastl, was presented with his award at the Spring Conference in Coventry. The 2002 Tyndall Medallist, Professor Tim Leighton, would receive his award at the 2004 Spring Conference in Southampton. A B Wood Medallists Dr Simon Richards (for 2002) and Dr Tony Lyons (for 2003) would also receive their awards at Southampton. The 2003 RWB Stephens Medal was awarded to Professor Greg Watts and the 2004 Tyndall Medal to Professor Trevor Cox. Professor Chris Rice and Professor Phil Doak received their Honorary Fellowships at the 2003 Spring Conference. An Honorary Fellowship was awarded to Professor Bob White and this would also be presented at the 2004 Spring Conference.
At the Autumn Conference in Oxford, awards for outstanding contributions to the life of the Institute were presented to Rob Hill and John Miller. The Association of Noise Consultants (ANC) prize for the Best Diploma Project was presented to Nigel Triner of Faber Maunsell, and the ANC prize for the Best Paper given by a Young Person at an Institute Meeting was presented to Rebecca Hutt, of the Health & Safety Laboratory. Both presentations were made by the ANC Chairman, Rupert Taylor, also at the Autumn Conference. At *Reproduced Sound 19*, the Peter Barnett Memorial Award was presented to Peter Mapp and the student prize was awarded for the first time, to Francis Li of Manchester Metropolitan University. Also, the Institute's prize for the Best Diploma Student was presented to Brian Donohoe of Torotrak (Development) Limited. The new Institute Engineering award was formally announced and nominations were sought for the first award, to be presented in 2004.

The Spring Conference's exhibition was well supported by instrument manufacturers

Pictured (left): IOA President Geoff Kerry presents the 2003 Rayleigh Medal to Professor Hugo Fastl during the Spring Conference; and pictured (below) the Peter Barnett Award 2003 to Peter Mapp at Reproduced Sound 19

Meetings Committee

During 2003, some 19 meetings and workshops were held under the auspices of Meetings Committee attracting a total of just over 1000 delegates. These meetings were held at venues throughout the country including London, Birmingham, Liverpool, Manchester and Edinburgh. The *Autumn Conference* and *Reproduced Sound* were held in Oxford for the first time. Once again we were fortunate that the year provided many topical issues for discussion. In addition, the Institute liaised with the contractors working on the proposed new standard, BS9142, and facilitated three workshops as part of the consultation process.
As always, none of the meetings would take place without assistance from members of the various Groups and Branches committees, who identify the topics and arrange speakers. Thanks are offered to the Head Office staff who carry out all the vital administration for the conferences and are remarkably patient as the committee stretches the important deadlines to the limit and beyond. Thanks are due to the members of the Meetings Committee, Stephen Turner, Jeremy Newton and Ken Dibble (as well as Roy Bratby and Linda Canty) for their invaluable contribution to this area of the Institute's activity.

Membership Committee

The revised By-Laws to include Technician Members and to rename Associates as Affiliates came into force during the year. Five members in the new grade (TechIOA) were elected. There were the usual four meetings during the year, and a total of 191 individual applications (all grades) were considered, including potential new members and transfers between grades; 187 (77 corporate, 110 non-corporate) were approved, including 9 reinstatements, and 7 new sponsor members were welcomed. There was a net gain in membership of 17 compared with 43 in the previous year.
The Professional Development Committee was subsumed into the Membership Committee, and Rachel Canham, Andrew Jellyman and David Watts thus came into the Committee. New terms of reference of the combined Committee were

continued on page 6

Institute of Acoustics

Annual Report

2003

continued from page 5

approved by Council. Alex Burd retired from the Committee after many years' service. The training scheme run by QinetiQ was inspected and approved for the purposes of corporate membership and (in appropriate cases) for Chartered Engineer status.

Publications Committee

2003 was another busy year for the Publications Committee. The *Acoustics Bulletin* is an essential part of communicating with members and this was achieved under the editorial supervision of Ian Bennett with assistance from John Tyler and many other contributors. Another important medium for keeping members up to date with current news and developments in the world of acoustics is the website, managed by Mark Tatham. Our Advertising Manager, Dennis Baylis, was also working hard to build on the work of the late Keith Rose, a difficult task in the context of changing patterns of advertising by companies. We saw a downturn in advertising revenue which affected financing the costs of producing the *Bulletin*. One of the high spots of the year was the progress made by Bridget Shield in setting up a national acoustics archive with the University of Southampton. This was a significant development and would enable us to maintain the important historical material owned by Institute members and others, to provide a resource for historians and researchers alike.

There were probably two major challenges to come. First was the development of the web site. With changing technologies the committee was looking to provide an increasing number of services electronically - services such as the *Register of Members*, the *Buyers' Guide*, and ordering publications - more efficiently over the internet. The second challenge was to increase advertising revenue and reduce costs, which were necessary in order that the *Bulletin*, web site and other publications were effective and provided good value to members. Any members who were interested in the work of the Publications Committee and would like to become involved should contact the Chairman, Dr Matthew Ling.

TABLE 1: MEMBERSHIP

Grade	2002	2003
Hon Fellow	18	18
Fellow	204	197
Member	1346	1371
Associate Member	704	702
Affiliate	113	106
Technician Member	nil	5
Student	56	49
Totals	2441	2448
Key Sponsor	3	3
Sponsor	29	30
Institutional Subscriber	13	15

TABLE 2: GROUP MEMBERSHIP

Group	2002	2003
Building Acoustics	424	676
Electroacoustics	93	189
Environmental Noise	565	1047
Noise and Vibration Engineering	350	639
Measurement & Instrumentation	86	253
Musical Acoustics	79	133
Physical Acoustics	61	94
Speech	64	101
Underwater Acoustics	116	134

Research Co-ordination Committee

The Committee met on three occasions in 2003. Liaison with EPSRC over categorisation of research grants concerning Acoustics continued to be an important function. Through Norman Bolton from DTI, who kindly provided a London venue for meetings in 2003, the Institute had considerable input into the development of the DTI/NPL research programme in acoustics. It was hoped that Prof Chris Scruby would join the committee in 2004 to improve representation of, and involvement with, the Non Destructive Evaluation (NDE) community.

The Chairman was involved with an EPSRC-funded summer school devoted to *Mathematics for Acoustics* for postgraduate students of acoustics, held at Southampton University in July 2003. There were around 50 students at the school and feedback was positive. It was hoped to organise a similar school in 2005. There was a continuing dialogue with Membership Committee over the Code of Conduct for members with respect to research activities.

Specialist Groups

The Institute reflects the broad spectrum of the science and application of acoustics and several Groups exist to foster contacts between members of the various specialisms

Building Acoustics Group

The focal point of the year was the *Autumn Conference* in Oxford which, for the first time in many years, was organised by the Building Acoustics Group. It was considered a well-attended resounding success, for which thanks especially go to Stephen Chiles. The AGM was held at the end of the conference, and elections took place with Peter Rogers taking over as Secretary.

Two half day meetings as part of the Group's new **Professional Practice** series were held during the year. These included *Design and Build Unplugged* and *Contractual Risks and Liabilities*. Both meetings were organised by Clare Wildfire of Fulcrum Consulting. A further successful meeting was held

TABLE 3: BRANCH MEMBERSHIP

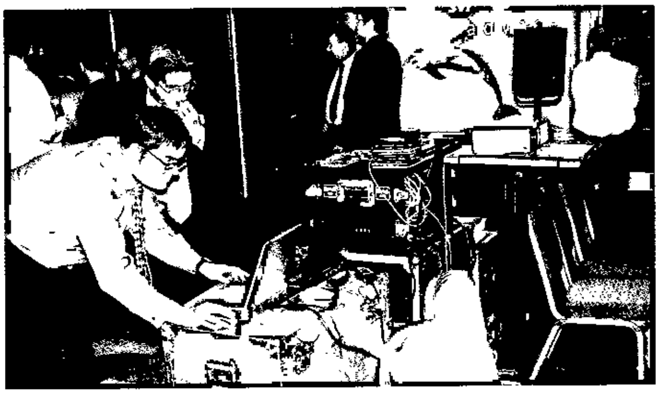
Branch	2002	2003
Eastern	253	235
Irish	115	101
London	558	560
Midlands	370	340
North-west	270	269
Scottish	129	120
South-west	215	200
Southern	443	418
Yorkshire & Humberside	190	171

TABLE 4: DETAILS OF EMPLOYMENT

Employment category	2002	2003
Architectural practice	11	19
Consultancy	501	838
Industry/Commerce	237	323
Education	158	190
Public Authority	343	538
Research & Development	150	207
Other	43	73
Retired	47	89

Soundbite debates continued during the Autumn Conference dinner

Taking *Exploring and sharing audio and acoustics* for its theme, Reproduced Sound 19 concluded with Genelec's demonstration of high definition audio and surround sound



on the *Robust Standard Details*, which led to the Institute's response to this consultation.
Preparations were well in hand for the third half-day meeting in the **Professional Practice** series on *Acoustics and Sustainability* planned for April 2004.

Electroacoustics Group

The *Reproduced Sound 19* Conference was the single event organised by the group Committee. This popular weekend conference took place at a new venue, the Oxford Hotel, Wolvercote near the city of Oxford. The organising committee, chaired by Mark Bailey, was essentially a subset of the group committee with all group members taking part and a number of co-opted individuals included to provide increased breadth and depth. The conference was entitled *Explaining and sharing audio and acoustics*. As was traditional, the idiosyncratic title managed to create an air of mystery about the conference contents. Delegates were at once relieved and comforted to learn that the usual topics were up for discussion. A full report of the conference can be found on the dedicated website www.reproducedsound.co.uk.
Three prestigious IOA awards were presented during the conference, marking it out clearly as the major event on this topic in the country today. No one-day meetings were held during the year. They usually cover hot topics where a timely discussion between interested parties would be of benefit.

Environmental Noise Group

The Environmental Noise Group continued to be very active throughout the year. *The Good Practice Guide on the Control of Noise from Pubs and Clubs* was finally published, and quickly proved to be a best seller. Thanks go to John Hinton and his team on the working party for their efforts and perseverance. The committee was now looking for feedback on the article published in *Acoustics Bulletin* (Nov/Dec 2003).
The Group organised a one-day meeting at the Commonwealth Conference Centre, which covered the impact that the 'Wilson Report' has had on the problem of noise in the 40 years since its publication in 1963. The meeting also considered the problems that still remained, and where the profession was heading in trying to solve these. A one-day meeting on *Planning and Permitting* was held in Birmingham to give members the opportunity to consider the implications of strategic issues such as the Environmental Noise Directive, the development of the Ambient Noise Strategy, and the review of PPG 24, on IPPC. Three half-day meetings, which enabled discussion on the emerging BS.9142 *Guidelines for Environmental Noise Management*, were also held in London, Manchester and Edinburgh.

Measurement & Instrumentation Group

The group enjoyed an influx of new members to the Committee during the year, and organised three one-day meetings throughout 2003, all of which were lively events. The first meeting of the year enjoyed the splendid setting of Blenheim Palace, when 60 delegates arrived on 19 March in the glorious winter sunshine for *Physical Agents 002 - Licensed for Safety*. A very full programme of eleven papers, organised by Martin Armstrong, brought delegates up to date on all aspects of the noise and vibration requirements of the Physical Agents Directive and also included a tour of the Palace. The paper presented by Rebecca Hutt of the Health and Safety Laboratory (HSL) went on to win the prize for the Best Paper given by a Young Person at an Institute Meeting, awarded annually by the Association of Noise Consultants (ANC).
On 5 June our venue moved to the Tate Gallery in Liverpool for *Call Centres - A Measurement Headache* covering the variety of approaches being employed to measure noise exposures of people using communication headsets for prolonged periods. Group Chairman and meeting organiser Richard Tyler steered the group of 43 delegates with very diverse interests through ten papers and a lively discussion at the end. The Group's AGM was held after the Liverpool meeting: the two Committee members required to stand down were duly re-elected unopposed; and a new member, Elizabeth Brueck from the HSL, was elected.
The final meeting of 2003 took place on 7 October in the brand new buildings of the National Physical Laboratory (NPL) at Teddington. *It's **how** loud ... are you sure?* presented nine papers, mostly by NPL staff including meeting organiser Sue Dowson, on state-of-the-art measurement capabilities and how improvements may be made in the future. A tour of the new acoustic test facilities still being commissioned by the NPL was included and proved very interesting to the 36 delegates present, a lower number than might have been expected given the increasing requirement for accurate acoustic measurements being demanded in many areas today. A full programme was already planned for 2004, and the successful events looked set to continue.

Musical Acoustics Group

Although the Musical Acoustics Group had been dormant for some time, and there was no activity in 2003, the group was planning a revival in 2004. In particular, a performance by the 'New Violin Octet' was being organised which would

continued on page 8

Institute of **Acoustics**

Annual Report 2003

continued from page 7

give members an opportunity to learn about these new instruments which were developed by Carleen Hutchins over the latter part of the 20th century. Additionally, a funding application was being submitted to EPSRC for a UK Musical Acoustics Research Network under the Culture and Creativity Programme. This was being co-ordinated by Murray Campbell at Edinburgh University and, if successful, would support a number of musical acoustics activities.

Noise and Vibration Engineering Group

There were several significant changes in legislation over the past year or so with the publication of the EU Noise and Vibration Directives and the implementation of the Integrated Pollution Prevention and Control Directive. Towards the end of 2002, the former 'Industrial Noise Group' was re-named as the 'Noise and Vibration Engineering Group' in an effort to suggest more immediately the wide remit of the Group. To publicise this, and to discuss the implications of the EU Directives, the group hosted the *Spring Conference*. There were 70 delegates at this meeting, which was held in Coventry on 15 and 16 May, when 18 technical papers and two Medal lectures were presented. The Group otherwise concentrated on furthering links with the NVH specialist community.

Joint IOA/IOP Physical Acoustics Group

As the second Anglo-French Physical Acoustics Conference (AFPAC '02) had taken place in December 2002, and planning was almost complete for AFPAC '04 to take place in January 2004, the group did not hold a major conference in 2003. However, a very successful Tutorial Day on *Physical Acoustics* was held at the Institute of Physics in London on 24 September. This took the form of three extended lectures on very different aspects of physical acoustics and ultrasound. These enabled the presenters to provide comprehensive reviews of their topics. The meeting was well attended and there was a general agreement among the delegates that this form of meeting was well worth repeating.

Speech Group

There was no activity this year.

Underwater Acoustics Group

The Underwater Acoustics Group organised an international conference on *Calibration and Measurement in Underwater Acoustics* on 9-10 January 2003, which was hosted by NPL. The two day event featured papers submitted from researchers in UK, India, USA, Russia and China. A total of 47 people attended with delegates originating from 10 countries (from the above countries as well as Italy, Norway, Sweden, Germany and Denmark). Joint conveners were Victor Humphrey (University of Bath) and Stephen Robinson (NPL). The conference attracted researchers from industry and academia and covered all the topical issues in underwater acoustic calibration, such as results of the recent Key Comparison of hydrophone calibrations; recent work to characterise both materials and acoustic transducers under ocean conditions; and research into a new generation of primary standards based on optical techniques. Delegates praised the conference and stressed the benefit from exposure to the latest research in these areas, and the rare opportunity to meet with other workers in the field, in particular those from other countries. A conference report was submitted to the Institute for inclusion in *Acoustics Bulletin*.

The 2002 A B Wood Medal was awarded to Dr Simon Richards for his work on suspended sediment absorption and scattering. The US recipient for 2003 was Dr Tony Lyons for his work on seabed scattering: he was nominated by the Acoustical Society of America. Dr Lyons spent a number of years at the NATO underwater research centre and returned to the US in 2000 where he joined the acoustics group at the Applied Research Laboratory, Penn State. His position at ARL continued his work on high frequency sediment acoustics.

At the Group's AGM, James Dunn completed his term of office as Chairman and Dr Gary Heald was elected to take over. Dr Peter Thorne was re-elected to continue as Secretary. The remainder of the Committee consisted of Mr J Dunn, Prof H Griffiths, Prof T Leighton, Dr P Dobbins, Dr V Humphrey, Dr D Hazelwood, Dr S Robinson, Mr D Goodson, Dr S Richards and Dr J Bell.

Prof Griffiths agreed to organise a conference on *Sonar Signal Processing*, and David Goodson and Peter Dobbins took on the task of organising a conference on *Bio-acoustic and Bio-sonar*. As the Bio-acoustics community also had an interest in signal processing techniques it was agreed to hold the meetings successively at Loughborough University during September 2004. Organisation of this combined event was well underway. Sadly, in December 2003 David Goodson was diagnosed with a progressive terminal illness and he passed away in early January 2004. David had made a significant contribution to the understanding of dolphin sonar (amongst other topics) and his services to the Underwater Acoustics Group Committee would be sadly missed. A memorial lecture would be given in David's honour at the bio-acoustics conference. Prof Brian Woodward of Loughborough University was co-opted onto the Committee.

Prof Leighton and Dr Richards took on the role of organising a special session at the Institute's 2004 *Spring Conference* on acoustics in fluids and tissues. This was co-organised with the Physical Acoustics Group. Over the years there had been a sequence of conferences on sonar transducers. It was planned to hold another conference on this topic but proved difficult to find a suitable organiser. This was resolved and the conference would now be organised by Dr Robinson of NPL.

The Underwater Acoustics Group recognised that the number of younger members (in the UK) coming into this area of research was decreasing. As a result they predicted that proposing suitable A B Wood medallists could become difficult. Thus

Victor Humphrey, University of Bath (left) and Wang Yuebing, Hangzhou Acoustic Research Institute, China (right) present their work during the international conference on *Calibration and Measurement in Underwater Acoustics*, organised by the IOA's Underwater Acoustics Group

the Committee submitted two proposals to the Medals and Awards Committee for changing the selection process for A B Wood medallists. The first proposal was that the UK awards should be extended to include acousticians from Europe. The second was to formalise the nomination process. This would involve calling for nominations, including a candidate's CV and two supporting references, by a given date. The Group would select two of the nominations (at most) and rank them in order of priority. These would then be forwarded to the Medals and Awards Committee. The Medals and Awards Committee ratified these proposals at its meeting in late 2003 and agreed that they did not contravene the original intentions of awarding this medal. The process for US nominations would remain unchanged.

Regional Branches

The Regional Branches of the Institute exist to further the technical and social activities of the Institute at local level

Eastern Branch

The Eastern Branch had a reasonable year with five technical meetings and one social meeting. These were organised through four committee meetings, having an average attendance of around 17 members. As always, the Committee members tried to provide a wide cross-section of topics with venues spread across the Eastern Region as much as possible, although many were held at Colchester Institute.

At the first meeting, held in February at Colchester, David Berriman gave a lecture on *Surface Sound Technology*. This was followed in May by a very interesting demonstration delivered by David Bull, entitled *Noise Control in Practice*. On 4 June - National Noise Awareness Day - Ed Beard gave an illustrated talk at Braintree on up-to-date aspects of *EU Noise Policy*.

After the summer break an interactive lecture and discussion was arranged at Bury St Edmunds which addressed the conflict of interest between PPG24 and PPG3. Fortunately Andrew Gough, from the Office of the Deputy Prime Minister, was available to oversee the ensuing debate. The planned social meeting was a very enjoyable Gourmet Meal and Magic Night in the Balkerne Room at Colchester Institute. Lastly, the AGM in November was combined with the final meeting at Colchester Institute when Toby Davey addressed *The Role of the Expert Witness*.

Irish Branch

There were two evening meetings during the year, the first of which was held on 27 February at Belfast Institute of Further and Higher Education. At this meeting a very informative talk on *Wind Noise, Hearing Loss and Motorcyclists* was presented by Dr Andrew McCombe, a consultant ENT surgeon from Frimley Park Hospital in Surrey. The AGM was held at Dublin City University on 13 March and was preceded by an invited lecture on *Active Noise Control* by Dr Geoff Leventhall, who gave a comprehensive update on advances in the field.

Noise Awareness Day was marked by the organisation of a display on 6 June at the Government Environmental Resource Centre (ENFO) in Dublin. This included information on environmental noise, workplace noise, noise from plant and equipment, noise measurement and a Noise Map of Dublin City. In addition, a press release was sent to three national daily newspapers and to one evening paper notifying them of the display and of the aim of the Noise Awareness Day. The Director of ENFO was enthusiastic about the display and has invited the Branch back next year.

TABLE 5: MEETINGS ATTENDANCE IN 2003

Topic, date and venue	attendance
Calibration and Measurement in Underwater Acoustics (9-10 January, NPL)	45
Assessment of Aircraft Noise. Are we doing it right? (12 March, Liverpool John Lennon Airport)	30
Physical Agents 002, Licensed for Safety (19 March, Blenheim Palace)	71
Design and Build: Unplugged (8 April, London)	37
The Mayor of London's Ambient Noise Strategy (30 April, London)	47
Spring Conference: IPPC, PA(N)D, NCE & NVH (15-16 May, Coventry)	73
Call Centres — a Measurement Headache (5 June, Liverpool)	50
Research Symposium 2003: Acoustic Characteristics of Surfaces (18-19 September, Salford)	51
Wilson 40 years on (23 September, London)	52
Contractual Risks and Liabilities (30 September, London)	37
The Application of Robust Standard Details (2 October, London)	57
It's how loud ... are you sure? (7 October, NPL)	36
Planning and Permitting — What's it all about? (16 October, Birmingham)	85
Autumn Conference: Sound-bite (5-6 November, Oxford)	143
Reproduced Sound 20 (7-9 November, Oxford)	99
BS9142 Guidelines for Environmental Noise Management (12 November, London)	48
BS9142 Guidelines for Environmental Noise Management (19 November, Manchester)	31
Urban Regeneration (27 November, London)	60
BS9142 Guidelines for Environmental Noise Management (3 December, Edinburgh)	30

London Branch

The London Branch was pleased to report another buoyant year which included a successful one-day conference, a stimulating 'Royal' visit, the Annual Dinner and a full programme of evening meetings. In all, ten events were held throughout the year. Seven evening meetings were held at the offices of Symonds in Holborn, a half-day visit took place at the Royal Albert Hall, a one-day conference was held at the Commonwealth Conference Centre and the Annual Dinner was at the Cittie of Yorke in Central London. Attendance at

continued on page 10

Institute of Acoustics

Annual Report 2003

continued from page 9

the meetings and functions was good and generally on a par with previous years' figures. It was noticed that there was a general core group of members (10 to 20) attending these meetings on a regular basis, with the remainder consisting of new attendees or people who came occasionally depending upon the topic under discussion.

The half-day visit to the Royal Albert Hall proved to be a very interesting and stimulating afternoon, including a talk and tour of the recently refurbished auditorium. The day conference in April was held at the Commonwealth Conference Centre. This was another popular meeting on the subject of *Noise Strategy for London*. More papers were offered than could be included, and no fewer than nine were presented. These ranged from the London Noise Strategy, health effects in London, quiet areas, and entertainment management zones, to noise mapping and transportation noise. A passionate and healthy debate ensued.

A branch meeting to discuss the Mayor of London's Ambient Noise Strategy heard that road traffic is the most widespread source of noise and related annoyance in the capital

The speakers at the meetings were:
January - *Debate on Noise Mapping*
March - *Roadside Noise Barriers* (Mike Wright)
May - *Physical Agents Directive* (Keith Broughton)
June - *Noise and IPPC* (Lesley Ormerod)
September - *Night Flights after Hatton* (Colin Stanbury)
October - *Classroom Acoustics* (Bridget Shield and Richard Daniels)
December - *PPG 24* (Paul Freeborn and Andrew Colthurst)

An entertaining evening was enjoyed by all at the Annual Dinner. There was a pleasant atmosphere in the restaurant with good quality food. The evening was completed by the entertaining after-dinner talk from Dr Mike Fillery which included a number of stories related to his 20 years of lecturing at Derby University. A full programme was being planned for the forthcoming year and the committee looked forward to the continued support from members.

Midlands Branch

The Midlands Branch held four evening meetings in 2003. The first was on 16 April at the Jaguar Engineering Centre, Coventry where Martin Cockrill and his team gave a superb presentation on *Virtual Noise Vibration Harshness Engineering*. They described how the correct sound differentiates a vehicle from its competitors and is a vital component in defining its image and character. Getting the sound quality right is a vital part of the overall design of a modern motor car and this presentation revealed some of the many techniques and methods that go into sound quality engineering. The talk was supported by many demonstrations including Vehicle CAE, Noise Path Analysis, Power Train and Whole Vehicle De-composition. Overall the evening set a very high standard for the rest of the year.

Next up was Rolls Royce Aero Engines at Hucknall on 15 May where the recently upgraded noise certification and research facility was visited. To manufacture powerful, fuel-efficient and 'quiet' aero-engines, required extensive research using the latest methods and state of the art data acquisition equipment. To continue to reduce whole-engine noise it was necessary to measure within fine tolerances any changes of noise characteristics due to trial modifications and changes from a basic 'datum' engine standard. Many novel microphone installations were possible ranging from 30 to 300+ microphones for a single test. The presentation demonstrated how these microphone arrays were used to extract 'delta' changes between years of successive experiments made on this facility since 1982. The evening included a visit around the control rooms and the large test arena, where a typical test engine installation ready for testing was on show. The group was also treated to a tour of the museum of historic aero engines housed on the Hucknall site, and to finish off an excellent visit, Rolls Royce provided a buffet at its social club.

Another excellent buffet was in evidence as guests of the University of Derby on 16 September when a 'young members' meeting' was held. Three presentations were given by students on the Institute's Diploma course at Derby. The student presentations were based on their projects, carried out as part of the Diploma. The standard was excellent and the difficult task of deciding the best presentation fell upon Ian Campbell of Campbell Associates and Dr Gen Cannibal of the University of Derby. The Institute award was given to Sara Warne of North-west Leicestershire District Council for her talk on the assessment of shotgun noise.

The final meeting of the year, and the AGM, were held on 12 November at Birmingham University. After the formal business of the AGM was concluded (the existing committee was re-elected in its entirety) there was a presentation by Phil Atkins of Birmingham University. Phil used his experience of over twenty years' work in the area of sonar research and development to take a *Gentle Meander through Sonar Systems*. The talk compared and contrasted the 'state-of-the-art' technology of the early 1970s with that of today. Current technology was driven by the entertainment and telecommunications market and as a result the level of performance achievable by an enthusiastic amateur shopping for items on the local High Street and raiding the nearby scrap yard was shown to be surprisingly good. However, the physical constraints still remained unchanged and many of the esoteric aspects of sonar signal processing still lay beyond the reach of readily available hardware implementations.

In all, this talk upheld the fine standard of all the presentations in this year's interesting and varied programme. Whilst the evening meetings had gone well, it was not all plain sailing, for yet again the half-day visit had to be cancelled. We had planned to visit the railway manufacturer Alstom in Birmingham, but uncertainties over the future of the factory prevented our tour in September. This cancellation followed on from the cancelled trip to the Arrows Formula One team last year, and the disrupted visit to Birmingham Airport in 2001. Better luck was hoped for next year.

North-west Branch

The first meeting of the year in February was a presentation by Richard Greer of Arup Acoustics. Richard described the background and basics on the ANC *Guidelines for the Measurement and Assessment of Groundborne Noise and Vibration*. In March, Paul Freeborn of Casella Stanger organised a half-day meeting in the Cavern Suite of Liverpool John Lennon Airport. The subject, of course, was the *Assessment of Aircraft Noise, and Have We Got* *it Right*. The conclusion was that nobody said we were doing it wrong, at least not generally. Jeff Charles of Bickerdike Allen and Stephen Turner of Casella Stanger provided the substance and the workshop organisation.

April saw another half-day meeting, this time on the subject of *Urban Regeneration*. A large audience at Salford University, including a welcome contingent from local authorities, was treated to presentations from Mike Ankers, Richard Llewellyn, a planner from Manchester City Council, Duncan Templeton of BDP Acoustics, Cliff Inman and Paul Stringer of Glidevale Ltd. The topic caused significant questioning and it became clear that not all the issues associated with planning development were black or white. With summer fast approaching, it was time to visit the Peak District for a tour of Federal-Mogul Friction Products Ltd. It was led by Tristan Hargreaves, who provided his visitors with an insight into condition monitoring and brake product manufacture. Then in July, Tracey Bettaney of Congleton BC organised a trip to Jodrell Bank, where a rumour arose that the planetarium allowed some people to catch up with their sleep before the pub.

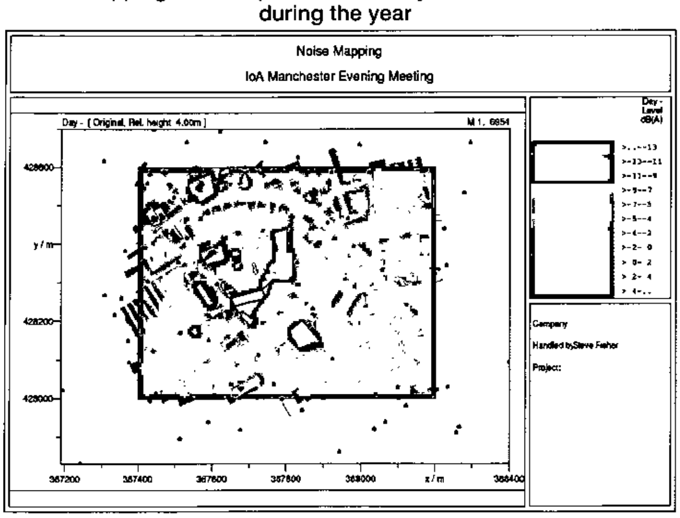
In September, Steve Fisher of Casella Stanger provided an insight into noise mapping. This was followed in October by the customarily efficient AGM, and at the time - being the occasion of the last flight of a Concorde - a topical presentation on sonic booms was given by Geoff Kerry. He described the survey undertaken by Salford University at St Michael's Mount in Cornwall during Concorde test flights, to determine the likelihood of damage to historic buildings.

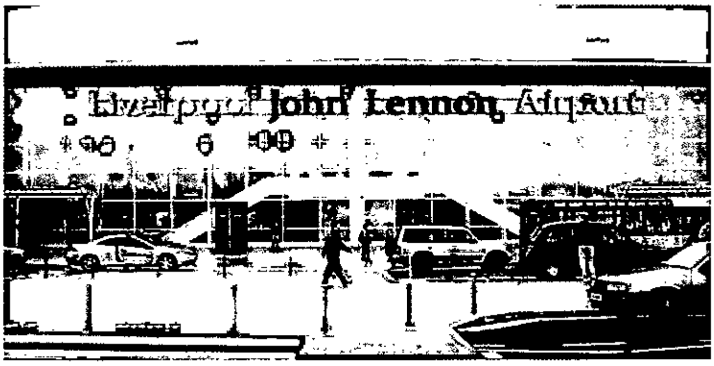
Following the successful half-day meeting earlier in the year, the Branch agreed to organise a full day meeting on *Urban Regeneration in London*. David Trew (Bickerdike Allen Partners), Emma Clark (London Borough of Camden), Dani Fiumicelli (Casella Stanger) and Sarah Radcliffe (Peter Brett Associates) provided the basis for a successful meeting and were ably supported by Mike Ankers, Cliff Inman and Paul Stringer. The year ended with a presentation on the new Licensing Act by Hamish Lawson of Cobbetts Solicitors, who provided the background to approaching legislation and the issues. As usual, the North-west Branch members were indebted to Ove Arup & Partners, BDP and Salford University for hosting the meetings so well.

Scottish Branch

Although the year was fairly quiet for the Scottish Branch in terms of activities and visits, it was also one of significant change. After many years as our Branch Chairman, Dr Bernadette McKell stepped down and this role was taken over by David MacKenzie, a lecturer in building acoustics within the School of the Built Environment, Heriot-Watt University,

Noise mapping was a topic discussed by a number of branches during the year





Liverpool John Lennon Airport was the appropriate venue for a workshop devoted to various aspects of aircraft noise assessment and its control

Edinburgh. He is confidently expected to prove an able and enthusiastic successor. The Branch Committee was extremely grateful for Bernadette's years of service and looked forward to David bringing his input and energy to the role. Bernadette's experience would not be lost entirely as she agreed to continue to serve as a committee member. Lilianne Lauder remained Branch Secretary and thanks were due to her for her continued commitment to this work.

The Branch Annual General Meeting took place on 23 September and was preceded by a visit to the Scottish Parliament Building. It was good to have Ian Campbell at the AGM in his capacity as Vice President of Groups and Branches. The meeting concluded with a lively discussion and debate on the future direction of the Branch and wider concerns about the control of competence in those purporting to be acoustic specialists. The visit to the Scottish Parliament Building included a presentation by Sandy Brown Associates on the acoustic design of the building and all who attended found both the tour of the site and the presentation very interesting. It is hoped to arrange a return visit once the project is complete.

Southern Branch

The Branch held one meeting in 2003, at Winchester Guildhall. This was a presentation by Keith Broughton, entitled *Forward into a Quieter Europe - Can They Hear?*, attended by 19 members. Keith discussed the history of the EU Directives leading to the recently published Physical Agents Directive on Noise and Vibration, which formed the basis for the new Noise at Work Regulations, and the effects of the revised criteria in the Directive on noise control in the workplace.

South-west Branch

Following a number of quiet years the Branch Committee was reconvened, and welcomed several new young and enthusiastic members to bolster the regulars. The current Committee membership was Tim Clarke (Chairman), Stan Simpson (Secretary), Stephen Chiles, Peter Dobbins, Adam Lawrence, Paul Marks, Steve Peliza, Richard Perkins, Gareth Phillips, Graham Rock and Mike Squires. The Committee met twice in 2003 and organised two Branch meetings. The first was in March on the topic of *Noise Modelling in Practice*, a case study by Richard Perkins of Parsons Brinckerhoff Ltd. This excellent presentation, a foretaste of Richard's presentation at the 'Planning and Permitting' meeting later in the year, was followed by an opportunity for hands-on use of noise-mapping software. The meeting was enjoyed by around 30 delegates from a variety of backgrounds within acoustics.

The second meeting took place in June and focused on *Building Bulletin 93: New Requirements for School Acoustics*. This very interesting topic was presented by Stephen Chiles,

continued on page 12

Institute of **Acoustics**

Annual Report 2003

continued from page 11

University of Bath, and outlined the provisions within BB93. Stephen was well qualified to talk authoritatively about this document having been closely involved in its production. The meeting was attended by around 45 people who also benefited from a lively question and answer session. The Branch would like to thank Stan Simpson and the University of the West of England for their hospitality for both of these meetings. The Branch looked forward to a successful year in 2004 and planned a programme of visits and meetings with a variety of topics including Automotive Noise Control, a visit to the BBC, Noise and Wildlife, and Noise Modelling of Outdoor Concerts.

TABLE 6: INSTITUTE PERSONNEL AT 31 DECEMBER 2003

COUNCIL		
Officers		**Ordinary Members**
President	Mr G Kerry FIOA	Mr N Antonio MIOA
President Elect	Dr A J Jones FIOA	Prof T J Cox MIOA
Immediate Past President	Prof M A A Tatham FIOA	Prof R J M Craik FIOA
Honorary Secretary	Dr R J Orlowski FIOA	Prof B M Gibbs FIOA
Honorary Treasurer	Mr K A Broughton MIOA	Mr C J Grimwood MIOA
Vice Presidents		Dr G C McCullagh MIOA
Engineering	Mr C E English FIOA	Prof B M Shield FIOA
Groups & Branches	Mr I J Campbell MIOA	Mr A W M Somerville MIOA
International	Mr B F Berry FIOA	Mr S W Turner FIOA

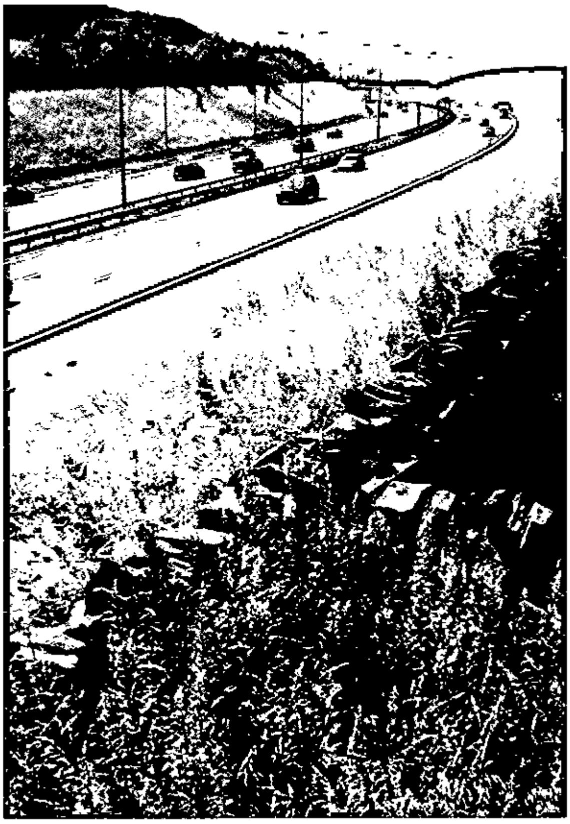
Committees & Sub-Committees	**Chairman**
Education	Dr M E Fillery FIOA
Diploma in Acoustics and Noise Control, Board of Examiners	Prof K Attenborough FIOA
Certificate of Competence in Environmental Noise Measurement	Mr D Trevor-Jones FIOA
Certificate of Competence in Workplace Noise Assessment	Mr D G Bull FIOA
Certificate in Measurement of Sound Transmission in Buildings	Prof R J M Craik FIOA
Certificate in Management of Occupational Hand Arm Vibration	Mr T M South MIOA
Engineering Division	Mr C E English FIOA
Medals & Awards	Mr G Kerry FIOA
Meetings	Mr S W Turner FIOA
Membership	Mr J R Dunn MIOA
Publications	Dr M K Ling MIOA
Research co-ordination	Prof K Attenborough FIOA

Specialist Groups	**Chairman**	**Secretary**
Building Acoustics	Prof R J M Craik FIOA	Mr P J Rogers MIOA
Electroacoustics	Mr R C Cross FIOA	vacant
Environmental Noise	Mr K M Collins MIOA	Ms N D Porter MIOA
Noise and Vibration Engineering	Mr M D Hewett MIOA	Mr J Richards MIOA
Measurement & Instrumentation	Mr R G Tyler FIOA	Mr M J Armstrong MIOA
Musical Acoustics	Dr P F Dobbins FIOA	vacant
Physical Acoustics (Joint with the Institute of Physics)	Mr D Cartwright	Dr N Saffri
Speech	vacant	vacant
Underwater Acoustics	Dr G J Heald FIOA	Dr P D Thorne FIOA

Regional Branches	**Chairman**	**Secretary**
Eastern	Mr M P Alston MIOA	Mr C L Batchelor AMIOA
Irish	Dr G C McCullagh MIOA	Mr S Bell MIOA
London	Mr J E T Griffiths FIOA	Mr A J Garton MIOA
Midland	Dr M E Fillery FIOA	Mr J F Hinton MIOA
North-west	Mr P E Sacre MIOA	Mr P G Michel MIOA
Scottish	Mr D J MacKenzie MIOA	Ms L Lauder MIOA
Southern	Dr N D Cogger FIOA	Dr H Sagoo MIOA
South-west	Mr T Clarke MIOA	Mr S Simpson MIOA
Yorkshire and Humberside	Mr P Horsley MIOA	Dr K V Horoshenkov FIOA

Yorkshire and Humberside Branch

During the past twelve months the local Committee of the Yorkshire and Humberside Branch of the Institute organised a series of seminars and meetings. A seminar entitled *Noise Control by Natural Means* took place in February at Hull University. Hosted by Keith Attenborough, it attracted a considerable number of members from the UK acoustics community and professionals from other areas, including horticulture, forestry, landscape design and architecture. In July an EPSRC grant application was submitted by members of the En:Able Network which consolidated the ideas resulting from the above seminar.
Another successful event was held in October at Bradford University on the subject of *Noise Maps: Are these hard to map?*. Those attending had the opportunity to test the capabilities of



A seminar on *Noise control by natural means* attracted delegates across a wide professional field, including acoustics, horticulture, forestry, landscape design and architecture

each of three noise mapping PC packages: Cadna (Campbell Associates Ltd), NoiseMap 2000 (Atkins plc) and SoundPLAN (Technical Development and Investigation Ltd). The three companies provided, installed and demonstrated their software to over 40 attendees. The company representatives answered many questions and the session ran for over five hours. Two more potentially exciting events were organised by the Branch, but these had to be cancelled at the last minute. One particular event, a seminar *Noise, Construction and Environment* supported by the Institution of Civil Engineers, was originally scheduled at Bradford in May 2003, but it became possible to re-schedule it for March 2004.

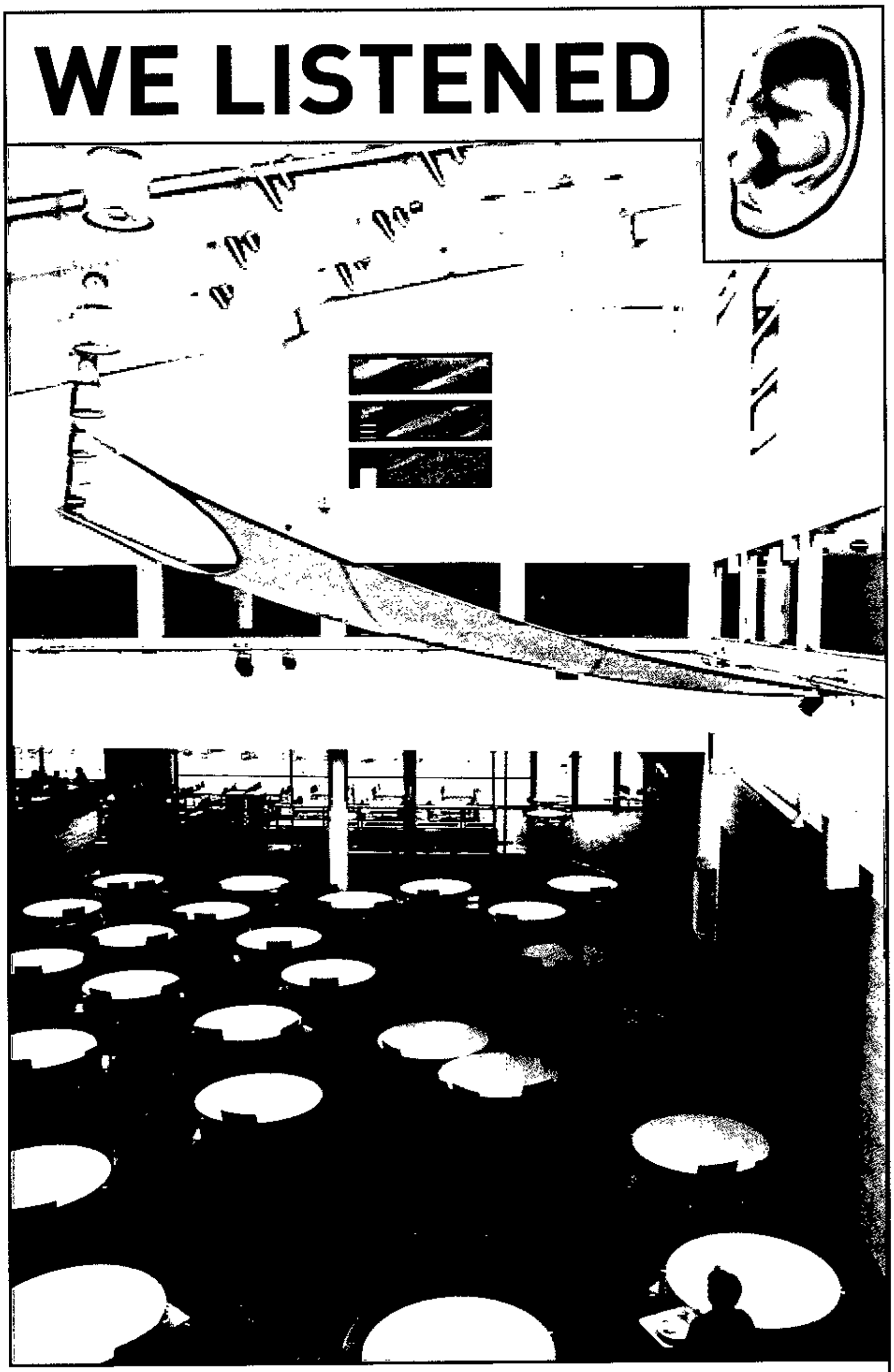
Institute of **Acoustics**

You said for certain projects you require a **smooth flat** high performance acoustic finish

Sonacoustic is the new sound absorbing finish for ceilings and walls with a **flat smooth surface**

With the exciting introduction of **Sonacoustic** completing the range of **SonaSpray** products, we now have the finish and performance you require, and with environmentally friendly materials.

We have listened. **Sonacoustic** is the perfect finish for office receptions, atria, restaurants and high quality residential developments



For more information:

Tel: 01474 873122
www.oscar-acoustics.co.uk
mail@oscar-acoustics.co.uk

OSCAR ACOUSTICS

Sonacoustic© and SonaSpray® are manufactured by ICC, Houston, Texas USA

Building Acoustics Group

Acoustics and sustainability

Forty delegates attended this half day seminar, held on 27 April 2004 at the Commonwealth Conference Centre in London. Number three in the 'professional practice' series run by the Building Acoustics Group, it was aimed at considering the principal of sustainable development within building design and exploring areas where it may affect the role of the acoustic consultant.

Four speakers presented topics that identified the approach being taken in environmental design. The topic of acoustic comfort was introduced, contrasted by an update on the acoustic issues surrounding wind power generation on or near buildings.

Sustainable development is described by the government as 'providing a better quality of life for everyone - now and for future generations'. As far as sustainable building design is concerned this essentially means driving downwards a building's reliance on the planet's natural resources. The purpose of the seminar was to discuss whether this approach in the design of buildings was likely to provide cohesion or conflict with acoustic design principles.

Mike Wilson and **Fergus Nicol** (LEARN, London Metropolitan University) set the scene by postulating that the concept of acoustic comfort may follow similar rules to the more clearly understood areas of visual and thermal comfort, these being thought to be affected by a need to relate to the outside world (such as a requirement for daylight, and windows that may be opened).

They reported a study in which acoustic comfort appeared to be linked with adaptation to a particular environment.

The conclusion was that more research in the built environment could now be done to explore acoustic comfort, to question whether current guideline levels were appropriate in all instances. However, questions from the floor stressed a need to be aware of when human tolerance is adversely affected.

Ashley Bateson (Fulcrum Consulting) offered an environmental consultant's view on sustainable building design approaches to the building envelope. He explained how he was driven by issues like the solar impact of orientation, thermal barriers, air leakage barriers, air flanking paths at junctions and glazing. The solutions complemented many of the areas relevant to acoustic design.

It was suggested that this provided an opportunity for parallel development rather than conflict with sustainable building design in the outline phases.

Clare Wildfire (Fulcrum Consulting) outlined low energy design solutions and alternative energy sources, and considered the possible implications for acousticians.

Generally environmental engineers were suggesting solutions based on exposing the thermal mass of a building, using larger size ducting for ventilation, burying earth tubes for passive tempering of air, or creating boreholes for long term heat recovery.

It was considered likely that although more careful design may be necessary to preserve good room acoustics in exposed mass rooms, the noise levels from mechanical and electrical services may actually end up considerably lower. Sometimes this might prompt a requirement for sound masking systems to preserve privacy. Alternative energy solutions may avoid the need for noisy chillers, but where thermal mass of a building was used the likelihood that mechanical plant would run at night for 'free' night-time cooling should be borne in mind. The talk threw up some obvious conflicts for the sustainable solution in relation to acoustics.

Andrew Bullmore (Hoare Lea Acoustics) gave an engaging presentation on wind power, and the consequence of the government's drive towards a 10% contribution by 2010 in the UK. He explained the trend from large scale wind farms towards integrated wind power solutions in future projects (some of them already under detailed consideration). An integrated wind power solution would have turbines using the building design to make wind power generation a feasible option close to the building.

Acoustically speaking, the consequence would be a much greater need to tackle noise break-in from the blade swish that occurs in the immediate vicinity of the turbine, and also control the vibration effects caused by the generation of structureborne energy. The challenge to all acoustic consultants was to offer a forward-thinking acoustic approach to help such projects become a reality.

The workshops identified that some real solutions exist to issues such as coping with exposed soffits, but prompted questions of manufacturers and acousticians on the provision of natural ventilator solutions. This was especially so in the topical case of acoustic design of schools.

With the UK government's commitment to move towards sustainable design it seems clear that acoustic consultants will play an important part in making it possible: in so doing, they will encounter healthy doses of cohesion and conflict with the rest of the design team. Currently, there seems to be a lack of focus on whether the acoustician should be driving the issues or taking a back seat, prompting the need for more work into the effect of noise on people in buildings.

Peter Rogers
BAG Secretary

Southern Branch meeting

BS 9142: Guidelines for environmental noise management - the new standard

An AGM was held on 27 April 2004 before the evening's main presentation. Nigel Cogger opened the meeting by welcoming 22 members of the Southern Branch. A very brief summary of events since the last AGM was followed by the adoption of committee members, who currently comprise Nigel Cogger (chairman); Hardial Sagoo (secretary); Andy McKenzie; Alan Saunders; Ron Smith; Colin Waters; and Mike Westcott.

Nigel Cogger then opened the main event, which related to the proposed new standard BS 9142 Guidelines for environmental noise management. He is part of the consortium that is formulating the standard and therefore was well placed to make the presentation.

Initially the draft version of the proposed standard was outlined, to show the areas to be covered; the background; and requirements to provide the management of noise or sound. Currently there are a number of British Standards, codes of practice and guidance documents for tackling sound issues relating to planning and existing situations. Similarly there is a range of sound descriptors, which may or may not relate to one another. The result is that one or more interpretations can be made for any one particular situation, leading to inconsistencies in conclusions and the management of any action required. This is clearly unsatisfactory.

BS 9142 is intended to provide a framework to ensure that assessments, decision making and the ultimate management of noise or sound control are consistent. The standard should allow for all relevant issues to be addressed, rather than adopting a single path. This approach was expected to result in more consistent decisions by presenting a fuller assessment of a potential or actual noise problem to the decision maker.

Nigel stressed that the standard was not intended to be prescriptive or encourage the adoption of an excessively rigid approach.

In conclusion there was a lively discussion and several points were raised by members. These included an assurance that a consistent approach could be adopted in the management of noise. It was suggested that a list of the relevant standards, guidance and codes of practice should be incorporated in the new standard. Nigel agreed to convey these points to the consortium preparing the draft.

Ron Smith MIOA

Examination Results

Certificate of Competence in Environmental Noise Measurement

The following were successful in April 2004 examination

Liverpool University
Ellison S J
Faulkner R
Goodwin J G
Grattan B L
Marrs R
McGhee J A
Mountford J
Neighbour L
Norman S
Palmer B W
Tarbuck N

Colchester Institute
Allen C M
Bristow S J
Crisp D L
Farrell T
Hook C M
Masterson A
O'Kelly D K
Ziervogel H L
Agnew E A
Aboyade-Cole A

University of Strathclyde
Coull L J
Cruickshank I
Dundas E N
Higgins J E
McKay M J
Mulcahy C
Smith D N
Walls D
Tough S D
Thomson J S

Leeds Metropolitan University
Glyn Jones C E
Harriss G
Lesley R H
McCormack G P
Rands E
Tait J W
Smith C J
Riley A L

NESCOT
Arnold A
Bradley M L
Coldbourne J
Crofton-Martin D E
Flavin D A
Gouge V
Haslett J P
Lawless D J
Nesbit J E
O'Brien M M
Pigeon L
Smith M J
Templeman B J

University of Birmingham
Klaus A
Rollinson J
O'Sullivan D
Dean E J
Baggott S J

University of Derby
Willis R J
Waghorn A I
Slater D
Standring R
Reynolds P
Jamieson R I
Henderson F
Dyson P M
Ball S J

University of the West of England, Bristol
Chambers S
Cole A
Hawkins N C
Marchbank F
Morris B C
Morris S
Nicholls S R
Roberts D C
Turbervill D F
Anderson A S

Bell College
Brown C
Cruickshak A
Johnstone I S
Hillis M A
Holmes W J
McAvenna A
Middleton J
Rains J H
Reid M
Seditas B

Certificate of Competence in the Management of Occupational Exposure to Hand Arm Vibration

The following were successful in May 2004 examination

EEF Sheffield Association
Bramwell I A
French D
Hadfield PP S

Institute of Naval Medicine
Gippert B
Hill B
Houltby G
Stather J A

Happy Birthday ASA!

A letter has been sent to the Acoustical Society of America, on behalf of the Council and membership of the Institute of Acoustics, to congratulate the ASA on reaching its 75th anniversary. The Institute thanks its American counterparts for all they have done to promote the study of the science of acoustics, and looks forward to continuing the relationship and working with them over their next 75 years. The actual anniversary was in mid-May 2004.

Tutorial Day in Physical Acoustics

Thursday 23 September 2004

Institute of Physics, London

Organised by the Joint Physical Acoustics Group of the Institute of Physics and The Institute of Acoustics

The Physical Acoustics Group is holding a one day Tutorial Day and their AGM on 23 September 2004 at the Institute of Physics, 76 Portland Place, London.

The following lectures will be given:

Wavelets – *Paul Addison*
Sonoluminescence & Sonochemistry – *Gareth Price*
Ultrasonic Transducers - *TBC*

Editor's Notes

Ian F Bennett BSc CEng MIOA
Editor

Summer is here, and the thoughts of acoustic consultants across the land dwell fondly on environmental noise surveys that are relatively uninterrupted by the weather. It seems that in June and July at least, the meteorologists are able to predict with some accuracy how windy and wet it will be, sometimes as far as a whole day ahead. That is all very well, and we all know that noise measurements on 5 November and 31 December can give 'iffy' results, but I am yet to come across a textbook that suggests noise surveys should be avoided when England are playing football! Either the roads are devoid of traffic (as I found out driving into Manchester at 6pm last week) or the acoustic climate is dominated by celebratory motor horns. By the time you read this, the fate of the English team at Euro 2004 will be known. Apologies (very quiet ones) to the Celtic fringes of these islands of ours, but let us not forget that at real (rugby) football we are World Champions.

My grateful thanks go to all contributors, as always, and especially to Tim Leighton for providing an insight into space exploration and how acoustics may be able to give a unique picture of conditions on other worlds. Now that's what I call eavesdropping! I am also delighted to be able to publish articles covering some less familiar aspects of our fascinating field, from medicine to music.

All material for the September/October issue should reach me by Friday 6 August, please. Remember to complete those write-ups *before* you go on holiday!

Ian Bennett
Editor

The sound of Titan

a role for acoustics in space exploration

T G Leighton and P R White

This month (July) Cassini, the largest spacecraft ever launched by man, will go into orbit around Saturn. On Christmas Day 2004 this NASA vehicle will release Huygens, a probe of the European Space Agency, which in early 2005 will undertake a 2.5 hour parachute descent through the atmosphere of Titan, Saturn's largest moon. This probe contains a range of sensors which will communicate data on Titan's atmosphere back to Cassini until Huygens runs out of power. Whilst the primary mission has been directed at investigating Titan's atmosphere, for many the big question is whether or not Titan possesses an equivalent of the features associated with the terrestrial water cycle: seas, lakes, streams, falls, breaking waves, rain etc.

It is possible that Huygens will not answer this question, since its ability to probe the surface is restricted to perhaps three minutes. One item of equipment which might answer this question, whose ruggedness, low power requirements, low mass and small bandwidth make it in many ways an ideal inclusion on a space vehicle, is a microphone. Huygens carries two microphones, primarily to record signals associated with the atmospheric buffeting during the parachute descent, and to measure the speed of sound in the atmosphere. It is possible that these might record sounds associated with electrical discharge in the atmosphere (as did microphones on the Soviet Union's Venera missions to Venus). However, were the microphones of Huygens to detect the sound of a 'splash-down' end to the parachute descent, the question of Titan's lakes would have been answered.

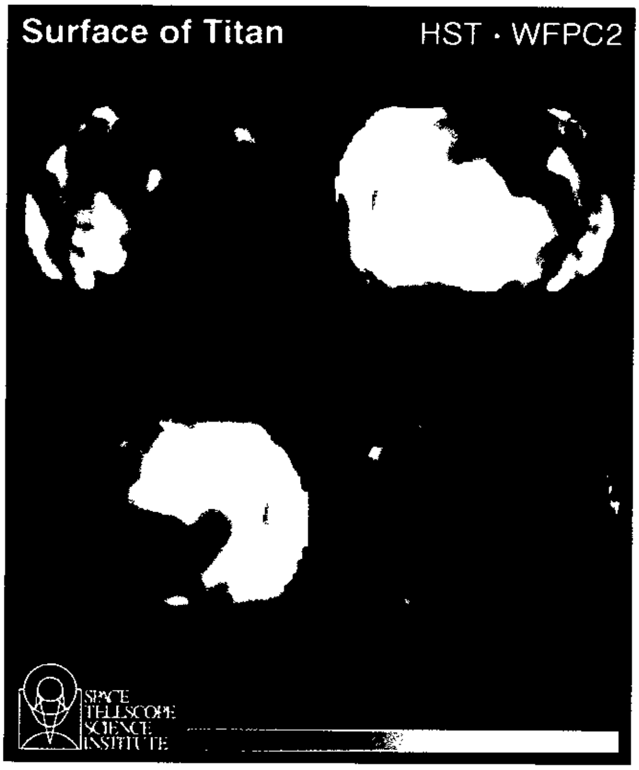


Figure 1: four global projections of Titan, separated in longitude by 90 degrees, taken by the Hubble Space Telescope's WideField/ Planetary Camera 2 at near-infrared wavelengths (between 0.85 and 1.05 microns). Upper left: hemisphere facing Saturn. Upper right: leading hemisphere (brightest region). Lower left: the hemisphere which never faces Saturn. Lower right: trailing hemisphere. These assignments assume that the rotation is synchronous. The single prominent bright area is a surface feature 2,500 miles across, about the size of the continent of Australia, and may be a continent. *(Image credit: P. H. Smith and M. Lemmon of the UA Lunar and Planetary Laboratory, and NASA)*

But can we be sure that the sounds we associate with seas and lakes on Earth would find recognisable counterparts on Titan? The object of this article is to explore that question **(1)**. Furthermore, if we have a model for how sound is generated by environmental processes such as falls, wavebreaking and precipitation over a sea, then it is in principle possible to invert the measured sounds to obtain environmental parameters on Titan.

Cassini, Huygens and Titan

Probably the only place in our Solar System other than Earth which could contain free-flowing surface streams, lakes and seas open to an atmosphere is Titan *(Figure 1)*, the largest of Saturn's 20 known moons. At around 1.4 billion kilometres from the Sun, and 1,221,830 km from Saturn, Titan has a diameter of about 5,150 km, which is around half that of Earth (12,756 km) and slightly larger than that of Mercury. Titan was discovered in 1655 by the Dutch astronomer Christian Huygens. In 1944 another Dutch astronomer, Gerald P Kuiper, confirmed the presence of an atmosphere through spectrographic detection of gaseous methane (CH_4). The atmosphere generates a reverse greenhouse effect, preventing penetration of solar ultraviolet radiation but allowing infrared to escape Titan.

Currently it is this atmosphere which generates most human interest in Titan. Its outermost fringes extend 600 km into space, ten times further than does Earth's. The reason why Titan (with an escape velocity of 2.7 km/s, compared with 2.4 km/s on Earth's moon, and 11.2 km/s on Earth) has a dense atmosphere (the only moon in the Solar System to do so), whereas Mercury (with an escape velocity of 4.5 km/s) does not, is because Titan's low surface temperature (-180 °C, 93 K) keeps atmospheric molecular velocities below escape velocity. With an atmospheric pressure at the surface which is one and a half times that of Earth, the major gas component is nitrogen (90%). It was probably formed by the solar ultraviolet breakdown of ammonia (NH_3) deposited from comets, producing N_2 and hydrogen (which is sufficiently light to escape Titan's gravity). Other components include argon (10%), hydrogen cyanide (HCN), ethane, methane, propane (C_3H_8) **(2)**.

This rich chemistry results from solar radiation and the passage of Titan through the vast fields of charged particles which are trapped by Saturn's magnetic field. There are methane clouds at an altitude of 25 km (although only 1% of the surface is covered by cloud, compared with 50% on Earth). However the atmosphere is very thick and hazy owing to suspended aerosols and condensates of hydrocarbons, forming a smog which is much thicker than any over cities on Earth. Although the temperature would predispose against the formation of life at the surface of Titan

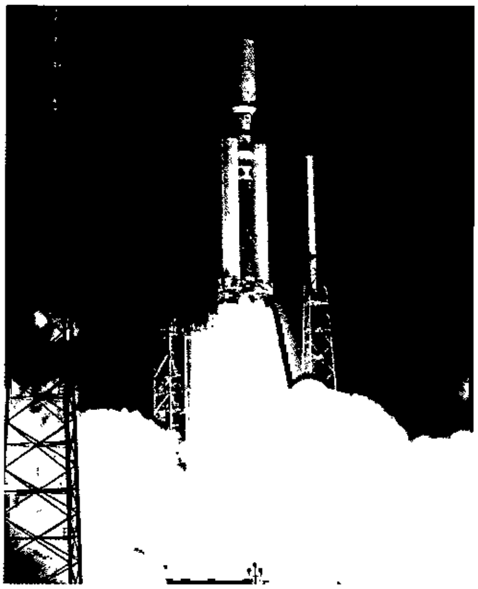


Figure 2: the launch of *Cassini-Huygens* on 15 October 1997. *(Image credit: NASA/JPL/Caltech)*

(noting that in principle locally higher temperatures may be generated on moons through radiation and geothermal processes, meteorite impacts, lightning, seismic activity etc.), the potential for these chemicals to provide a pre-biotic environment similar to that of Earth during the early stages of the evolution of life has stimulated interest in Titan, and even prompted speculation that it might support life when our Sun becomes a red giant.

At $3.4 billion the Cassini-Huygens mission is one of the most expensive ever launched, a collaboration between seventeen countries and three space agencies (NASA, the European Space Agency and the Italian Space Agency). Probably the most complex space mission launched, its start was controversial: the 5650 kg Cassini-Huygens bus-sized craft is not only the largest launched, but also carries the greatest mass of plutonium 238 (32.5 kg) ever put into space. This raised fears in some quarters of a possible disaster at its launch on October 15 1997 using a massive Titan IV-B/Centaur launch vehicle from Florida's Cape Canaveral Air Station *(Figure 2)*, and the later Earth fly-by in August 1999 which was designed to exploit Earth's gravity in a 'sling-shot' manoeuvre.

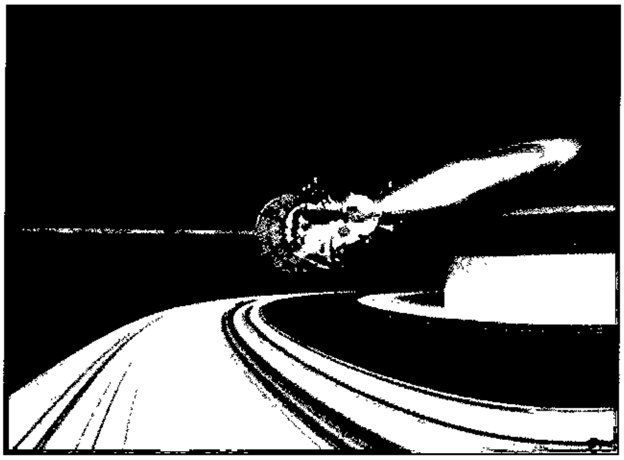


Figure 3: this is a computer-rendered image of *Cassini-Huygens* during the Saturn Orbit Insertion (SOI) manoeuvre, just after the main engine has begun firing. The spacecraft is moving out of the plane of the page and to the right (firing to reduce its spacecraft velocity with respect to Saturn) and has just crossed the ring plane. The 96 minute SOI manoeuvre will allow *Cassini-Huygens* to be captured by Saturn's gravity into a five-month orbit. *(Image credit: NASA/JPL/Caltech)*

Following a flyby of Phoebe (the outermost moon orbiting Saturn) at an altitude of 2000 km on 11 June 2004, NASA's Cassini on 1 July 2004 crosses Saturn's ring plane during the spacecraft's critical Saturn Orbit Insertion manoeuvre *(Figure 3)*. It will fire its engine for 96 minutes to become the first man-made object to enter orbit around Saturn, passing 15000 km above the rings and within 20000 km of its outer atmosphere. During its 4-year orbital study of the Saturn system, Cassini will pass Titan several times, making radar maps of its surface.

Piggybacking on Cassini is the European Space Agency's Huygens probe, which is scheduled to be the first man-made spacecraft ever to land on the moon of another planet. After a seven-year journey strapped to its side, Huygens will separate from Cassini at a relative speed of 30 cm/s on 25 December 2004, then coast for 20 days on its way to Titan, and finally enter the moon's atmosphere on 14 January 2005. This is seven weeks later than originally planned, in order to minimise the effect of a telecommunications problem, which would have resulted in loss of data transmitted to Cassini from Huygens through failure to compensate for the Doppler shift on the radio signals between the two. In the original flight plan, Cassini would be rapidly approaching Titan during Huygens' 2.5 hour parachute descent through the thick atmosphere. It will now fly over Titan's clouds at an altitude of 65000 km, more than fifty times higher than originally planned (hence the discrepancy between the eventual orbit and those illustrated in *Figure 4* and *Figure 5*).

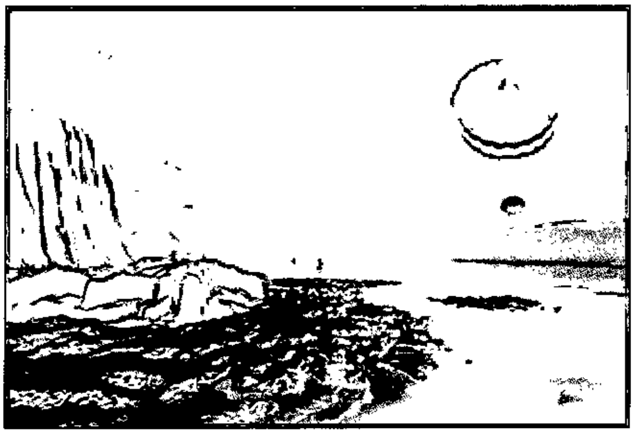


Figure 4: an artist's impression of Titan's surface, with Saturn dimly visible in the background through Titan's thick atmosphere. The *Cassini* spacecraft flies over the surface with its High Gain Antenna pointed at the *Huygens* probe as it nears the end of its parachute descent. Thin methane clouds dot the horizon, and a narrow methane spring or 'methanefall' flows from the cliff at left and produces considerable vapour. Smooth ice features rise out of the methane/ethane lake, and crater walls can be seen far in the distance. *(Illustration by David Seal, Image credit: NASA/JPL/Caltech)*

Huygens will now need to be pre-heated to improve tuning of the transmitted signal. Cassini's arrival date at Saturn is unaltered (1 July 2004), and the flybys of Titan will occur on 26 October and 13 December 2004. From February 2005 Cassini will continue on its four year primary mission of studying Saturn's rings, moon and magnetic field.

Huygens' primary mission is to analyse the atmosphere during this descent. Examination of Titan's surface is limited by the lifetime of the five onboard batteries, which are capable of generating 1800 Watt-hours of electricity. These will constrain the Huygens mission to just 153 minutes, corresponding to a maximum descent time of 2.5 hours plus at least three additional minutes (and possibly an extra half

continued on page 18

The sound of Titan

a role for acoustics in space exploration

continued from page 15

hour) on Titan's surface. It is hoped that Huygens will be able to record images from the surface of Titan. The dense smog proved to be impenetrable at the visible wavelengths utilised by the cameras aboard the Pioneer and Voyager spacecraft that flew past Saturn in the late 1970s and early 1980s. Earth-based radar, however, and near-infrared wavelengths from the Hubble telescope *(Figure 1)* have indicated the possible existence on Titan of lakes and seas consisting of hydrocarbons, mainly ethane C_2H_6. There are probably mountains which include water ice.

The surface conditions on Titan are close to triple point of methane/ethane, and therefore it is possible that methane/ethane may play a similar role on Titan as does water on Earth, with methane/ethane seas, methane/ethane ice and methane/ethane vapour. Hence on a Titan beach, should one exist, the sea may be fed by streams, falls, and rain consisting primarily of methane (which, on Earth, is the main component of the domestic heating fuel 'natural gas'). Although tidal forces are 400 times greater than on Earth, like most of Saturn's moons Titan is tidally locked, keeping the same face oriented towards the planet during its 16-day synchronously rotating orbit. As a result, massive tides will not be seen on these possible seas. However Titan's orbit is elliptical, and as the distance to Saturn (and its moons) changes over this 16-day month a tide of about 3m would not be unexpected, nor would gravitationally generated winds of a few metres per second. Neither, therefore, would sea waves be surprising if such a sea exists, and indeed these might be detected by accelerometers on Hygens. Given appropriate parameters, it should be possible to predict the sound generated on Titan by such natural phenomena, and this will now be done for the underwater sound of falls *(Figure 4)* (with associated recordings for these, 'splash-down' and breaking waves, available via http://www.isvr.soton.ac.uk/fdag/uaua.htm). The necessary physical parameters are summarised in *Table 1*, the values for Titan being estimates.

		EARTH	TITAN
LIQUID:		**Water**	**Mainly ethane**
Surface tension (σ)	$N\ m^{-1}$	0.075	0.031±10%
Vapour pressure (p_v)	Pa	3500	2.2±10%
Dynamic viscosity (η)	$Ns\ m^{-2}$	1.433×10^{-3}	1.12×10^{-3}±10%
Mass density (ρ)	$kg\ m^{-3}$	999.93	648.4±5%
Sound speed (c)	$m\ s^{-1}$	1434.4	1982±2%
GAS		**Air**	**Mainly nitrogen**
Thermal conductivity (K_g)	$W\ m^{-1}\ K^{-1}$	0.02598	0.0088±5%
Molar heat capacity ($C_{p,m}$)	$J\ mol^{-1}\ K^{-1}$	28.96	26.9±3%
Mass density (r_1)	$kg\ m^{-3}$	1.293	6.131
Molecular diameter (L_g)	m	3.15×10^{-10}	3.15×10^{-10}
Molecular mass (m_g)	kg	4.99×10^{-26}	4.99×10^{-26}
Specific heat at constant pressure (C_p)	$J\ kg^{-1}\ K^{-1}$	1.0414×10^3	1.03×10^3±7%
Specific heat at constant volume (C_V)	$J\ kg^{-1}\ K^{-1}$	0.7429×10^3	0.76×10^3±7%
Ratio of specific heat at constant pressure to that at constant volume ($\gamma=C_p/C_V$)		1.402	1.45±10%
Speed of sound (c_g)	$m\ s^{-1}$	334	192.5
Local parameters			
Temperature	K	283	93
Atmospheric pressure	Pa	10^5	1.5×10^5
Acceleration due to gravity (g)	$m\ s^{-2}$	9.81	1.35
Fundamental parameters			
Boltzmann's constant (k_B)	$J\ K^{-1}$	1.38×10^{-23}	1.38×10^{-23}
Avogadro's number (N_{Av})		6.023×10^{23}	6.023×10^{23}

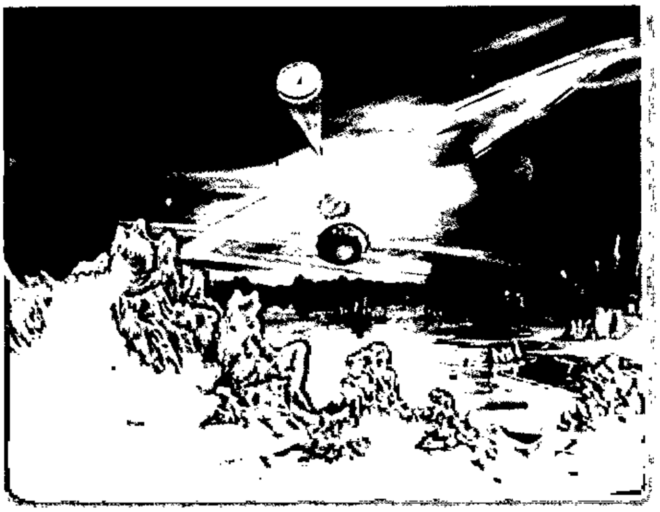


Figure 5: an alternative rendering of the *Huygens* descent, showing clouds at 20 km altitude. The descent will occur during daylight to provide the best illumination conditions for imaging the clouds and surface. *(Illustration by Craig Attebery, Image credit: NASA/JPL/Caltech)*

Method

Bubble dynamics

This paper will illustrate the possibilities of acoustic inversion by predicting the pressure signal which an underwater microphone (a hydrophone) might measure close to Titan's equivalent of a waterfall. This is first-order estimation, and based on two key simplifications. The first is that the pressure signature above a certain frequency is dominated by bubble sources of sound, whilst below that frequency non-bubble sources (e.g. hydrodynamic) are mainly responsible. The second arises because the technique requires input of a bubble size distribution for Titan. Until a better estimate for use with the method of this paper is found, this first calculation will assume that bubbles generating audio-frequency sound will follow the distribution found in a terrestrial waterfall. This is not an unreasonable first guess given the dynamics of gas entrainment by waterfalls and the fluid properties *(Table 1)*. The issue of wave-breaking in the large waves that might result from Titan's low gravity is more complicated.

When, in response to an impulse excitation, a bubble pulsates at low amplitude about an equilibrium radius (R_0), it resembles a damped harmonic oscillator: the stiffness is invested primarily in the gas, and the inertia arises mainly through the surrounding liquid, which must move if the bubble wall is to oscillate **(3)**. Spherical pulsations only will be considered here, because they dominate the far-field radiation. Damping can arise through many sources, but for

Left: Table 1 properties relevant to the generation of underwater sound by bubbles at surface of Earth and Titan. The sources of the Titan parameters are very numerous, from formal to informal, and at times contradictory. Hence they are not cited, and researchers wishing to undertake similar calculations are encouraged to carry out independent searches for these parameters. Because no value of any parameter listed in the table is derived from the value listed for another, certain internal consistency checks (e.g. $C_{p,m} = N_{Av} m_g C_p$ and $\gamma = C_p / C_V$) will not behave as expected. The decision was made to use what were judged to be the best values available, rather than force internal consistency. Although values of gas thermal diffusivity D_g at atmospheric pressure are available in the literature, for the calculations here D_g was calculated from K_g so that any dependence of D_g on bubble size (through surface tension) could be incorporated. (TGL is grateful to P R Birkin for checking the estimates he made in this table) most gas bubbles in liquids the primary ones are associated with viscous losses in the liquid as the wall moves, with radiation losses as acoustic energy propagates away from the bubble, and with thermal losses as the gas is compressed and rarefied during the pulsation. Most bubbles on Earth are lightly damped, and on entrainment are not at equilibrium *(Figure 6)* such that their subsequent wall motions, and acoustic pressure emissions, resemble exponentially decaying sinusoids at the bubble natural frequency ν_0 *(Figure 7)*. In 1933, Minnaert **(4)** hypothesised that this might be the source of 'the murmur of the brook, the roar of the cataract, or the humming of the sea'; and in 1987 a bubble population in the natural world (under a waterfall) was for the first time estimated using such passive entrainment emissions **(5)**. In 1991 this was done for breaking waves, where the entrainment rates were far greater **(6)**.

The key characteristics of such low-amplitude natural oscillations (quality factors and natural frequencies) can readily be calculated for air bubbles in water on Earth **(7, 8, 9)**. The undamped natural frequency can of course be estimated from the square root of the ratio of the stiffness of the bubble gas to the inertia of the associated liquid. The stiffness of the gas is itself dependent on the relationship between the pressure p and the volume V in the gas. A useful engineering approximation is to characterise this by

continued on page 20

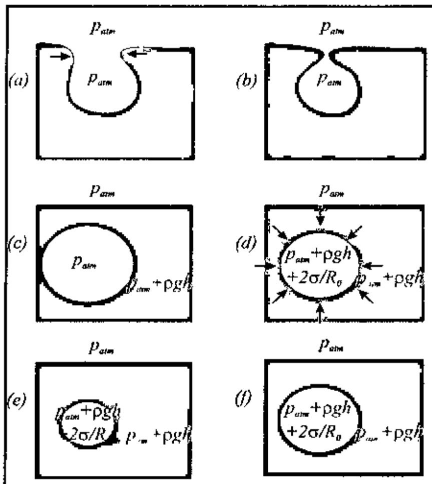


Figure 6: an idealised entrainment of a bubble from a liquid/air interface, where the acceleration due to gravity is g. *(a)* Interface distortion. *(b)* Liquid (of surface tension σ and density ρ) closes around the nascent bubble. *(c)* At the moment of its birth in this scheme, the bubble is at some depth h in the liquid, and has a radius exceeding the value it will have at equilibrium, and with internal pressure equal to that of the atmosphere p_{atm}. Consequently the bubble is unstable on formation, and will shrink towards equilibrium (where in this approximation internal pressure will match that of the surrounding liquid, $p_{atm} + \rho g h$, plus the Laplace pressure $2\sigma / R_0$ commensurate to its size [3§2.1.1]). *(d)* Therefore the bubble contracts, passes through equilibrium size because of the inertia of the surrounding liquid, until *(e)* the work done by the compressed gas halts the wall motion at some minimum bubble radius R_{min}, and starts the rebound. The bubble undergoes pulsations, the amplitude of which decay through radiation, viscous, thermal and any other losses, until *(f)* it is stationary at equilibrium size

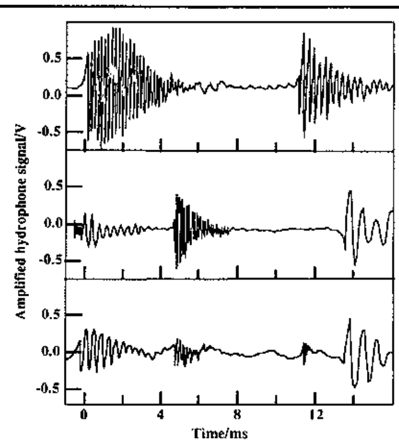
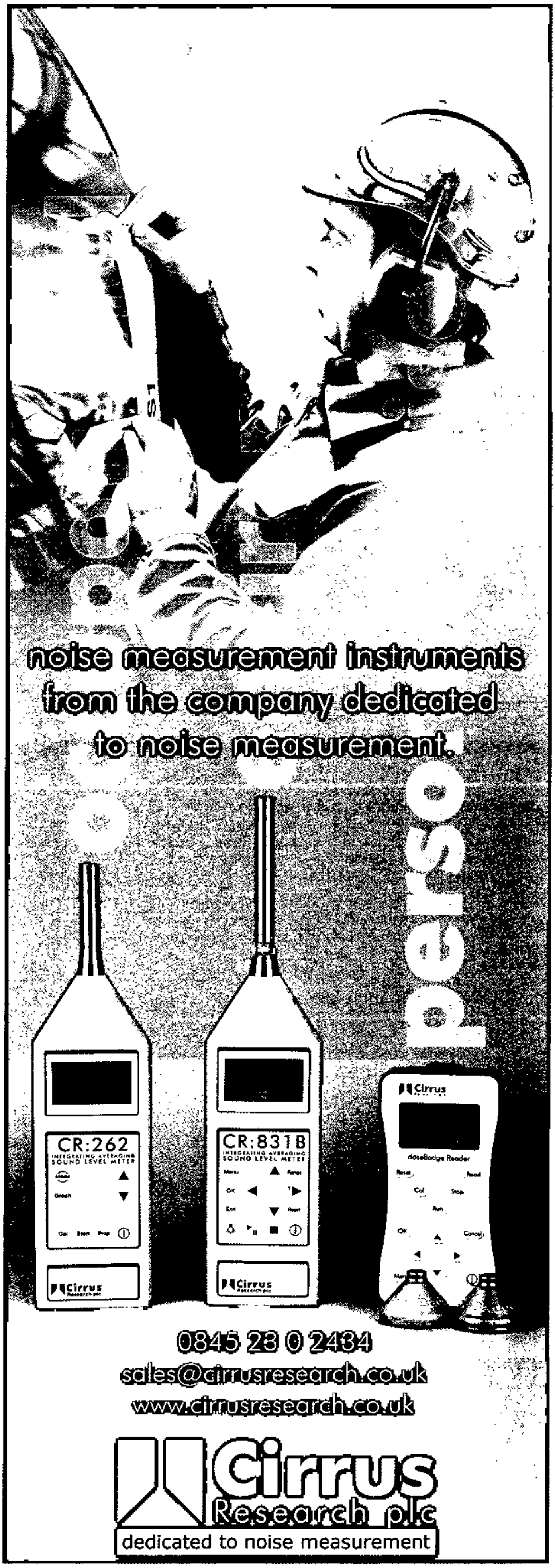


Figure 7: hydrophone time history from a recording made in a babbling brook at Kinder Scout, in the Peak District, UK. A number of distinct bubble entrainments are clearly identifiable, demonstrating a range of natural frequencies and dampings. From Leighton and Walton **(5)**



The sound of Titan

a role for acoustics in space exploration

continued from page 19

a polytropic index, κ, such that for a perfect gas $pV^{\kappa} = constant$, where κ can take values between γ (the ratio of the specific heat of the gas at constant pressure, C_p, to that at constant volume, C_V) and unity, depending on whether the pulsations are adiabatic, isothermal, or of an intermediate nature **(10)**. Of course since *pdV* is a perfect differential, the use of a polytropic index that is constant during the oscillatory cycle of a given bubble can never describe net thermal losses from the bubble **(11)**. In this limit, that is done by characterising a dimensionless damping coefficient δ_{tot} for the bubble undergoing natural pulsations, such that δ_{tot} is the reciprocal of the quality factor of the bubble. In turn, δ_{tot} is a simple summation of the dimensionless damping coefficients calculated for viscous losses (δ_{vis}), acoustic radiation losses (δ_{rad}), and net thermal losses (δ_{th}).

Expressions for these have remained largely unchanged since the 1950's, except for a suggested correction [3§3.4.1b(iv)] to the use in δ_{th} of a constant thermal diffusivity for the gas (D_g). Strictly, this depends on the gas

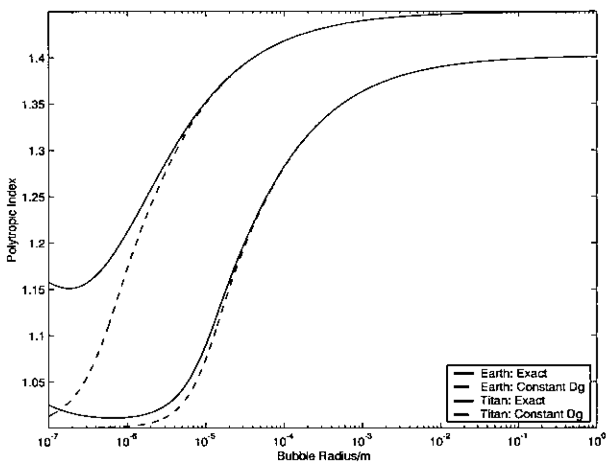


Figure 8: calculated values of the polytropic index for gas bubbles pulsating at their natural frequencies. The calculations are made for bubbles containing atmospheric gas in water (for Earth, black lines) and ethane (Titan, blue lines) with appropriate planetary surface conditions *(Table 1)*. In each case, two curves are plotted (solid and dashed). The dashed lines assume a constant value for D_g in the usual manner, but the solid lines allows D_g to vary as a result of the surface tension effect [3§3.4.2b(iv)]. The calculations for Titan are based on the estimated values in *Table 1*. Whilst the trends seem realistic, the offset between the two curves falls within the uncertainty of the values in *Table 1*

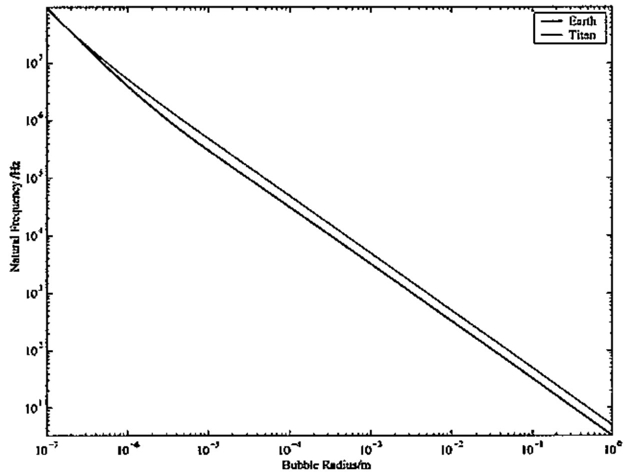


Figure 9: the relationship between the bubble radius and the natural frequency. The calculations are made for bubbles containing atmospheric gas in water (for Earth, black line) and ethane (Titan, blue line) with appropriate planetary surface conditions *(Table 1)*. For each planet, two curves are plotted (solid and dashed), but they overlie. The dashed line assumes a constant value for D_g in the usual manner, but the solid line allows D_g to vary as a result of the surface tension effect [3§3.4.2b(iv)]

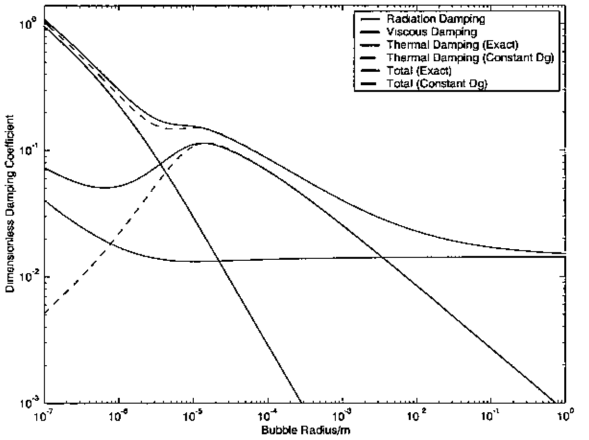


Figure 10: damping coefficients for air bubbles in water at standard conditions for the surface of the Earth. The thermal (δ_{th}, red), viscous (δ_{vis}, blue), and radiation (δ_{rad}, green) damping coefficients are plotted, as is their sum, the total dimensionless damping coefficient (δ_{tot}, black). For the thermal and total coefficients, two curves are plotted. In each case, the dashed line assumes a constant value for D_g in the usual manner, but the solid line allows D_g to vary as a result of the surface tension effect [3§3.4.2b(iv)]. These calculations are based on the estimates of *Table 1*

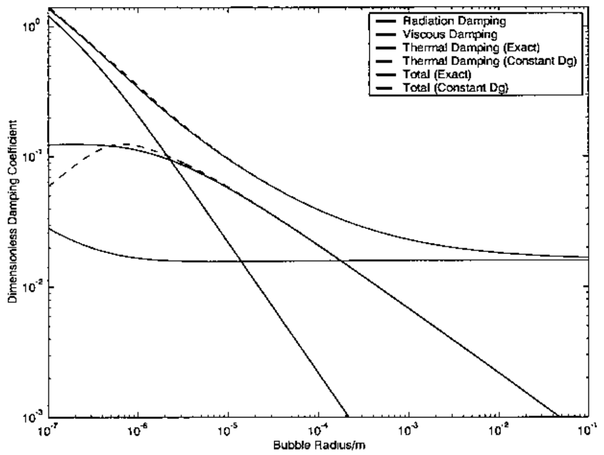


Figure 11: dimensionless damping coefficients for gas bubbles at the surface of Titan. Otherwise the caption is as for *Figure 10*

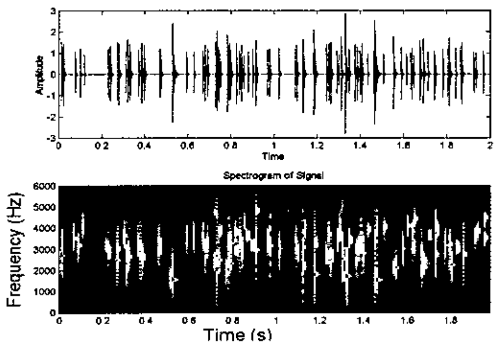


Figure 12: the upper plot shows an artificially constructed hydrophone signal when fifty bubbles per second are introduced without noise. The spectrogram of this signal is shown in the lower plot, which displays high acoustic energy as 'hot' colours, distributed across frequency bands as indicated in the vertical axis, at times as marked on the horizontal axis. In the spectrogram it is easy to identify the frequency of the individual bubbles and their amplitude. This signal can be heard via http://www.isvr.soton.ac.uk/fdag/uaua.htm, where it is very easy to hear the individual bubble signals. However it does not sound like realistic rain or a babbling brook

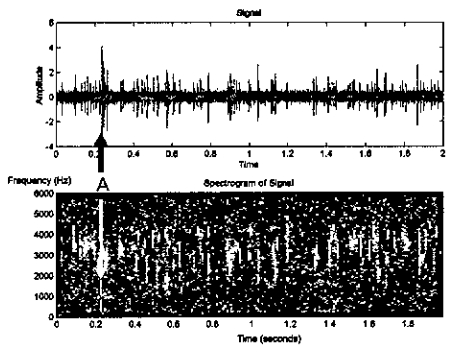


Figure 13: a two-second hydrophone time history (upper plot) and the corresponding spectrogram (lower plot) are constructed with the same underlying statistics for the bubble size distribution as in *Figure 12*, and with the same rate of bubble generation (50 per second), but with added random Gaussian noise at a similar level to that which might be found at some natural sites on Earth. This signal can be heard via http://www.isvr.soton.ac.uk/fdag/uaua.htm, where it sounds a little more like rain or a babbling brook than do the data of *Figure 12*. You should be able to hear a high amplitude, low-frequency signal from a large bubble near the beginning of the recording (labelled A)

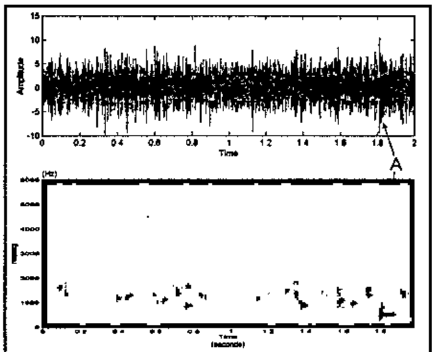


Figure 14: a two-second hydrophone time history (upper plot) and the corresponding spectrogram (lower plot) are constructed with the same underlying statistics for the bubble size distribution and statistics for added noise as in *Figure 13*, but the bubble generation rate has increased to 2500 per second. This signal can be heard via http://www.isvr.soton.ac.uk/fdag/uaua.htm, where it sounds a lot more like rain or a babbling brook than do the data of *Figures 12 or 13*. You should be able to hear a high amplitude, low-frequency signal from a large bubble near the end of the recording (labelled A)

pressure, and so in turn should depend on the bubble radius through the influence of surface tension *(Figure 6(d)-(f))*. In practice, in air bubbles in water on Earth, the effect for natural frequency oscillations is only significant when the bubble radius is sub-micrometre. This is evident in *Figures 8 to 11*, which plot the polytropic index *(Figure 8)* and natural frequencies *(Figure 9)*, as a function of the equilibrium radius of the bubble; and the various dimensionless damping coefficients for natural frequency oscillations on Earth *(Figure 10)* and Titan *(Figure 11)*. Note that for macroscopic bubbles $\nu_0 \propto R_0^{-1}$ *(Figure 9)*. Having determined these quantities, they can now be used in the acoustic model.

The inversion

The required inversion here entails estimating the bubble size distribution from the acoustic emissions **(10)**. Since in nature the result is normally not amenable to independent verification **(11)**, the efficacy of the technique will first be illustrated using simulated acoustic data. The model (see previous section) for the sound field that a single bubble generates on entrainment is programmed into a PC, and the PC then chooses the statistics of the bubble size distribution from which it wishes to predict the acoustic emission. Appropriate randomisation is given to the positioning of the bubble with respect to the hydrophone, the depth of entrainment etc. The PC then generates an artificial acoustic pressure time history. This is then inverted by a program which is ignorant of any information regarding the bubble population used to generate that time series, other than the nature of the gas, the nature of the liquid, the depth of the hydrophone, and the physical model which was used to predict the acoustic emission.

This programme then estimates the original bubble size distribution using the inversion. This is of course a trivial process, since the same physical model is used both for generating the time series (the 'forward problem') and for inverting it to estimate the bubble size distribution, although the addition of noise makes it less so. However this exercise is only to illustrate the potential of the technique before it is applied to real acoustic time series, where the true 'answer' (the bubble size distribution) will not be known. *Figures 12 to 14* show three two-second predictions of the acoustic emission for the same bubble size distribution, but with increasing levels of complexity in the sound field as noise is added and the entrainment rate increased. *Figure 15* shows that the bubble size distribution estimated by the inversion of the data of *Figure 14* resembles the actual bubble size distribution used to predict the acoustic time series.

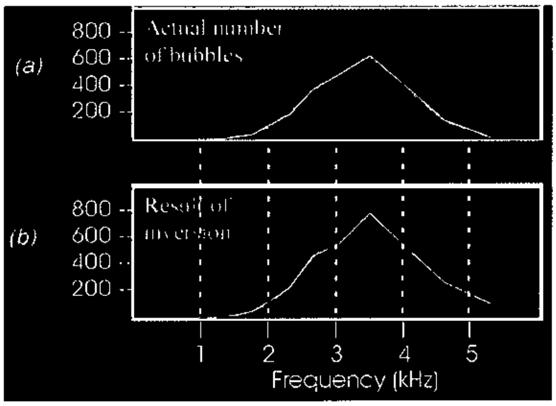


Figure 15: inversion of the data of *Figure 14* produces the bubble population given in *(b)*, the lower plot (the red curve corresponding to the bubbles which are generated in the first second of the hydrophone trace, and the yellow curve to those generated between 1 and 2 seconds). The number of bubbles counted is plotted as a function of their natural frequencies, which in turn can be readily related to bubble size through *Figure 9*. Having in the lower plot estimated the bubble population the computer used to generate the time series, this can be compared with the upper plot *(a)* to see the actual bubble population that was used by the PC in generating the acoustic time history of *Figure 14*. The degree of agreement illustrates the degree to which the inversion has been successful. The centre frequencies (in Hz) for the bins above 1000 Hz are: 1000, 1149, 1320, 1516, 1741, 2000, 2297, 2639, 3031, 3482, 4000, 4595, 5278

Having illustrated the efficacy of the inversion in this

continued on page 22

The sound of Titan

a role for acoustics in space exploration

continued from page 21

relatively trivial example, *Figure 16* shows the bubble size distribution inferred by inverting the acoustic emission generated in a waterfall to provide an estimate of the population of 'ringing' bubbles (as distinct from the full bubble population which optical techniques or active sonar might measure **(11)**). The data were recorded by TGL around three metres from the base of the small waterfall at Sadler's Mill, Romsey, Hampshire *(Figure 17)*. "This beauty spot is known as 'salmon leap', recollecting the dull Autumn days when the fish leapt out of the water as they struggled to return upstream to their breeding grounds" **(12)**. From the statistics of this bubble size distribution it is possible to reconstruct a time series, as described above, randomly selecting bubbles for placement in that time series based upon the statistics of *Figure 16*: whilst the exact form of the reconstructed time series or time-frequency representation will not of course be identical to the original, the two spectra should be very similar. This procedure will now be conducted.

Predicting the sound of falls on Earth and Titan

Given the similarity in fluid properties between water on Earth and ethane on Titan *(Table 1)*, it is not unreasonable as a first approximation to assume that the statistics of the populations generated by falls in the audio frequency regime on Titan are similar to terrestrial ones. Assuming a receiver depth of 10 cm, and exploiting the relationships determined for Titan between the bubble radius and the polytropic index *(Figure 8, blue curve)* and natural frequency *(Figure 9, blue curve)*, it is possible to construct hydrophone time series based on the statistics of *Figure 16*, obtained from the Salmon Leap at Sadler's Mill *(Figure 17)*. *Figure 18* shows three spectrograms, taken from time series of 10 s duration. The upper plot is from the signal recorded at the site of *Figure 17*. In this, that component of the signal with a frequency higher than 1 kHz was designated as being due to bubbles (in addition a low-pass filter set to 17.5 kHz was applied, since the Salmon Leap data was recorded with a sampling frequency of 44.1 kHz). It was this component which was then used to infer the population of *Figure 16*.

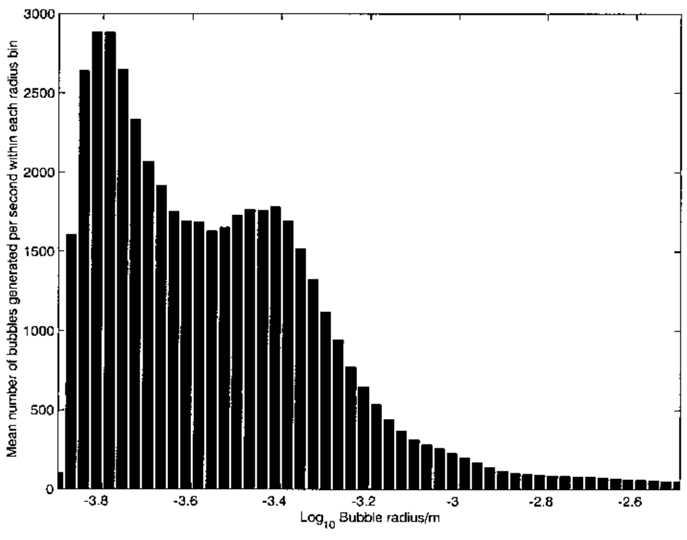


Figure 16: bubble size distribution as inferred from hydrophone data at Sadler's Mill, Romsey, showing number of bubbles entrained per second (averaged from a ten-second record). The bin sizes are shown explicitly

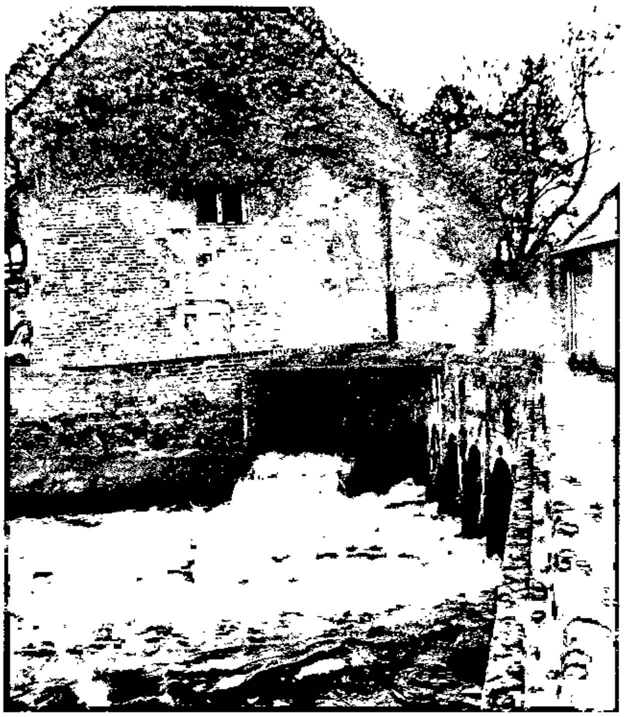


Figure 17: the Salmon Leap, Sadler's Mill, Romsey (Longitude 1°30' W; Latitude 50° 59'N). Side view, looking to the west-south-west. The hydrophone was placed at a depth of 10cm in clear water, about 3m from the turbulent bubble cloud

The middle plot of *Figure 18* shows a spectrogram constructed using the statistics of the population of *Figure 16*, for Earth. It is not of course intended to mimic the upper plot, for two reasons. First, it is constructed using only that portion of the data in the Salmon Leap recording which was identified as being generated by bubbles (and hence low frequency noise, hydrodynamic fluctuations etc. which are present in the upper plot are not included in the middle plot). Second, the exact time and natural frequency of the entrainment of a given bubble is determined at random, constrained to the statistics of the population of *Figure 16*. The same process is repeated in the lower plot for the conditions on Titan. There is clearly more energy at the higher frequencies, a fact confirmed by examination of the power spectra (taken over 10 s of data) in *Figure 19*. Whilst the reconstructed Earth waterfall (green line) closely resembles the original Salmon Leap spectrum (blue line), the slope of the Titan spectrum (red line) is more shallow, and the overall level increased by up to ~10 dB in the audio range. A quick check in the tendency to generate higher frequencies is found through inputting the data of *Table 1* into Minnaert's theory **(4, 10)** to reduce Earth's $\nu_0 R_0 \approx 3.26$ Hz.m relationship for audio-frequency air bubbles in water under surface atmospheric pressure, to $\nu_0 R_0 \approx 5.05$ Hz.m for Titan. Hence the change in spectral slope seems reasonable. The ~10 dB increase in levels for the population of *Figure 16* is less certain at this stage, the extrapolation from excitation *(Figure 6)* on Earth to that on Titan involving significant speculation **(10)**.

Discussion

The same procedure has been applied to estimate the underwater sound of breaking waves, and solid body impacts (splash downs) on Titan. Sound files are available via http://www.isvr.soton.ac.uk/fdag/uaua.htm

Acoustic techniques, particularly passive ones, might be applied cheaply to investigate a range of effects on planets and moons, including wind, storms and lightning, turbulence and hydrodynamic effects, volcanic activity, seismology and geophysics, gravitational forces (indirectly), boiling and precipitation, rockfalls etc. Passive sonar can indeed use the reverberation from natural sources, (particularly meteorite impacts, volcanic events, or ice cracking which can give rise to transient signals) to provide a low-cost quasi-active bistatic sonar.

Europa **(13)** may support a water ocean beneath a covering of ice. Estimates of the ocean depth and ice thickness give values far greater than those found on Earth, respectively ranging up to 100 km and 2-20 km. While this environment presents considerable challenges for placing a vehicle in these ocean depths, sound from those depths will propagate up to the surface. The ambient noise in that ocean may contain contributions from such environmentally significant features as ice cracking, hydrothermal vents, meteorite strikes, seismic activity etc. Off-world environments (real or laboratory) would also give the opportunity to test exotic acoustic effects. For example, it has been proposed **(14)** that peaks in ocean ambient noise arise through a resonance-like interaction between zero- and high-order modes of oscillation of the bubble wall, and the bubble radii (and hence frequencies) at which these occur depend on environmental parameters such as atmospheric pressure [3§3.6, 14].

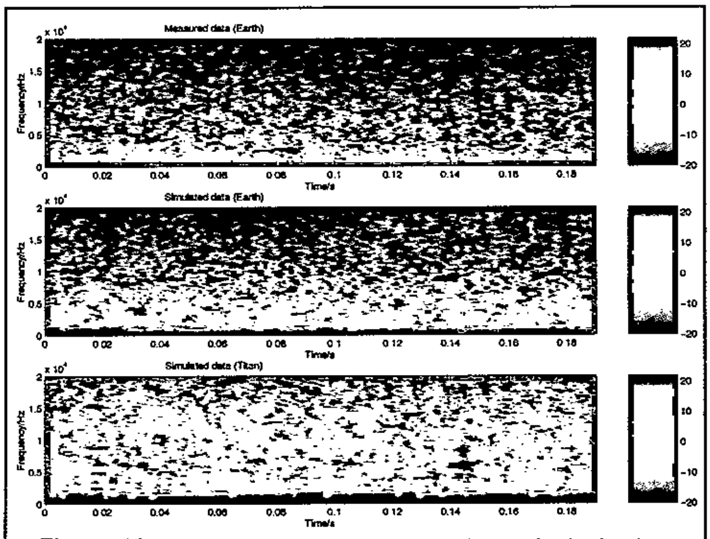


Figure 18: spectrogram of a sample of the time series hydrophone signals. Upper plot: measured signal on Earth at site of *Figure 17*. Middle plot: spectrogram reconstructed for Earth using the population statistics of *Figure 16*. Lower plot: spectrogram reconstructed for Titan using the population statistics of *Figure 16*. These recordings can be heard via http://www.isvr.soton.ac.uk/fdag/uaua.htm

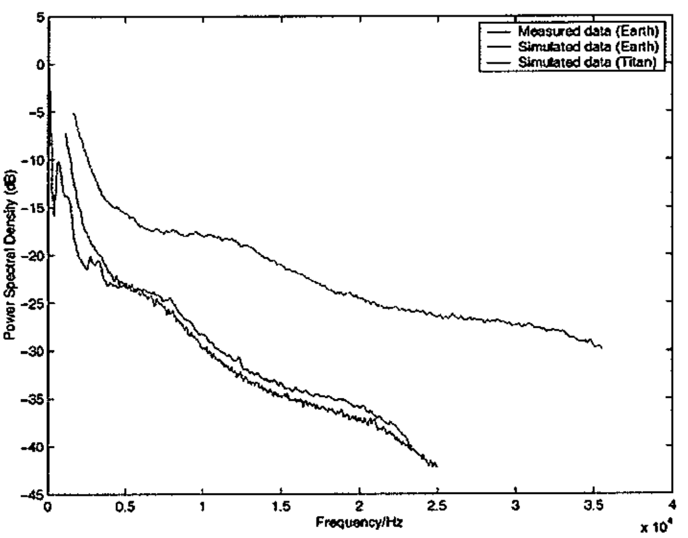


Figure 19: power spectral densities of 10s signals for: the signal recorded at site of *Figure 17*, from which those components due to bubbles were identified and used to infer the population of *Figure 16* (blue line); the signal containing only bubble-generated components, for Earth, predicted by applying the model of **(10)** to the population of *Figure 16* (green line); the signal containing only bubble-generated components, for Titan, predicted by applying the model of **(10)** to the population of *Figure 16* (red line)

Is there any purpose to such extraterrestrial speculation? The passive acoustic techniques described above exploit a small amount of processing, power requirements and rugged hardware, in comparison with most sensors on space probes. The signal bandwidth is very much less than that required for images, facilitating rapid transmission to an orbiter and thence to Earth. These features make acoustic sensors particularly suitable for deployment from a space probe, where of course energy, weight and communication restrictions are critical. Given that passive acoustic emissions have been used to provide such a range of environmental information on Earth **(15)**, it is worth considering how far acoustic information may be inverted to reveal the environmental information about the craft, space, and particularly the bodies on which they land.

References

1 T G Leighton, The Tyndall Medal paper: From sea to surgeries, from babbling brooks to baby scans: bubble acoustics at ISVR *Proceedings of the Institute of Acoustics*, **26**, Part 1, 357-381 (2004)

2 R Lorenz and J Mitton, Lifting Titan's veil (Cambridge U Press, 2002)

3 T G Leighton, The Acoustic Bubble (Academic Press, 1994)

4 M Minnaert, On musical air-bubbles and sounds of running water, *Phil Mag* **16**: 235-248 (1933)

5 T G Leighton and A J Walton, An experimental study of the sound emitted from gas bubbles in a liquid *Eur J Phys* **8**: 98-104 (1987)

6 M R Loewen and W K Melville, A model for the sound generated by breaking waves *J Acoust Soc Am* **90**: 2075-2080 (1991)

7 H Pfriem, *Zur thermischen dämpfung in kugelsymmetrisch schwingenden gasblasen* Akust Zh **5**: 202-207 (1940)

8 Z Saneyoshi, *Electro-technical Journal* (Japan) **5**: 49 (1941)

9 C Jr Devin, Survey of thermal, radiation, and viscous damping of pulsating air bubbles in water *J Acoust Soc Am* **31**: 1654-1667 (1959)

10 T G Leighton, From babbling brooks to baby scans, from seas to surgeries: The pressure fields produced by non-interacting spherical bubbles at low and medium amplitudes of pulsation, *International Journal of Modern Physics B* (in preparation), (2004)

11 T G Leighton, S D Meers and P R White, A nonlinear time-dependent inversion to obtain bubble populations from acoustic propagation characteristics, *Proceedings of the Royal Society* (in press; published on Royal Society FirstCite Website May 2004)

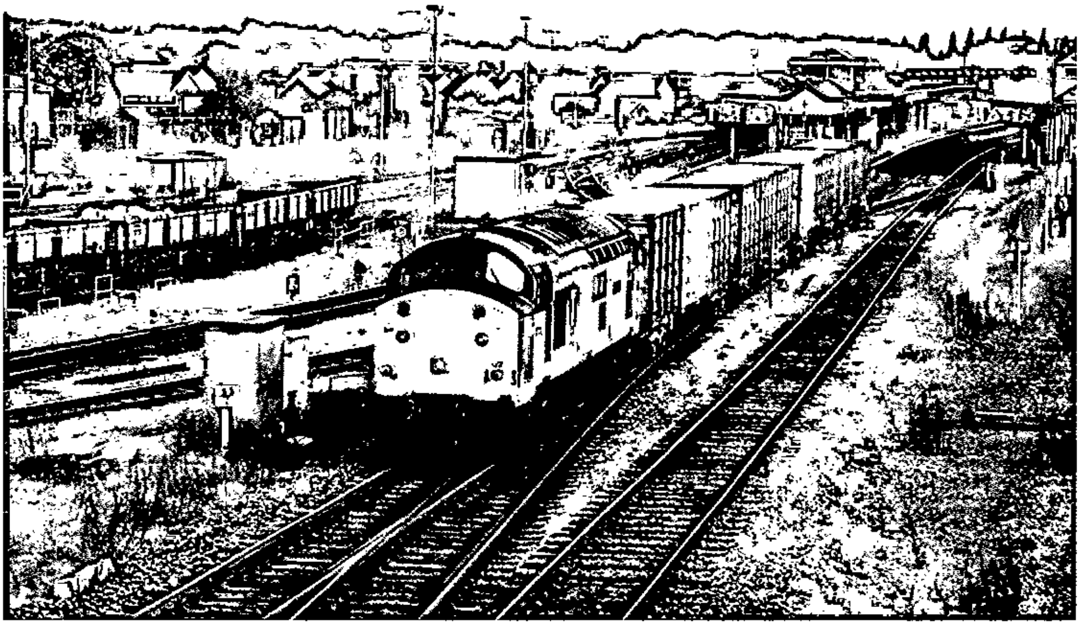
12 http://www.localauthoritypublishing.co.uk/councils/romsey/trail html

13 M G Kivelson, K K Khurana, C T Russell, M Volwerk, R J Walker and C Zimmer, Galileo magnetometer measurements: A stronger case for a subsurface ocean at Europa *Science* **289** (5483): 1340-1343 (2000)

14 M S Longuet-Higgins, Bubble noise spectra *J Acoust Soc Am* **87**(2): 652-661 (1990)

15 T G Leighton, (editor), Natural physical processes associated with sea surface sound. University of Southampton (1997)

T G Leighton FIOA *is Professor of Ultrasonics and Underwater Acoustics at the University of Southampton (ISVR).* **P R White** *is Senior Lecturer in Underwater Signal Processing at the University of Southampton (ISVR)*



Assessing transport noise

A comparison of A-frequency weighting and loudness-level weighting methods

Pal Bite and Ian H Flindell

Most countries in Europe are increasingly using some form of A-weighted equivalent level to assess environmental and community noise. However, because the overall relationship between L_{Aeq} and overall disturbance and annoyance is relatively weak, this has stimulated continuing debate about alternative indicators. For example Schomer **(1)** - among others - has suggested the use of dynamic frequency weighting based on equal-loudness-level contours as a potentially superior alternative to the standard A-weighting.

This article reports a number of analyses of large third-octave band noise monitoring databases, including both general airport noise and single vehicle pass-by events, which were carried out to investigate similarities and differences between the standard A-frequency weighting, equal-loudness level weighting (ISO 226), and the ISO 532b version of Zwicker's loudness calculation method.

The results of the analyses suggest that for many environmental noise assessment purposes, the small differences which exist between measurements using the standard A-frequency weighting, and measurements using the various alternative loudness level weighting schemes, might not in practice be sufficiently interesting to justify the adoption of any of these alternative schemes. There were, however, some indications that for aircraft noise events the use of loudness level measurements based on ISO 532b could be sufficiently different from the standard A-weighting to justify further subjective investigations.

With growing industrialisation and population density, there is an increasing risk that environmental noise will increasingly degrade quality of life. Typical examples of noise offenders include: aircraft; refineries; construction activity; and road traffic. Accurate noise measurement is an essential first step in dealing with these problems. In the case of environmental noise, proper quantitative assessment requires an accurate portrait of existing noise characteristics, together with an indication of the likely effect of noise reduction efforts. Because of the large number of different ways in which the frequency content of environmental noise can vary - depending on the number of noise sources present, on the time of day, and on the special characteristics of the receiver location - it would generally be preferable to measure noise in separate third-octave bands.

However, except for specialist applications, this would result in a considerable amount of data much of which would not be understood by the general public. For most applications, it has been found acceptable to adopt some form of simplified overall frequency weighted index so that the relative severity of the noise can be described by a single numeric indicator. The long time averaged A-frequency weighted sound level (L_{Aeq}) has become the *de facto* standard for this purpose, as based on original work carried out by Schulz **(2)** and various contemporaries. This work led to the general adoption of the A-frequency weighted day-night sound level L_{dn} which has been widely adopted in the USA and the broadly similar day-evening-night sound level L_{den} adopted in the recent European Environmental Noise Directive.

On the other hand, there has been a steady stream of papers questioning the standardised use of the A-frequency weighting for all environmental noise measurement purposes. In theory, the A-frequency weighting might not properly reflect the true impact of certain types of low frequency noise and cannot reflect the changing shape of standard equal loudness contours across different overall sound levels. For example, Schomer **(1)** has recently suggested the use of equal loudness level contours as a dynamic filter in place of the A-frequency weighting filter. In theory, an even better way to assess the impact of environmental noise would be the use of Zwicker's loudness level weighting.

This article compares measurements using the standard A-frequency weighting and the two main alternatives based on different interpretations of the equal loudness level contour concept. The purpose is to investigate empirical data obtained from real outdoor environmental noise measurements to determine whether or not these theoretically superior loudness level based indicators might be able to offer any potential advantages over much simpler A-frequency weighted indicators in practical situations.

Theoretical background

Limitations of the A- frequency weighting methodology

The A-weighting method uses a frequency dependent filter curve that does not change with sound level. The overall level in dB(A) can be determined by applying the standardised A-weighting filter curve or by summing appropriately adjusted third-octave band levels conforming to the same overall filter characteristic. The standard A-frequency weighting curve has become the most widely used method for measuring and assessing environmental noise in standards and regulations across Europe, but this may have happened more from convenience than from any convincing technical proof.

In the past, both laboratory and field data have accumulated which show that the standard A-weighting is not the best predictor of loudness and annoyance of community noise with significant low frequency content **(3)**. For sounds that exceed 60dB L_p, the standard A-weighting curve becomes increasingly less well matched to the equivalent equal loudness contours. In addition the standard A-weighting curve takes no account of the effects of mutual masking among the components in a complex sound, or the asymmetry of masking patterns produced in the auditory system **(4)**. By manipulating the balance between random noise and tonal components in complex sounds it is even possible to reduce the A-weighted sound level at the same time as increasing the subjective loudness **(5)**.

For these reasons and others there is increasing interest in testing the real-life advantages of the various and theoretically superior frequency weighting schemes based on so-called equal loudness contours which vary the relative emphasis placed on high and low frequencies present depending on the overall sound level.

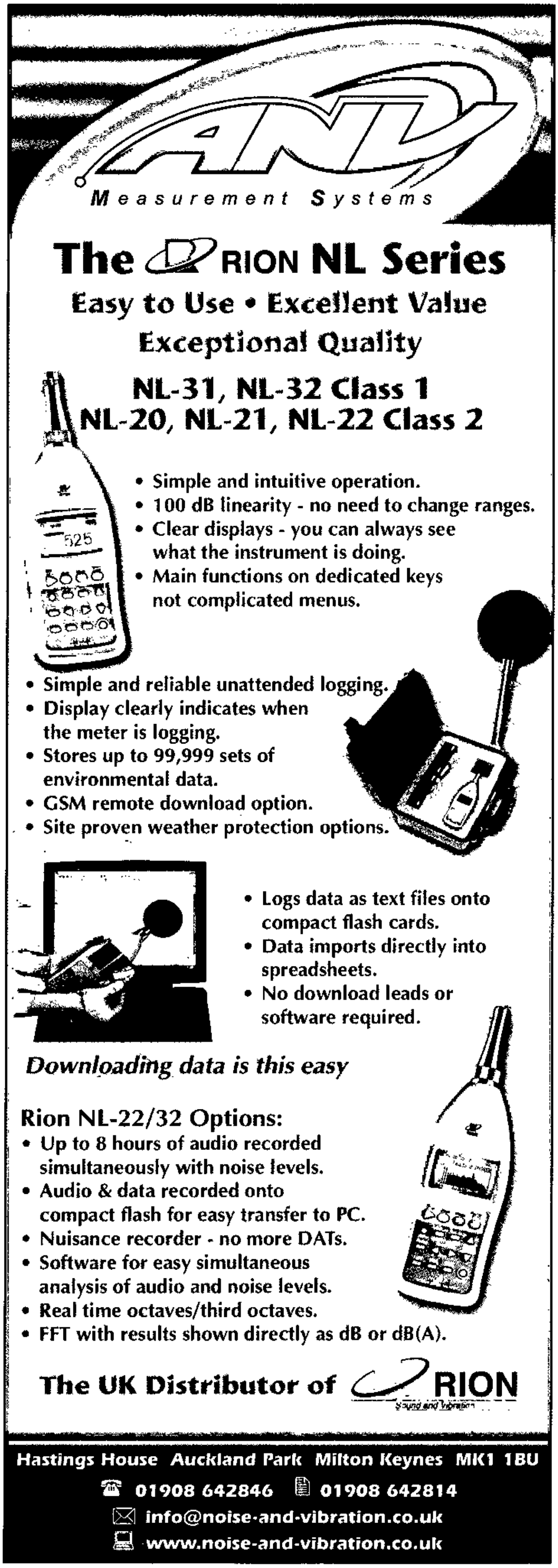
Review of the loudness level weighting methodology

The loudness level method **(6)** uses a level dependent filter curve that changes in accordance with empirically determined equal loudness contours, which are given in functional form in ISO 226. Each curve is defined at corresponding third-octave band centre frequencies from 20 to 12500 Hz. For analysis each third-octave band sound pressure level is assigned the phon level that corresponds to that frequency and that level. ISO 226 gives coefficients for equations that correspond to each third-octave band in the range from 25 to 12500 Hz. These equations are used to calculate the corresponding phon level for any given third-octave band level, then the overall phon level is calculated by energy summation of each frequency band phon level. Based on an empirical comparison of in-situ field measurements, Schomer concluded that compared with A-weighting, loudness level weighting better orders and assesses transportation noise sources.

Review of Zwicker's loudness model

Zwicker's loudness model **(7)** can (in theory) account for a wide variety of data on loudness perception and has been used in many practical applications. Zwicker's loudness

continued on page 26



Assessing transport noise

A comparison of A-frequency weighting and loudness-level weighting methods

continued from page 25

level calculation has the following steps **(8)**. First a fixed filter is applied representing an empirically determined transfer function through the outer and middle ear. In this step Zwicker assumed that, above 2000Hz, this transmission function was similar in form to the absolute threshold curve but inverted in shape. This is based on the assumption that the inner ear is equally sensitive to all frequencies. Below 2000Hz, Zwicker assumed that transmission through the outer and the middle ear was uniform.

The next step is the calculation of an excitation pattern from the physical spectrum. The model uses as a starting point empirically-determined masking patterns for narrowband noises. Zwicker assumed that the excitation patterns evoked by such noises were similar in shape to the masking patterns, but shifted by a few dB, the exact amount of shift varying dependant on frequency. This shift occurs because the signal can be detected when its peak excitation level is different from the excitation level evoked by the masker at the signal frequency.

The next stage is the transformation of the excitation pattern to a specific loudness pattern, by which is meant the transformation of the frequency scale of the excitation pattern to a scale more closely related to how any sound is assumed to be represented in the auditory system. The final stage is the transformation from excitation level to specific loudness. The area under the specific loudness pattern is assumed to determine the loudness.

This calculation method is fully described in ISO 532b **(9)**, and can be applied to environmental and transportation noise assessment. However, possibly owing to the relative complexity of the Zwicker loudness method compared with the standard A-frequency weighting method, it is hardly ever used for practical purposes.

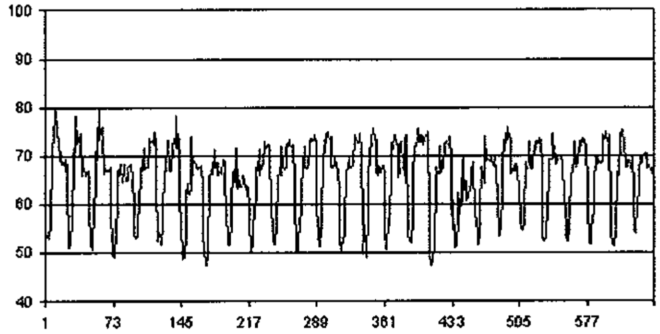


Figure 1a

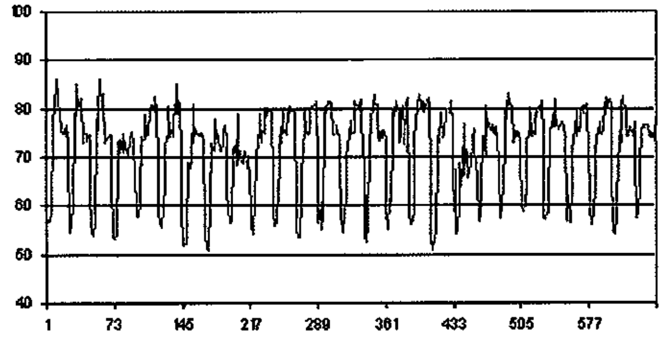


Figure 1b

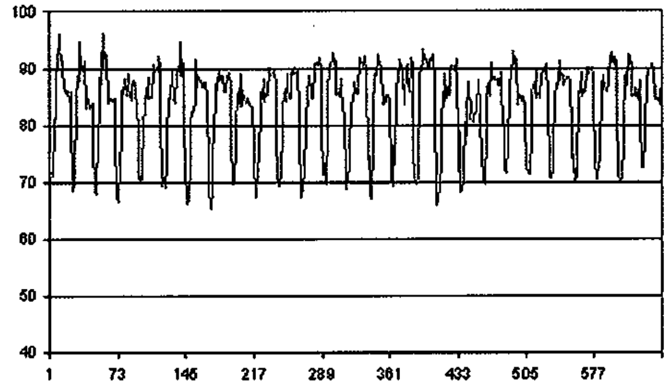


Figure 1c

Figure 1a: A-Leq; Figure 1b, L-Leq; Figure 1c, Zw-Leq, calculated from the third-octave band data

Environmental noise monitoring analysis

The standard A-frequency weighting (A-Leq), the equal-loudness level weighting according to ISO 226 (L-Leq), and the ISO 532b version of Zwicker's loudness calculation method (Zw-Leq) were compared using a large database of hourly averaged third-octave band noise levels. The data were collected by a Larson Davis model LD824 data logging sound level meter installed near a major international airport over two years ago and operating continuously ever since. The noise monitoring location is exposed to aircraft and road traffic noise sources in varying proportions depending mainly on the runways in use at the time and on the direction of the wind. The LD824 was set up for continuous measurement (with no event triggering) and stored a wide range of statistical parameters including average third-octave band levels at hourly intervals. An automatic calibration check is performed every 24 hours using an electrostatic actuator.

From these data, and as described in section 2, the corresponding hourly A-Leq, L-Leq and Zw-Leq values were calculated from the hourly third-octave band level data using the standard A-frequency weightings, the loudness level weightings defined in ISO 226, and the complete Zwicker loudness calculation procedure defined in ISO 532b. The measurement database used here covered 623 consecutive 24-hour days. For illustrative purposes only, *Figures 1a to 1c* show the results for a 27 randomly selected days out of the 623. The x-axis shows time in hours, and the y-axis shows the corresponding hourly dB(A) and phon levels varying through each 24 hour period.

Apart from the clear differences in long term average levels, the patterns of hourly variation shown in *Figures 1a to 1c* show an obvious degree of similarity. Differences in the long term average levels using the three methods are of limited practical significance as they are simply scaling factors of no value in distinguishing between different patterns on different days. To investigate this further a simple MS-DOS based program was used to calculate the correlation coefficients and the regression equations.

The high correlations observed between simultaneous measurements using the standard A-frequency weighting (A-Leq), equal-loudness level weighting according to ISO 226 (L-Leq), and the ISO 532b version of Zwicker's loudness calculation method (Zw-Leq) suggest that all of the indicators are measuring much the same properties of the noise climate in similar ways at this particular measurement location. In other words, it would not in practice make any difference if either of the more complicated equal loudness contour based indicators were to be adopted instead of the standard A-frequency weighting for environmental noise measurements at this location.

Single noise source analysis

Passenger cars, HGVs and passenger coaches were recorded in various locations. These were in single-lane town traffic, rural highways (speed limit 80km/h), and motorways (speed limit 130 or 80 km/h). In addition various engine conditions were investigated, such as hill climbs, hill descents, acceleration and braking. Near railways, several different types of passenger, goods trains and single locomotives were recorded at speeds varying from 50 to 130 km/h. Aircraft recordings were made close to the take-off and landing routes of a major continental European airport. The types of aircraft ranged from the large Boeing 767 to the smaller Fokker 70, as well as ATR 42 turboprop aircraft.

The recordings were evaluated using a Larson Davis 2900B analyser. The A-Leq values are the A-weighted equivalent levels of the single event from the output of the instrument. The L-Leq and Zw-Leq values were calculated from the corresponding third-octave band spectra according to the ISO standards.

Table 1 summarises the results. It contains the correlations observed in single pass-by measurements to standard A-frequency weighting, equal-loudness level weighting, and the ISO 532b loudness calculation method (*figure 2a and 2b*, A-Leq v L-Leq and A-Leq v Zw-Leq). The results suggest that for the road and railway noise sources investigated all these indicators are measuring much the same thing. However, there is a relatively low correlation between A-Leq and Zw-Leq, suggesting that there could be a possibility of differentiation between these two indicators for measurements of aircraft noise events. If it is assumed that loudness calculation according to ISO532b better reflects the effect of noises with a specific dominant frequency components **(10)** and that annoyance and loudness are closely related **(11-14)** then this low correlation suggests that Zw-Leq could be a better method to assess the community response to aircraft noise. In order to test this hypothesis the next step would be to compare

Correlation coefficients		
	A-Leq v L-Leq	**A-Leq v Zw-Leq**
passenger car	0.9642	0.9422
HGV / coach	0.9869	0.9749
Train	0.9725	0.9757
aircraft	**0.8485**	**0.5916**
(noise monitoring	0.9987	0.9893)

Table 1: summary of results

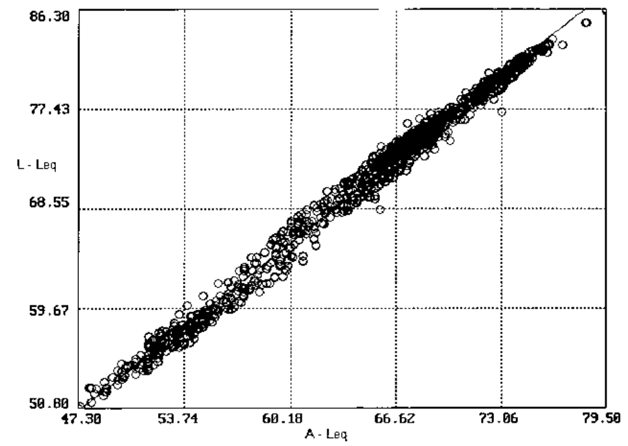


Figure 2a

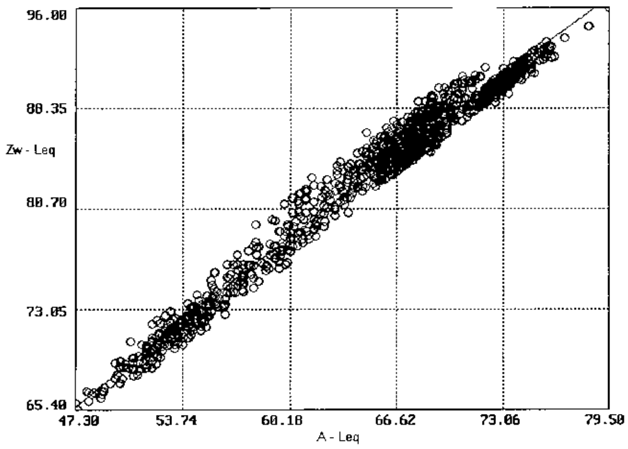


Figure 2b

figure 2 correlations:
regression equation (a) L-Leq = - 4.1856 + 1.157742 * A-Leq
correlation coefficient 0.99847
regression equation (b) Zw-Leq = 3.648 * A-Leq ^ 0.749
correlation coefficient: 0.98931

subjective responses against the alternative sound level measurement indicators.

Conclusion

Theoretical analysis suggests that the standard A-frequency weighting might have a number of deficiencies when applied to certain kinds of environmental noises, such as sounds with high levels of low frequency content and sounds at both higher and lower sound levels than the average. Sound level indicators which *(a)* adopt different frequency weighting curves at different sound levels in accordance with standardised equal loudness contours (L-Leq according to ISO 226), and *(b)* additionally take the differential spread of masking effects into account (Zwicker loudness level according to ISO 532b), could in theory offer closer correspondence to subjective loudness.

However, the analysis here shows that for at least one representative noise monitoring location measuring overall environmental noise, and for single vehicle and

continued on page 28

notified body : laboratory : site : building acoustics : dedicated pre-completion testing team
BPB The Building Test Centre
Fire Acoustics Structures
0115 945 1564
www.btconline.co.uk
btc.testing@bpb.com
UKAS TESTING 0296

Assessing transport noise

A comparison of A-frequency weighting and loudness-level weighting methods

continued from page 27

train pass-by events, high correlations can be obtained between all three indicators. This suggests that for these noise sources, there would not be any practical advantage in adopting either of the more complicated equal loudness level based indicators, over and above the standard A-frequency weighting for environmental noise measurements. For the assessment of individual aircraft noise events, the findings suggest that loudness level based on ISO 532b can differentiate between events in a different way from the standard A-weighting curve and might therefore be worthy of further investigation. It is recognised that loudness level calculated according to ISO 532b requires more calculation than the standard A-weighting curve, but this should not present a serious difficulty for modern computer-based instruments.

References

1 Schomer P D, Loudness level weighting for environmental noise assessment, *Acta Acoustica*, **Vol. 86**(1), pp. 49-61, 2000

2 Schultz T J, Synthesis of social surveys on noise annoyance *JASA*, **64**, pp. 377-405, 1978

3 Goldstein M, Low-frequency components in complex noise and their perceived loudness and annoyance. Alberte & Hälsa 1994:2

4 Zwicker E, Fastl H, Psychoacoustics – Facts and models, Heidelberg, Germany: Springer Verlag 1990

5 Hellman R, Zwicker E, Why can a decrease in dB(A) produce an increase in loudness? *JASA*, **82**, 1700-1705, 1987

6 International Organisation for Standardisation, ISO 226, Acoustics - Normal equal loudness level contours, 1987

7 Zwicker E, Über psychologische und methodische Grundlagen der Lautheit, *Acustica* **8**, 237-258, 1958

8 Glasberg B R, A Revision of Zwicker's Loudnes Model, *Acta Acoustica*, **Vol. 82**, pp. 335-345, 1996

9 International Organisation for Standardisation, ISO 532b, Acoustics – Methods for calculation loudness, 1975

10 Kuwano S, Advantages and disadvantages of A-weighted sound pressure level in relation to subjective impression of environmental noises. *Noise Control Eng. J* **33**, 107-115,1989

11 Berglund B, Berglund U, Lindvall T, Scaling loudness, noisiness and annoyance of community noises. *JASA*, **60**, 1119-1125, 1976

12 Berglund B, Berglund U, Lindvall T, Goldstein M, Loudness (or annoyance) summation of combined community noises. *JASA*, **70**, 1628-1634, 1981

13 Fastl H, Loudness and annoyance of sounds: Subjective evaluation and data from ISO 532b, *Proceedings InterNoise 85*, 1403-1406, 1985

14 Hellman R, Growth rate of Loudness, Annoyance and noisiness as a function of tone location within the noise spectrum, *JASA*, **75**, 209-218, 1984

Acknowledgements

The work carried out for this paper at the Institute of Sound and Vibration Research was financially supported by the European Commission's Engineering Doctorate in Sound and Vibration Studies whose assistance is gratefully acknowledged.

Pal Bite *is from ISVR, University of Southampton, University Road, Highfield Southampton, S017 1BJ and Budapest University of Technology and Economics, H-1117, Budapest, Magyar Tudósok Körútja 2.* **Ian H Flindell** *is also from ISVR, University of Southampton*

NoiseMap 2000 – WS Atkins

Get the top-of-the-range version

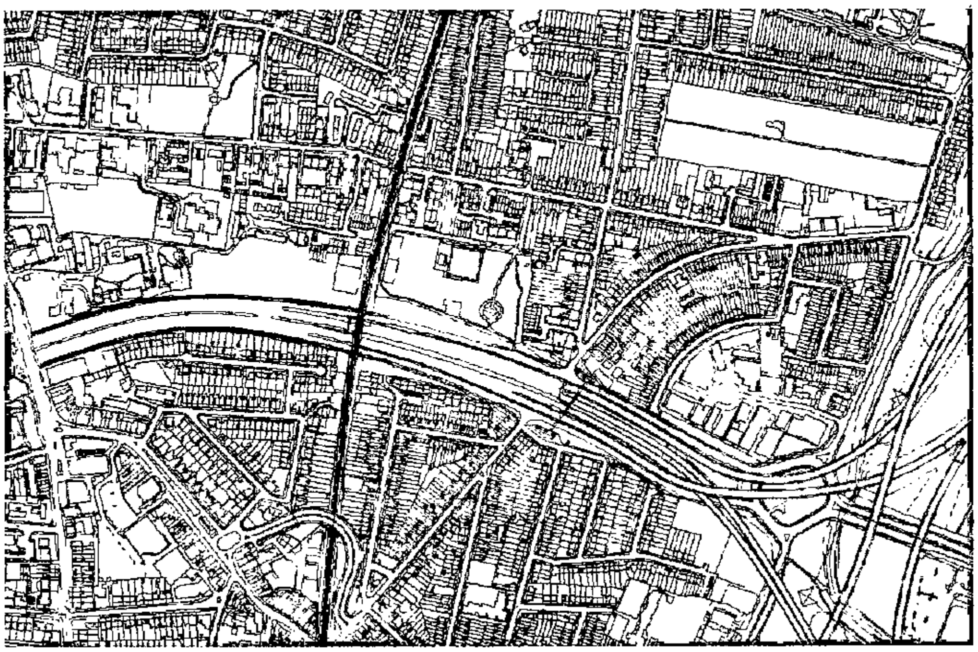
Pay only for the time you use

The more you use the cheaper it gets

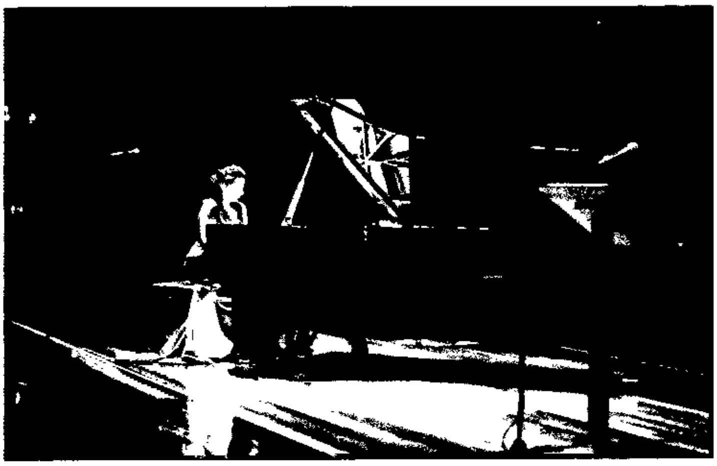
pay-as-you-go

Britain's most popular noise mapping software

For more information visit www.noisemap2000.com or write for a free demonstration CD to WS Atkins Noise and Vibration, Woodcote Grove, Ashley Road, Epsom, Surrey KT18 5BW, UK.



Analysing expression in musical performance



Andrew Earis and Barry M G Cheetham

Musical expression concerns the influence of the performer on the interpretation and performance of a musical work. The written musical score illustrates the notes that must be played and their durations, along with basic tempo, dynamics markings and other performance directions. The performer uses fine and subtle deviations from the musical score to convey expression to the listener. In this article, the computerised extraction of expressive timing and dynamics information from acoustic recordings of piano music is described. The expressive timing information is illustrated in terms of an *instantaneous tempo* and the expressive variability of a particular performance can then be described in terms of a *rubato number*. Similar measurements can be made for expressive dynamics.

Expressive musical performance

There are two elements to a skilled musical performance: a technical element and an expressive element. The technical element is the playing of a musical instrument and the accurate reading of the score and, theoretically at least, it is possible to perform a piece in a 'mechanical' way with no expression whatsoever. The expressive element is intentional variation in the way the notes are played, used by the performer to influence the outcome for the listener **(1)**. The art of great interpretation lies in using such deviations with skill and taste, since traditional notation is not sufficiently precise to represent fully the intentions of the composer **(2)**.

Musical expression is related to knowledge of the musical genre and the underlying structural and stylistic constraints of the piece in question. No two performances are exactly the same. However, there are constraints on what is perceived to be a 'sensible performance', and the expressive variability in any performance should lie within these boundaries. The aim of expressive performance analysis is to determine the extent to which performances are actually similar or different **(3)**.

Measurable features of expressive musical performance include: timing (note onset and offset times); dynamics (variations in the intensity of notes and chords); tone quality (timbre); articulation (the degree to which a performer detaches individual notes from one another); vibrato; pitch; and, for a piano, pedalling. Other features that can influence a performance include: instrument acoustics; room acoustics; and sound engineering in recordings **(4)**.

The nature and number of these features depends on the instruments being played and their characteristics. For a piano, the main parameters that can be controlled by the performer are timing and dynamics. Articulation and pedalling could be considered to be 'secondary' parameters, since they are related to timing and determine the degree of detachment or overlap of successive tones. Performers on other instruments can influence other parameters. For example, a violinist can vary pitch and a flautist can vary the tone quality (timbre) of the note being played. These expressive performance parameters are not constant - they evolve as the performance progresses, and can be measured on different scales - from the individual note level to whole bars, phrases, sections and movements.

Expressive performance parameters can be extracted from acoustic (audio) recordings of musical works for which the musical score is known. Whilst this analysis could more simply be performed on MIDI (Musical Instrument Digital Interface) recordings made on electronic pianos, there are a number of advantages in working with acoustic recordings. These contain a much more complete range of expressive performance features than MIDI and are universally available providing a vast supply of invaluable musical information. It is possible to access recordings spanning over a century, thus enabling the analysis of a wide range of performance periods and styles.

Investigations in music performance date back as far as 1895 **(5)**, with much musicological research taking place in the USA in the 1930s **(4)**. Currently, the main method of performing analysis of musical expression on audio recordings is by manual means - timing is extracted by studying the waveform of the musical signal and using visual and auditory clues to estimate the onset time of each 'event' **(4)**.

Event dynamics are estimated from the amplitude of the signal at different points. The earliest algorithm which attempted to extract expressive timings (both note onset and offset) and dynamics was developed by Scheirer **(6)**, using a combination of measurement of high frequency energy and comb filtering. More recently Dixon **(7)** has attempted to extract expressive timing by using a bank of filters centred on the frequencies of the fundamental and harmonics.

In order to locate in time individual notes and chords within a recording, a digitised version of the notated score must be synchronised with the acoustical signal. This can be achieved using digital signal processing (DSP) techniques, including spectral analysis and wavelet analysis. Such techniques can be used to analyse the time-varying frequency content of the acoustical signal and this

continued on page 30

Analysing expression in musical performance

continued from page 29

can be compared to the expected frequency content of the individual events (notes and chords) as estimated from the score.

As well as measuring the location in time (expressive timing) of individual events, such analysis techniques can also be used to measure the variation in dynamics, or the volume of individual notes and chords. Other parameters that could be measured include note offset times which could give information on articulation (the degree of separation of successive tones) and legato/pedalling (the degree of overlap or separation of successive tones).

Acoustic properties of piano tone

The main performance parameters that can be controlled by a pianist are timing (including articulation and pedalling) and dynamics. Modern pianos are almost universally tuned to equal temperament, the ratio of the fundamental frequencies of adjacent semitones being constant across the complete range of the piano keyboard. The percussive nature of piano notes is a key feature in the detection of precise note onset times. A real piano note, and its associated spectrograph, is illustrated in *Figure 1.*

There have been a number of studies in the acoustical properties of individual piano notes **(8, 9)**. When a piano key is depressed, the hammer hits the string, and this has the effect of exciting combinations of the modes of vibration of the string. In an ideal string, these modes would vibrate at frequencies that are integer multiples of the fundamental frequency of the string. However, in real strings, this relationship is not exactly harmonic, due to a number of factors including the stiffness of the string and imperfections in the string. For a piano, the higher modes become progressively sharper, and they are known as partials.

After the hammer and string contact has ended, the amplitudes of the excited modes, or partials, decay as time goes by. The tone quality, or timbre, of the note is determined by the relative frequencies and amplitudes of the partials, and their evolution in time **(10)**.

The piano note consists of three main parts:

❑ The onset transient. This includes the sound of the hammer hitting the string as well as other noise from the instrument keys and case. The hammer and string remain in contact for as much as 4ms;

❑ The waveform of the sound after the hammer is released displays a 'dual decay'. Initially, the sound decays quickly. This is known as the 'prompt sound'. This is followed by a slower decay known as the 'after sound'. Whilst both of these decays are exponential in nature, there is an identifiable change from the prompt decay to the after sound decay. There are two factors that are believed to contribute to this process **(11)**:

a) The polarisation of the vibrations of the strings. Initially, the dominant mode of vibration of the strings is vertical (in the direction of the hammer hit) although there is some initial horizontal motion, thought to be due to irregularities in the hammer and string. Energy can transfer between the two polarisations, and ultimately, the horizontal motion becomes dominant **(10)**; and

b) The multiple stringing of individual piano notes. When the strings are initially struck, the strings vibrate in phase, thus creating a strong driving force at the bridge which means that energy is lost more quickly. Soon afterwards, when the strings are not all exactly in phase, the corresponding bridge driving force is less, hence the rate of dissipation of energy is less and the sound decays more slowly **(12)**.

The time after onset at which the decay rate changes for a particular note is expected to be the same, irrespective of the initial amplitude i.e. it is believed that the duration of the prompt sound does not depend on the amount of initial displacement of the string **(12)**.

❑ When the key is released, the damper falls on the string and resonance ceases.

Time-frequency analysis of acoustic recordings of piano music

Time-frequency or spectrographic analysis can be performed on the acoustic waveform in order to determine the frequencies present and how these progress in time. The short time Fourier transform (STFT), using an FFT algorithm with fixed window size, is often used to perform the spectral analysis. Two FFT spectrographs of the opening few notes of a performance of a Chopin piano Etude are shown in *Figure 2.* Two different window sizes are used: narrow (20ms) and wide (200ms).

The graphs illustrate the individual notes, their harmonic structure, and how these change over time. With the narrow time window, good time resolution is achieved at the expense of less precise frequency resolution. With the wider time window, better frequency resolution is achieved at the expense of time resolution. When analysing a piece of piano music using an FFT spectrograph, choosing an appropriate window size, allowing the onsets and fundamental frequencies of notes and chords to be estimated with sufficient accuracy, is often a problem.

The compass of the piano and the speed of the

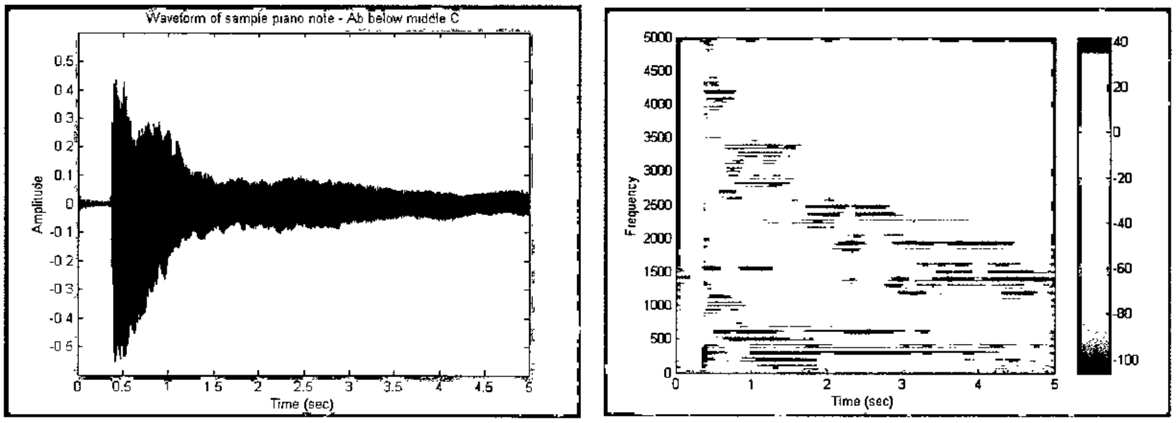


Figure 1 A piano note (A$^{b'}$) and its associated spectrograph

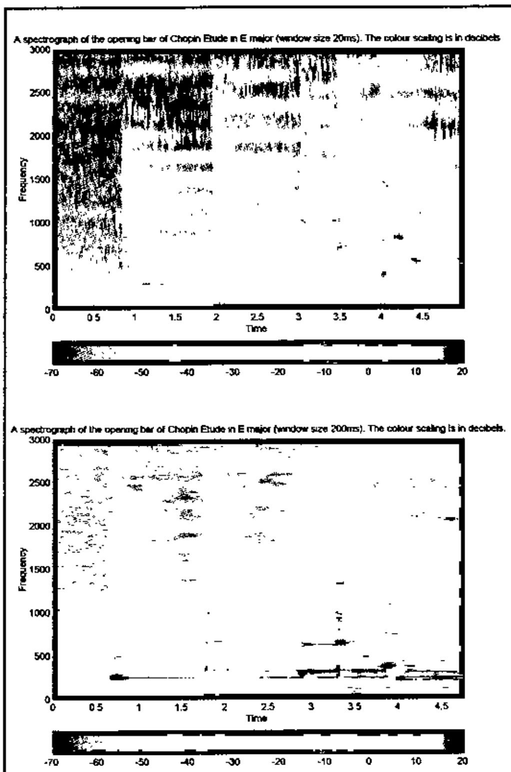


Figure 2 FFT spectrographs with 20ms (top) and 200ms (bottom) window sizes

performance determine the required time and frequency resolution in the following way:

❑ To resolve the fundamental frequency of a note, the resolution depends on the fundamental frequency of the note, in particular the frequency differences between the note and its adjacent semitones. This varies from about 1.6Hz at the bottom of the piano keyboard to over 120Hz at the top, with the corresponding fundamental frequencies ranging from 27.5Hz to just over 4kHz.

❑ The time resolution must be sufficient for rapid note passages where the shortest note duration could be around 50ms. Also, expressive timing variations can be very subtle, the human ear being capable of perceiving differences of as little as 10ms **(1)**, depending on the speed of the music, or frequency of note onset.

This suggests a form of analysis whereby the frequency resolution can be made proportional to the frequency being measured. This is the basis of the wavelet transform, in which a 'wavelet function' is compared with the acoustical signal at different points in time, and a measure of similarity (or correlation) is made between them. A typical wavelet function, used in the analysis of acoustical signals, is the Morlet wavelet shown in *Figure 3*.

The window size is the width of the Gaussian-shaped envelope in *Figure 3* and this is now made frequency-

continued on page 32

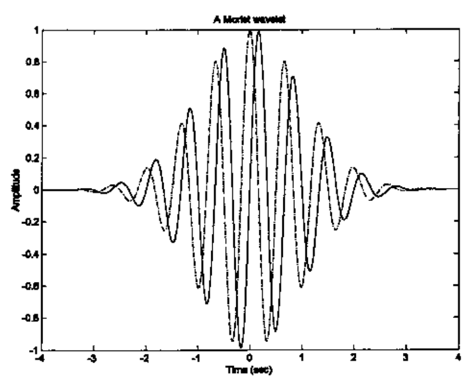


Figure 3 Morlet wavelet Real part (dotted line) and imaginary part (solid line)

ANC
THE ASSOCIATION OF NOISE CONSULTANTS

The ANC is the only recognised association for your profession

Benefits of ANC membership include:

- ANC members receive a weekly list of enquiries received by the ANC secretariat
- Your organisation will have a cross-referenced entry on the ANC web site
- Your organisation will be included in the ANC Directory of Members, which is widely used by local authorities
- The ANC guideline documents and Calibration Kit are available to Members at a discount
- Your views will be represented on BSI Committees – your voice will count
- Your organisation will have the opportunity to affect future ANC guideline documents
- ANC members are consulted on impending and draft legislation, standards, guidelines and Codes of Practice before they come into force
- The bi-monthly ANC meetings provide an opportunity to discuss areas of interest with like-minded colleagues or to just bounce ideas around
- Before each ANC meeting there are regular technical presentations on the hot subjects of the day

Membership of the Association is open to all consultancy practices able to demonstrate, to the satisfaction of the Association's Council, that the necessary professional and technical competence is available, that a satisfactory standard of continuity of service and staff is maintained and that there is no significant financial interest in acoustical products. Members are required to carry a minimum level of professional indemnity insurance, and to abide by the Association's Code of Ethics.

www.association-of-noise-consultants.co.uk

Analysing expression in musical performance

continued from page 31

dependent. It is stretched out for lower frequencies and compressed for higher frequencies so that the same number of cycles appears in the window. A narrow window is used in the analysis of high frequencies giving a high time resolution, and a wide window is used in the analysis of low frequencies giving a high frequency resolution. A Morlet wavelet spectrograph for the Chopin extract is shown in *Figure 4*. In this spectrograph, both low frequency note discrimination and high frequency time resolution can be observed.

It has been demonstrated recently by the authors **(13)** that even better time-frequency accuracy for piano music may be achieved by replacing the Morlet wavelet shown in *Figure 3* by a waveform which more closely resembles the harmonic structure of actual piano notes. Such a waveform is shown in *Figure 5* with a rate of attack and decay which may be estimated by examining piano note waveforms as illustrated in *Figure 1*.

This wavelet analysis technique has been used to measure the location in time and amplitude of individual notes. In *Figure 6*, the expressive timing in the opening bars of three recordings of Bach's *Fugue in C major* BWV 846b (from the 'Forty-eight' Preludes and Fugues) is illustrated, along with the musical score. The recordings are:

- a computer-synthesised performance from a MIDI file with piano synthesiser;
- a performance from an acoustic recording by Glenn Gould; and
- a performance from an acoustic recording by Friedrich Gulda

The expressive timings are presented in terms of an instantaneous measure of the number of beats per minute, referred to as *instantaneous tempo*.

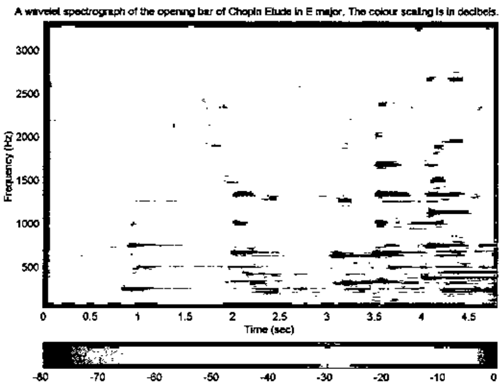


Figure 4 Morlet wavelet spectrograph of the opening notes of a Chopin piano Etude

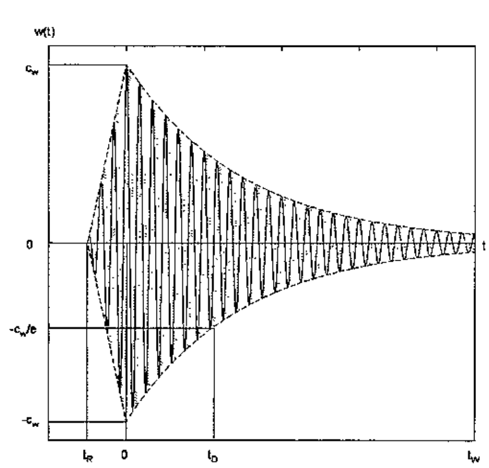


Figure 5 Waveform with envelope characteristic of piano tone

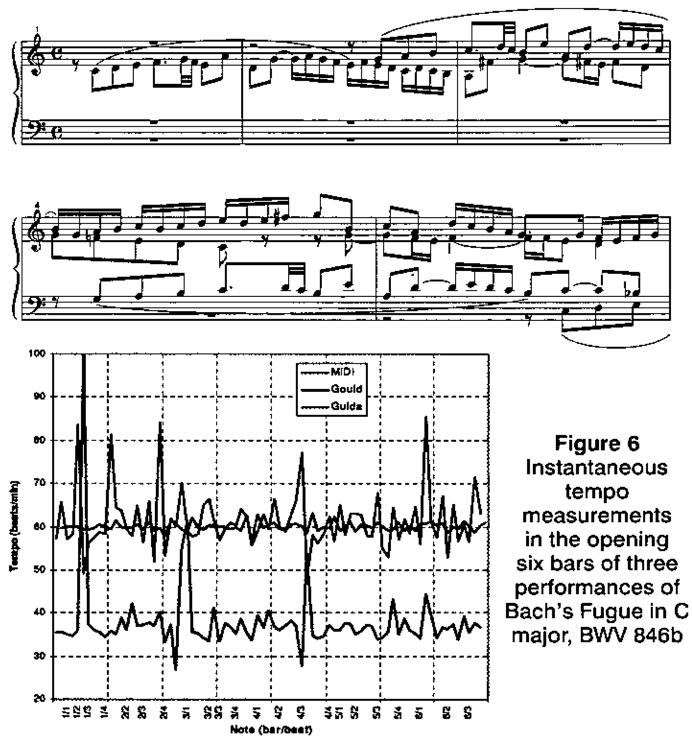


Figure 6 Instantaneous tempo measurements in the opening six bars of three performances of Bach's Fugue in C major, BWV 846b

Table 1 shows the average tempo of each of the three extracts, together with the standard deviation of the tempo. The relative (or percentage) standard deviation of the instantaneous tempo is used as a measure of the overall amount of rubato over the passage. This is referred to as the *rubato number*.

	MIDI	Gould	Gulda
Mean instantaneous tempo (beats/min)	60.01	61.56	37.82
Standard deviation	2.67	6.89	9.86
Rubato number (%)	**4.5**	**11.2**	**30.0**

Table 1. Derivation of rubato number for the opening six bars of three recordings of Bach's Fugue in C major BWV 846b

Measured event dynamics (the volume of individual notes or chords) are illustrated in *Figure 7*. In each case, the results are scaled such that the mean dynamics (volume) is 1.0.

A useful measure of the overall dynamic variation within a passage of recorded music is the relative percentage standard deviation of the individual event dynamics as

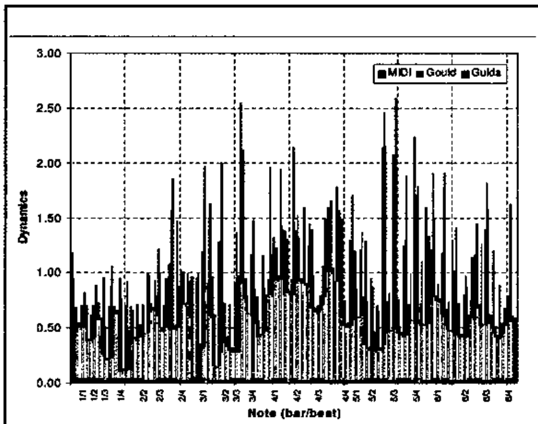


Figure 7 Event dynamics of the opening six bars of three performances of Bach's Fugue in C major, BWV 846b

illustrated in *Figure 7* for the three passages. The standard deviations in dynamics of the MIDI, Gould and Gulda passages are shown in *Table 2.*

	MIDI	Gould	Gulda
Overall dynamic variation (%)	39.6	45.1	57.1

Table 2. Overall dynamic variation in the opening six bars of three recordings of Bach's Fugue in C major BWV 846b

Glen Gould's performance proved faster and more rigid in both timing and dynamics

The perception of the listener to the performances is that the Gould performance is both faster and more rigid in both timing and dynamics than the slower and more 'expressive' Gulda performance. This is confirmed by the results which show quantitatively that the performance by Gulda is the slowest, exhibits the most rubato, and exhibits the most dynamic variation. This analysis provides a simple measure of variability in timing and dynamics over a short passage as a means of comparing different performances. Over more extended passages and complete movements and works, the variation can be measured on different levels *eg* at the individual bar level as well as the individual note level, and can be related to the global tempo and dynamics structure of the performance.

The data illustrated here provides a snapshot of the potential capabilities of applying time-frequency analysis techniques to the study of expressive musical performance. Whilst judgements about the relative similarity and difference between, and the quality of, musical performance are frequently made by music lovers, critics and adjudicators, these are made on the basis of their auditory impressions and accumulated knowledge. Whilst these may often be highly accurate, they cannot be described as objective as they are subject to listeners' perceptions, their memory and attention and therefore exhibit considerable individual differences. Objective performance analysis enables these differences to be quantified. There are a number of applications, from the analysis of individual performance and measurement of differences between performances to the study of motor processes, sight-reading and practising.

References

1 J A Sloboda, 'Individual differences in music performance', *Trends in Cognitive Science* **4.10**, 397-403

2 B H Repp, 'Patterns of expressive timing in performances of a Beethoven minuet by nineteen famous pianists', *J Acous Soc Am*, **88**, pp 622-650 (1990)

3 C E Seashore, Psychology of music, New York: McGraw-Hill (Reprinted 1967 by Dover Publications, New York) (1938)

4 B H Repp, 'A microcosm of musical expression: I Quantitative analysis of pianists' timing in the initial measures of Chopin's Etude in E major', *J Acous Soc Am*, **104**, pp 1085-1100 (1998)

5 A Binet and J Courtier, 'Recherches graphiques sur la musique', *L'Année Psychologique*, **2**, pp 201-222 (1895)

6 E D Scheirer, 'Tempo and beat analysis of acoustic musical signals', *J Acoust Soc Am*, **103**, pp 588-601 (1998)

7 S Dixon, 'Towards automatic analysis of expressive performance', *5th Triennial Conference of the European Society for the Cognitive Sciences of Music (ESCOM5)*, 8 - 13 September 2003, Hanover, Germany, pp 107-110 (2003)

8 B H Repp, 'Some empirical observations on sound level properties of recorded piano tones', *J Acoust Soc Am*, **93**, pp 1136-1144 (1993)

9 D.W Martin, 'Decay rates of piano tone', *J Acoust Soc Am.*, **19**, 535-541 (1947)

10 B E Richardson, 'Cambridge Companion to the Piano', Ed D Rowland, Cambridge University Press, 96-113 (1998)

11 G Weinreich, 'The coupled motion of piano strings', *Scientific American*, **240**, 94-102 (1979)

12 G Weinreich, 'Coupled piano strings', *J Acoust Soc Am.*, **62**, 1474-1484 (1977)

13 A Earis & B M G Cheetham, 'Extraction of expressive performance parameters from acoustic recordings of piano music', *Institute of Acoustics Spring Conference 2004*, Southampton (2004)

Andrew Earis *and Barry* **M G Cheetham**, *Department of Computer Science, University of Manchester, Oxford Road, Manchester, M13 9PL, UK e-mail: earisa@cs.man.ac.uk*

LONDON SOUTH BANK UNIVERSITY

FACULTY OF ENGINEERING, SCIENCE & THE BUILT ENVIRONMENT

MSc/PgDip ENVIRONMENTAL & ARCHITECTURAL ACOUSTICS

(Starting September 2004 or February 2005)

Covering a wide range of topics relating to environmental acoustics, this course provides ideal training for noise consultants, environmental health officers and noise control engineers.

Taught specialist material includes:

- The measurement and assessment of environmental and occupational noise
- Building acoustics
- Noise and vibration control
- Environmental control of the built environment
- Research methods
- Management

MSc students additionally undertake a research project in some aspect of environmental or architectural acoustics.

Full or part-time study options.

For further information please contact Dr Steve Dance on 020 7815 7013 or email: dances@lsbu.ac.uk

Further details are available from the Course Enquiries Office, London South Bank University, 103 Borough Road, London SE1 0AA. Telephone: 020 7815 7815. www.lsbu.ac.uk

A new sensor for detecting and characterising acoustic cavitation in vivo during ESWL

F Fedele, A J Coleman, T G Leighton, P R White and A M Hurrell

Extracorporeal Shock-Wave Lithotripsy (ESWL) is the leading technique for the non-invasive treatment of kidney, ureteric and biliary stones. It was first **(1)** introduced in 1981 to treat kidney stones. Nowadays it is also being used in the cure of salivary stones and management of some orthopaedic diseases **(2-4)**.

Lying on a table, the patient is coupled to an external ultrasound shock source through a water cushion *(Figure 1)*. Thousands of ultrasound shocks, with peak-positive pressure up to 100MPa, are focused on the stone in order to break it into fragments small enough to be passed naturally by the body. The stone is localised using x-ray and ultrasound (US) systems.

The shock source may belong to one of three different families **(5)**: electrohydraulic (EH), piezoelectric (PZ) and electromagnetic (EM). The two lithotripters used in this study have an EM source. The shock is generated by a high-voltage capacitor discharging through a flat coil coupled to a copper membrane, which is fixed at the end of a shock tube *(Figure 2)*. Though the procedure is well established, the re-treatment rate **(6)** is still around 50 per cent.

Both x-ray and US systems are affected by alignment errors **(7)**. Several projects have examined the development of auxiliary targeting techniques that may identify if the stone has actually been hit by the beam **(8-10)**. Olson *et al* **(10)** suggested a system based on the classification of the audible sound that is generated when the shock hits the stone, while other authors **(8-9)** worked on solutions based on the elaboration of ultrasound echoes from signals generated by active ultrasonic probes.

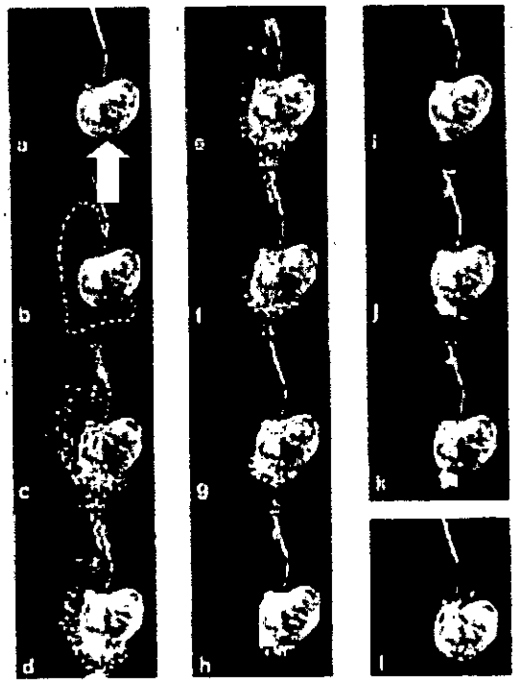


Figure 3 Sequence of high speed photographic pictures of human gallstone being hit by a shock wave in Sass et al 1991. The interval between each frame is of 01ms *(a)* Taken 01ms prior to the shock hitting the stone. The white arrow indicates the shock orientation. The shock reaches the stones between (a) and *(b) (b-h)*. These frames show cavitation activity. Note bubbles on the stone referring to cavitation within small cracks *(i-k)*. Rapid material outburst *(l)* Disintegration of the stone within the crack

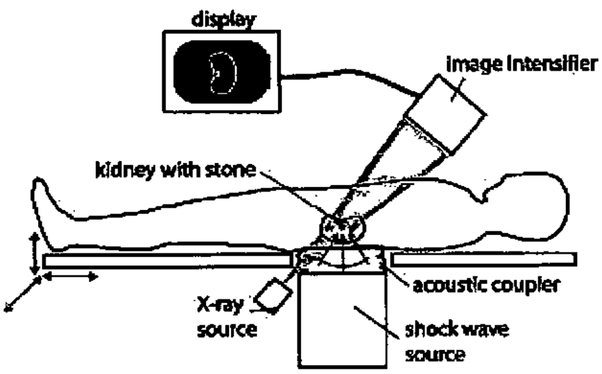


Figure 1 Schematic of Lithotripsy

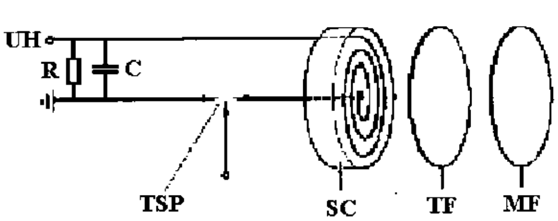


Figure 2 Schematic representation of the EM source (TSP) Triggered spark-gap (SC) Flat solenoid (IF) Polyamide film (MF) Copper membrane

A significant limitation of the present lithotripters is that there is no capability for on-line monitoring of the degree of fragmentation of the stone. Usually the urologist tries to assess this by observing if any changes appear in the density or size of the stone in the x-ray image. Frequent checks may be done if low dose x-ray fluoroscopy is used, but a continuous monitoring can not be used to limit the patient's x-ray dose, and the method does not provide a quantitative measurement of the grade of fragmentation of the stone.

The underlying physical mechanisms responsible for fragmentation of the stone are still subject to investigation. Several studies indicate that both direct stress damage and indirect cavitation erosion seem to be necessary to obtain eliminable fragments **(11)**. The impacting shockwave produces the first fissures in the stone *(Figure 3)*. Later cavitation bubbles imploding within these splits cause the actual disintegration **(12)**.

In previous studies the authors **(13)** monitored cavitation *in-vivo* through the associated acoustic emissions, exploiting an experimental focused piezoelectric bowl. The objective of this study was to design a new passive and unfocused acoustic sensor to detect and characterise cavitation *in vivo* during ESWL.

The first phase of the study used an experimental cavitation sensor *(Figure 4*, developed by the National

Figure 4
NPL cylindrical cavitation sensor

Physical Laboratory UK (NPL), **(14)** to record passive emissions from cavitation generated *in vitro* by an experimental lithotripter **(15)**. This paper reports on the analysis of these emissions and shows that they possess characteristics that depend on the degree of fragmentation of the stone.

Exploiting these preliminary results, some clinical prototypes (an example of which is displayed in *Figure 5*) were developed in collaboration with Precision Acoustics Ltd (PAL) UK. The prototypes have been patented **(16)** and they are currently being tested in the clinical environment.

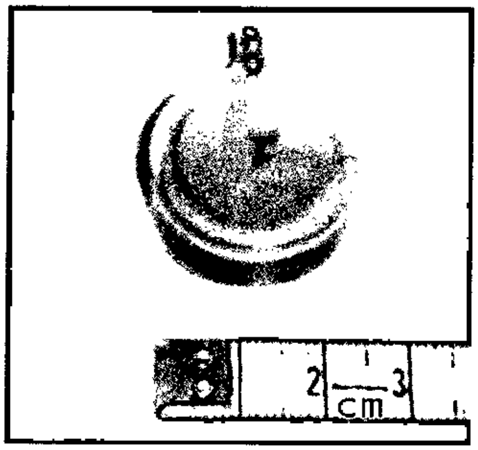


Figure 5
Clinical prototype developed with PAL

In vitro experiments

Experimental set-up

Figure 6 shows a diagram of the experimental set-up. Stone samples were placed at the focus of a bench top EM lithotripter in spherical holders (table-tennis balls) of 2cm diameter. Tests ensured that the holder walls did not significantly alter the lithotripter pressure field. A novel cylindrical broadband cavitation sensor **(14)**, made by NPL, was then coupled to the stone holder. The balls were each filled with different grades of sand, minimising the presence of entrained air bubbles: coarse sand (CS; grain diameter 10-30 mm); medium sand (MS; grain diameter 4-10 mm) or fine sand (FS; grain diameter 1-4mm).

These graded sand targets were used to simulate a stone at different well-characterised stages of fragmentation as it is encountered during the course of an ESWL treatment. One ball was filled with tap water (TW) to act as a control.

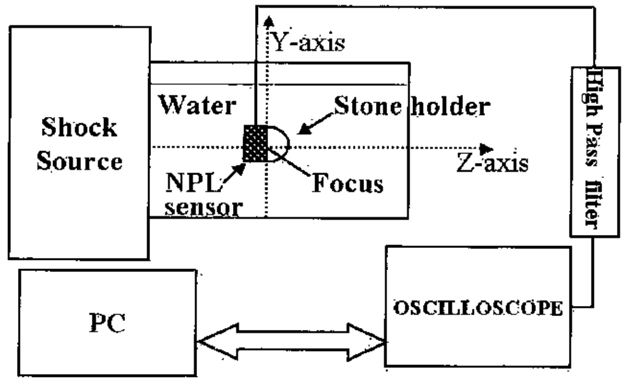


Figure 6 Experimental set-up

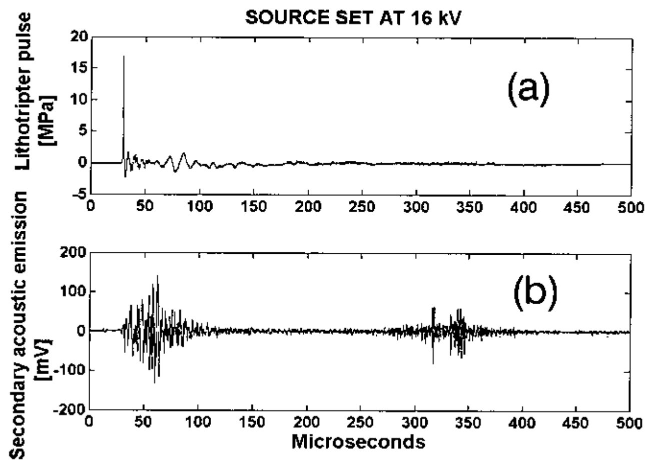


Figure 7 (a) Experimental lithotripter pulse at 16kV **(b)** Secondary acoustic emission detected using the NPL cavitation sensor

The discharge potential of the EM source was set and maintained at 16kV, which gave lithotripter shocks of 16MPa peak-positive pressure and 3MPa peak-negative pressure. The lithotripter pulses were measured using a Marconi Y-34-3598 PVDF bilaminar membrane hydrophone (sensitivity 53 mV/MPa). The detected signals were filtered using an analogue high pass filter with a cut-off frequency of 0.2MHz, to suppress most of the background noise due to the EM source itself. The filtered signals were acquired using a LeCroy 9354L digital scope with a sampling frequency of 100 Msamples/s and the digital data were transferred to a PC with a LabVIEW interface to be stored as text files. The stored data could then be processed using the MATLAB signal processing toolbox.

Figure 7(a) displays a 16 kV lithotripter pulse, measured as described above. The maximum positive pressure and the maximum negative pressure in the shock are respectively named peak-positive pressure and peak negative pressure. *Figure 7(b)* displays a typical output from the NPL cavitation sensor (currently uncalibrated). Two main bursts in the lower plot may be identified in the acoustic emission above the noise level. Previous work **(17)** indicates that these components are related respectively to the first and second collapse of microscopic bubbles (present in a cloud around the beam axis and in proximity of the stone **(18)**) during the shock-bubble interaction. The interval between these two bursts probably represents the mean interval (t_c) between the first and second rebound of each individual cavitation bubble during ESWL.

continued on page 36

A new sensor for detecting and characterising acoustic cavitation in vivo during ESWL

continued from page 37

and close to the main frequency of the lithotripter pulse (0.2MHz). This result is in agreement with the hypothesis there is considerable scattering component of the first burst. Comparison of a set of measurements related to the same burst shows no significant difference between the frequencies of the different samples.

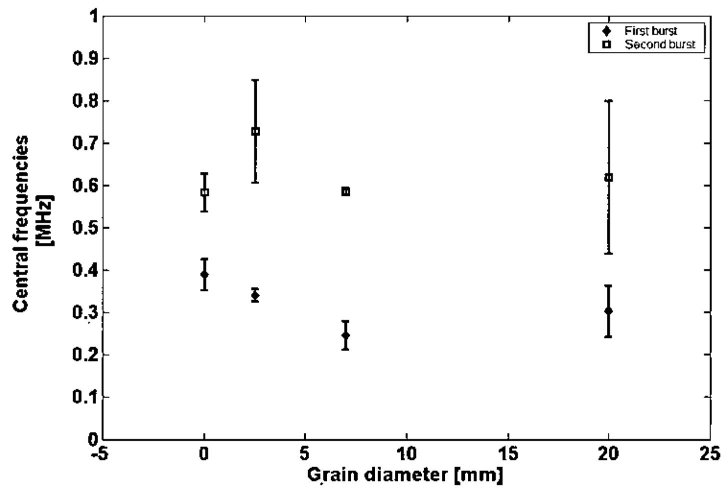


Figure 13 Central frequencies of the two bursts. The error bars equal the ratio between the maximum error and the root square of the number of measurements per stone sample. A grain diameter of zero indicates that the table-tennis ball was filled with tap water only

ADDKA RESOURCING

Acoustic Design Engineer

Addka Resourcing is the market leader in providing Acoustic Engineers throughout the European market. We have established ourselves by forming alliances with large Acoustic organisations that are creating/designing sound devices for the next generation.

Currently we have an urgent contract requirement for an experienced Acoustic Design Engineer that specialises in either; Head Phones, small multi-media devices, PDA phones, Hearing Aids or Ear Plugs, i.e. we are looking to secure the services of someone that has experience of the design of Acoustics with small devices.

This is a fantastic opportunity to be part of an organisation that is involved in the latest Audio/Acoustical technology. It is essential you have the ability to fit into a dynamic, highly capable team with a real can-do approach.

English speaking environment – Excellent communication and interpersonal skills is the key to the position.

Contract Duration: 12 months
Location: Belgium
Rate: Negotiable/Excellent
Start Date: Immediate

Send your CV direct to David the current Account Manager of the Acoustic Recruitment Team at david.macciocca@addka.com or call directly for an immediate telephone discussion on Tel:– 0044 (0) 208 891 1139

Design of a clinical prototype

The prototype *(Figure 5)* is a passive hydrophone made of a circular piezo-polymer PVdF element of 2cm diameter encapsulated in an external insulating shield. The size of the element has been designed to ensure that a path difference no greater than 0.1mm occurs for emissions coming from the kidney at 3MHz. The sensor is applied to the patient satisfying the restrictions of a class BF medical device according to the IEC60601-1.

Test of the prototype in vitro

Several sets of recordings were made simultaneously using the NPL cavitation sensor and the PAL clinical prototype. The NPL was left at the focus of the lithotripter (coupled to the stone holder) while the PAL was placed at different positions laterally off-axis, facing the NPL and the stone. The PAL was placed off-axis to reproduce the configuration it would be *in vivo*, where it is not possible to place any sensor between the source and the stone, because this would interfere with the treatment itself. A correlation coefficient of 0.4 was found when the two sensors were close together (PAL 5mm off-axis), which decreased moving them further. *Figure 14* shows an example of the data recorded by the two sensors when they were close together.

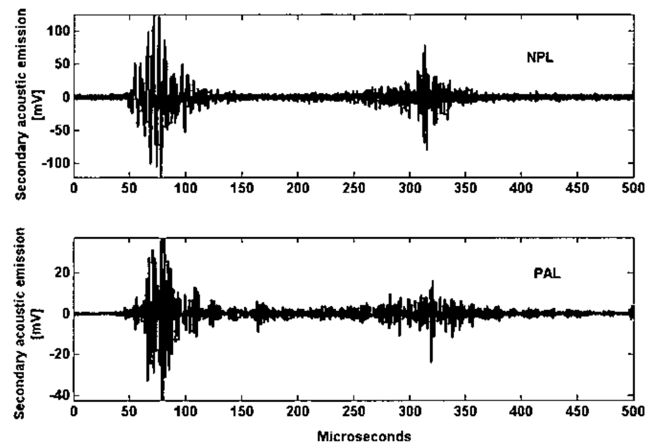


Figure 14 Data simultaneously recorded by the NPL (upper box) and PAL (lower box) sensors

Test of the prototype in vivo

The prototypes were tested on 40 consenting patients undergoing lithotripsy at Guy's and St Thomas' Hospital, after the design of the experiments was approved by the ethical committee of the hospital. The clinical lithotripter, at Guy's Hospital, London, is a Storz Modulith SLX-MX.

The sensor lead is connected to a portable digital oscilloscope (Tiepie Handyscope 3), which is in communication with a laptop (seen in foreground on the right of *figure 15*) through the USB port. The oscilloscope is automatically triggered by an electrical signal emitted by the EM source when it generates a shock. The digital scope does not require external power supply and the laptop is self-powered by its own battery (20V). Thus any possible connection between the patient and the main power supply is avoided and the sensor satisfies the restrictions of a class BF medical device according to the classification of the International Electrotechnical Commission (IEC60601-1). Prior to its use in the theatre, the equipment

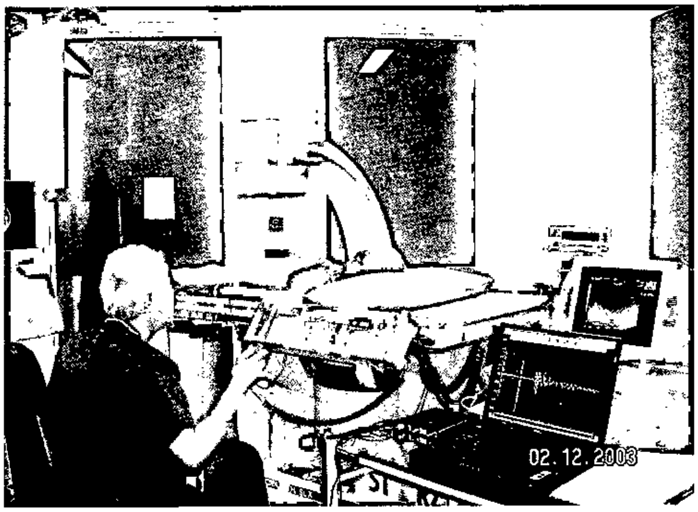


Figure 15 Experimental set-up in vivo

successfully passed electrical safety tests. The recorded traces are stored as text files using a software interface produced by Tiepie and subsequently analysed off-line.

Figure 16 shows an example of secondary acoustic emissions recorded *in vivo*: at the beginning of a treatment section, using a calibrated PA prototype, a maximum emitted pressure of approximately 13kPa is recorded on the patient abdomen.

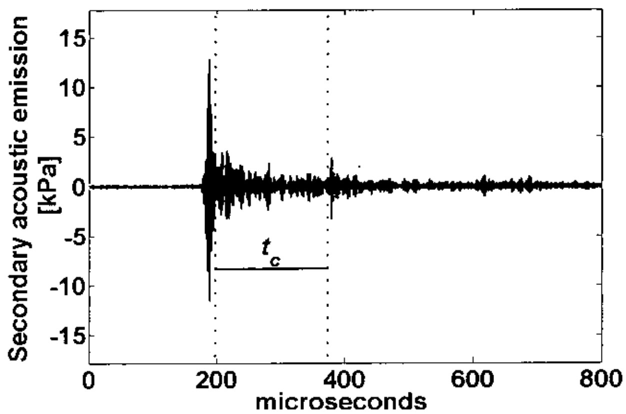


Figure 16 Secondary acoustic emissions recorded in vivo using a PAL calibrated prototype

Conclusions

It has been shown *in vitro* that it is possible to use a passive acoustic device for diagnostic monitoring during lithotripsy, by exploiting the information carried by the passive cavitation emission. The prototype device has been tested in the clinic, and shown to be capable of detecting the first and second bursts of acoustic emission from the target. Preliminary analysis of the signal demonstrates similar features to those observed *in vitro*. Further work is needed to establish the parameters that correlate with the condition of the target material.

Acknowledgments

This research was financed by the Engineering and Physical Sciences Research Council, UK GR/N19243. The authors thank Mrs Terri Gill at PAL, Dr Bajram Zeqiri and Ms Catherine Bickley at NPL, Mr Jonathan Glass, Mr Richard Tiptaff, Mr Simon Ryves and all the Lithotripsy Unit, the Mechanical Workshop and Electro Biomedical Engineering Section at Guy's and St Thomas' Hospital, London, for their collaboration.

References

1 C Chaussy, E Schmiedt, D Jocham, W Brendel, B Forssmann and V Walther, 'First clinical experience with extracorporeally induced destruction of kidney stones by shock waves 1981', *Journal of Urology* **167(5)** 1957-1960 (2002)
2 H Iro, N Nitsche, J Meier, P M Wirtz and C H Ell, 'Piezoelectric shock wave lithotripsy of salivary gland stones: an in vitro feasibility study' *Journal of Lithotripsy Stone Disease* **3(3)** 211-216 (1991)
3 M Maier, S Milz, T Tischer, W Munzing, N Manthey, A Stabler et al, 'Influence of extracorporeal shock-wave application on normal bone in an animal model in vivo Scintigraphy, MRI and histopathology' *J Bone Joint Surg Br* **84(4)** 592-599 (2002):
4 C Von Eiff, J Overbeck, G Haupt, M Herrmann, S Winckler, KD Richter et al, 'Bactericidal effect of extracorporeal shock waves on Staphylococcus aureus' *J Med Microbiol:* **49(8)** 709-712 (2000)
5 K T Ison, 'Physical and technical introduction to lithotripsy', in: MJ Coptcoat, RA Miller and JEA Wicklam Eds, 'Lithotripsy II Textbook of second generation extracorporeal lithotripsy', BDI Publishing, London, 7-12 (1987)
6 D A Tolley and P Downey, 'Current advances in shock wave lithotripsy', *Current Opinion in Urology* **9(4)** 319-23 (1999)
7 R M Schmitt, H Wuster, W Kraus and M Bibinger, 'The effects of errors in positioning lithotriptor and imaging kidney stones ultrasound', *Proc of Annual international conference of the IEEE Engineering in Medicine and Biology Society*, **Vol 12(1)**, 252-253 (1990)
8 E Hausler, V Rech and M Wache M, 'Transient cavitation based ultrasonic lithotriptor positioning system', *Proc of the Annual international conference of the IEEE Engineering in Medicine and Biology Society*, **Vol 13**, 185-186 (1991)
9 C C Chang, S M Liang, Y R Pu, C H Chen, I Manousakas, TS Chen et al, 'In vitro study of ultrasound based real-time tracking of renal stones for shock wave lithotripsy', *Journal of Urology*, **166(1)** 28-32 (2001)
10 L Olsson, L O Almquist, A Grennberg and N G Holmer, 'Analysis and classification of secondary sounds from the disintegration of kidney stones with acoustic shock waves', *Ultrasound Med Biol*, **17(5)** 491-495 (1991)
11 S Zhu, F H Cocks, G M Preminger and P Zhong, 'The role of stress waves and cavitation in stone comminution in shock wave lithotripsy', *Ultrasound in Medicine and Biology*, **28(5)** 661-671 (2002)
12 W Sass, M Braunlich, H P Dreyer, E Matura, W Folberth, H G Preismeyer *et al* 'The mechanisms of stone disintegration by shock waves', *Ultrasound Med Biol*, **17(3)** 239-243 (1991)
13 K B Cunningham, A J Coleman, T G Leighton and P R White, 'Characterising in vivo acoustic cavitation during lithotripsy with time-frequency methods', *Acoustics Bulletin*, **26(5)** 10-16 (2002)
14 B Zeqiri, S C Davies, P N Gelat, M Hodnett and U I Lula, 'Novel sensors for monitoring acoustic cavitation', *Proc of IEEE Ultrasonics Symposium*, **Vol 1**, 417-420 (2000)
15 F Fedele, A J Coleman and T G Leighton, 'Use of cylindrical PVdF hydrophone in a study of cavitation adjacent to stone phantoms during extracorporeal shockwave lithotripsy', *Proc of the IPEM Annual Scientific Meeting, 66* Bath, UK, September 2003
16 T G Leighton, A J Coleman, F Fedele and P R White, 'A passive acoustic system for evaluating the in vivo performance of extracorporeal shock wave lithotripsy', UK Patent Application No 03198637 (2003)
17 A J Coleman, M J Choi, J E Saunders, T G Leighton, 'Acoustic emission and sonoluminescence due to cavitation at the beam focus of an electrohydraulic shock wave lithotripter', *Ultrasound in Medicine and Biology*, **18** 267-281 (1992)
18 A J Coleman, M Whitlock, T Leighton and J E Saunders, 'The spatial distribution of cavitation induced acoustic emission, sonoluminescence and cell lysis in the field of a shock wave lithotripter', *Phys Med Biol*, **38(11)** 1545-1560 (1993)
19 A R Jamaluddin, G J Ball and T G Leighton, 'Free-Lagrange simulations of shock/bubble interaction in shock wave lithotripsy' *Proceedings of the Second International Conference on Computational Fluid Dynamics*, 541-5461 (2002)
20 T G Leighton, 'The Acoustic Bubble', Academic Press, London (1994)

F Fedele, *Medical Physics Department, Guy's and St. Thomas' NHS Trust, UK and the Institute of Sound and Vibration Research, University of Southampton, UK;* **A J Coleman,** *Medical Physics Department, Guy's and St. Thomas' NHS Trust;* **T G Leighton** *and* **P R White**, *Institute of Sound and Vibration Research, University of Southampton; and* **A M Hurrell,** *Precision Acoustics Ltd., UK*

CAREER OPPORTUNITIES

PDA Ltd is a respected and well established company in the field of acoustics, having a reputation for the quality and speed of our service to clients. This has lead to a significant growth in our workload and we are now looking for several Consultants and Senior Consultants.

Consultants

PDA are looking for at least two Consultants to be based at our offices in Warrington. You should have two year's experience, show good initiative, and be able to work effectively in a professional and enthusiastic team. Experience in architectural acoustics and environmental noise is desirable together with enthusiasm for these areas. You should have a working knowledge of current standards and procedures and you should have good spoken and written communications skills.

Senior Consultants

PDA are looking for a number of Senior Consultants to be based in satellite offices throughout the country. A minimum of five years experience is desirable, in addition to excellent business development, and client liaison skills. Candidates should have hands on experience in delivering services in architectural, environmental, planning and the residential property sectors. You should be able to demonstrate a robust understanding of prevailing standards and procedures, and will have mature spoken and written communication skills.

The salary for Consultants is in the range £23,000 to £35,000, Senior Consultants £35,000 to £45,000, depending on age, qualifications and experience, plus a substantial benefits package that includes a profit related bonus.

Candidates making applications should state which position they are applying for. Applicants for the position of Senior Consultant should identify the area of the country in which they would wish to be based. In the first instance please e-mail your CV to philipdunbavin@pdaltd.com or by mail to:

Mr. P. R. Dunbavin
Principal Consultant

PDA

Vincent House, 212 Manchester Road, Warrington WA4 2EX
Tel: 01925 418188 Fax: 01925 577116
Web: www.pdaltd.com

All applications will be treated in strictest confidence

Oral answers

18 May 2004

Light aircraft (noise pollution)

Mr Robert Key (Salisbury): To ask what plans the minister has to reduce noise pollution from light recreational aircraft.

The Parliamentary Under-Secretary of State for Transport (Mr Tony McNulty): Light aircraft have to comply with an internationally agreed noise certification standard unless they were on the UK register before 1980. This standard was tightened for aircraft certificated after 1999. There are currently no plans for additional measures to reduce noise from light aircraft, although we expect aerodromes to set, and to enforce, appropriate rules to minimise noise nuisance.

Mr Key: Does the Minister understand how sorry we feel for him, given this can of worms with which he must deal? My constituents are pleased to put up with the noise of fast jets and military helicopters five days a week, but for two days a week and particularly during the summer weather, their quality of life is diminished by light recreational aircraft. Indeed, hundreds of thousands of people throughout the country will have their quality of life diminished by the pilots of some 8,000 light aircraft and, of course, of those 'lawnmowers' that take to the skies, and which take so long to get across them. As part of his big conversation, will he please start a debate on the balance between the right of pilots of light recreational aircraft to fly in our skies, and the right of the vast majority of our citizens to have peace and quiet?

Mr McNulty: I am sympathetic to the points that the hon. Gentleman makes. In addition to the certification standard and the general noise standard, there are considerations in terms of the planning framework and the other frameworks that need to be taken into account. However, I shall look into the matter further and get back to the hon. Gentleman.

Commons written answers

11 May 2004

Car stereos

Adam Price: To ask the Secretary of State for the Home Department if he will make a statement on the use of Regulation 97 of the *1986 Road Vehicle Regulations* to combat noise pollution emanating from car stereos.

Caroline Flint: Regulation 97 of the *Road Vehicles (Construction and Use) Regulations 1986* provides that no motor vehicle shall be used on a road in such a manner as to cause any excessive noise which could have been avoided by the exercise of reasonable care by the driver. I understand from the Association of Chief Police Officers that the police find the provision effective to deal with noisy car stereos. When enforcing the offence, police officers will give an oral warning to the driver, issue a fixed penalty notice or report for prosecution as appropriate.

Adam Price: To ask the Secretary of State for the Home Department if he will make a statement on the powers available to the police to combat noise pollution emanating from car stereos.

Caroline Flint: Regulation 97 of the *Road Vehicles (Construction and Use) Regulations*

FROM HANSARD

1986 prohibits the use of a vehicle emitting avoidable excessive noise. If in a particular case playing a stereo at excessive volume amounted to driving without reasonable consideration for others contrary to Section 3 of the *Road Traffic Act 1988* and was causing or was likely to cause alarm, distress or annoyance, the driver may be liable to having his vehicle seized by the police under the provisions of Section 59 of the *Police Reform Act 2002*.

18 May 2004

Noisy roads

Tony Baldry: To ask the Secretary of State for Transport if he will make a statement on measures to address the problem of noisy roads.

Mr Jamieson: The government recognises that traffic noise from main roads can be a nuisance. Our strategy is to set vehicle construction standards that reduce noise at source wherever feasible and desirable on safety grounds. We also encourage the mitigation of noise with insulation, barriers, traffic management measures and low noise surfaces.

24 May 2004

Fireworks

Chris Ruane: To ask the Secretary of State for Trade and Industry what progress has been made in tackling the issue of noisy night-time fireworks.

Mr Sutcliffe: The Department launched a formal consultation on 23 April 2004, which details proposed regulations to be made under the provisions of the *Fireworks Act 2003*. One of the proposed measures is to create a curfew on the use of fireworks between the hours of 11pm and 7am, with the exception of 5 November, New Years Eve, Chinese New Year and Diwali.

We expect that the police will enforce this measure - and that the police will have the power to issue Fixed Penalty Notices for infractions of the curfew.

Lords written answers

25 May 2004

Motorcycles - engine noise

Earl Peel asked Her Majesty's Government: What action they plan to take to tackle motorcyclists in the North Yorkshire Moors and the Yorkshire Dales National Parks who adapt their motorcycles to increase their engine noise.

Lord Davies of Oldham: There are several ways in which we regulate noise from motorcycles. These include noise limits for new motorcycles, plus requirements for maintenance and for silencer markings. In response to a request from the department's Advisory Group on Motorcycling we produced some guidance to help riders to comply with the regulations and to aid the police in enforcement. Copies of this note *Motor Cycle Noise -Statutory Controls on Noise Limits and Silencer/Exhaust Systems* have been placed in the House Libraries.

Enforcement at a local level is a matter for the police. I understand that the North Yorkshire Moors National Park Authority is liaising with the police to address the problem in the area.

26 May 2004

Loudhailers - use in public

Lord Monson asked Her Majesty's Government:

Whether human rights legislation prevents government and local authorities banning or restricting the use of loudhailers in public: what is the nature and scope of such restrictions as may be permitted by the legislation.

Baroness Scotland of Asthal: There is legislation in place to restrict the use of loudhailers in public. Section 62 of the Control of Pollution Act 1974 governs the use of loudhailers in the streets, and prohibits their use between 9.00 pm and 8.00 am.

There is also a City of Westminster bye law, which makes it an offence to cause or permit to be made any loud or continuous noise by operating an amplifier or similar instrument, after being warned to desist by a constable.

The government believes that this legislation is compliant with the right to freedom of expression and assembly under Article 10 of the European Convention on Human Rights.

The right to freedom of expression is not absolute and the rights of others not to be subjected to noisy protests must be taken into account. The legislation finds an appropriate balance between these conflicting rights.

Road surfaces

Lord Patten asked Her Majesty's Government:

By what date they expect *(a)* all of Britain's motorways, and *(b)* all of the dual carriageway sections of Britain's non-motorway standard trunk roads, to have been surfaced or resurfaced with noise-deadening materials.

Lord Davies of Oldham: As indicated in the government's 10-year transport plan, quieter surfaces should be installed on over 60% (2,500 miles) of the English strategic road network (motorways and trunk roads), including all concrete stretches, by April 2011, subject to the availability of funds. Carriageways are being resurfaced with quieter materials as maintenance becomes due to keep them in a safe and serviceable (available for use) condition. However, where concrete carriageways will not require maintenance by April 2011, their resurfacing is being prioritised to address those locations where the most homes are affected by traffic noise first. In addition, quieter surfaces will be used in all new major junction improvements, bypasses and road widenings. On the basis of current maintenance expectations for the strategic road network, nearly all dual carriageway sections should be resurfaced by around 2015.

MSX International

Using SEA as a predictive tool before prototype

The use of Statistical Energy Analysis (SEA) has become recognised as a useful technique to predict high frequency noise and vibration. It provides a method based on an analytical and simplified representation for modelling the transmission of complex multi-source and multi-path noise through cavities and structures.

For some time SEA has been successfully applied by a range of industry sectors from aerospace, automotive, marine and rail to building construction and offshore. Considered an effective tool for modelling both existing and virtual structures, it is capable of predicting overall internal noise levels as well as the relative effects of design changes to the sound package and structure. SEA simulation allows fast calculation of average broad-band vibration and noise levels across a wide frequency range, which makes the technique ideal for concept level assessment and design optimisation studies.

The time-efficient and wide-ranging nature of the analysis also provides a high level of added value to the Noise Vibration and Harshness (NVH) process, without requiring a high level of resource. The analysis can be performed successfully as a 'virtual' study or in conjunction with a test programme.

MSX International has a proven track record of providing engineering consulting services to leading companies in the automotive, aerospace and similar industries. Through work with clients, the company believes that SEA is at its most useful as a predictive tool before prototypes are built. Considerable effort has therefore focused on the application of SEA methods to develop theoretical models of 'virtual' vehicles to assist throughout the vehicle development programme, even to the point of influencing concept design.

MSXI's processes utilise best practice techniques developed through successful implementation on a wide range of automotive and non-automotive programmes. By using a proven and robust process the maximum benefit can be obtained through the latest technology and experienced engineers. Thorough understanding of how to model delivers a high standard of predictive accuracy on automotive vehicle structures at frequencies above 250Hz.

SEA is a proven optimisation tool, eg. for cost and weight reduction. Once the initial model has been built iterations can be carried out quickly, allowing for the rapid assessment of 'what if' scenarios. Increased simulation early in the development process leads to the early availability of data, which in turn results in fewer test programmes and prototypes and ultimately reduced costs. This helps to ensure the lightest and most cost effective solutions are identified to achieve the target noise and vibration performance.

Further details contact: Dr Jez Smith on tel: ++44 1268 245 073 or visit the website at http://msxi.com

Sensors UK

4-in-1 environment meter

The Model *MPT-5035* multi-function environment meter has been added to **Sensors UK's** range of portable instrumentation. Recent changes to the Noise at Work Regulations and the minimum health and safety requirements for the exposure of workers to risk have introduced a new requirement for employers take specific protective measures and carry out risk assessments.

This meter measures sound levels, light levels, relative humidity and temperature all within one easy-to-use package. Functions include 'max hold', which retains a current measured value, and 'max memory', which retains the highest reading since the last switch-on. There is an automatic power-off device to prolong battery life, and a low battery warning.

The durable housing includes a standard 4mm camera bush for tripod mounting, and the 9V PP3 battery is easily accessed. The unit is supplied in a carrying case with lux, humidity and temperature sensors, battery, and windscreen. A calibration certificate confirming one data point for each function is also included.

Further details: David White tel: 01727 844323 e-mail: dwhite@sensoruk.com

IAC

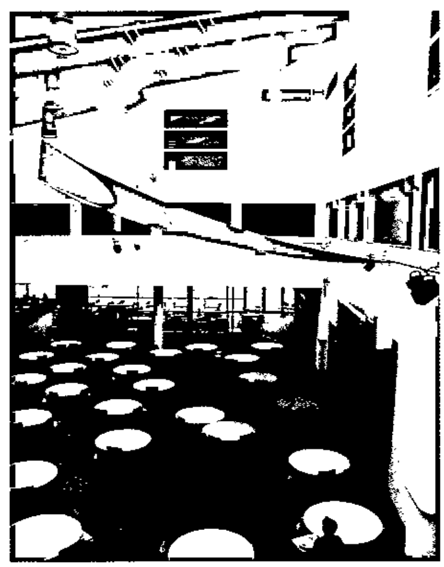
Keeping the noise down for neighbours

When the Oshwal Centre of Worship and Community Hall in Northaw, Hertfordshire, received a warning from the local environmental health department about noise nuisance, management contacted **IAC** for assistance, having found details of its steel acoustic doors on the internet. IAC fitted five, high performance door sets in the Centre. All were positioned in emergency escape areas, each with integrated emergency escape panic hardware. These backed onto the community hall and were the only sound barrier to the outside.

Scott Simmons, IAC's product manager, doors, explains: "We're called on more and more for this kind of job. In this case the doors themselves were standard, and it was just the threshold plates that required modification. This building was quite modern -1980s, or thereabouts - but we can fit acoustic doors into virtually any age of building. We also supply acoustic moveable partition walls where venues are looking to subdivide large spaces and maximise revenue."

Mr Tushar Shah, who manages the Oshwal Centre, said: "Although we are in the countryside, four houses have since been built close by. As we hire out the hall for weddings and parties, fitting the acoustic doors has made a tremendous difference. IAC responded quickly even though they were very busy at the time".

More information on IAC's range of architectural products can be found on the website at www.iacl.co.uk or contact Scott Simmons on tel: 01962 873016 or e-mail: scotts@iacl.co.uk



Oscar Acoustics

Sonacoustic for ceilings and walls

Sonacoustic, a flat seamless treatment for ceilings and walls, is now available from **Oscar Acoustics**. As with *Sonaspray*, this spray-on treatment will greatly reduce reverberation whilst satisfying the desire for smooth unobtrusive finishes.

Sonacoustic, which is based on the same environmentally friendly organic fibre, offers the following features: flat unstructured or light stucco texture; seamless spray application to most surfaces; fast installation; firm and fire resistant finish; a range of colours; and maintenance requirements just like plasterwork.

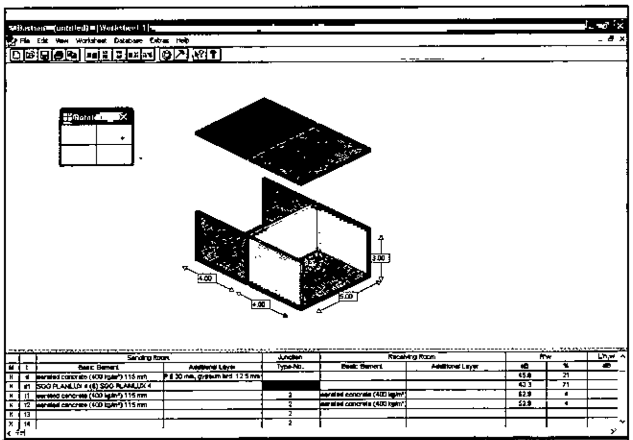
Corporate or private executive applications for Sonacoustic are numerous. The company is happy to support design presentations with samples and photographs on request.

Further details: tel: 01474 873122; e-mail: mail@oscar-acoustics.co.uk or website: www.oscar-acoustics.co.uk

Campbell Associates

The latest in building acoustics tools

For a long time noise transmission has been an important issue within the construction industry, although often overlooked. With the change in focus created by the introduction of the new Building Regulations, the need for construction companies and architects to make noise a greater driving force behind the designs of new buildings is increasing.



Bastian allows simple but accurate modelling

Bastian is software that allows simple but accurate modelling of the acoustic performance of a building construction based on a simple system of selecting and layering partition types from a detailed database of hundreds of performance values. It utilises a simple to use 3D interface from which just a double click can select a construction type.

Advanced features include: airborne and impact testing to EN 12354-1, 2 & 3; data input for in house test data; auralisation of noise in source and receive rooms; instant result of your preferred performance parameter; and transmission values calculated in under half the time of spreadsheet methods.

This package, which costs £1,345 plus VAT, is also available for short term hire at £8 per day. It is produced by the Datakustik group, based in Germany, which also produces the acoustic mapping software CADNA-A that also interfaces with Bastian.

STIPA and schools

The introduction of *Building Bulletin 93* to the building regulations places a requirement to measure speech transmission in large spaces within schools. **Norsonic** has now introduced a STIPA option for the NOR-118 Sound Level Meter. Using the tripod mounted source unit, the *Nor-118 STIPA System* provides a cost efficient, quick, simple and accurate method of measuring speech transmission.

NOR-118

It measures distortion of the source noise in accordance with the new STIPA standard and gives an on-screen single number and octave band values.

Further details contact: John Campbell tel: 01279 718 898; fax: 01279 718 963; email: info@campbell-associates.co.uk

LMS International

Virtual.Lab Revision 4 introduced

Rev 4 of *LMS Virtual.Lab*, the company's award-winning simulation environment for functional performance engineering, is now available. This integrated software suite simulates the performance of mechanical systems on attributes such as structural integrity, comfort, sound quality, system dynamics, handling and durability.

The latest version introduces a new Morphing module enabling users to modify existing Finite Element (FE) models and perform a multitude of analyses before complete CAD or new FE models become available. The performance and capability of all the integrated simulation applications, including Motion, Noise and Vibration, Interior and Exterior Acoustics, and Durability, are also increased.

Since its market introduction, over 150 major manufacturing companies worldwide have implemented *LMS Virtual.Lab* to support their NVH and acoustics engineering processes, optimise the reliability and lifetime performance of their products, and analyse the structural integrity and system dynamics of their designs long before expensive prototype testing.

With its new Interior Acoustics solution, engineers can accurately model the vibro-acoustic behaviour of a vehicle body, and simulate its interior sound. This allows users to study the effect of increasing the structural damping of the body, stiffening the roof or the floor panels, changing the volumetric absorption from vehicle seats, or adapting the trim thickness of specific body panels.

Interior Acoustics includes cavity meshing capabilities that allow users to start from a structural full vehicle or trimmed body model and automatically generate the Finite Element mesh for the cavity. The full simulation process is supported in a single user environment, from the creation of the acoustic vehicle model, through the prediction of system-level transfer functions, to the refinement and optimisation of the acoustic performance long before running prototype tests.

Further details visit: www.lmsvirtuallab.com

Autograph Sales

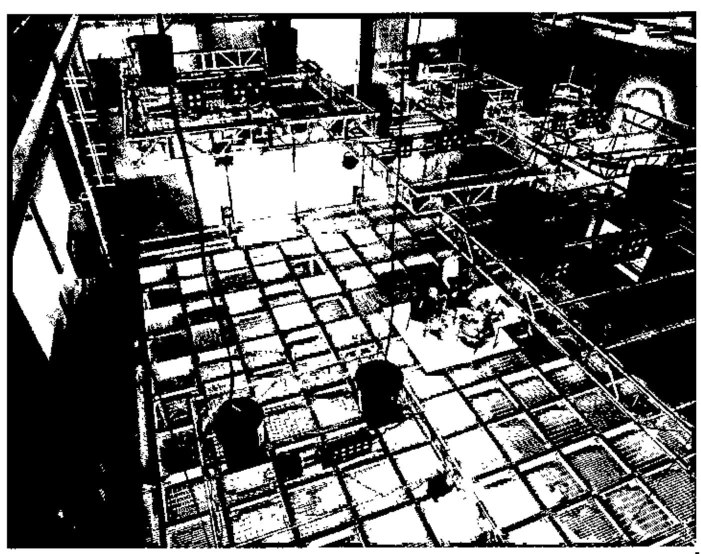
Loudspeaker system for first sonic arts centre

Audio specialist **Autograph Sales** has supplied and installed a complete Meyer Sound loudspeaker system at Queen's University, Belfast, in its new and unique Sonic Arts Research Centre.

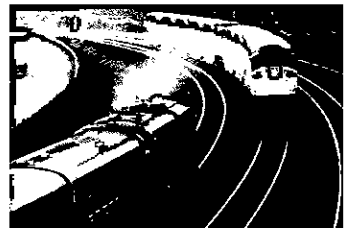
This Sonic Laboratory Concert Hall has a steel mesh floor to allow diffusion from speakers above and below the audience, all of which are driven independently by ProTools. The system was set-up by the company's technical department using Meyer Sound's SIM II analyser to align the system to perfection.

A total of 32 Meyer Sound loudspeakers were supplied - 16 UPJ-1Ps and 16 UPM-1Ps. Four 'rings' of eight speakers are either suspended or mounted on stands at different heights, while an additional four UMS-1P subs were strategically placed around the venue. Further equipment included a custom rigging system designed by Autograph Sales, and hybrid power/signal cable from Reference Laboratories.

As the centre's director, Michael Alcorn, commented: "Having created a near-silent working environment, the right choice of loudspeaker was essential. Autograph Sales conducted extensive noise tests and demonstrated that the Meyer Sound loudspeakers were the right cabinets for the job."







Talented? Then ERM is listening...

Environmental Resources Management (ERM) is one of the world's leading providers of environmental management and technical consulting services, employing over 2,400 professionals in more than 30 countries. Fundamental to our success is the excellence of our people and the depth of our client relationships. In the UK, ERM has staff based in offices in London, Oxford, Manchester, and Edinburgh.

We are looking to recruit a number of talented people to join our growing acoustics team which works with both the public and private sectors.

Senior Consultant

The successful candidate will have more than 3 years consulting experience and will be able to demonstrate business development and innovation capabilities.

Consultant

You will have a relevant degree or higher level qualification and at least two years relevant experience and be able to demonstrate the ability to use your initiative, learn quickly and take on responsibility.

Both Roles

Both roles will include noise surveying, noise modeling, reporting and project management. There will be opportunities to work on a wide range of environmental noise assessment projects, including major transport and infrastructure developments.

Successful candidates will be Associate or Corporate Members of the Institute of Acoustics with a relevant degree or higher level qualification in engineering or physics/acoustics. Good verbal and written communication skills are essential and a flexible approach to working in multi-disciplinary project teams is important. Experience in environmental noise assessment, particularly in the transport sector, would be an advantage, but is not essential.

At ERM you will have the opportunity to realise your full potential and are encouraged to be entrepreneurial and innovative in delivering quality business solutions.

For further information about ERM, please visit our website www.erm.com

Please send applications to:
Steve Mitchell ERM, 8 Cavendish Square, London, W1G 0ER or
Email: steve.mitchell@erm.com

Closing Date: 2nd August 2004. *No Agencies Please.*

Delivering sustainable solutions in a more competitive world

ERM

Obituary

Anthony David Goodson MPhil FIOA

As a long-serving member of the Department of Electronic and Electrical Engineering at Loughborough University, David Goodson established himself by becoming a world authority on bio-acoustics. He crossed the divide between engineering and biology with such success that he was regularly invited to present his research at prestigious institutions around the world. This is all the more remarkable given that he was not formally an academic but an experimental officer who was not expected to do research at all, let alone initiate and lead international projects.

David, who was born on 3 July 1942, attended two schools on the Isle of Wight - Cowes Secondary School (1953-59) and Carisbrooke Grammar School (1959-61). The next phase of his education was at Shoreditch Teacher Training College, Surrey (1961-64) at the end of which he gained a London University Institute of Education Teacher's Certificate.

His first teaching post was at Harold Malley Technical Grammar School, Solihull (1964-67); he then took charge of engineering education at Loughborough College School (1967-73).

Next, during 1973-76, he worked as a broadcast video engineer with Ampex (GB) Ltd, becoming a Member of the Royal Television Society and serving as chairman of the RTS East Midland Centre, and as a member of the RTS Council.

David was appointed Experimental Officer at Loughborough University in 1977 and gained promotions on merit to Senior Experimental Officer in 1980 and Chief Experimental Officer in 1994. Initially, he worked with Professor Roy Griffiths on a variety of sonar signal processing and imaging systems, including the development of a high-power parametric sonar transmitter, which he tested in reservoirs in Derbyshire and in Loch Goile. His expertise on this work led to the award of the MPhil degree in 1990 for his thesis: *A multi-mode sonar transmitter*.

'David crossed the divide between engineering and biology'

From 1992, David worked with Professor Bryan Woodward and Professor Jim Cook on the design of a high-power phased array sonar transmitter for studying the structure of the sea-bed and for the detection and characterisation of objects buried on and under the sea-bed. The system was used for four major European Commission projects, *REBECCA* (under the MAST-II Programme), *DEO* and *SIGMA* (MAST-III Programme), and *ACUSTICA* (International Scientific Co-operation Programme). Later, he also worked on a constant-beamwidth sonar system for fish stock biomass assessment and species identification for the FRS Marine Laboratory, Aberdeen.

Gradually, David shifted his interests to bio-acoustics, becoming a member of both the European Cetacean Society and the European Association of Aquatic Mammals. His particular interest was the signal processing functions of biological sonar, which led to cross-disciplinary research, funded by the Conservation Foundation and the Racal Group, with the University of Cambridge, the University of Aberdeen, DERA Portland and Flamingoland Dolphinarium.

In 1991, Dr David Bellamy launched an international appeal, co-ordinated by Windsor Safari Park, for funds to support the joint Loughborough/Cambridge bio-acoustics research into the development of efficient warning devices to prevent the entrapment of dolphins and porpoises in fishing nets. This led to a series of sea trials in the Moray Firth during 1991-93 to study the effectiveness of passive acoustic net reflectors on wild bottlenose dolphins. A further sea trial, with the Hull Sea Fish Industry Authority, was to test acoustic reflectors on a commercial gill net.

From 1992, David co-wrote project proposals for funding by the Ministry of Agriculture Fisheries and Food, the Department of the Environment, the Danish Institute for Fisheries Research, and the European Commission. The EC proposals included two special study projects, followed by *CETASEL* (AIR-III Programme), then *EPIC* and *ADEPT*, all concerned with the by-catch theme.

In 1998 the Irish Seafish Board invited David to take part in yet another EC project to produce a prototype acoustic deterrent for use in pair pelagic trawling. The research carried out in all these projects led to a US Patent, with David as a co-inventor, on an acoustic 'pinger' for reducing the by-catch of porpoises in fishing nets; this is now marketed by Aquatec Ltd under licence to Loughborough University.

David was an enthusiastic author who contributed chapters to several books and papers for many international conference proceedings. He organised three Institute of Acoustics Symposia on Bio-sonar and Bio-acoustics at Loughborough University, and presented many invited lectures abroad, including to the US Office of Naval Research, the University of Kentucky, the German Navy Research Centre, Woods Hole Oceanographic Institution and the Indian Institute of Technology.

He was also invited to attend workshops by the US Marine Mammal Commission, the US National Marine Fisheries Service and the International Whaling Commission. As a result of his many years of bio-acoustics research he was elected Fellow of the Institute of Acoustics and was invited to serve as a committee member of the IOA Underwater Acoustics Group.

David was an excellent asset to Loughborough University, always cheerful and ever helpful to generations of students whose projects he supervised. He set a fine example of selflessness for others to follow and many people will miss him, both at Loughborough and around the world. He died on 13 January 2004, aged 61. We extend our condolences to David's wife Paula, and to all his family and friends.

Bryan Woodward FIOA

New group CEO for Casella

Ian Sparks has been appointed Chief Executive Officer of the Casella Group. He joins the environmental consultancy and manufacturer following completion of an aggressive acquisitions programme and subsequent consolidation into two divisions: consultancy (Professional and Technical Services); and equipment (Measurement Technology Services).

With his extensive general management and business building experience, Ian Sparks has a proven track record in business development, assisting companies to capitalise on their opportunities, creating and implementing strategies for growth. During the past eight years he has headed the European operation of an American real estate services giant, creating a highly profitable industry-leader with 65% market share.

Given the 'enormous potential', he says he is joining the Casella group at a most exciting time. He will be focusing on achieving real growth through a market-driven strategy taking advantage of the huge opportunities that exist.

Arup appointments

Rachel Capstick, who has joined Arup Acoustics, London, graduated from the Institute of Sound and Vibration Research at the University of Southampton in 1998. She then went on to complete an MA in Music, Science and Technology at Stanford University, California.

Rachel has studied room acoustics, sound perception, psychoacoustics, digital audio technology, music performance and computer programming and took for her undergraduate project 'An investigation into the impulse response of brass wind instruments using an impulse technique.'

She spent several years working for AuSIM Inc in California, becoming involved in a range of 3D Audio Simulation projects for mission critical applications. After returning to the UK she worked for two years on audio test and measurement applications at Prism Sound, Cambridge.

Following a temporary contract working on venue projects, **Julien Francois** has now taken up a full-time post with Arup Acoustics, Winchester. A French national, Julien graduated with a Master of Science Degree in Image and Sound Engineering, Brest (Brittany, France). Before coming to the UK he was a trainee in the acoustics group in Arup's Hong Kong office. With experience in sound recording, sound post-production, and video editing, Julien's main interests are movies and 3D animation with an emphasis on performance venues.

Institute Sponsor Members

Council of the Institute is pleased to acknowledge the valuable support of these organisations

Key Sponsors

Brüel & Kjær CASELLA CEL Cirrus Research plc

Sponsoring Organisations

Acoustic Air Technology Ltd

Acoustic Consultancy Services Ltd

AcSoft Ltd

AEARO

Allaway Acoustics Ltd

AMS Acoustics

A Proctor Group Ltd

Arup Acoustics

Bridgeplex Ltd (Soundcheck™)

BRE

Burgess - Manning Europe Ltd

Campbell Associates

Castle Group Ltd

Civil Aviation Authority

Eckel Noise Control Technologies

EMTEC Products Ltd

FaberMaunsell

Firespray International Ltd

Gracey & Associates

Greenwood Air Management Ltd

Hann Tucker Associates

Hodgson & Hodgson Group

Industrial Acoustics Company Ltd

LMS UK

Mason UK Limited

National Physical Laboratory

Rockfon Limited

Sandy Brown Associates

Shure Brothers Incorporated

Spectrum Acoustic Consultants

Titon Hardware Ltd

Wardle Storeys

Applications for Sponsor Membership of the Institute should be sent to the Institute office. Details of the benefits will be sent on request

Institute Diary 2004

1 July
Medals & Awards & Executive
St Albans

15 July
Council
St Albans

10 August
Diploma Moderators Meeting
St Albans

14-15 September
Underwater Acoustics Group Sonar Signal Processing
Loughborough

16 September
Underwater Acoustics Group Symposium on Bio-Sonar & Bioacoustics Systems
Loughborough

16 September
Membership
St Albans

23 September
Diploma Tutors & Examiners & Education
St Albans

30 September
Executive
St Albans

6-7 October
Autumn Conference

8-9 October
Reproduced Sound 20

14 October
Council
St Albans

19 October
Engineering Division
St Albans

20 October
Publications Committee
St Albans

26 October
Research Co-ordination
London

28 October
Membership
St Albans

9 November
CCENM Examiners & Committee

11 November
Meetings
St Albans

25 November
Medals & Awards & Executive
St Albans

7 December
CCWPNA Examiners & Committee
St Albans

9 December
Council
St Albans

ACOUSTICS BULLETIN ADVERTISING

To advertise in the Bulletin,or the annual Register of Members contact Dennis Baylis MIOA, on Tel/Fax 00 33 (0)5 62 70 99 25. His postal address is: Peypouquet, 32320 Montesquiou, France and his e-mail address is dbioa@hotmail.com

ADVERTISERS INDEX

Gracey & Associates
Noise and Vibration Instrument Hire

Gracey & Associates specialize in the hire of noise and vibration instruments

All analysers, microphones, accelerometers etc., are delivered with current calibration certificates, traceable to NPL.

Our Laboratory is ISO approved and audited by British Standards.

Many instruments available for dozens of applications

Engineers available to discuss applications

Next day delivery by overnight carrier

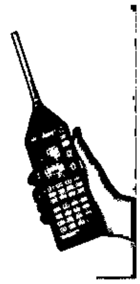
Established in 1972

Full details on our web site www.gracey.com

Gracey & Associates - 01933 624212
Chelveston, Northamptonshire NN9 6AS

Campbell Associates

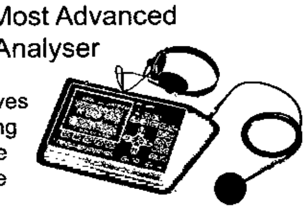
Norsonic
Sales Support and Calibration



Nor 118 Real Time Pocket Analyser

- Real Time 1/1 & 1/3 Octaves
- 120dB Dynamic range
- Parallel Reverberation Time Measurements
- Sound Power Measurements

Nor 121 The Worlds Most Advanced Environmental Noise Analyser



- Real Time 1/1 & 1/3 octaves
- Hard Disk Audio Recording
- Annyance Recorder mode most advanced of its type

GRAS Sound & Vibration
Measurement Microphones and Signal conditioning systems

Cadna A
Computer Aided Noise Abatement

State of the art in noise prediction software

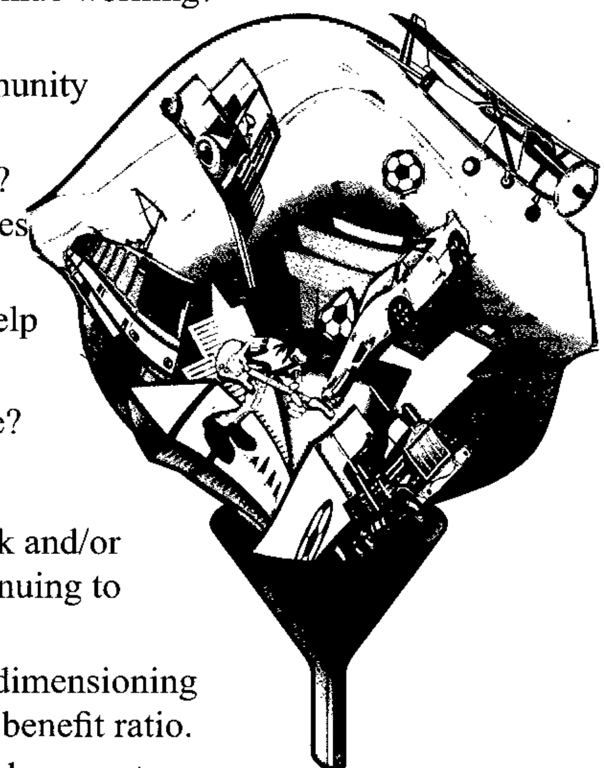
- User friendly
- Free reader licence and demonstration CD
- Regular training sessions for all levels of experience
- Full technical support

For Further details contact us on, Tel 01279 718898 Fax 01279 718963 info@campbell-associates.co.uk

SoundPLAN -one software for all environmental acoustic problems

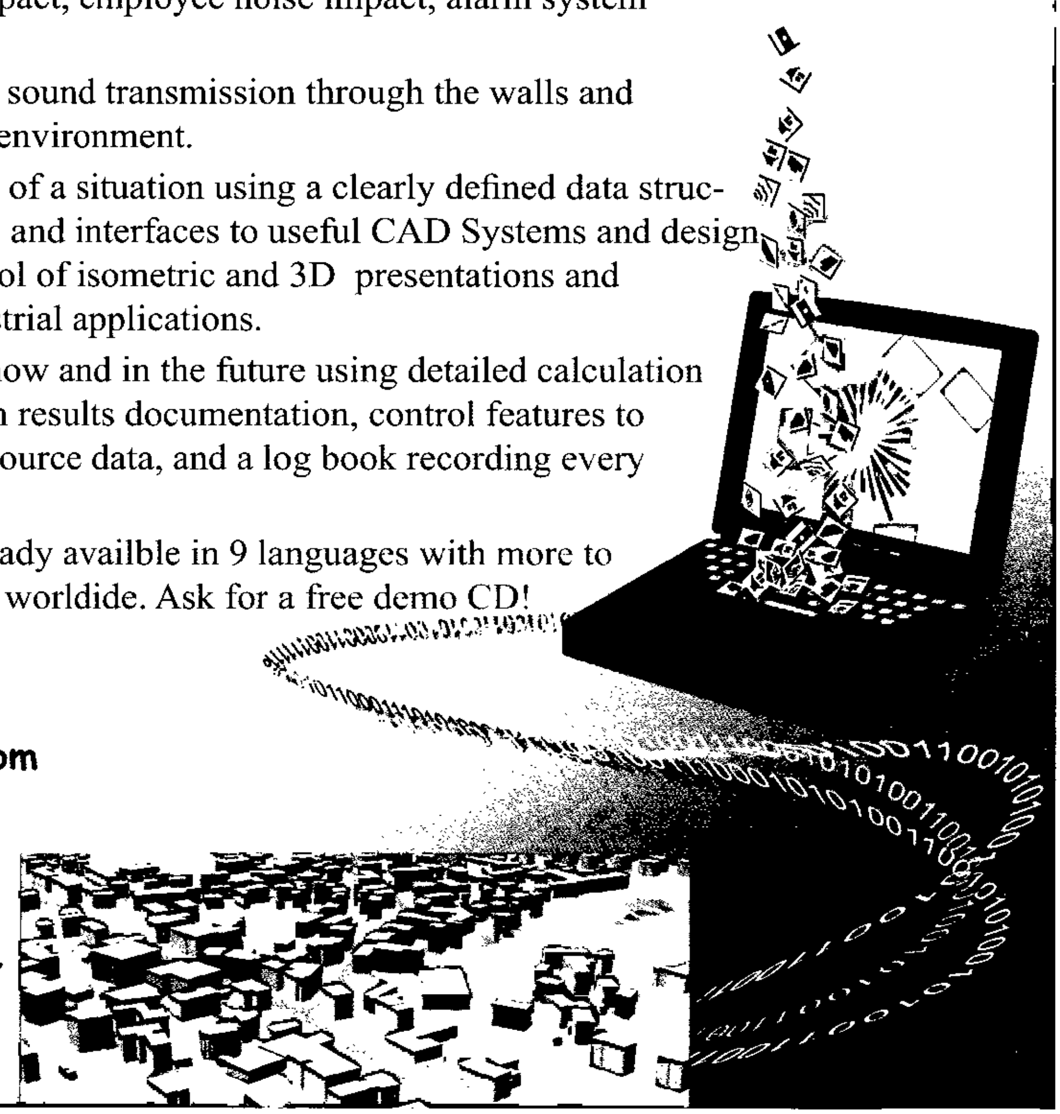
Do you have these kinds of questions:

- ❐ How can I efficiently map the transportation and industrial noise from an agglomeration? Can the software calculate in the background while I continue working? Can I use a PC network to distribute the calculations?
- ❐ What is the most cost effective method to minimize community noise?
- ❐ How loud is it inside a building? Which sounds dominate? Can the noise breakout be minimized with new doors, gates or window applications?
- ❐ Can I document my data sufficiently? Will the software help me comply with ISO 9000 quality control?
- ❐ Will I get the hotline support I might need in my language?



SoundPLAN has the answers!

- ✔ Analyze and map any size road, rail and air traffic network and/or industrial site. Calculate large models quickly while continuing to enter data. For even faster execution use a PC network.
- ✔ Develop noise reduction strategies using interactive wall dimensioning and an industrial expert system to find the optimal cost to benefit ratio.
- ✔ Target community noise impact, employee noise impact, alarm system design, etc.
- ✔ Model interior noise levels, sound transmission through the walls and sound propagation into the environment.
- ✔ Produce multiple variations of a situation using a clearly defined data structure optimized for planners, and interfaces to useful CAD Systems and design programs, with visual control of isometric and 3D presentations and extensive libraries for industrial applications.
- ✔ Trace and repeat past jobs now and in the future using detailed calculation execution protocol, in-depth results documentation, control features to verify input geometry and source data, and a log book recording every calculation.
- ✔ Software and service is already availble in 9 languages with more to follow. Distributors located worldide. Ask for a free demo CD!



Contact information:

David Winterbottom
Drwint@btopenworld.com
TD&I
7 Pownall Crescent
Colchester
Essex CO2 7RG; U.K.
Tel: +44 1206 762617
www.soundplan.com