THE BULLETIN

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AUSTRALIAN ACOUSTICAL SOCIETY

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NEWS & NOTES

1975 AAS CONFERENCE "PLANNING FOR NOISE"

A very successful 1975 Conference was held at the Hydro Majestic Hotel, Medlow Bath from Friday 19th to Sunday 21st September.

More than 120 delegates registered for the technical sessions and over 180 booked into the Hotel to enjoy a weekend in the beautiful Blue Mountains.

The opening session "Planning for Noise" was presented by Tom Uren, Minister for Urban and Regional Development, and established the theme for the Conference by describing the Department's activities and particularly its approaches to the various aspects of development planning.

The technical sessions which followed generated strong interest from the delegates and the panel format of the sessions encouraged considerable discussion and comment.

It was quite apparent, at the end of several sessions dealing with more controversial subjects, that many delegates still had much more to discuss. If it had not been for the Conference Committee's firm control, those sessions may still be going strong!

Financially, the Conference was quite a success. The profit of around $1100.00 will go towards the Tenth ICA to be held in Sydney in 1980.

All delegates received copies of keynote papers prior to the Conference. Transcripts of Session 10, the summing up by Convenors of the previous technical sessions are currently in preparation and a copy will be forwarded to each delegate.

NEW DIVISION OF THE SOCIETY

A noteworthy event since the previous issue of the Bulletin that will be of interest to all members was the meeting held in South Australia. Its purpose was to consider the formation of a division of the Society in that State.

Little news of the discussions has come through since the meeting but it is expected that the move to establish a South Australian Division will proceed apace.

VICTORIAN DIVISION NOTES

Victorian Division Technical Meetings are now well summarized in an excellent Newsletter edited by Richard Schurmann. The Newsletter also gives details of other items of interest such as the Audio Engineering Society, E.P.A. Noise Control Branch and the Noise Abatement Group.

In May, Dr. Murray Littlejohn of Melbourne University Zoology Department spoke about some aspects of communication between frogs and between crickets. Allocation of broadcasting frequencies and time-sharing are concepts as old as frogs apparently.

Jim Bryant et al gave a very comprehensive coverage of the statistical description of noise at the June meeting and in August Paul Rossiter and Greg Cambrell from Monash University spoke on loudspeaker design, including the design of a new electrostatically actuated cylindrical radiator (see also previous edition of The Bulletin).

Included in the Victorian Division Newsletter is a letter from Dr. R.G. Barden (Chairman, Acoustics Committees, Standards Association of Australia) which, for obviour reasons, should receive a wider distribution than the Newsletter can achieve:

It is fairly widely known that Bob Mearns has recently been replaced as Engineer/Secretary of the Acoustics Committees of the Standards Association of Australia by Mr. R. Nagarajan, of the

Sydney Office.

I am quite sure that all the members of the Society would wish Bob Mearns well in his new duties, and make due acknowledgement of the part that Bob played in the work of the many Technical Committees and Working Groups of the Acoustics Section of recent times. His activity in contributing to standards and legislative documents was primarily made during a most important formative period for the work in acoustics.

I wish to express to Bob Mearns my sincere thanks for his devoted effort and substantial contribution to the work on acoustics. All will join me in wishing him an interesting and successful future.

R.G.B.

END OF YEAR DINNER DANCE

The N.S.W. Division will hold a Dinner Dance on the evening of 29th November at the Ryde-Parramatta Golf Club, Victoria Road, West Ryde.

The evening should be a fitting and most enjoyable culmination to the year's social and technical activities.

Sherry will be served at 7.30 p.m. followed by a tasty smorgasbord dinner at 8.00 p.m. Dancing will go to 1.00 a.m. to the music of a specially selected four piece band. Price: $8.50 each.

Full details and application forms will be circulated soon. For further information, phone Phil Williams, (259 4066).

VISIT TO THE QANTAS ENGINE TEST CELL

On the evening of July 22nd, a party of about 30 Society members and friends visited the QANTAS engine-testing installation at Mascot. Under the genial and knowledgeable guidance of Bob Bennett and Bill Bourke, we were given a verbal introduction to the acoustical precautions associated with engine testing and flying, and then crossed a dubious tributary of the Alexandra dranage canal to inspect the newest and largest of the QANTAS test cells which is devoted to testing engines for Boeing 747's after their maintenance.

Because this test cell had to be built outside the airport boundary, it came within the jurisdiction of the Local Council, who gave it only a 3-month conditional approval, subject to proof that its operation would not add materially to the noise load of residents. As the cost of construction was around $2 million, there was obviously strong pressure upon those responsible for the acoustic design to get their sums right first time and it was gratifying to learn that they had been abundantly successful.

In some ways it was a pity that the party was not able to observe the spectacle of an engine actually running, but this minor disappointment was amply compensated for by our being able to enter the test area and pass through to gaze up at the few stars showing between the splitter stacks, where the work of exhaust-noise absorption is done, without having our eyes defocused by the sound pressure or being baked in the slow oven temperature (275°F) of the exhaust gases.

All the visitors joined in a cordial vote of thanks to our hosts for an entertaining and informative evening.

Dennis Gibbings

ERGONOMICS SOCIETY

The Ergonomics Society of Australia and New Zealand has expressed its interest in the work of the Australian Acoustical Society in that the interests of our members commonly border on those of members of that Society.

The aims of the Ergonomics Society are:

1. To promote learning and research into the relationship between man, his occupation and his environment.
2. To promote the use of the human sciences and engineering knowledge to solve problems arising from the relationship.

The Society issues a newsletter in March, June, September and December of each year. Any interested person who wishes to receive the newsletters is invited to write to the editor, Dr. W.H. Gladstones of the Psychology Department, Australian National University, Canberra, A.C.T., 2600. Telephone (062) 49 2814.

VIBRATION AND NOISE PANEL

A Vibration and Noise Panel has been formed by the National Committee on Applied Mechanics of the Institution of Engineers, Australia, with the promotion of the science and practice of the engineering control and investigation of vibration and noise as its objective.

The panel published an inaugural issue of a newsletter in July. The newsletter explained that attainment of its objective would be sought through the organisation of conferences and symposia and by the dissemination of information. The latter activity will be carried out in part by the newsletter which is intended to appear twice yearly. The inaugural issue includes a calendar of events in the spheres of vibration and noise through to VANCE-76, the vibration and noise control engineering conference to be held in Sydney on 11th-12th October 1976. The Society's 1975 conference, "Planning for Noise" is, of course, listed in the calendar, and the newsletter states its intention to provide news on the activities of AAS as well as on those of other organisations such as SAA, NATA and ISO.

This first issue of the newsletter includes an invitation for interested people to register with the Editorial Office (The Department of Mechanical Engineering, Monash University, Clayton, Victoria, 3168) to ensure that they receive future copies. They are further invited to write to the editor with suggestions concerning the scope of the newsletter, and to provide news and material they consider may be of interest to readers.

LEGAL ASPECTS OF THE N.S.W. NOISE CONTROL LEGISLATION

Leslie Katz, lecturer in Law at Sydney University spoke about some of the shortcomings of the N.S.W. Noise Control Act at a meeting of the Acoustical Society held at the University of N.S.W. on the 19th August, 1975.

Although the N.S.W. Noise Control Act was passed with the concurrence of the opposition, the manner in which it was guillotined through the House has raised the question of whether the Government or the Opposition really understand the problems or the ramifications of the problems.

Mr. Katz's main criticisms of the Act were:

(1) No absolute noise limits have been set and this means that the Act lacks 'teeth'.

(2) There is an ad hoc approach to industry whereby a noise maker may continue until he is 'caught up with'.

(3) Licensing of noise premises does not aid the Noise Control concept.

(4) Noise Control Notices are issued for one year. This together with right of appeal virtually means no enforcement. However, they will provide revenue source.

(5) Articles prohibited from sale are not defined by level in the Act. Manufacturer planning is therefore difficult.

(6) Why should appeals go to a District Court? They could better be directed to a specialised body like an Expert Appeals Tribunal.

(7) The existence of the Noise Advisory Committee in no way guarantees that full consideration will be given to a problem.

The fact that there is no other legislation in Australia comparable to this Act (other than the Australian Design Rules for Noise Emission ADR 28) means that the concept is in a 'trial' stage and it will be dependent on acceptance, modification and patience for its success. The whole subject of noise legislation would be much more readily enforceable if it had become part of the National Legislature.

I.J. LAWRENCE

SYMPOSIUM

More than fifty people attended a symposium entitled "Noise Measurement and Assessment in Buildings" which was held at the University of New South Wales on 18 and 19 June 1975.

The symposium was preceded by an Introductory School which consisted of lectures, demonstrations and tutorials on Introductory Acoustics and Audiology presented by Professor Pollard (School of Physics), Mrs. B. Skurr (Prince of

Wales Hospital) and Mr. R. Caddy (University of N.S.W.).

The first session of the Symposium comprised lectures on the Acoustic Environment, Sources of Noise, Airborne Sound Transmission and Measurement of Sound Attenuation given by Professor A. Lawrence, Dr. J. Dunlop, Mrs. M. Burgess (University of N.S.W.) and Mr. E.T. Weston (E.B.S.). A buffet dinner followed, to which members of the Acoustical Society were invited and an interesting talk entitled "The Do-It-Yourself Noise Divorce Kit", was given by Dr. F. Fricke (University of Sydney). The symposium continued on Thursday morning with two lectures on Structure-Borne Noise by Dr. K. Byrne (University of N.S.W.) and a discussion on the Interpretation of Specifications and Ratings in Building Codes by Professor A. Lawrence. A Laboratory and Field Measurement Session was held during the afternoon and there was sufficient time for discussion of many of the aspects of noise measurement and assessment introduced during the Symposium.

THERMAL COMFORT ANALOGY FOR ENVIRONMENTAL ACOUSTICS

Fergus Fricke

It is a common misconception that if the impact of noise on the environment is to be assessed, all that needs to be done is to measure one decibel level. I have found that a thermal comfort analogy is useful in explaining why it is not just a matter of pointing a soundlevel meter in the right direction and taking a reading; that there are far more factors than just the intensity of a sound which influence the noise caused by it.

Most people are familiar with the concepts of hot and cold. They are also familiar with the fact that the weather, their clothing, house and activity all affect their thermal comfort. Further, they are aware that various factors such as temperature and humidity, cloud cover, windspeed etc., and the rate of change of these variables all affect their comfort.

In the thermal analogy, sound pressure level is equated to air temperature. Thus, if we quote one temperature reading for a month, or even the average temperature for a month, it will not be an accurate measure of how often we feel hot or cold throughout the month. A much better measure is the maximum and minimum daily temperatures though a continuous record of air temperature would be even better.

To be even more accurate, we need to specify humidity, windspeed and radiant temperature but even these measures will help very little in predicting thermal comfort if we don't know anything about activity, clothing and the building (it may be air-conditioned or it may be poorly insulated) unless the humidity is 100% and the air temperature is above body temperature (condition analogous to sounds that will cause deafness).

The acoustic equivalents to these various factors are, I think, fairly obvious and do not need to be spelled out. Once they are pointed out to persons not familiar with acoustics, a better understanding of the difficulties involved in specifying environmental noise levels and their effects usually results.

CONFERENCE & SYMPOSIUM ANNOUNCEMENTS

AUSTRALIAN ASSOCIATION OF SPEECH AND HEARING

The New South Wales Branch of the Australian Association of Speech and Hearing (A.A.S.H.), formerly the Australian College of Speech Therapists, has extended an invitation to attend the first Annual Convention to be held in Sydney from 5th to 9th July, 1976.

The Central Theme for the Convention will be "Auditory Aspects of Speech and Language". Papers presented will cover recent developments in this and closely related fields.

The Conference will be held in the Boulevard Hotel, Sydney, and associated activities will include a trade exhibition and an extensive social and tour programme.

Further details may be obtained from:

The Secretariat,
A.A.S.H. Convention,
P.O. Box 391,
DARLINGHURST N.S.W. 2010

9th INTERNATIONAL CONGRESS ON ACOUSTICS

The 9th ICA, encompassing all branches of acoustics, will be held in MADRID from 4th to 9th July, 1977. Satellite Symposia are planned for BARCELONA (1st-2nd July) and SEVILLA (11th-12th July).

The technical sessions and equipment exhibition will be held at the "Palacio de Congresos y Exposiciones" located in the central area of Madrid, close to major hotel facilities.

Further information regarding the Congress may be obtained by writing to:

SOCIEDAD ESPANOLA DE ACUSTICA - IX ICA
c/ Serrano, 144
MADRID - 6, SPAIN

NOTICE OF SYMPOSIUM ON ROAD TRAFFIC NOISE

A Symposium on Road Traffic Noise (jointly sponsored by the Australian Acoustical Society and Murdoch University) will be held at Murdoch University, Western Australia on November 12th, 1975.

There will be two sessions, the first chaired by Professor D.C. O'Connor and the second by Mr. J. Spillman.

Registration fee is $10.00, which includes morning and afternoon tea and lunch as well.

Further information can be obtained from Mr. Spillman on Perth 41 2814.

VIBRATION AND NOISE CONTROL ENGINEERING

- Conference and Workshop

Sydney, October 11 - 12, 1976

Call for Papers

A Conference and Workshop on Vibration and Noise Control Engineering will be held in Sydney on October 11-12, 1976. It will be organised as a National Conference of the I.E. Aust. National Committee on Applied Mechanics and should be of interest and value to practising engineers and architects.

Contributions are invited on subjects in both vibration and noise and particularly in the interface area concerning the relationship between vibration and noise.

Papers will be selected to cover the following broad areas:

- Vibration and noise generation and transmission
- Sources of noise in machinery and buildings
- Design of products, equipment and structures to reduce noise and vibration
- Mountings and treatment to reduce

vibration and noise

- Protection of humans from excessive vibration and noise
- Measurement and analysis of vibration and noise
- Statutory limits and criteria for noise and vibration
- Ground vibration
- Calibration of vibration and noise measuring instruments
- Vibration and acoustic testing

Two types of paper are invited. For *conference* sessions papers are invited on new research, investigations and developments. For *workshop* sessions, shorter contributions are invited on case histories, procedures, techniques, problems and their solutions. In the selection of contributions for presentation and in the general organisation of the programme, emphasis will be on applications for the practising engineer and architect.

Prospective contributors are invited to submit brief summaries by November 30, 1975. These should be accompanied by a statement of the author's intention to attend the Conference. Authors of contributions provisionally accepted by the Organising Committee will then be asked to submit their full text by May 31, 1976.

The following deadlines should be noted:

Receipt of synopses
- November 30, 1975

Notification to authors of provisional acceptance of papers
- February 21, 1976

Receipt of full text for final review
- May 31, 1976

All correspondence should be addressed to:

Vibration and Noise Control Engineering,
The Institution of Engineers, Australia,
157 Gloucester Street,
SYDNEY N.S.W. 2000

BULLETIN PUBLICATION DEADLINES

Members and persons interested in the Society and acoustics are invited to submit items for publication in forthcoming Bulletins: technical articles, shorter technical notes, brief reports on current research, news of members' and Divisions' activities, letters, or any items of general interest to members.

Contributions should be forwarded to "The Bulletin, Australian Acoustical Society, c/o Science House, 157 Gloucester Street, Sydney, 2000".

Acceptance deadlines for publication are as follows:

	Vol. 3, No. 3	Vol. 4, No. 1
Full Technical Articles	5th Dec., 1975	6th Feb., 1976
Other Shorter Items	26th Dec., 1975	27th Feb., 1976

LETTER TO THE EDITOR

The Editorial Subcommittee invites letters on subjects which are of general interest to members of the Society. Letters which stimulate discussion or further comment from other members would be particularly welcomed. Letters should be addressed to "The Bulletin, Australian Acoustical Society, c/o Science House, 157 Gloucester St., Sydney, 2000"

Dear Sir,

The following items of acoustic equipment were stolen from the University of Sydney in June this year:

Nagra Tape Recorder Type 111B S/N 656569

Revox A78 Stereo Amplifier S/N G 16726

Revox A77 4 track recorder series 1224 S/N G090853

Reed Equaliser and 2.5 ft^3 speaker enclosures

B & K Sound Level Calibrator Type 4230 S/N 298349

Phillips PM 3110 Oscilloscope S/N 1629

B & K Sound Level Meter Type 2205 S/N 239747

B & K F.M. Tape Recorder S/N 212752

B & K Probe Microphone Set Type UA 0040

B & K 1" Microphone S/N 235838

B & K $^1/_8$" Microphone S/N 513192

B & K ¼" Microphone S/N 513192

B & K ½" Microphone S/N 97747

B & K 1" Microphone S/N 389482

B & K ½" Cathode follower S/N 236861

B & K 1" Cathode follower S/N 438089

AKG D224C Microphones S/N 8386 and 8628

Hewlett Packard Calculator HP35 S/N 1302A 92416

and many other smaller items.

Should any of your readers know the whereabouts of this equipment, or any item of it, I would be very pleased to hear from them.

Yours faithfully,

FERGUS FRICKE
Department of Architectural Science,
University of Sydney N.S.W. 2006

Telephone: 02 660 8490

STANDARDS REPORT

STANDARDS ASSOCIATION OF AUSTRALIA

R. NAGARAJAN

Engineer - Secretary
Standards Association of
Australia

The Association's work on acoustics standards continued to develop during the last year. The Association's Acoustics Committees held about 15 meetings during the year, published two standards, issued three documents for public comment and dealt with thirty projects. These activities are summarised briefly below:

Standards Published

AS 1633-1974, Glossary of Acoustical Terms
AS 1270-1975, Hearing Protection Devices

Public Review Documents Issued

DR 74163, Draft Code for Building Siting and Construction Against Aircraft Noise
DR 75060, Method of Normal Incidence Sound Absorption Coefficient and Specific Normal Acoustic Impedance of Acoustic Materials by the Tube Method
DR 75075, Method for Measurement for the Determination of Motor Vehicle Noise Emission

Draft Documents Issued for Limited Comment

Doc. AK/4/75-3, Method for Field Measurement of the Airborne Sound Isolation Provided by Building Elements

Stages of Projects in Hand

NOTE: The numbers used to indicate the stage of projects have the significance indicated hereunder:

1. Investigation and preliminary work
2. Committee drafting
3. Draft issued for public review
4. Review of comment
5. Postal ballot and final stages
6. In course of publication

Asterisks indicate new activities during the year

Pressure calibration of microphones by the reciprocity technique 5

Measurement of airborne noise emitted by rotating electrical machinery 6

Precision sound level meter for the measurement of impulsive sounds 5

Measurement of airborne noise emitted by air compressors 3

Code of practice for hearing conservation 5

Motor vehicle noise 3

Pure tone audiometer for advanced audiological use 2

Measurement of noise on board vessels 4

Measurement of noise emitted by vessels on inland waterways and harbours. 4

Test methods for air duct sound attenuators 6

Additional requirements for a precision sound level meter 4

Aircraft noise and building insulation 4

Noise annoyance in commercial areas 2

Noise annoyance in industrial areas 2

Guidance for the use of sound level meters 2

Speech audiometers 5

Background noise levels for audiometer rooms 2

Field measurement of airborne sound insulation provided by building elements 4

Laboratory measurement of airborne sound transmission loss of building partitions 5

Method of rating sound insulation of building's 3

*Design criteria for ambient sound levels 2

*Measurement and rating of sound insulation for building envelopes 1

*Measurement of normal incidence sound absorption coefficient and specific normal acoustic impedance of acoustic materials by the tube method 3

Noise from agricultural machines and earth moving equipment 2

*Calibration devices for checking sound level meters 2

*Amendments to 1055 2

*Tape Recorders for acoustic purposes 1

*Plumbing noise 1

*Measurement of reverberation and absorption in rooms 1

*Ceiling sound attenuation test by two room method 1

Active liaison was maintained with the relevant technical committees of the International Organisation for Standardization (ISO) and International Electrotechnical Commission (IEC). Liaison was also maintained with the Acoustics Sub-committees of National Health and Medical Research Council, Canberra, A.C.T.

This year witnessed considerable increase in interest on standards in acoustics from all sections of government, industry and general public and the Association's standards and in certain cases even draft documents have been utilised by government departments and regulatory bodies to provide the technical basis of regulations in this field. The Association is currently examining a number of requests for preparation of new standards.

The Association's programme on Acoustics Standards is being coordinated by the Acoustics Standards Committee, with Dr. R.G. Barden, Chairman and Mr. H.V. Taylor, Deputy Chairman. This Standards Committee is being assisted by the following six technical committees:

COMMITTEE DESIGNATION	CHAIRMAN
AK/1, Glossary of Terms	Mr. A.K. Connor
AK/2, Instrumentation	Mr. R.A. Piesse
AK/3, Hearing Conservation	Dr. R. Neil Reilly
AK/4, Architectural Acoustics	Dr. C. Mather
AK/5, Community Noise	Assoc. Prof. A. Lawrence
AK/6, Aircraft Noise	Dr. R. Willis
AK/7, Engineering Acoustics	Mr. R.B. King

The work of the above technical committees are assisted by a number of Sub-committees and working groups.

The Association acknowledges gratefully the assistance received from Australian Acoustical Society and its members, many of whom have directly and indirectly contributed to this important work.

THE AUTHORS

DR. C.E. MATHER

Dr. Carolyn Mather is the recently-elected President of the Australian Acoustical Society, and is a distinguished figure in Australian acoustics. Her formal qualifications, B.Arch., M.Bldg.Sc., and Ph.D., were obtained at Sydney University. Her present position is Investigating Architect with the Public Works Department of Western Australia. She is also considerably involved in other activities in acoustics which include: Chairperson of the Standards Association of Australia AK/4 Committee on Architectural Acoustics, Member of AK/5 Committee on Community Noise, Member of the W.A.Noise Abatement Advisory Committee. Carolyn is also a recipient of a Churchill Fellowship and past Chairperson of the W.A. Division of the Australian Acoustical Society.

W.L.J. BURKE

Bill Burke is a Development Engineer with Qantas Airways Ltd. He is engaged in technical evaluations of aircraft relating to performance and environmental impact, including noise, sonic booms, and the effects of engine emissions at tropospheric and stratospheric altitudes. He participates as a company representative on the noise abatement committees of several Australian airports, including Kingsford-Smith and at international aviation meetings on aircraft environmental matters.

THE SITING AND CONSTRUCTION OF BUILDINGS AGAINST AIRCRAFT NOISE INTRUSION

C.E. Mather

SUMMARY

The Standards Association of Australia has recently issued as a draft for public review a code of recommended practice entitled 'Building Siting and Construction Against Aircraft Noise Intrusion'. This code is directed to organisations and persons associated with urban planning and building production and maintenance, and provides guidelines on the location and construction of new buildings and on the acoustical adequacy of existing buildings in areas near airports. This paper provides a summary and explanation of the draft code, which should be published as a code of recommended practice before the end of 1975.

1. AN OVERVIEW OF THE CODE

The code is divided into two distinct sections; one relates to the siting of buildings and the other to the construction of buildings required to reduce the intrusion of aircraft noise to generally acceptable levels. The section on siting expands and further defines the broad recommendations contained in the land use compatibility table in the Department of Transport's Appendix A to its Noise Exposure Forecast maps. The section on construction indicates the extent of noise reduction required of the building's envelope and gives a technique for selecting the construction necessary to achieve this reduction, together with some examples of building components and their predicted aircraft noise attenuation values.

The code commences by recommending when its application should be considered. This recommendation is in terms of distance and airport category, as follows:

- within a 16 km radius of an international airport,
- within a 13 km radius of a main domestic airport or major military airbase,
- within a 5 km radius of a secondary domestic airport, and
- within a 3 km radius of any other type of civil or military airport.

The airports are categorised to the types of aircraft operating from them, and their associated radii are based on known and predicted noise levels for these aircraft.

To determine a building site's acceptability (throughout the code building site, by definition, includes existing buildings as well as proposed sites), a copy of the relevant NEF map or, if this is unavailable, a locality map of the airport and its environs must be obtained. From the NEF map the location of the site relative to the NEF contours is ascertained. Next, the building type or activities that are being, or will be, accommodated are entered into a table and, depending on which contour the building site lies within, the degree of its acceptability is read off (see table 1 which gives values for two examples; educational

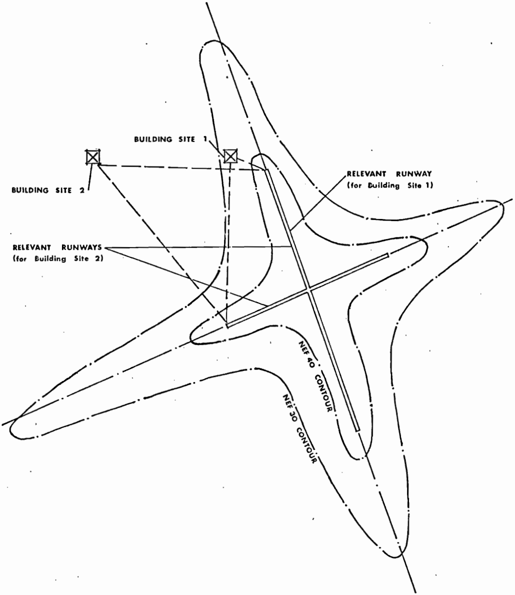

Fig. 1. Determination of Relevant Runways.

and residential buildings). Except for certain buildings and activities which require a high degree of acoustic protection, for example studios and auditoria, sites lying outside the NEF 25 contour are generally classed as "clearly acceptable", whilst those lying within the NEF 40 contour are classed as "clearly unacceptable". Exceptions to the latter are those building sites and activities which require only negligible or minimal protection against aircraft noise, for example foundries and steel and timber mills.

When no NEF map is available, the building type or activities being, or to be, accommodated is still determined and the site assessed in terms of the extent of noise reduction necessary.

For "normally acceptable", "normally unacceptable" and "clearly unacceptable" building sites, the extent of noise reduction and type of construction required may be determined from the second part of the code; however it is recommended that new construction should never be considered for clearly unacceptable sites.

To determine the amount of noise reduction and type of construction necessary for a given building, the maximum aircraft noise level to which its site is likely to be exposed must be ascertained. This is done firstly by selecting the relevant airport and associated aircraft types, secondly, using the NEF or locality map and a survey map of the area, by calculating the distance and elevation of the building site relative to the airport's runway(s) (see figure 1 for an example), and lastly, using this information in conjunction with a set of noise level tables, by reading off the maximum noise levels (in dB(A) units) for take-off and landing movements. The higher of these two values is selected for design purposes.

Next the indoor design sound level (in dB(A)) appropriate to the building or activity type under consideration is selected (see table 1 for example), and subtracted from the maximum aircraft noise level determined previously to obtain the amount of noise reduction required.

To assess the types of construction necessary to provide this noise reduction, each space within the building with differing requirements is considered separately. The building's constructional components are divided into four categories - ceilings, external walls, windows and external doors, and the attenuation required of each component to achieve the desired noise reduction is assessed from the formula:

$$ANA = NR + 10 \log_{10} (Sc/Sf \cdot 3/h \cdot 2TN)$$

where

- ANA = aircraft noise attenuation (dB(A))
- NR = required noise reduction
- Sc = area of component under consideration
- Sf = area of floor of space under consideration
- h = height of space
- T = reverberation time of space
- N = number of component categories in space

Now the appropriate component type can be selected using Sound Transmission Class or Sound Reduction Index data, examples of which are included in the code. These indices were found to give a good approximation to the component's aircraft noise attenuation for the movements of several aircraft types, and can be adjusted to give a good approximation for the remaining aircraft types included in the code.

2. SOME ASPECTS OF DATA ACQUISITION AND REDUCTION

2.1 The Aircraft Noise Level Tables

These tables, used to determine the average maximum aircraft noise levels in dB(A) to which a building site is likely to be exposed, were compiled using derived curves of noise level versus slant height (SH) and superimposing these on plots of actual noise levels measured around Sydney's and Melbourne's International Airports. The derived curves were determined using averaged aircraft noise spectra, measured at the smallest slant height and corrected to zero slant height and an A-weighted spectrum. These spectra were then corrected for attenuation caused by distance and by air absorption (20 dB per tenfold increase for the former and the SAE atmospheric absorption coefficients for the latter). Average relative humidity, dry bulb temperature and wind conditions were used in the calculations

TABLE 1

SITE AND NOISE REDUCTION ASSESSMENT FOR BUILDINGS

(two examples only)

Building Space/Type and Activity/Event	Indoor Design Sound Level dBA (See Note 1)	Site Acceptability (See Clause 4.5) in relation to NEF contours			
		Clearly Acceptable	Normally Acceptable	Normally Unacceptable	Clearly Unacceptable
EDUCATIONAL BUILDINGS					
1. Schools, Universities, Lecture, Class, Tutorial, Seminar, Laboratory Teaching and Music areas	50	Less than 25	25 - 30	-	Greater than 30
Gymnasia, workshops	85				
Libraries, Study Areas, Assembly Halls, Common Rooms	55				
RESIDENTIAL BUILDINGS					
1. Homes (houses, home units, old people's homes), relaxing, sleeping	55	Less than 25	25 - 30	30 - 40	Greater than 40
Normal domestic	60				
2. Flats, hostels, residential halls, barracks	65	Less than 30			Greater than 40
Relaxing, sleeping	60				
3. Hotels, Motels relaxing, sleeping Dining, drinking, social gatherings	60	Less than 30	30 - 40		Greater than 40
Food preparation	70				
Public areas, service activities	75				

to obtain generalised take-off profiles, and hence only the average maximum noise from a particular aircraft type can be predicted from the tables.

The actual noise levels, in dB(A) maximum units (see Section 2.2), were obtained using the ten monitoring terminals around Sydney's International Airport. (Up to 2000 noise levels per aircraft type per terminal were obtained.) As the position and elevation of the monitoring terminals are known accurately, the average slant height for each aircraft type at each terminal could be calculated, using generalised take-off profiles and the standard 3° glide slope. For each aircraft type, the noise levels in dB(A) were plotted against the logarithm of the slant height for take-off and landing, the appropriate derived noise level curve was superimposed at the position of best fit, and the point at which the derived distance attenuation curve cut each graph's vertical or noise level axis was recorded. (This point was log SH = 2 for landing and log SH = 3 for take-off movements.)

The effects of ground attenuation and shielding were taken into account when they became significant (i.e. at angles greater than 15°), and all this information was then combined in a computer programme designed to calculate noise levels for any ground position for each aircraft type and movement. For ease of application, the programme tabulated the noise levels in terms of centre - and sideline distances. (The centreline distance used for take-off movements is that distance from the further end of the relevant runway to the building site, measured along the centreline of the runway - DT. The centreline distance used for landing movements is that distance from the nearer end of the relevant runway to the building site - DL. Sideline distance is the perpendicular distance from the extended runway centreline to the building site - DS.)

Correction factors, to be applied to the centreline distances when the building site is 10 metres or more above or below the airport, were compiled using

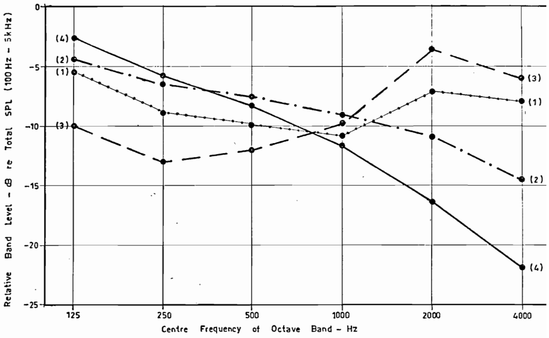

Fig. 2. Aircraft Noise Spectra Measured at NEF 33 Contour.

generalised take-off profiles and the 3° landing glide slope to compute the amount by which these distances would have to be reduced or increased to give the actual slant height.

2.2 The Indoor Design Sound Levels

The indoor design sound levels are in dB(A) maximum units and were selected in terms of levels that would be unlikely to be regarded as intrusive or annoying when heard inside a building by the average person. Because they represent absolute maxima of a very short duration, these levels exceed those recommended for broad band noise of much longer duration, for example the recommendations contained in AS 1055 'Noise Assessment in Residential Areas'. The selection of the indoor design sound levels was based on some overseas research into the intrusiveness of aircraft signals as well as on Australian experience and, because of their novelty, they may be subject to significant review following their application during the code's public review period.

2.3 Aircraft Noise Attenuation by Building Components

The A-weighted attenuation of aircraft noise by building components was determined using a computer to simulate the extent of attenuation to averaged aircraft noise by a number of components as received in a hypothetical room with the appropriate amount of absorption. The averaged aircraft noise was derived by summing the aircraft noise energy received, as calculated (during 1970) at a number of points on the NEF 33 contour about Sydney's International Airport. The values so obtained were not instantaneous spectra, but spectra of the maximum levels that a NEF 33 contour point would receive during a flyover. The spectra are documented as the sound pressure level in each frequency band in respect to the overall sound pressure level summed over these bands, (100 to 5000 Hz; see figure 2).

As mentioned previously, the STC and Ia provide a close numerical approximation to a component's A-weighted aircraft noise attenuation for the movements of certain aircraft types. These types have a spectrum shape of Curve 1 (see figure 2), which approximates pink noise. Curves 2, 3 and 4 represent three spectra in which the balance of low and high frequencies is sufficiently different from that of pink noise for the dB(A) reductions of many building components to differ significantly, (by 3 dB(A) or more), from the STC and Ia ratings. Therefore, correction factors of +3 for international jets landing, -3 for international jets taking-off and -6 for domestic jets taking-off are applied. These factors were calculated from values averaged over 104 building components with a wide range of transmission losses (STC 33-35 up to STC 57-59). Applying these corrections, the error in using STC and Ia values was reduced to less than 3 dB(A) for most components.

3. CONCLUSIONS

The draft code of recommended practice, "Building Siting and Construction Against Aircraft Noise Intrusion" should provide valuable design information for planning authorities, developers and architects despite the small range of conditions under which it has been tested so far. Its relevance to existing communities near future airports and to future trends in environmental standards is still in doubt, but until such time as data may be obtained to modify that on which the code is based, this aspect cannot be refined further. Meanwhile, it is anticipated that when the draft is published as a code of recommended practice it will provide the best and most concise method of compatibility assessment presently available to meet Australian conditions.

THE NOISE IMPACT OF AIRCRAFT OPERATIONS AT SYDNEY AIRPORT *

W.L.J. BOURKE

SUMMARY

Operation of today's airports highlights the complex problems associated with the integration of large numbers of people and mass transportation systems in an efficient and smooth manner. However, an increasing awareness of environmental quality has led to further problems concerning the health and welfare of the airport community exposed to this operation - the incompatibility of airport and community due to aircraft noise exposure and pollution by-products of engine combustion is a well known problem.

This paper looks at the influence of environmental impact of air transportation on the community, using Sydney (Kingsford-Smith) Airport as a good illustrative but also very relevant example. It outlines something of its activity, analyses its impact on the community and its response, and describes operational procedures and design techniques which have been developed to help minimise this impact.

THE AIRPORT AND ITS LOCATION

Sydney Airport is Australia's leading airport for both international and domestic air traffic. Located on the northern shores of Botany Bay, the airport covers approximately 1,800 acres. The cross runway configuration consists of a 13,000 ft north-south runway and an 8,300 ft east-west runway. Densely populated areas are located under approach paths to these runways in the northern, eastern and western sectors - nearly 600,000 people presently reside within a 5 mile radius. The airport is therefore impacted by close-in communities, a situation which has led to a serious noise problem.

AIRPORT ACTIVITY

This is directly related to passenger traffic demand, but modified by the carrying capacity of aircraft types and the need for acceptable airline schedules. Figures 1 and 2 present the historical trends in passenger movements and aircraft movements respectively, at Sydney Airport. Since late 1964, when jet aircraft were first introduced by the domestic airlines, domestic passenger traffic growth has averaged 10% per year, with a slump in 1971 due to an economic recession that year. On the other hand, international passengers have increased at an average 17.4% per annum. Domestic aircraft movements have averaged 4 to 5% growth during this period. International movements up to 1970 have increased at an average rate of 14%, but have tapered off

*Paper first presented at the National Convention of the Society of Automotive Engineers - Australasia, November 1974.

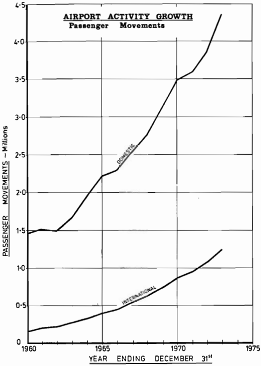

Fig. 1. Airport activity growth. Passenger movements.

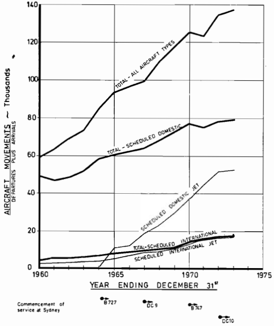

Fig. 2. Airport activity growth. Aircraft movements.

to less than 10% per annum since the introduction of wide-bodied aircraft.

To illustrate the influence of aircraft capacity on airport activity, the average number of passengers per aircraft movement reveals interesting figures. In 1960 the domestic fleet consisted predominantly of Lockheed Electra (80 seats) and Viscount aircraft (40 to 50 seats). The international fleets comprised short-bodied versions of the B707 and DC8 aircraft (100 seats). At that time the average number of passengers per movement were 30 and 33 - domestic and international respectively.

Today's domestic DC9 (95 seats) and B727 (130-150 seats) aircraft have increased this ratio to 55 passengers. The influence of the wide-bodied B747/DC10 jets (250-370 seats) has increased the international ratio to 74 passengers per movement. At least 30% of today's international movements are by wide-bodied aircraft. One can expect that, as more and more wide-bodied aircraft operate into Sydney Airport, there will be further upward trends in this ratio contributing towards a lower growth rate in future aircraft movements.

Figure 2 further illustrates the growth in jet aircraft activity at Sydney Airport. This has now reached significant proportions, and was approximately 51% for the year 1973. The downward trend in movements in 1973 was due to the airport technicians' strike in the one-month period September/October which

TABLE 1 - ESTIMATED AVERAGE DAILY LTO CYCLES BY AIRCRAFT TYPE

Aircraft Type	No. of LTO Cycles
VC10/B707/DC8	18
B747	5
DC10	3
B727-100/200	29
DC9	46
F27	46
DC4 - Piston Transport	2
Executive Jet	2
General Aviation	
- Single Engine	23
- Twin Engine	23
TOTAL	197

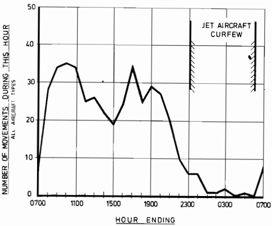

Fig. 3. Airport activity. Hourly usage.

seriously disrupted airline services, leading to virtual closure before the industrial dispute was settled. The other 49% of movements were mainly domestic turbo prop (F27 Friendship) and general aviation aircraft.

Department of Transport statistics have been analysed to determine the average daily mix of aircraft types operating at the airport. Table 1 indicates the results of this analysis expressed in numbers of landing/take-off cycles (LTOs) per day, by aircraft type. Out of a total of 197 LTOs it is significant to note that nearly 25% are associated with general aviation. Obviously during peak periods of activity, Easter and Christmas/New Year, total daily movement rates associated with scheduled services will increase above this average figure. During the Easter periods, for example, total LTOs increase up to nearly 250 per day on some days.

Airport activity is not constant throughout the day. Figure 3 illustrates the variation in the rate of aircraft movements per hour for one day in July 1974 - this distribution is considered reasonably representative of present normal daily operation. A definite pattern of activity is evident - peak movement rates occur during early morning and late evening hours. Activity is very low during the jet curfew from 2300-0600 hours. The reason for this pattern is, first the need for domestic airline schedules to respond to business market demand in the morning and evening hours. Secondly, many international flights are scheduled to arrive after the Sydney curfew - in addition arriving and departing flights have to meet scheduling requirements at overseas airports, either due to noise curfews or commercially acceptable arrival and departure times.

Sydney's activity, however, is relatively low in comparison with major international airports overseas - refer to Table 2 for 1973 annual figures.

Sydney's jet aircraft movements are considerably lower than the 80-90% proportion of total activity at these overseas airports, thereby contributing to smaller environmental impact, by comparison. In general, the influence of wide-bodied aircraft on activity growth now being seen at Sydney has also been in evidence overseas for a couple of years now.

In a later section the noise exposure from aircraft operations is discussed. However, before doing so it is important to discuss here the mode of operation of the airport, i.e. how each runway is utilised, as this has a significant influence on the distribution of noise exposure. Figure 4 illustrates the runway utilisation for the 137,221 movements for the year 1973. As mentioned later, this is a direct result of the preferential runway noise abatement policy adopted by the D.O.T. and administered by its Air Traffic Controllers. It is important to note here that 83% of all take-offs were routed over Botany Bay - in general, for a given noise level, more residential area is exposed to take-off noise rather than landing noise. For all operations

TABLE 2 - AIRPORT STATISTICS 1973

Airport	Aircraft Movements	Remarks
Sydney	137,221	All types, take-off and landings
London - Heathrow	268,200	
Paris - Orly	203,300	"
Frankfurt	202,500	"
Chicago - O'Hare	278,728	Scheduled airline traffic - departures only
Los Angeles International	146,330	
New York - J.F. Kennedy	114,343	"
San Francisco International	117,558	"

Note: U.S. airport statistics - U.S. Air Transport Association

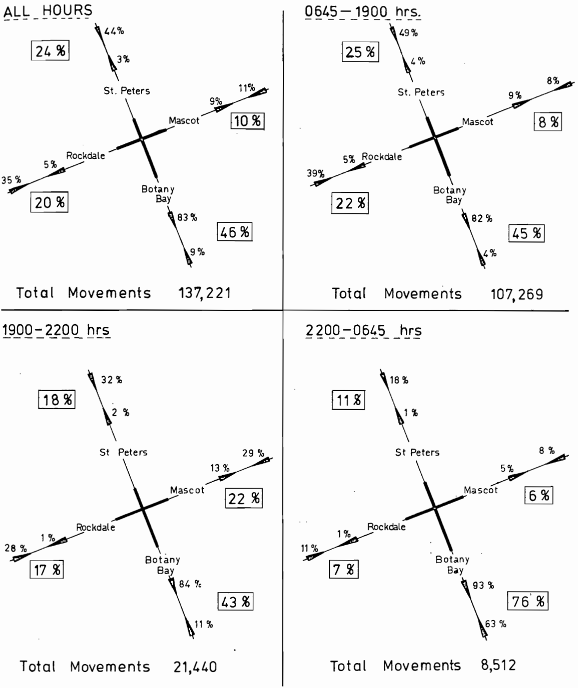

Fig. 4. Airport mode of operation - 1973. Runway utilization.

Botany Bay is exposed to the most movements, a total of 46%. These figures have been averaged over the full 12 months of 1973, and account for the airport daily weather patterns and any other factors that influenced the airport's operation. For example, during the winter months strong westerly winds will result in short periods of many take-off overflights of the Rockdale area to the west - the same will occur in the northern sector when strong north/north-easterly winds are blowing.

NOISE EXPOSURE FROM AIRCRAFT OPERATIONS AT SYDNEY AIRPORT

Suitable Noise Units

Social surveys investigating airport community annoyance to aircraft noise have determined its response to be very complex, being influenced by many parameters. In addition to the noise factor, socio-economic factors which influence airport resident attitudes are found to be very important. Notwithstanding this, significant technological research and development has been undertaken to reduce the noise at its source - the engine. To enable a scientific approach to noise reduction, noise units that provide a valid prediction of human annoyance have had to be developed. Serious research into this field commenced in the late 1950's - incentive for this research was brought about by increasing adverse community reaction with the introduction, at that time, of the early subsonic B707 and DC8 aircraft.

Noise generated by an aircraft's jet engines is very complex (refer to Figure 5). Its frequency spectrum is broadband. The jet exhaust roar is predominantly low frequency, and whine from the fan stages and rotating turbo machinery (compressor and turbine stages) produces some low frequency, but mostly mid to high frequency sound above 1000 Hz. Tonal spikes are also generated by the newer high bypass ratio large diameter fan engines - these spikes correspond to a fundamental frequency, equal to the product of the number of blades and the stage rotational speed, and subsequent harmonics. Variation with engine power of each component's contribution to the overall sound pressure level further complicates the picture.

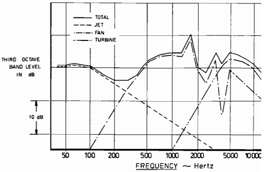

Fig. 5. Jet engine noise sources. Hig by-pass fan engine at take-off power (unsuppressed).

Due to its complex nature more sophisticated units have been developed to describe aircraft noise. Researchers have conducted laboratory experiments with large numbers of persons to determine what parameters influence personal judgement of noisiness or annoyance, and to what extent. These have been shown to be sound pressure level, frequency spectrum, tonal spikes and duration of the noise when above a threshold level. From the statistically averaged results of these tests the perceived noise decibel PNdB unit was evolved to analyse the noise in bandwidths and weight each bandwidth according to its intensity and frequency - the higher frequencies were found to be perceived as more annoying, or "unwanted". An increase of 10 PNdB is generally considered to represent a doubling of annoyance.

The next stage of development was the EPNdB, effective perceived noise level unit, which is essentially a further refinement of the PNdB unit. It accounts for the additional parameters of duration and the obtrusiveness of tonal spikes. This unit is presently used as the basis of aircraft noise measurement for achieving certification levels. It has international status and represents the state-of-the-art in annoyance prediction.

In discussing noise exposure at Sydney Airport, however, we have to talk in terms of some unit which describes the total noise exposure from many aircraft flyovers, not just a single take-off or landing. One of the recommendations of the Australian House of Representatives Select Committee on Aircraft Noise in its October 1970 Report was to adopt the U.S. Noise Exposure

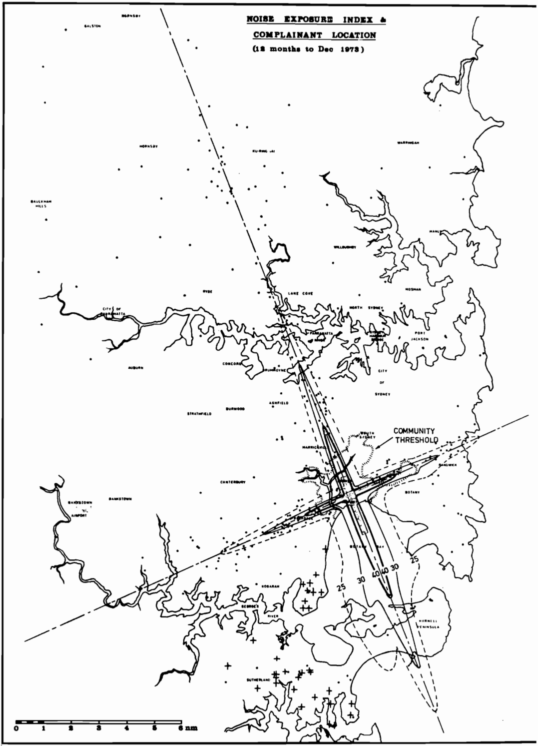

Fig. 6. Noise Exposure Index and Complaint Location.

Forecast (NEF) system for describing noise exposure. This is based upon the EPNdB unit and is an equal energy summation of noise allowing for:

- take-off and landing procedures and flight paths
- average daily number of aircraft movements
- mix of aircraft movements by aircraft types
- average daily runway utilisation
- noise level contours for each flyover
- weighting of noise levels for time of day (i.e. day or night)

Aircraft Noise Contours

Late last year, the Department of Transport released a Noise Exposure Index (NEI) based upon aircraft operations at Sydney Airport for the 12 months ending December 31st, 1973. The Noise Exposure contours are illustrated in Figure 6, overplotted on the airport and surrounding suburbs. Examination of these contours highlights some interesting observations:

- The general shape of the contours is a 4-pointed star reflecting the cross-runway configuration and its associated flight paths.
- The broadness of the contours over Botany Bay is indicative of the 83% of all take-offs being routed over that sector. Narrow contours in the other directions indicate predominance of landing operations. Quite conclusively, the NEI illustrates the reason for confining take-offs to the south, as significantly more areas of community would have been exposed to aircraft otherwise.
- The Southern sector contours illustrate complicated shapes - the reasons for this shall become clearer when the noise abatement departuer procedures in operation have been discussed.

Community Reaction to Sydney Airport Noise

The U.S. NEF system has been used in social surveys around several major U.S. airports to correlate community reaction with airport noise. The ranges of response (Cohen 1971) from these surveys have been quite wide, as can be judged from Table 3.

This wide variation in response highlights the important influence of socio-economic factors which can lead to difficulties in identifying patterns of response when just the noise alone is considered in isolation.

TABLE 3 - COMMUNITY RESPONSE

NEF Level	Range of Response
25	No complaints to Anti-Noise Group activity
30	Some complaints to legal action
40	Anti-Noise Group activity to legal action

At present, there is no substantiative data available on community reaction to aircraft operations at Sydney Airport. Until a comprehensive social survey has been conducted the results of overseas studies can only be read across as an indication of the likely community annoyance. An examination of recorded complaints does, however, give some measure of this in addition to indicating the effectiveness of noise abatement procedures established. Figure 6 has been overplotted with the location of complaints (dots and crosses) who registered objections to aircraft operations during the 12 months ending December, 1973. Total complaints registered amounted to 477 for 1973, a significant reduction below the 606 of the previous year. This trend continued in 1974 when total complaints further reduced to 298. Complaints against engine ground running associated with airline maintenance activities have not been plotted - these constitute less than 10% of total complaints and are located mostly within a 3 nautical mile radius of the airport.

A detailed analysis of these complaints brings to light some interesting behavioural patterns:

- The northern sector is by far the most vocal area with 40% of total complaints - the area of complaints extends far out into the Upper North Shore suburbs.
- Operations from the east/west runway (mostly landings) produced a total of 42%, 15% in the eastern and 27% in the western sectors.
- The 18% proportion in the southern sector was unduly high. As explained later, noise abatement departure procedures have been designed to avoid the communities in these areas.

However, during the airport technicians strike in September/October 1973, these procedures had to be abandoned as certain navigational aids became unserviceable and were not rectified. Abnormal overflights of areas such as Brighton, Ramsgate and Cronulla occurred with subsequent predictable community response - indicated by the crosses on Figure 6.

- Location of complainant in relation to the airport follows interesting patterns. Although there is a trend towards these being located along runway flight paths, there are also significant numbers in areas outside the NEI contours, in areas of low noise exposure. This tends to support theories that socio-economic factors such as economic status, educational status, numbers of years of residence in the area, health, distance from the airport, etc., need to be quantified to improve correlation with community response.

Strong patterns are, therefore, evident in Figure 6. It can be said, however, that complaints are "the tip of the iceberg", there being many more people who are just as annoyed, but for a variety of reasons do not register a complaint either by letter or telephone call to the Department of Transport, Airport Director, Local Member or Federal Minister for Transport. The results of a social survey planned for the Sydney Airport community are eagerly awaited and will hopefully provide much more insight into these matters.

INDUSTRY EFFORTS TO REDUCE AIRPORT NOISE

Aircraft Noise Monitoring

It is now possible to monitor aircraft noise levels within the community. In September 1973, the Department installed a Hewlett-Packard noise monitoring system, in compliance with another recommendation of the House of Representatives Select Committee on Aircraft Noise. The actual locations of the 11 permanent sites are plotted on the map in Figure 8. Each site consists of a microphone located at the top of a mast with an associated amplifier and noise level to frequency conversion unit attached. Each unit monitors continually on a 24 hour basis and transmits flyover noise levels when above a set threshold level (the background level for each site so as to exclude extraneous noises) over standard telephone cable to the central processing unit at the Kyeemagh Operations Centre. An on-line computer records the maximum noise level of a flyover in dBA units and the time of day. Data from the airport control tower flight cards identifying aircraft type, movement, runway used together with meteorological data is stored on tape for use on the off-line computer. A correlating programme then matches noise event and aircraft movement.

The system was commissioned in 1974 and provides valuable information by monitoring noise levels and the effectiveness of noise abatement procedures. A very useful by-product of the correlating computer programme is its ability to provide daily statistics of the airport's operation - leading to the sort of data illustrated in Figures 3 and 4 and Table 1.

Engine Noise Reduction Technology

An engineering solution is proving the most effective means of reducing aircraft noise, i.e. a solution at the source, the engine. Knowledge of the mechanisms of noise generation and reasonably accurate units for predicting annoyance have led to the development of effective noise reduction technology. Indicative of industry effort is the US$100 million spent by the Boeing Company on R & D programmes during recent years. Today we have visible or auditory evidence of this with the new wide-bodied aircraft now operating into Sydney Airport in increasing numbers. These aircraft meet

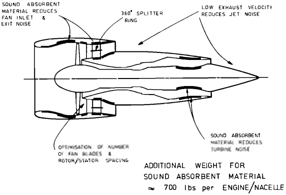

Fig. 7. P & WA JT9D high by-pass fan engine. Noise reduction features.

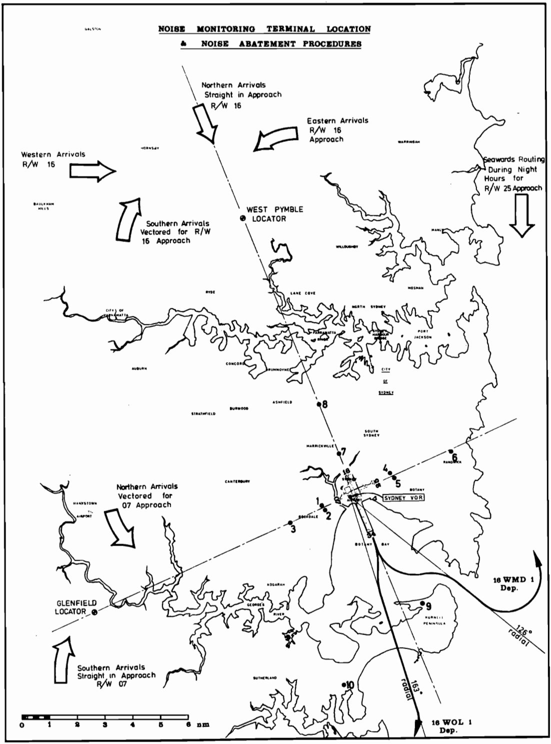

Fig. 8. Noise Monitoring Terminal Location and Noise Abatement Procedures.

stringent noise level requirements laid down by the U.S. Federal Aviation Administration (FAA) and the International Civil Aviation Organization (ICAO) as a normal part of certification. Such requirements reflect present technological and economic feasibility and are aimed at descalation of the airport noise problem. As further technological progresses are made these certification limits will be lowered so as to ensure subsequent generations of aircraft are quieter. Most recent data from aircraft manufacturers suggest the following lowering of the current FAA and ICAO noise limits is technologically feasible:

- 7 EPNdB for take-off
- 4 EPNdB for approach
- 13 EPNdB for sideline

To illustrate the sort of design techniques and hardware developed to reduce engine noise, Figure 7 presents features incorporated in the Pratt and Whitney Aircraft JT9D high by-pass fan engine that powers the B747 aircraft. In the first place, the by-pass thermodynamic cycle develops thrust by increasing the momentum of larger masses of air compared to the pure jet cycle. This results in lower exhaust jet velocities. As the intensity of the jet roar varies as the eighth power of the relative jet velocity, a significant reduction in noise has been achieved. Jet noise from the JT9D engine of up to 50,000 lbs thrust is, in fact, quieter than the 20,000 lbs thrust JT3D engine of the B707 aircraft.

Additional noise suppression material has been incorporated to quieten the high frequency tones generated by the front fan, compressor and turbine stages. This material consists of perforated sheets with an internal honeycomb structure - each cavity acts as an acoustic resonator which dampens the sound pressure level of selected frequencies to which the material is tuned. Adequate treatment area is provided by nacelle inlet and exhaust duct walls and also external engine case walls. Additional area is provided by a concentric ring in the fan exit duct. Generation of high frequency noise has been further suppressed by elimination of inlet guide vanes and selection of the optimum number of blades and the separation distance between rotor and stator stages.

Noise Abatement Operational Procedures

Due to airport activity growth and the impact of densely populated areas close to Sydney Airport, the Department of Transport has developed noise abatement operational procedures to ease the noise problem. Essentially, these either divert aircraft around noise sensitive areas or, where this is not possible, ensure that aircraft maintain adequate altitude or operate at lower engine powers. It is important to emphasise here that at all times during such procedures the following factors are fully recognised:

- the responsibility of the pilot to conduct the flight in accordance with mandatory safe flight standards is retained;
- the procedures do not result in degradation of flight safety;
- the procedures do not require above average piloting skill or result in excessive pilot work load.

As indicated previously, a preferential runway use system in the interests of reducing community noise exposure is currently in operation at the airport, and has been so for some years now. The success of the system is evident from the statistics presented in Figure 4. Briefly, Air Traffic Control applies preferred runway directions for departing and arriving aircraft during three periods throughout the day. Over-riding conditions which may preclude its use are:

- adequate runway length not available in the preferred direction;
- unserviceability of radar and instrument approach aids;
- cloud base and visibility less than 2,000 ft and 4 nm respectively;

TABLE 4 - PREFERRED RUNWAYS

Order of Preference	Departures 1st	Departures 2nd	Departures Eq.3rd	Arrivals 1st	Arrivals 2nd	Arrivals Eq.3rd
Period						
1600 - 1900 hours	16	07	25 & 34	Straight-in-approach		
1900 - 2100 hours	16	07	25 & 34	34	25	07 & 16
2100 - 2300 hours	16	07	25 & 34	34	25	07 & 16

- runway cross wind and/or tail wind component exceeds 15 knots and 5 knots respectively. These limits are for dry runways only and include gusts. For wet runways the limits are (including gusts) 10 knots crosswind and any tailwind component;
- Air Traffic Control requirements to sequence departing and arriving aircraft in an efficient and expedient manner during peak activity periods.

Table 4 sets out the runway preferences for the three time periods. Each runway direction is indicated on Figure 8. The 1900-2100 hour period is a transitional period between the daylight and evening hour preferences. The transition from evening to the daylight preference is usually applied at 0645 hours. The Sydney Airport Noise Abatement Committee (set up at the recommendation of the House of Representatives Select Committee and comprising representatives of the Department of Transport, Airlines, Pilots' Federation, Local Councils, Local Government and State Planning Authority) has examined these procedures and determined their effectiveness in providing noise abatement.

Figure 8 further illustrates Standard Instrument Departures (SID's) which were first introduced at Sydney Airport in September, 1972. With the combination of four possible departure directions and numerous airway routings from Sydney, a total of 73 SID's are available. Not all of these are solely for noise abatement - the two shown on Figure 8 are, however, designed to reduce community annoyance. The residential areas of Cronulla and Kurnell are located (potentially) beneath the flight path of aircraft departing from Runway 16. To avoid these noise sensitive areas aircraft need to be guided over the sandhills between Cronulla and Kurnell or through Botany Bay heads. The installation of a navigational aid, Visual Omni Range (VOR) located at the airport provides radial radio beams for this precision tracking.

To illustrate the SID concept, the following describes the procedures illustrated in Figure 8. Prior to take-off, the Captain of an aircraft proceeding to Melbourne receives an airways clearance, together with a particular SID, to intersect the airway route, in this case "16 Wollongong One Departure". This means that after take-off, the aircraft is to maintain runway heading (approx. 160 degrees magnetic) until 800 ft altitude, then execute right, then left turns to track along the 163° Sydney VOR radial over the sandhills. This heading is to be maintained until the aircraft is 8 nm from the airport before a right turn is made to intersect the 195° Sydney VOR radial airway route to Melbourne. The occurrence of overflights of the Cronulla area is, therefore, significantly reduced.

A Brisbane-bound aircraft would receive a "16 Maitland One Departure" instruction. As soon as possible after reaching 500 ft altitude the aircraft is required to make left, then right turns to track via the 126° Sydney VOR radial through the heads. At a point 6 nm from the airport, a left turn is then permitted before proceeding north via West Maitland near Newcastle.

Preferred procedures and arrival flight paths are in use subject to weather and Air Traffic Control requirements. Examples of these are:

- Seaward routings are flown during night hours for aircraft arriving from the north and south and landing on Runway 25.
- Aircraft are normally kept at 3,000 ft altitude until they are aligned with the runways at the Glenfield and West Pymble locators.
- Landing gear and full landing flap extension are delayed until about 5 nm from touchdown when approaching runways 16 and 07. This reduces engine power requirements and hence noise levels by up to 10 dB in the far-out communities.

A curfew on the operation of jet aircraft between 2300 and 0600 hours is at present in force. Exceptions to this curfew are permitted for operational safety reasons, scheduled flights delayed en route by unforecast headwinds, and use of Sydney as an alternate when Melbourne Airport is not available due to fog, say.

Ground running of engines in-frame for maintenance purposes between 2100 and 0700 hours is also subject to Department of Transport regulations.

FUTURE ENVIRONMENTAL IMPACT

The question of how aircraft operations at Kingsford-Smith Airport will impact in the future, is inextricably bound up with the future of the airport itself. There has been considerable discussion for and against the retention of the airport in its present form, proposals to extend or reduce its capacity or even to re-locate Sydney's air transportation at another site. The final decisions on this matter will no doubt be made after continuing joint studies by airport planning consultants and the Commonwealth State Committee responsible for planning Sydney's future aviation requirements, have been completed.

However, in a technical paper of this nature it is considered pertinent to list here some factors which it is believed possess potential for reducing noise exposure in the future.

- There will be an increase in domestic and international airline fleet composition of the current advanced technology wide-bodied aircraft. These offer today reductions in noise exposure compared to the older DC9, B727-100, B707 and DC8 aircraft. It is forecast that by 1980 wide-bodied aircraft will have increased to 90% of all international movements. This will offset forecast passenger traffic growth with lower LTO activity growth.
- Reduction of the US FAA and ICAO noise certification limits, as advances in noise suppression technology occur, will produce future generations of aircraft quieter than today's B747 and DC10 aircraft.
- Extension of Sydney Airport's runway capacity by the building of a second parallel north-south runway has possibilities. With a length of 9 to 10,000 feet, suitable for both domestic and international aircraft, the new runway threshold could be located near General Holmes Drive and extend out into Botany Bay. With a 200 foot runway width and surface grooving, the new runway's characteristics could be improved to provide acceptable operational standards under wet and high crosswind conditions. It could therefore be possible, with this new runway, to reduce operations on the east-west runway to a minimum. Aircraft would operate only when extremely high crosswinds precluded operation in a north-south direction or that runway was unavailable for some other reason, e.g. runway works. As complaints from the Rockdale and Botany areas totalled a significant 42% of all 1973 complaints, restricted use of the east-west runway could offer considerable noise relief in those areas. The airport development proposed here would result in an increase in the number of arrivals over the northern suburbs. The opportunity to land on the new runway with its threshold displaced about 1.3 nm from the existing runway 16 threshold, would result in aircraft being higher above the community during approach and therefore quieter. This reduction in noise level could assist in offsetting the increase in number of overflights.

CONCLUSIONS

Airport activity and close-in densely populated residential areas have caused incompatibility between Sydney Airport and its surrounding community. To ease the problem a night curfew on jet operations is rigidly enforced. Noise abatement procedures are in use to shed take-off noise over Botany Bay, divert departures around noise sensitive communities, maintain arriving aircraft above minimum altitudes, and reduce engine powers during approach.

Large capacity wide-bodied aircraft incorporating noise suppression technology are currently in operation. These aircraft provide significant relief to the community. Future generations will have to meet more stringent noise certification standards.

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