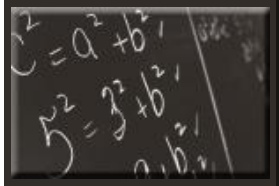
Back to Basics - Speech Intelligibility in Courts & Tribunals

Mark Hanson

The Tribunal of Tomorrow - 7&8 June 2012

ICE Design
Integrated Communication Environments

COAT
COUNCIL OF AUSTRALASIAN TRIBUNALS



h-panel

Court & tribunal room acoustics

- Courts & Tribunal rooms have some of the most stringent acoustic requirements of all venues

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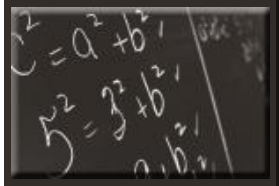

h-panel

Why are tribunal room acoustics so complex?

- Multiple communication paths
- Orientation of talkers
- Articulation of talkers: skilled/unskilled, nervous, language
- Complexity of spoken information
- Aesthetics, heritage
- Remote site video and teleconfencing
- Noise (incl. in-court technology)

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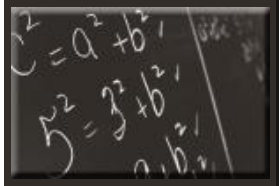

h-panel

Room Acoustics for Different Purposes



- Open Plan Office
  - Face to face communication only
  - Controlled or ‘dead’ sounding space
  - Quiet environment (but not too quiet)

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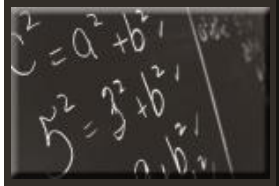
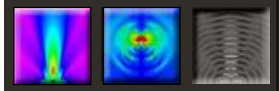


h-panel



Room Acoustics for Different Purposes



- Courtroom / Tribunal Room (Speech)
  - Communication with all present
  - Natural sounding speech
  - Relatively ‘dead’ sounding space
  - Good clarity
  - Quiet environment

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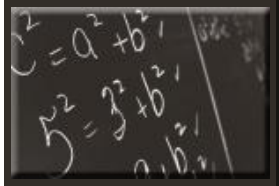

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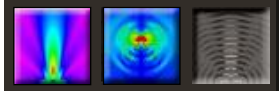

Room Acoustics for Different Purposes



- Concert Hall
  - ‘Live’ sounding space
  - Gives a sense of warmth to music
  - Envelopment
  - Quiet environment

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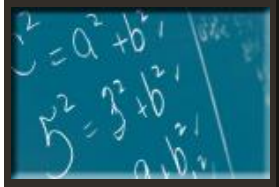

theory

Designing for Speech Communication

- Excellent speech intelligibility
- Natural sounding speech
- Distraction free (for speaker & listener)
- Quiet background noise
- Minimise acoustic fatigue
- “Acoustic Comfort”
  - Prolonged concentration period
  - Increased productivity

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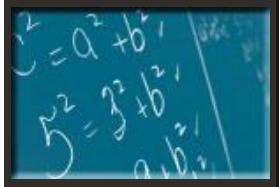

theory

Speech Intelligibility & Acoustic Comfort

- Speech to noise ratio
- Temporal response
- Frequency response
- Localisation

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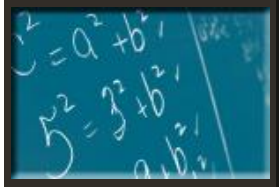

theory

Speech to noise ratio

- Building services noise
- Occupational noise
- Reverberant energy
- Room acoustics to naturally enhance sound
- Sound reinforcement system to artificially enhance

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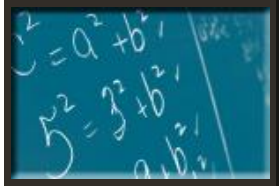
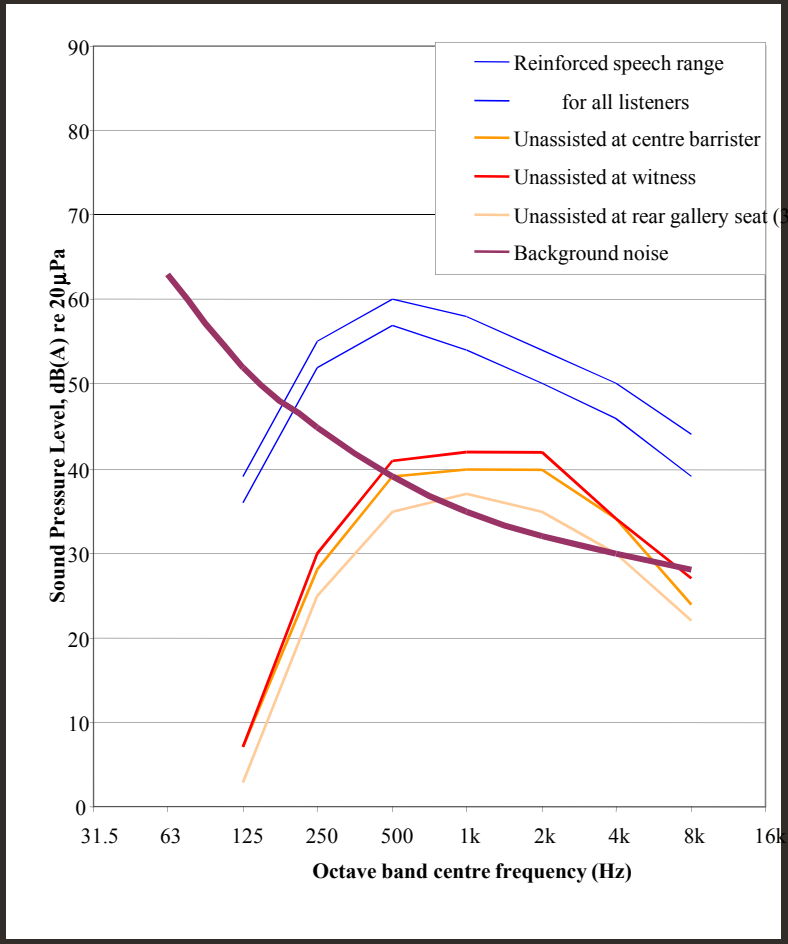


theory

Speech to noise ratio

- Background noise (40dBA not uncommon)
- Unassisted Speech
- Speech reinforced



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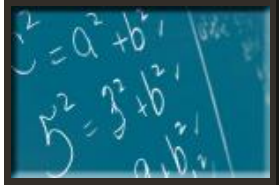
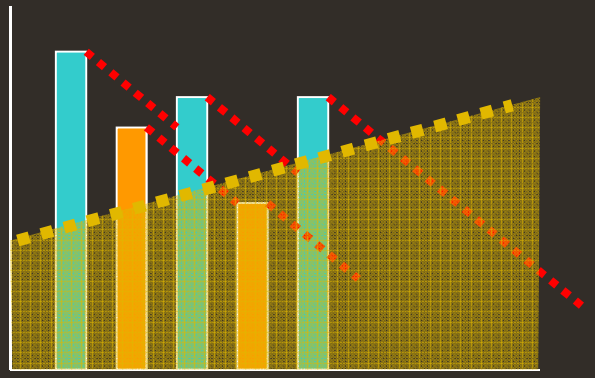


theory

Impact of noise on Speech Intelligibility



- Railway Station

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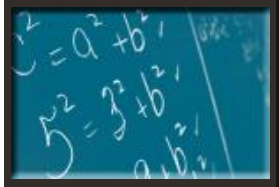
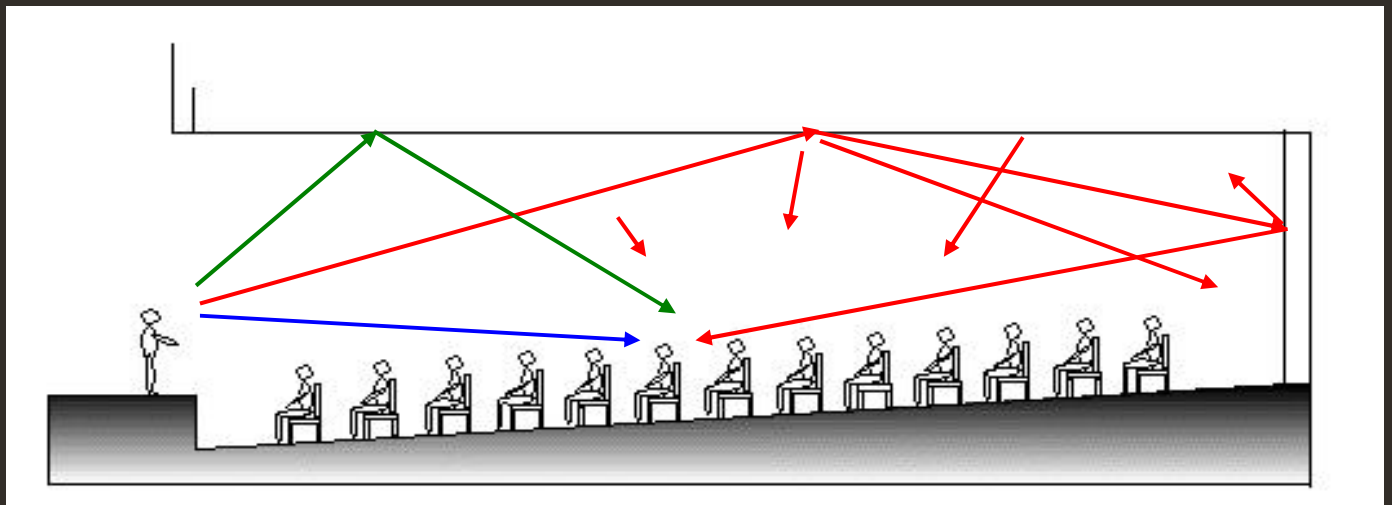


theory

Temporal Response

- Early arriving to late arriving energy
  - ie useful to detrimental energy



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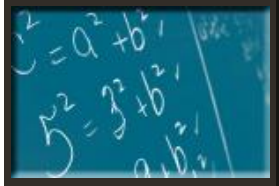

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Temporal Response

- Early arriving to late arriving energy
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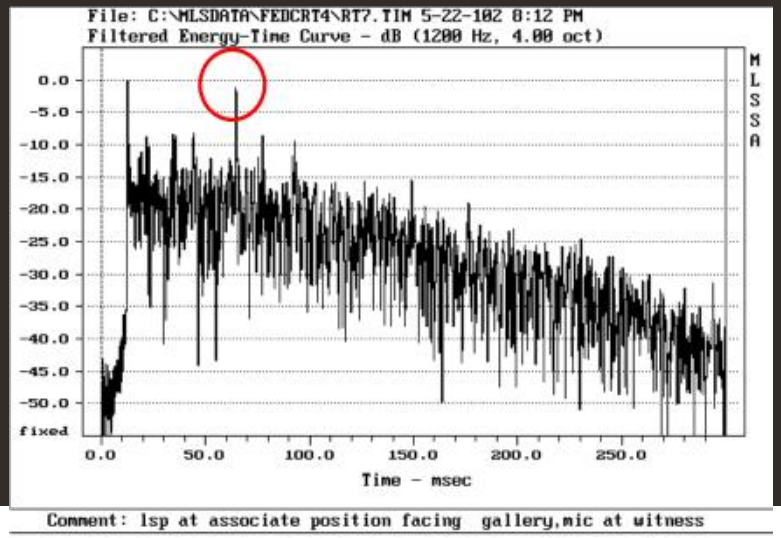
- Acoustic anomalies
  - Echoes, flutter echo, focussing



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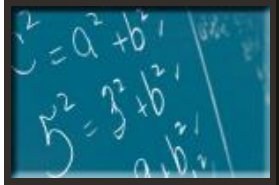

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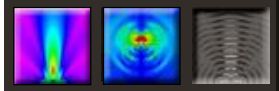

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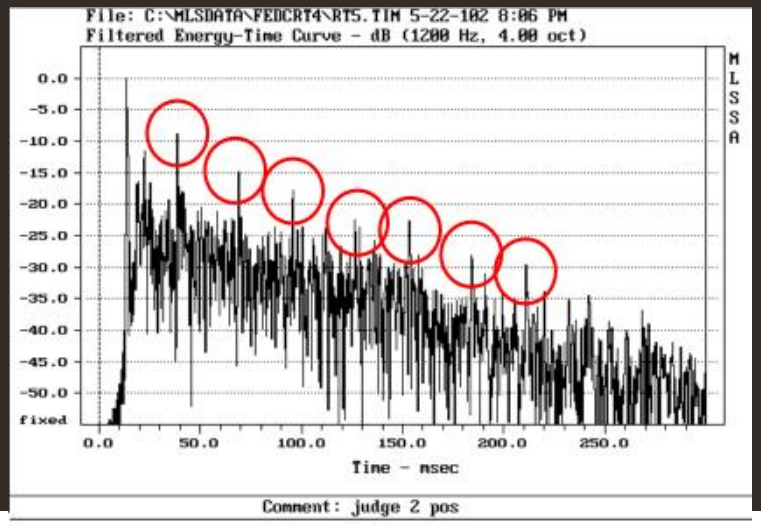

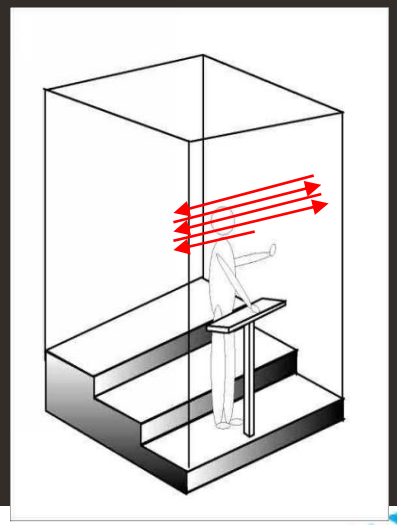

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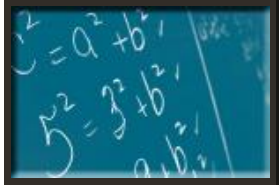

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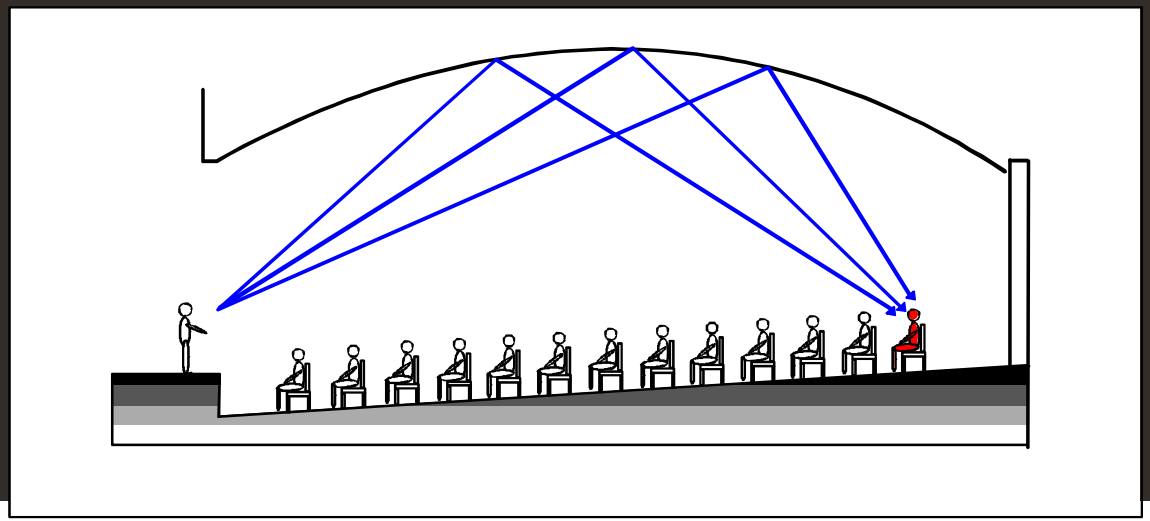

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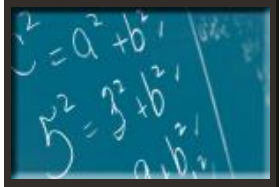
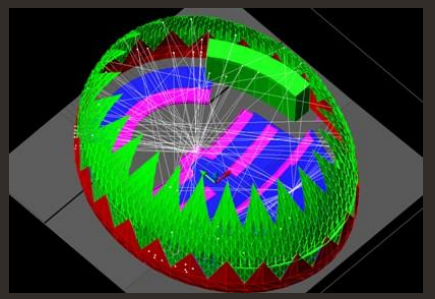
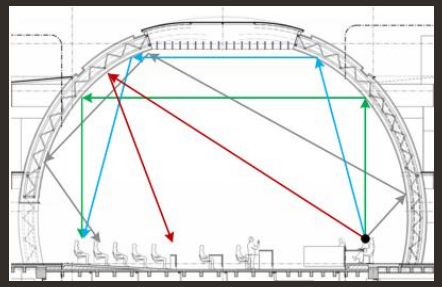


theory

Temporal Response

- Focusing – New Zealand Supreme Court





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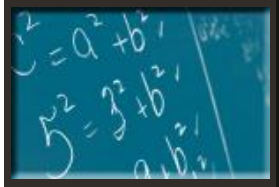

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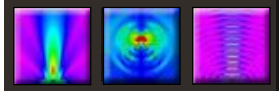

Impact of temporal response on Speech Intelligibility


- Shopping Mall
- More is not necessarily better…

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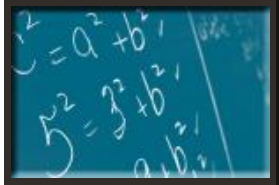
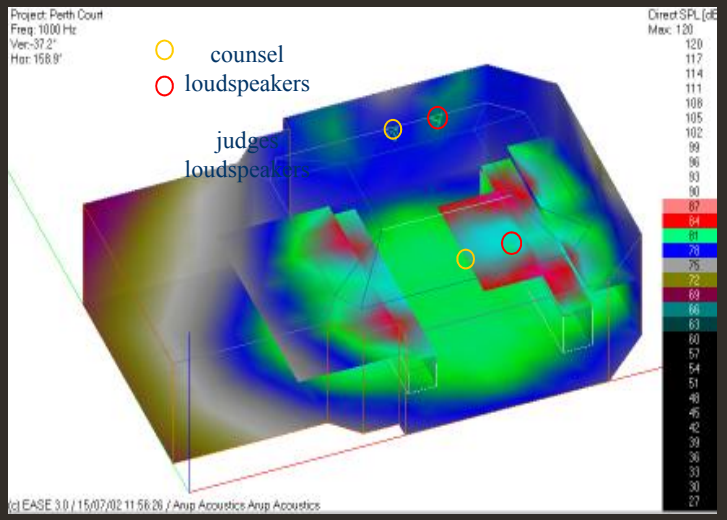


theory

Frequency Response



- Orientation of talker
- Room acoustics
- Loudspeaker coverage (significant)

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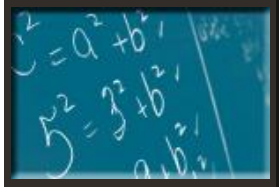

theory

Frequency Response

- unnatural sounding
- upward masking

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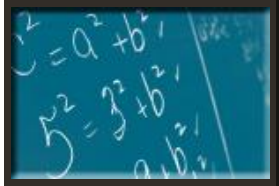
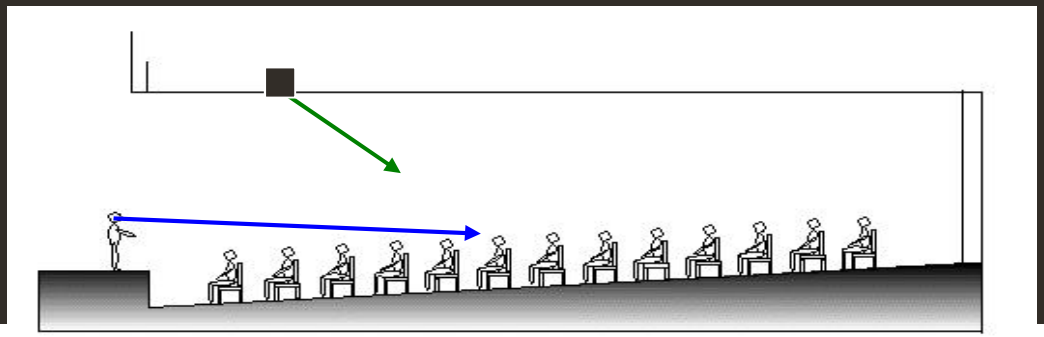


theory

Localisation

- Haas effect (Precedence Effect)
- Localisation determined by first wave front arrival
- Delayed signals (<25ms) may be up to 10dB higher without disturbing localisation



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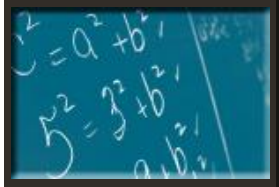

theory

Limitations of Room Acoustics only

- Room size, communication distance
  - Voice projection
  - Lack of presence, intimacy (important for focus)
  - Comfort (accustomed to face-to-face conversation or across meeting table)
- Speaker orientation
- Background / occupational noise
- Inappropriate existing condition (temporal & frequency)

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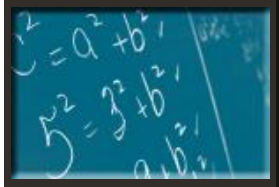

theory

Solution: sound reinforcement

- to raise speech to noise ratio
- to address frequency response imbalance with speaker orientation
- to possibly improve early to late ratio, overcome temporal anomalies
- to maintain sound localisation
- to generate listener conditions equivalent to those in close conversation

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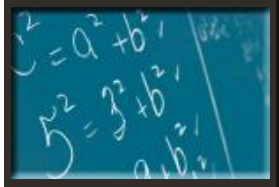

theory

Measurable parameters governing overall performance

- Speech to Noise
  - EAD (equivalent acoustic distance)
  - Background Noise
- Temporal
  - STI (Speech Transmission Index)
  - Clarity Index, C_{50}
- Frequency
  - Frequency deviations about the ideal linear response

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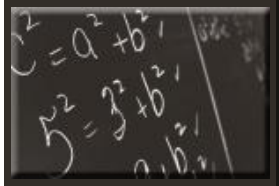
Virtual Tours



examples: courts

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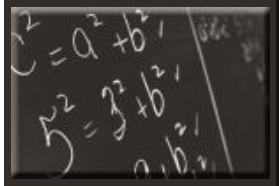
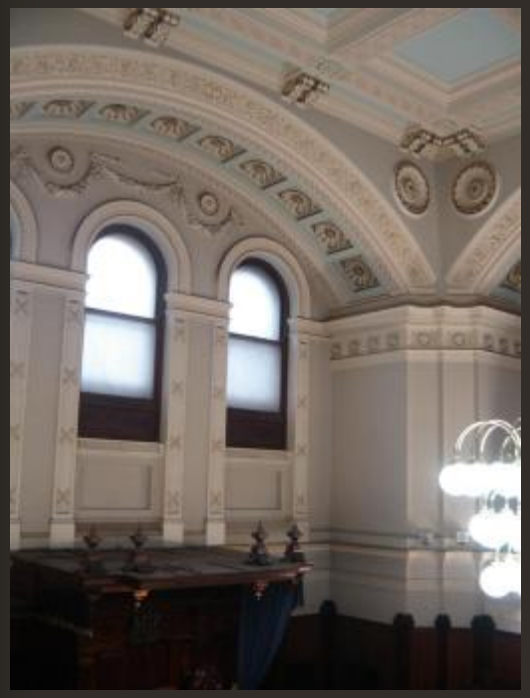


case study:
melbourne supreme

Banco Court, Supreme Court
Melbourne, Australia



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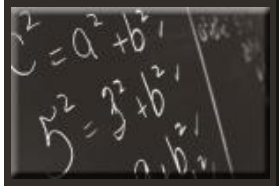

case study:
melbourne supreme

Room Conditions - Comparison

- Courtrooms

	Bld services noise, dBA	Reverberation Time, s
AS/NZ DESIGN TARGET	25 – 35	**0.7 – 0.9**
Court of Appeal 2, Wellington	36	1.3
High Court 1, Wellington	33	0.9
Supreme Court 1, Melbourne	41	1.35
County Court 1-2, Melbourne	33	0.7
High Court 1, Canberra	34	1.3
Federal Court 4, Perth	35	0.55
Commonwealth LC, Adelaide	35	0.8

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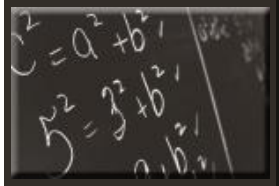

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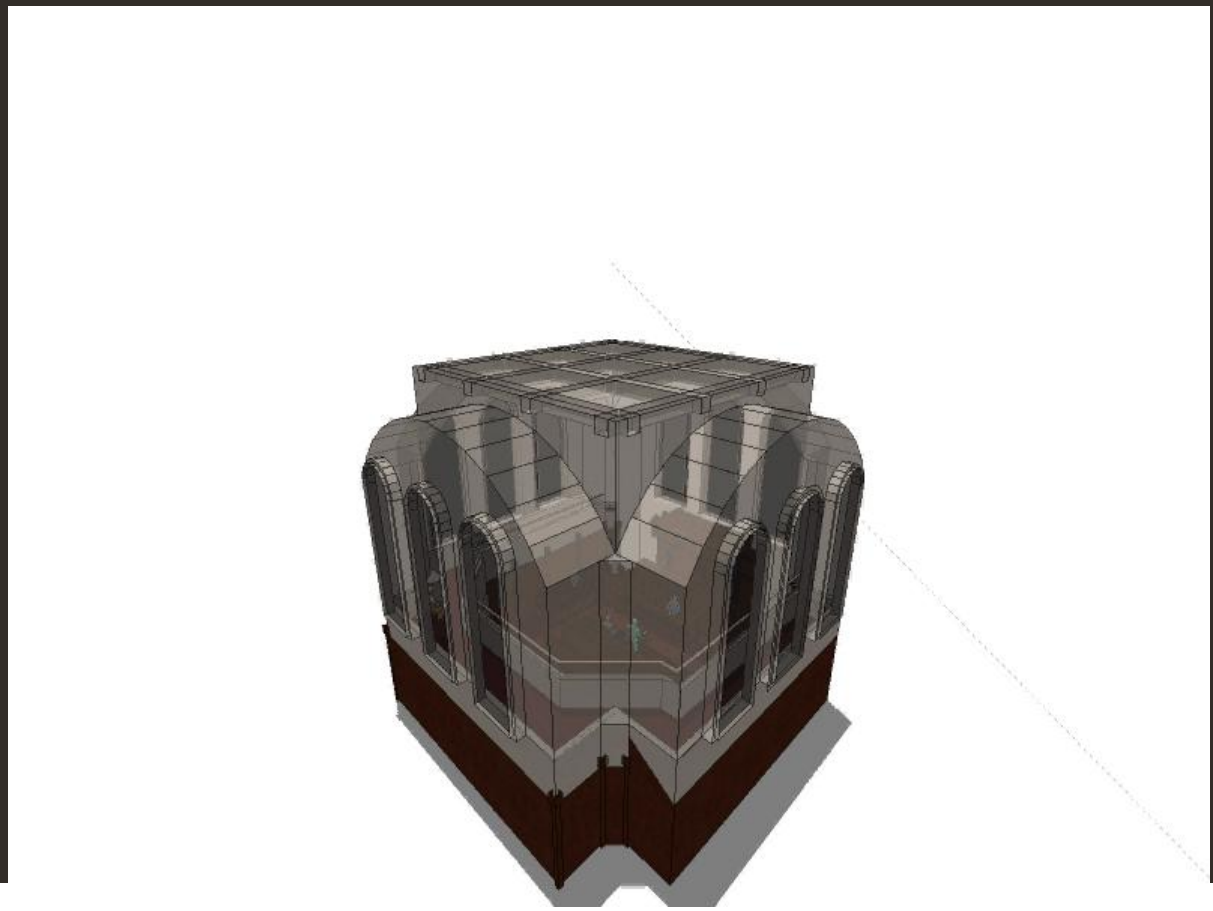

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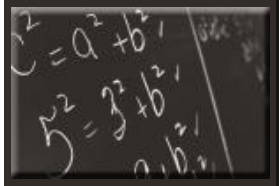

case study:
melbourne supreme

Counsel to Judge

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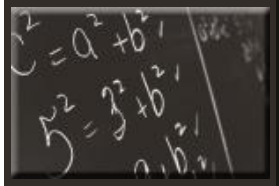

case study:
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Counsel to Judge

- 4m communication distance
- overhead reinforcing reflections
- (visual – microphones)

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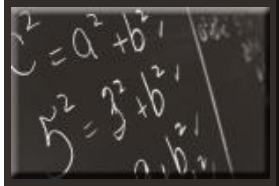

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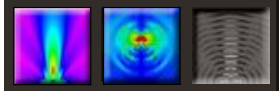

Counsel to Judge – No Amplification

Level

Temp

BGnd

Freq

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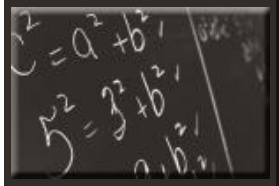

case study:
melbourne supreme

Counsel to Judge – Existing SR

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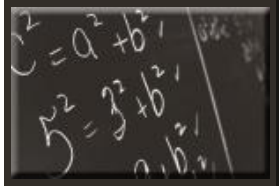
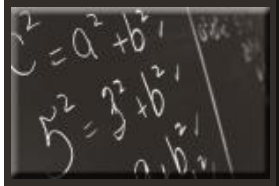


case study:
melbourne supreme

Witness to Jury

ICE Design
Integrated Communication Environments

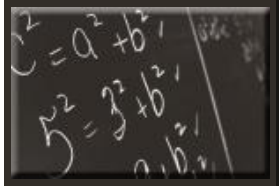


case study:
melbourne supreme

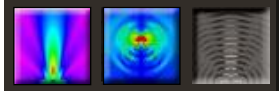
Witness to Jury

- 8.5m communication distance
- Potentially nervous witnesses – prone to mumbling

ICE Design
Integrated Communication Environments



case study:
melbourne supreme



Witness to Jury – No Amplification

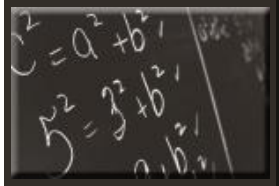
Level

Temp

BGnd

Freq

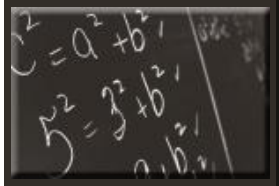
ICE Design
Integrated Communication Environments



case study:
melbourne supreme

Witness to Jury – Existing SR

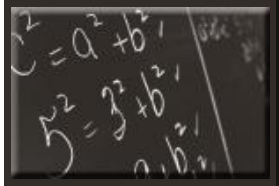
ICE Design
Integrated Communication Environments



case study:
melbourne supreme

Counsel to Lower Gallery

ICE Design
Integrated Communication Environments

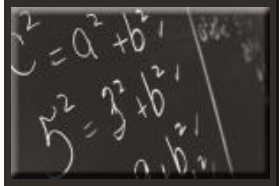


case study:
melbourne supreme

Counsel to Lower Gallery

- 2 to 7.5m communication distance
- Speaker orientation issues

ICE Design
Integrated Communication Environments



case study:
melbourne supreme

Counsel to Lower Gallery – No Ampl.

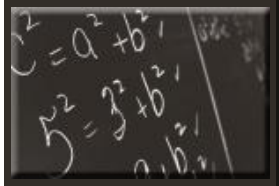
Level

Temp

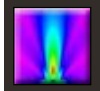
BGnd

Freq

ICE Design
Integrated Communication Environments



case study:
melbourne supreme



Counsel to Lower Gallery – Existing SR

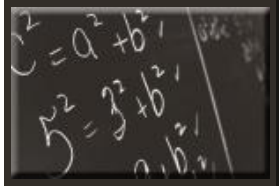
Level

Temp

BGnd

Freq

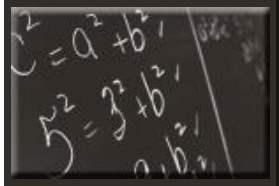
ICE Design
Integrated Communication Environments



case study:
melbourne supreme

Judge to Upper Gallery

ICE Design
Integrated Communication Environments

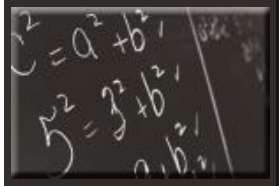


case study:
melbourne supreme

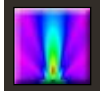
Judge to Upper Gallery

- 12m communication distance
- Proximity to external windows & noise ingress

ICE Design
Integrated Communication Environments



case study:
melbourne supreme



Judge to Upper Gallery – No Ampl.

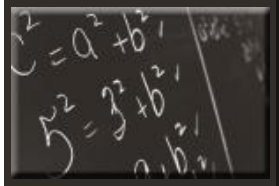
Level

Temp

BGnd

Freq

ICE Design
Integrated Communication Environments



case study:
melbourne supreme

Judge to Upper Gallery – Existing SR

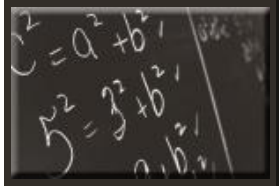
Level

Temp

BGnd

Freq

ICE Design
Integrated Communication Environments

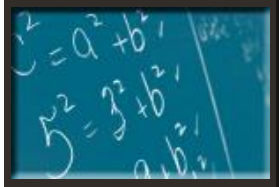


case study:
melbourne supreme

Recommendations

- Deal with background noise
  - reduce only to 35dBA (25dBA ideal)
  - secondary glazing
  - mechanical services
- Room acoustics
  - heritage restrictions - do nothing
- Electroacoustic solution
  - Improve speech to noise ratio
  - Improve temporal response
  - Improve frequency response

ICE Design
Integrated Communication Environments

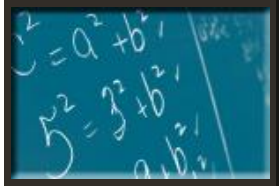


theory

Electroacoustics

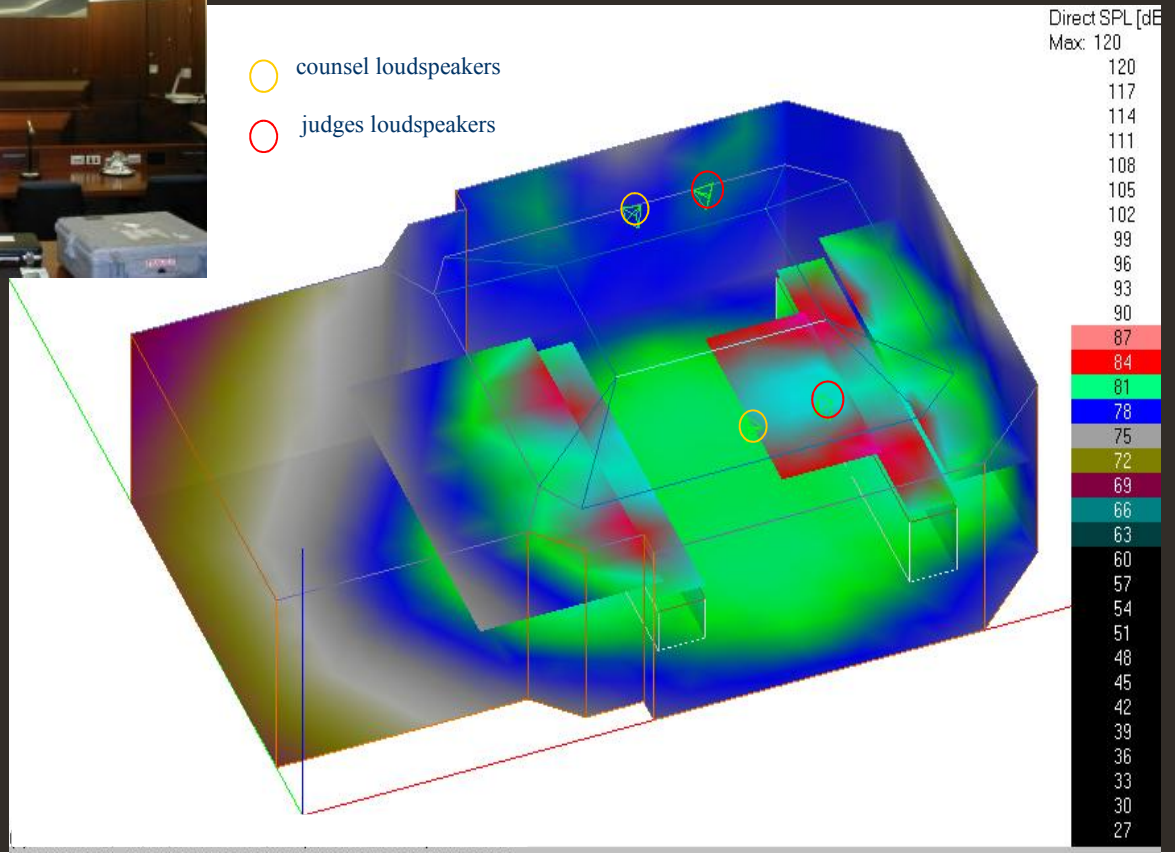
- Even coverage across listener plane over ALL frequencies
- Control of sound to listeners only, minimising ‘spill’ to reverberant volume
- Location of loudspeakers as close to listeners as practical
- Placement & performance selection of loudspeaker & mics for good system gain
- Loudspeaker placement and signal processing for localisation

ICE Design
Integrated Communication Environments

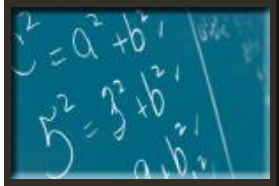


theory

Electroacoustics - Coverage

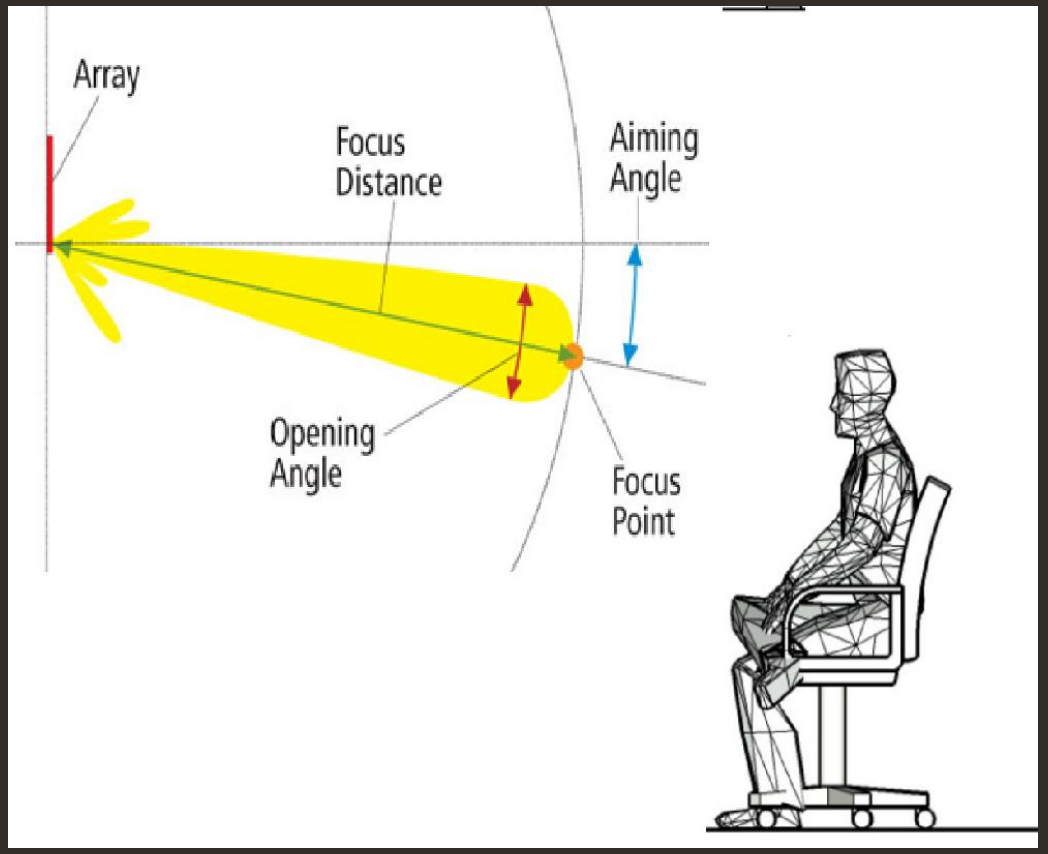


ICE Design
Integrated Communication Environments

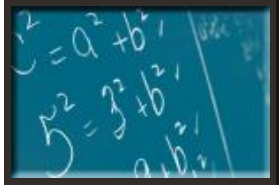


theory

Electroacoustics - Directivity

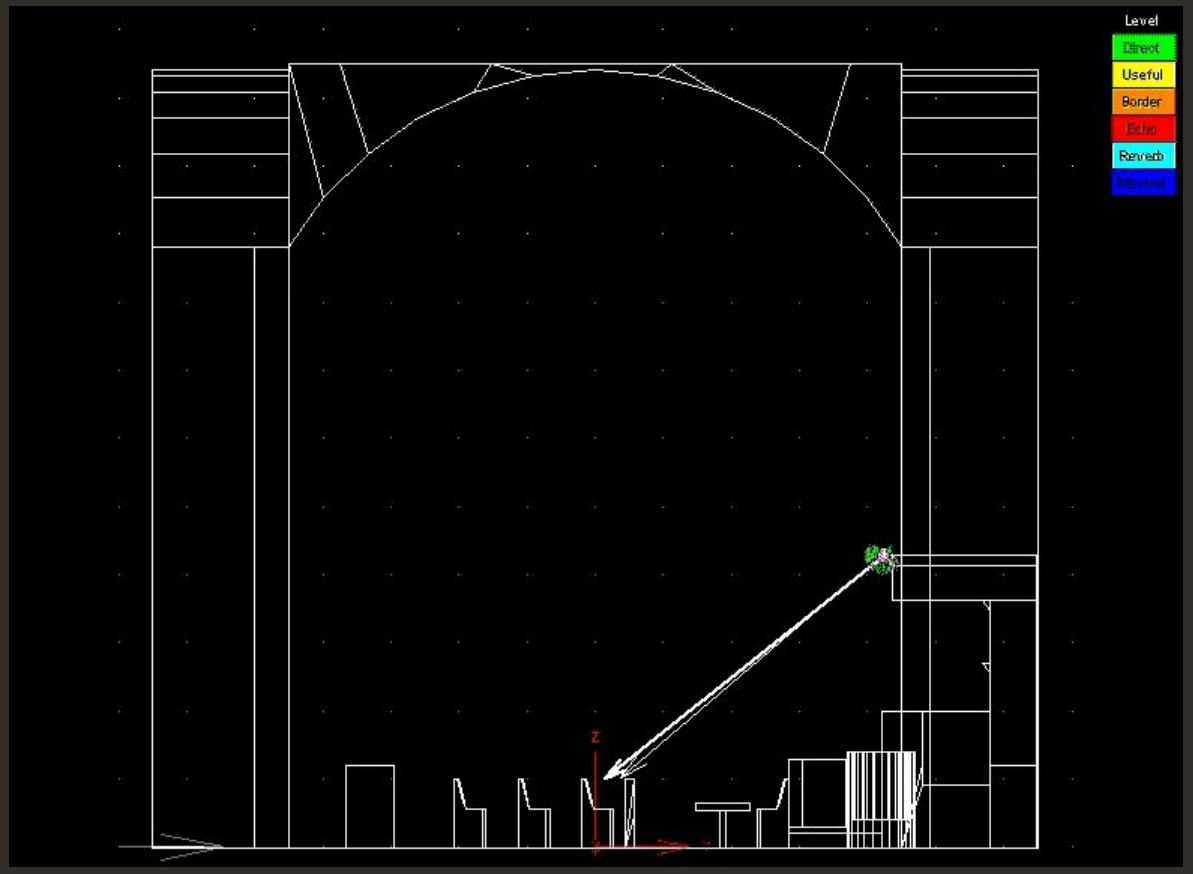


ICE Design
Integrated Communication Environments



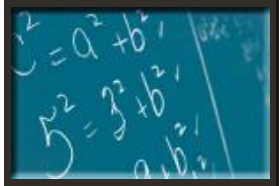
theory

Electroacoustics - Directivity



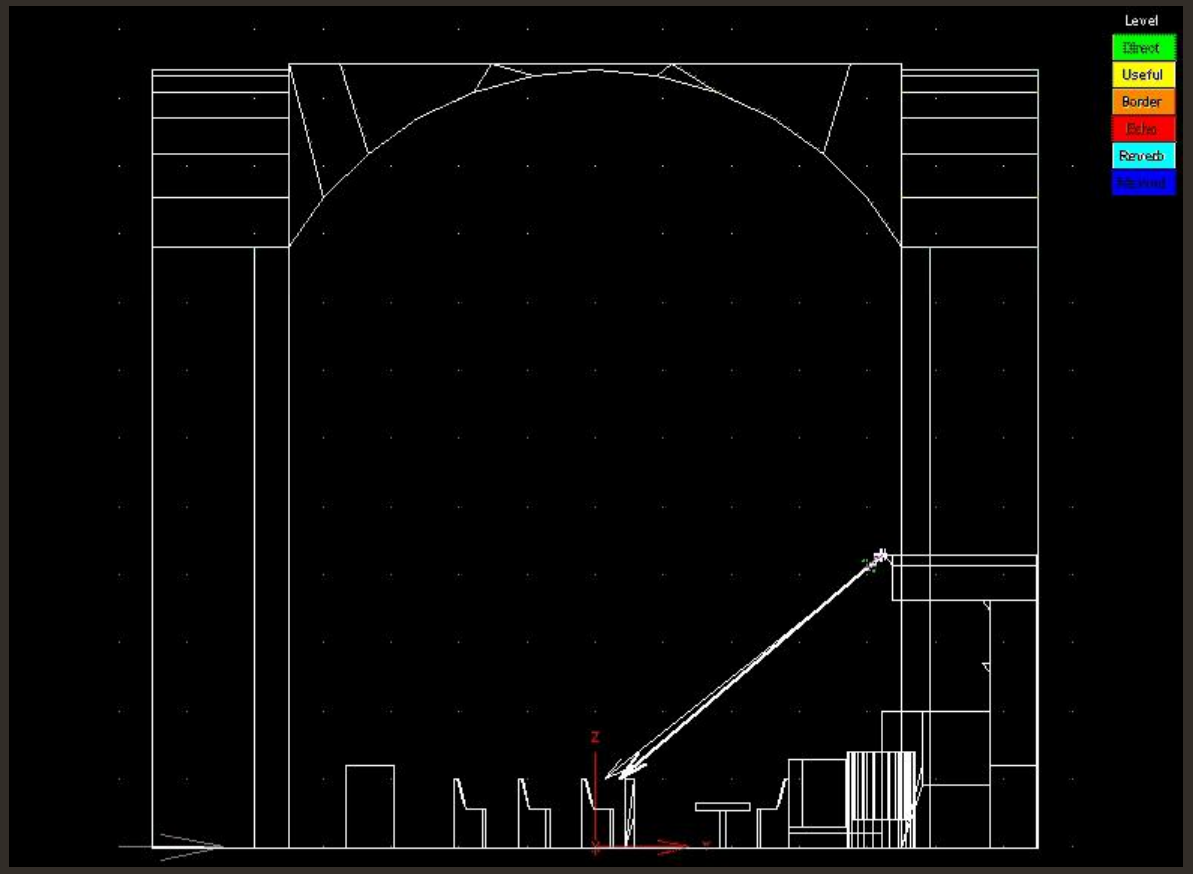
Existing loudspeaker cabinet with no control of directivity

ICE Design
Integrated Communication Environments



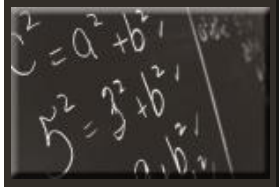
theory

Electroacoustics - Directivity



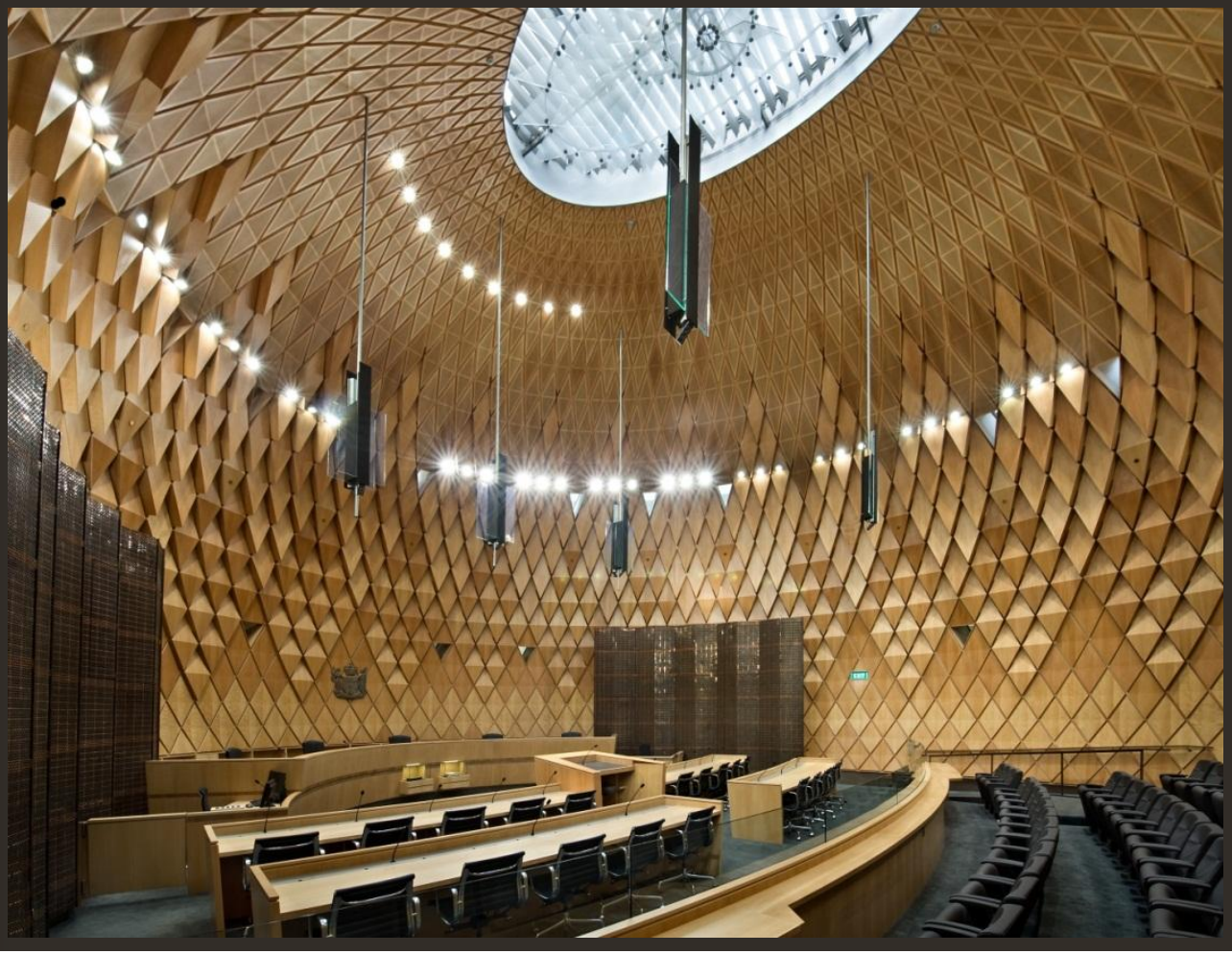
Line array with configurable control of directivity

ICE Design
Integrated Communication Environments

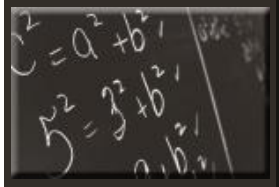


examples: courts

Suspended Line Array – Supreme Court NZ



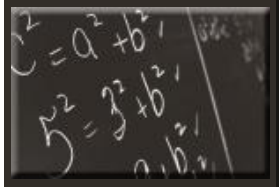
ICE Design
Integrated Communication Environments



examples: courts

Suspended Line Array – Queens Square Law Courts

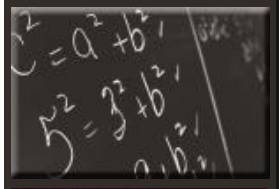
ICE Design
Integrated Communication Environments



examples: courts

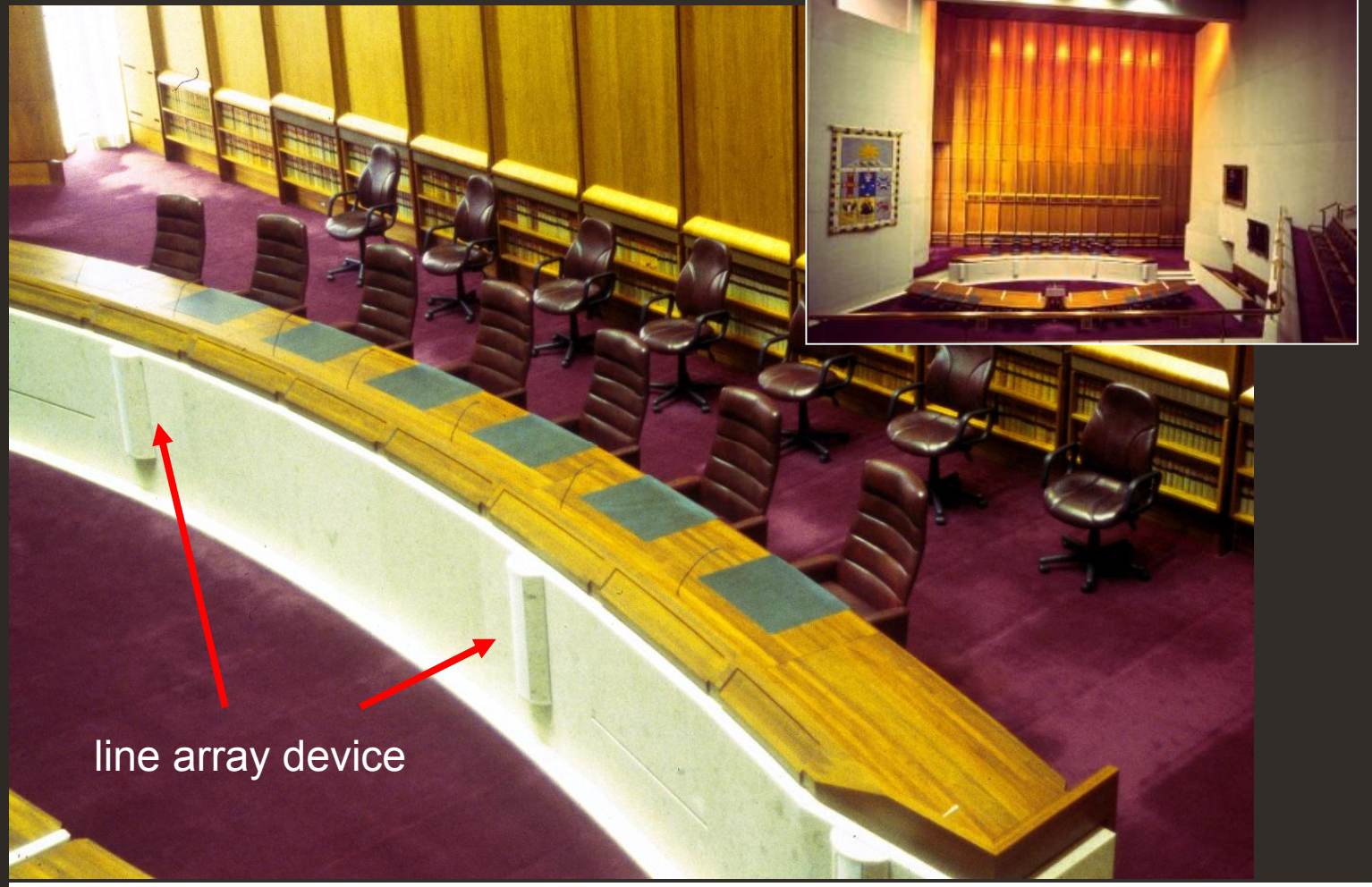
Flush mounted Line Array – Adelaide Commonwealth Law Courts

ICE Design
Integrated Communication Environments

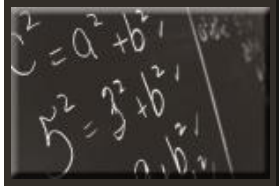


examples: courts

Surface mounted – High Court, Canberra



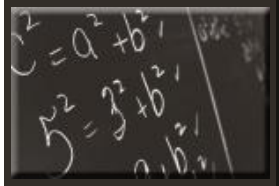
ICE Design
Integrated Communication Environments



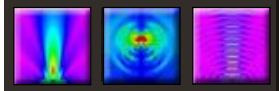
case study:
melbourne supreme

Banco: Suspended Line Array Solution

ICE Design
Integrated Communication Environments



case study:
melbourne supreme



Counsel to Judge – System

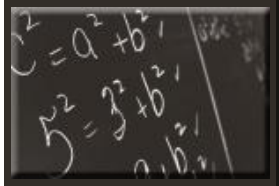
Level

Temp

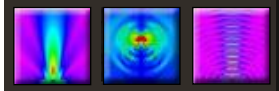
BGnd

Freq

ICE Design
Integrated Communication Environments



case study:
melbourne supreme



Witness to Jury – New System

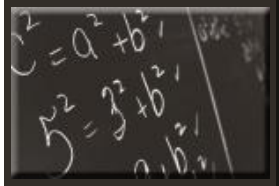
Level

Temp

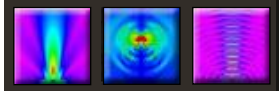
BGnd

Freq

ICE Design
Integrated Communication Environments



case study:
melbourne supreme



Counsel to Lower Gallery – New System

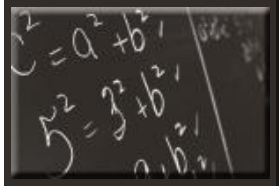
Level

Temp

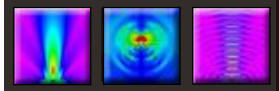
BGnd

Freq

ICE Design
Integrated Communication Environments



case study:
melbourne supreme



Judge to Upper Gallery – New System

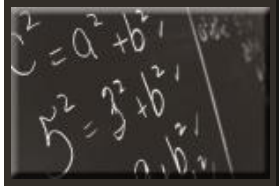
Level

Temp

BGnd

Freq

ICE Design
Integrated Communication Environments

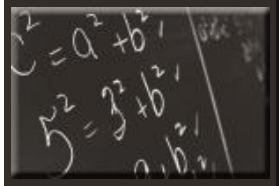


case study:
melbourne supreme

Conclusions - Banco Court

- Room acoustics and background noise present significant challenges
- A properly engineered electroacoustics solution will address the shortfalls
- The same electroacoustics solution is appropriate for all court technologies
- Potential for improvement: HIGH

ICE Design
Integrated Communication Environments

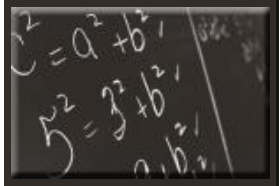


h-panel

Designing for Speech Intelligibility

- Laws of physics don't change. Room acoustic design is still important.
- Sophisticated audio technology is now available and accessible
- This is an appropriate time to raise the bar in designing for speech intelligibility

ICE Design
Integrated Communication Environments

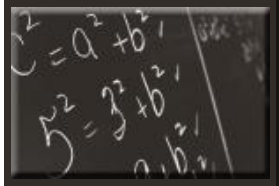


h-panel

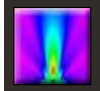
I’m acoustically comfortable – so what?

- Prolonged concentration span
- Increased productivity… ?
- Fairer judicial process… ?
- Better work conditions
- Cost savings

ICE Design
Integrated Communication Environments



h-panel



And finally…..
Alternative Uses for Banco Court?

- !

ICE Design
Integrated Communication Environments

Back to Basics -

Importance of Speech Intelligibility in Courts & Tribunals

Mark Hanson

The Tribunal of Tomorrow - 7&8 June 2012

ICE Design

Integrated Communication Environments

COAT

COUNCIL OF AUSTRALASIAN TRIBUNALS