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Directional Sound Evacuation


Prof Deborah Withington
Leeds University

Mike Lunch
Sound Alert


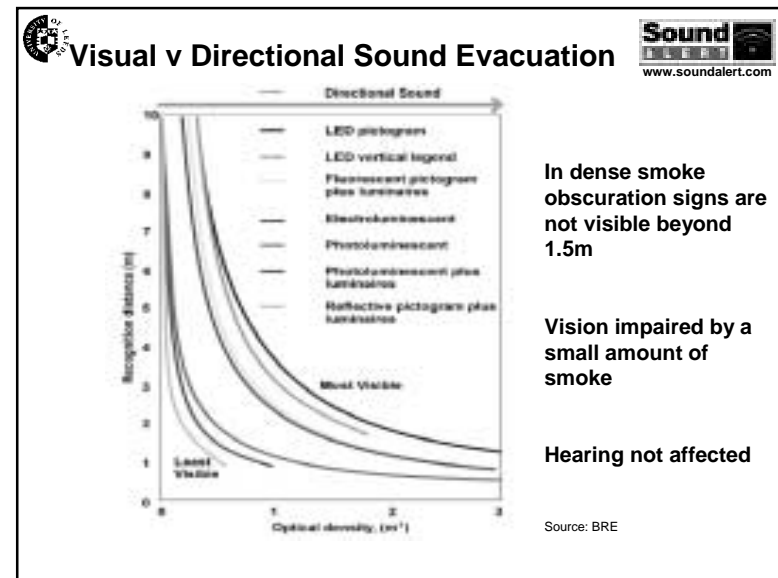
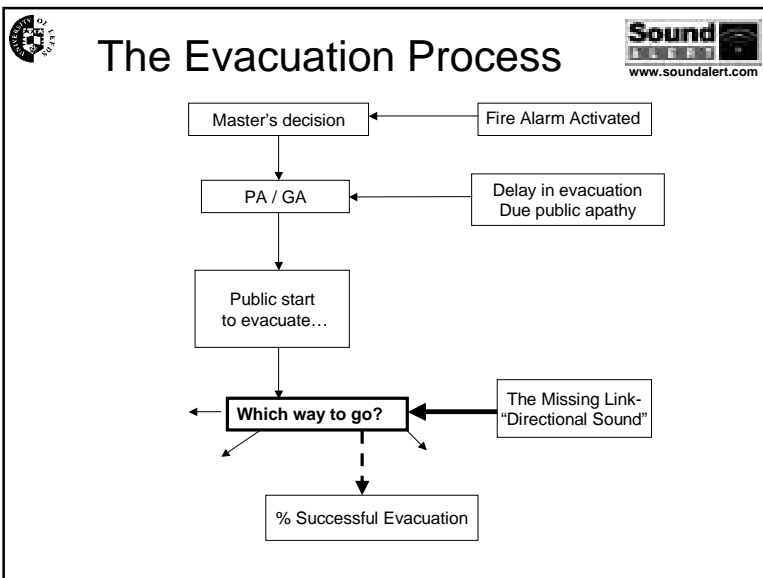
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Evacuation Tragedies Do Happen







Also problems when no smoke



- Visual clutter in Open Spaces
 - Shopping
 - Casino
- People know only one route to cabin – is it shortest?



Solution – add sound to exits points



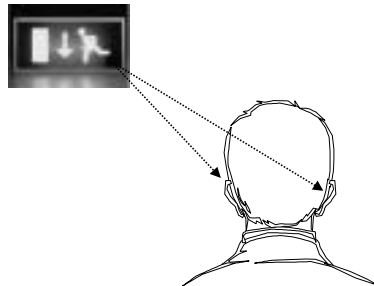
- At Exits and decision points
- Must be Directional / Directing sound
- Language Independent



How does the brain locate sound?



- Needs all 3 frequency bands:
 - Low
 - Mid
 - High

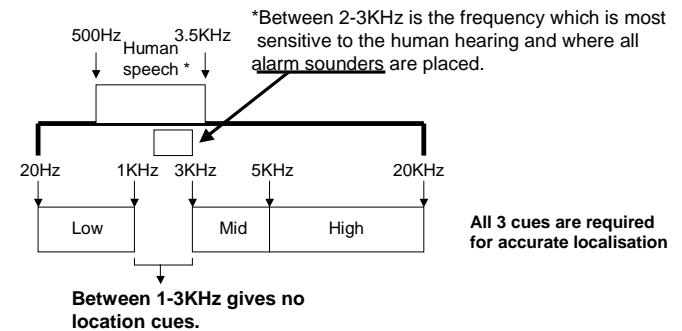


All three elements above, gives broad band sound

COGNITIVE LOAD



The Human Hearing Range



Typical DSE Sounder locations

Open Plan Area

Accommodation Area

Sounders

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Independent Research

— over 8 years

Buildings
Aircraft
Tunnels
Ships...

UK & German governments are proposing to IMO

British Government's Web site: www.directionalsoundevacuation.com

Strathclyde University Trials
Corridor / Cabins

- Simple accommodation layout
- 3 exits – 2 blocked
- 8 rooms – 20 people per trial
- Escape plans on backs of doors
- Dense smoke

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Corridors / Cabin Trials
1 exit available

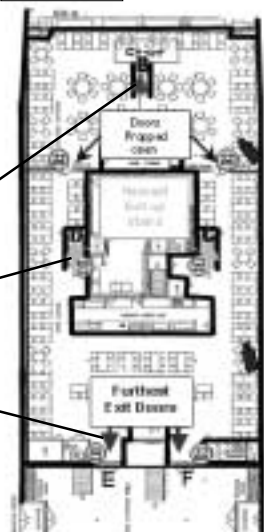
Low Location Lighting	Sound	Briefed	18 th exit time secs
	(No assistance)		4 Mins 46 sec
Yes			3 Mins 25 sec
	Yes		1 Min 22 sec

Over 60% quicker with directional sound assistance



Open Space Trial

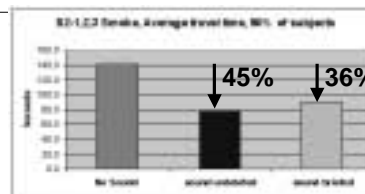
- Smoke / No smoke
- Sound / No sound
 - briefed / not briefed on sound
- 20 volunteers per trial – fed down stairs 15 secs apart
- Four exits
 - Nearest 2 – up stairs
 - Furthest 2



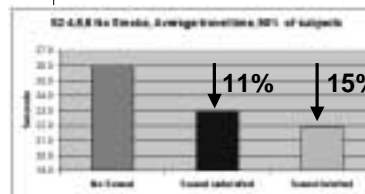
® Directional Sound Evacuation Beacon



Speed of exit – Open Space



- In smoke, sound improved
 - 45% no briefing
 - 36% with briefing



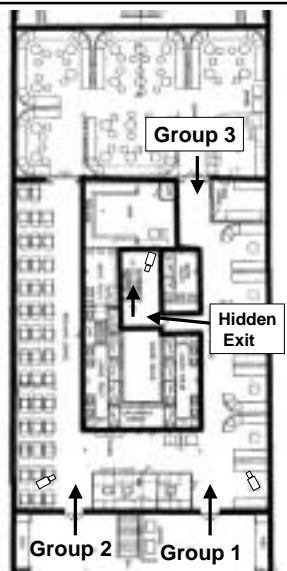
- No smoke, sound improved
 - 11% no briefing
 - 15% with briefing

Results adjusted to reflect family groups travelling together, who waited at stairs for each other



Open Space & Hidden exit

- One hidden exit – leads to stairs – exit down
- Entrances blocked after entry



Open Space & Hidden Exit Speed of exit



Sound	Open area	Exit time 1 st exit	Exit time 13 th exit
No	Clear	1 Min 05	2 Min
Yes	Clear	45	1 Min 15 (-35%)
No	Smoke	6 Min 50	7 Min 37 (+5 helped out)
Yes	Smoke	1 Min 05	2 Min (-75%)



Stairwell – always with no smoke

- No Sound
 - All went wrong way – UP stairs
- Sound
 - All went correct way – **DOWN** stairs
- **Sound was able to direct against conflict of signs and instinct**



Open space – 9 deck atrium

- No SOLAS evacuation guidance requirement
- Challenging acoustic environment
- 26 sounders audible in same space
- Smoke filled for USCG smoke vent test
 - Participants from USCG, Lloyds, RINA, MCA, Carnival, Costa, Meyer Werft, Strathclyde University, Viking, Fincantieri



Many exits with directional sounders were audible at same time within the atrium

20 on the lower three decks




Atrium test - results



- No difficulty following the sounds,
- Able to locate nearest (loudest) exit,
- Able to find other exits if the first was blocked
- From centre of atrium
 - Illuminated exit signs not visible
 - Direction of each door speaker was easy to hear

4 good exits
1 blocked exit
Observers outside
Thermal video cams



32 Volunteers in difficult cabin
Locations

LLL and DSE tests
Direct comparison of results





 Cabin Evacuation test – Feedback 
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- **LLL**
 - Many followed their expert training and stayed low
 - Found exits, but slow
 - Some problems with low vs high movement
 - Some could not see next section of LLL across corridor
- **DSE**
 - Following the sound was easy to walk straight up - evacuation time reduced.
 - From cabin easy to decide which way to go (sound already audible)
 - Nearest route very discernable.

 Cabin Evacuation Tests - Results 
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Analysis summary	Everyone (32 participants)			"Knew layout" group (16)		
	LLL	DSE	Saving	LLL	DSE	Saving
Average Exit Time	135.7	60.5	55%	136.88	63.1	54%
Average shortest distance (metres)	20.1	20.6		19.5	20.5	
Average actual route distance	24.0	21.7		24.2	21.6	
% wasted travel distance vs optimal	19%	5%		24%	5%	
Travel speed m/sec	0.18	0.36		0.18	0.34	
Numbers of people over 90 secs (exceeded survival time in smoke)	22	2		13	2	
% survived	31.3%	93.8%		19%	88%	
In real smoke which would you prefer?	6%	84%	10% both	0%	86%	14% both

- DSE 55% faster exit than LLL
- DSE 14% more efficient routing
- In 90 second survival test, DSE gave over 3 times improvement
- Those with layout knowledge had no advantage

 Approvals Status 
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- UK & Germany proposed to IMO for equivalence to LLL
- MSC 75 considered in May 2002:
 - “At least as effective as LLL and its use not diminished or obscured by smoke”
- Draft ISO standard under review for FP 47 in Feb 2003
- Full proposal to MSC 76 May 2003 – in SOLAS 2004?
- Meantime...**available now...**
 - SOLAS 2-II-17 “Alternative Arrangements” case by case

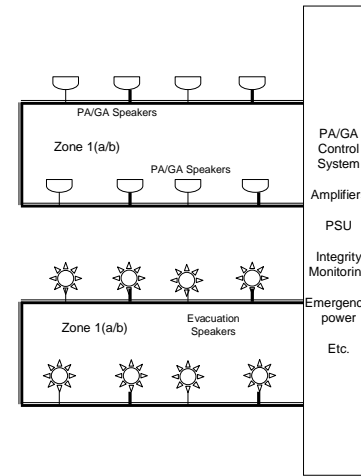


Implementation

Extension to PA/GA system

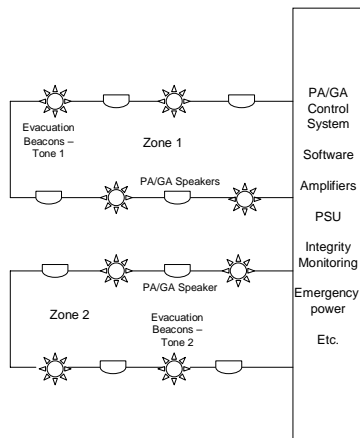
- Existing technology
- Existing suppliers
- Existing standards
- Existing approvals

Conventional Analogue PA/GA System extended to support Directional Sound Evacuation



- Evacuation Sounders placed on PA/GA System
 - Normal 100v line speakers
 - maybe mounted in special cosmetic casings
- Additional Control Amplifiers & DSE Tone circuitry per fire zone
- Additional tones (up & down for stairs) require additional circuits
- 2 Independently wired loops for each zone (a/b) in addition to PA/GA loops or could be 2x4 core cables to save cabling
- PA/GA interface automatically present
 - Hierarchy of sound signals
 - PA from Master
 - General Alarm
 - DSE
 - Normal BGM functions
- May use existing switch panel for triggering
- Utilises currently approved technology
 - Standard components
 - Standard emergency power arrangements
- Draft ISO standard available

Direct Addressable Digital PA/GA System extended to support Directional Sound Evacuation



- Evacuation Sounders placed on PA/GA System
- Speakers can be either PA/GA or DSE
- Software directs DSE tones to correct speaker
- Independently wired loop for each zone
- PA/GA interface automatically present
- May use existing switch panel for Evacuation
- Possible to include -
 - Masters decisions coded into software (cause / effect trees)
 - Pre-Set Scenarios programmed in
 - Evacuation routing change in real time
- New PA/GA technology - not yet implemented
 - Higher system costs
 - Lower installation costs
 - More flexibility



In implementing a DSE system - who does what?

Design Consultancy	Sound Alert Technology (SAT)	Produce specification for PA/GA system extensions location / number of speakers
License to use DSE technology	SAT	Once only license fee
PA/GA system supply	PA/GA manufacturer or Systems Integrator	Deliver to Shipyard
Installation	Shipyard	Cabling, speakers, connection & test
Commissioning	SAT	Provides certificate of compliance for Class
Periodic Survey	SAT	Provides certificate of compliance for Class



Implementation Comparison to LLL

LLL consists of:	DSE consists of:
LLL strips & mounting channel Control systems & PSU	Extensions to PA/GA system in central rack Extra DSE speakers
Mounting brackets and channels welded in situ for each section of LLL strip	Cabling (but if 4 core acceptable, no additional runs)
Cabling and protective trunking to both ends of each strip	Mounting and wiring speakers above exit doors
Special attention to decorative designs to incorporate LLL strip within décor	
Commissioning and test	Commission and test

Detailed costing requires a worked example to illustrate the comparison, however a saving of at least 20% has been calculated in the total costs much of the saving is in shipyard work



Summary

- Extensive independent trials showed at least equivalent to LLL in corridors & stairs
- Provides only evacuation solution in Public Spaces
- Government support – UK, Germany, Singapore....
- Significant benefit to visually impaired
- also of benefit to most hearing impaired
- Cost saving vs active LLL - 20% ?



Conclusion

Directional Sound Evacuation

- Works
- Available now – with PA/GA
- Could make the difference...



Contact:

Mike Lunch

Old Village Hall
The Street, Effingham
Surrey, KT24 5JS
UK

+44 1372 456037
Mike_Lunch@soundalert.com
www.soundalert.com

