# MAKING A SOUND ESCAPE

**Directional sounders, an emerging technology, could provide the way forward in the evacuation of buildings and public transport.** Fathi Tarada **investigates their potential role in fire exit strategies**

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**It is the stuff that nightmares are made of.** You are browsing in a shop, when suddenly the fire alarm sounds. You cautiously make your way back to the shop entrance – but within a couple of minutes, a thick cloud of smoke descends, blocking out the light, and irritating your eyes. How do you find your way out?

If this shop had directional sounders, your ears could quickly direct you to the nearest safe exit. Despite the thick smoke, you could then simply follow the direction of the sounder into safety. Because of their potential for enhancing life safety, directional sounders represent an emerging technology that could change the way that buildings are designed for escape.

Directional sounders work by providing the brain with 'cues' relating to their positions. Relative to a single sound beacon, a person can identify their position relative left and right, in front or behind and vertically relative to the sounder. The locations of single tones are ambiguous to the human brain – hence a wide range of tones, within the normal hearing range of 20 to 20,000 Hz, is required.

A series of directional sounders can be mounted to direct people along a corridor or escape route, with the pulse rate of each sounder increasing the closer its location to the exit. In this way, people can identify that they're moving in the right direction, towards the exit. Similarly, if the exit route involves stairs, the signals can give an upwardly or downwardly sweeping melodic sound to direct people up or down stairs.

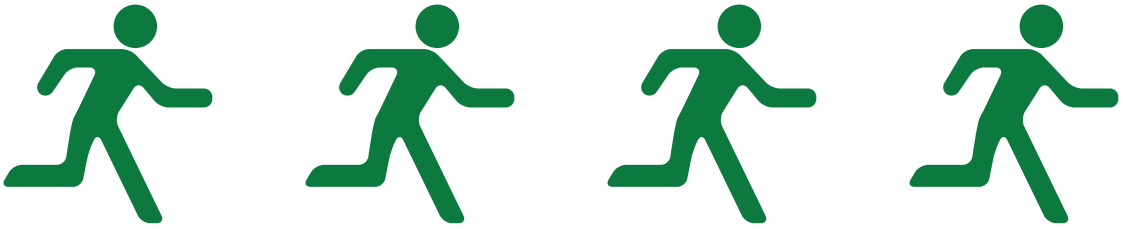
Research undertaken by Professor Deborah Withington of Leeds University indicated an improvement in evacuation times of up to 70% when using directional sounders in smoke-filled conditions, and an improvement of up to 35% in conditions without smoke. Professor Withington has set up a spin-off company, Sound Alert, to license directional sounders for a variety of applications including buildings, ships and aircraft. Fire alarm manufacturers including Honeywell also offer them.

Directional sounders can help overcome people's natural tendency to try to leave a building via the same route they used to enter it, even if there is an alternative exit that is much closer to them. If dense smoke is present, evacuees may not even be aware that they are close to a safe exit. During the Dusseldorf Airport fire in 1996, seven people died when seeking an evacuation route from a stopped lift – even though some of them were found only three metres away from the nearest exit.

These sounders are not alternatives to public address and voice alarm (PA/VA) systems, but can provide a complementary function. PA/VA systems are good tools for alerting building occupants to the need for evacuating a building, but are not suitable for directing people towards exits. Once these have alerted the public that an evacuation is necessary, directional sounders can take over in leading people to the nearest exits. Careful acoustic design may be required to ensure that the sounds from different directional sounders can be adequately heard, and that they do not interfere with a building's PA/VA system. Interfacing with the building's fire detection system is essential, to ensure that evacuees are not directed to the seat of the fire.

## Signals in combination

There are very few independent tests that indicate how well people might respond to directional sounders in an emergency, although some experiments were undertaken by the Dutch research organisation TNO. Under test conditions, only a modest percentage of 75 participants found their way out of the smoke-filled Benelux Tunnel in Rotterdam without prior instruction regarding the presence and locations of the sound beacons. In



contrast, almost all the test participants found their way out of the tunnel when an oral message saying 'exit here' (in English and Dutch) was inserted in between the directional noise. The importance of a spoken message is a key finding – however, it does mean that such sounders rely on one or more languages, which can be a drawback when building occupants speak several languages.

The combination of visual and auditory information is significantly more effective in directing people than either of these stimuli individually, so good visual signage to the nearest exits is always required.

Directional sounders are not a panacea for emergency evacuation from buildings. They are less useful where escape routes are designed to be clear of smoke, for example through adequate ventilation and high ceilings. They may be more effective where the building occupants are not intimately familiar with their surroundings, for example in shopping centres. Also, since directional sounders essentially relate to self-rescue, they are not necessarily of great value when assisted rescue is called for, for example in hospitals. If queuing at exit doors, rather than finding the way to the exit doors, consumes the longest time for evacuation, adding directional sounders may not necessarily reduce overall evacuation times.

Disability and human rights legislation may give a boost to the adoption of directional sounders. The UK's Disability Discrimination Act prohibits building owners to discriminate by providing less safe access and exit for disabled users. The European Convention on Human Rights calls for the right to liberty and security of all persons, and this may be interpreted as a prohibition against discrimination towards disabled people in an evacuation scenario. In the USA, the Americans with Disabilities Act outlaws discrimination against disabled people and obliges owners of buildings with public access to provide equivalent exit guidance for sighted and non-sighted citizens. The American Council for the Blind has passed a resolution advocating the installation of directional sounders in buildings, aircraft and passenger vessels.

Because directional sounders are still an emerging technology, there are only a limited number of standards that refer to them. The British Standards Institution has published a publicly available specification – PAS 41 – that relates to the test requirements for such sounders. The National Fire Protection Association will incorporate a section on directional sounders in the 2007 edition of its NFPA 72 code. More standards are likely to follow as additional research is undertaken, which should lead to a more mature technology and a greater awareness of its potential benefits. ■

## Psychoacoustics: how our brains localise sound

**Our brains use three sources of information to allow us determine the direction of sound. The first two 'binaural' (relating to both ears) cues help us work out whether a sound is coming from the left or right, and are based on the distance between our two ears. At low frequencies, differences in arrival times of a sound between our ears help us ascertain the left/right direction of a sound. At higher frequencies, differences in loudness across the ears are the determining factor. This 'duplex theory of sound lateralisation' ('duplex' referring to high/low frequencies) is attributed to Lord Rayleigh (1907).**

**Lord Rayleigh's theory, however, has several drawbacks – one of them being that it does not explain how we determine whether a sound is coming from ahead or from behind us. In order to explain this phenomenon, 'head transfer related functions' (HTRF) have been proposed, based on the fact that sounds are slightly modified by the shape of our ears. The pinna or external ear amplifies certain frequencies and attenuates others, in a way that is unique for each individual. These minute changes can be associated by our brains as relating to sounds ahead of us or behind us. The HTRFs have also been associated with the perception of the sound source's elevation.**

## Cause for alarm: hotel fire safety for guests with hearing disabilities

**"A prisoner in my own room," is how profoundly deaf Clare Chilton, 35, describes the sense of frightening isolation and concern for her safety she experiences when staying in Britain's hotels. Clare, a BBC2 TV presenter on deaf issues, is spearheading the 'Deaf to Change' campaign to coincide with the second anniversary of the Disability Discrimination Act and to raise awareness of negligence in hotels that make no provision for communicating with the deaf and hard of hearing, or safeguarding them against fire.**

**A survey of British hotels reveals that thousands of hotel guests with hearing disabilities are at risk. Commissioned by deaf-aids manufacturer Fireco, the survey found that, although one in seven people in the UK has a hearing loss, some 80% of UK hotels do not have the basic level of services necessary to meet the needs of deaf and hard of hearing guests.**

**Deafness in the British population is increasing at a remarkable rate, with a 45% overall increase in the number of registered deaf people since 1989 – yet the survey reveals that only 13% of hotels follow the recommendations of the Royal National Institute for Deaf People (RNID), which defines the essentials required to make hotels safe for the deaf community. It's a situation Chilton describes as "unacceptable".**

**To ensure the safety of deaf people, Chilton says hotels need to have smoke alarms suitable for people with a hearing loss. "Most deaf people take their hearing aids out at night, making them less likely to hear a normal audible fire alarm," she explains. Instead, she says, hotels should be equipped with flashing alarms and fire alarm systems with vibrating under-pillow pads to ensure that all guests are alerted in the event of a fire.**