Alarm sounds based on Human Factors

Natasha Barrett

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Background:

Alarm sounds for Equinor's Hywind Tampen control room.

Challenges and solutions are relevant to different situations.

Problems with today's common alarms:

The sounds:

- Unpleasant aurally
- Unpleasant experientially
- Can be too loud
- Can be too startling
- Could be more informative

The result:

- Silence the alarm as soon as possible
- Disturbance to communication
- Work fatigue
- (Muting the complete alarm system!)
- (Adding personal sounds!)

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sound designer
sound artist
composer

What should alarms be like?

- Indicate what response is required without the negative effects of current alarms sounds.
- Be easy to understand.
- Unique
- Be designed in keeping with the control / notification system (which in turn should consider human limitations).

What else could alarms do?

- Indicate which console is sounding in a multi-console environment
- Provide more information about the type or class of alarm.

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sound designer
sound artist
composer

New alarm sounds:

Function | Sound-design | Acoustics |Work environment |Perception

NATASHA BARRETT
sound designer
sound artist
composer

Past work: Patterson (1982)

Most of the past work in alarm sound builds on ideas published by Roy Patterson in 1982:

- A burst of sound with its own set of frequencies in the range 150–3000 Hz at a dB level.
- A repeated pattern of sound-pause durations
- Different levels of priority are indicated by changes in the sound-pause pattern
- Subsequent variations on this idea have added pitch / note patterns to the sound-pause pattern.

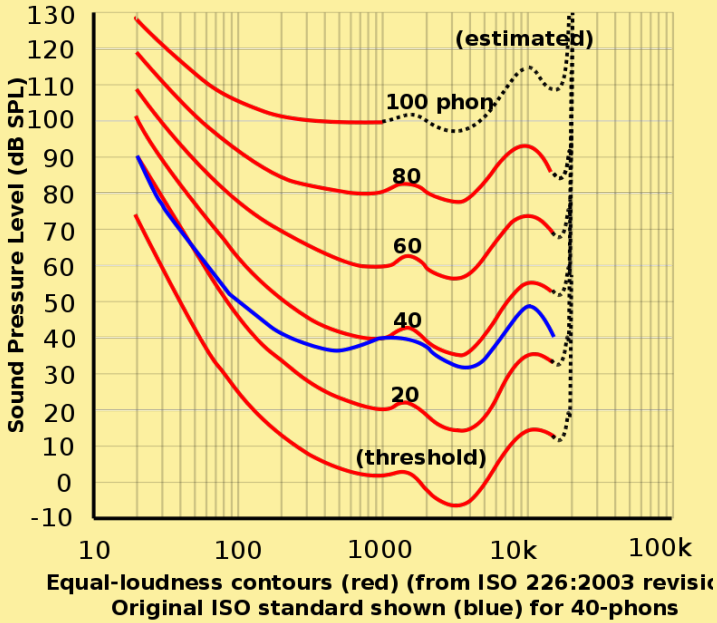
These solutions neglect some obvious problems:

Sounds were chosen to 'cut through' noisy environments:

Background noise has decreased.

- To avoid confusing levels of urgency, fast note sequences are needed. These create stress.
- Development: note sequences are shown to create confusion rather than add clarity.
- A lack of design compounds negative factors concerning uninteresting sounds.

The suggested frequencies are located in our most sensitive hearing range.



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sound designer
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Past work: Alarms and 'earcons'

- Sounds that may range from representational (resembling real-world sounds) to abstract (pure tones, buzzers or instrumental sounds).
- The idea is that there is some identifiable content that overcomes the problems associated with learning the meaning of single tones.
- Experimental work on representational sounds: less appropriate in the workplace.
  - Too strange
  - Experienced as annoying
  - Spectrally (frequency content) not clear enough

Specification from Equinor

- ’Alarm’ sound design to signal difference levels of priority
- ‘Earcons’ sound design as indication sounds.

‘Alarms’ and 'earcons'? → Alarms and notifications

The idea of ‘earcons’ is obsolete if we instead assume that our alarms overcomes the problems associated with learning the meaning of single tones.

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sound designer
sound artist
composer

Basic design considerations

Environment:

- Background noises and other sounds.
- People interaction.
- People location.
- Acoustics.
- Loudspeaker locations.

Perception and action:

- Audibility.
- Identity.
- Affect.
- Repetition.
- Redundancy.
- Interaction (silencing alarm).

Design process

Move away from:

- Extreme differences in pattern speed reflecting urgency.
- Attacking the most sensitive frequency area of our hearing.
- Simple / boring note sequences.

Instead ask:

- What kind of sounds we are used to hearing?
- What kind of sounds we can accept as alarm sounds?
- How would the different sounds fit together as a set?
- How to optimise the volume and spectrum onsite by simple calibration?
- Urgency / priority as relative rather than absolute (i.e. only archetypes such as fire alarm bells and the like should be absolute).

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sound designer
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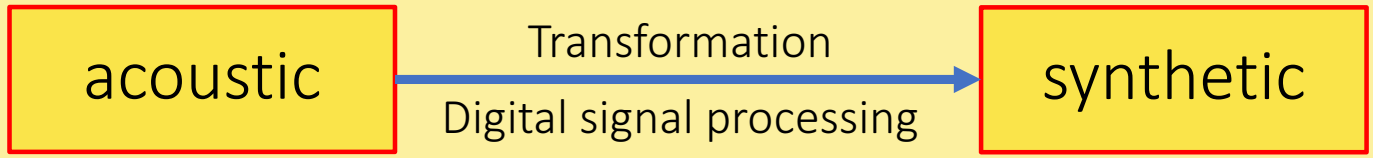
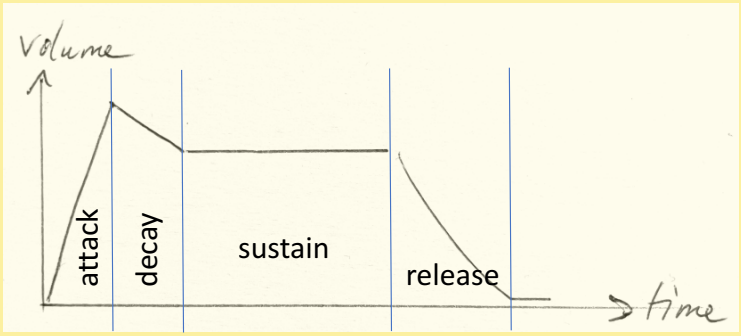
Choice of sound types

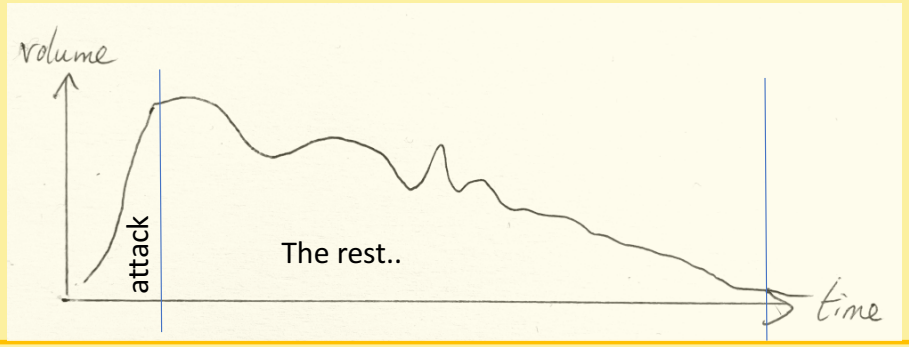
- Acoustic sources and their transformations (identity / uniqueness).
- Synthesised sources (identity / genre).
- Pitch ranges and spectral distribution.



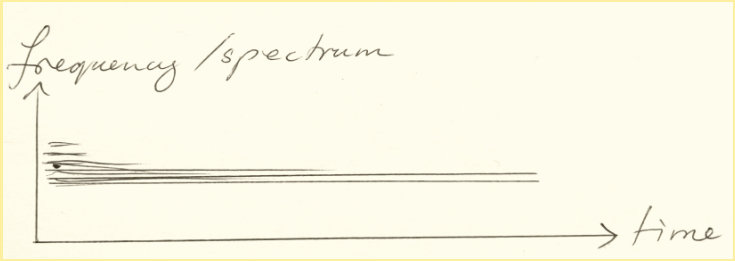
Morphology, identity and interest

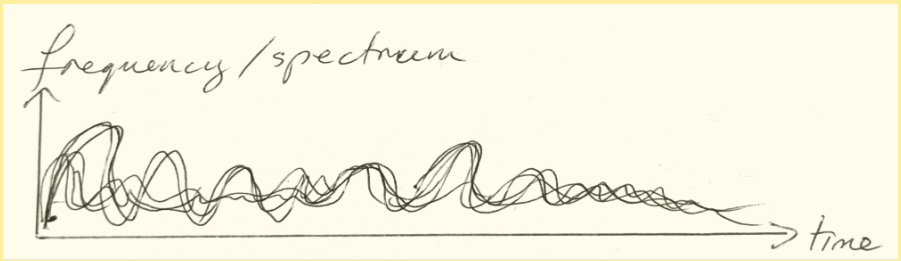
Amplitude





Spectrum





First set of sounds

- A selection of acoustic sounds transformed with digital signal processing.
- A selection of synthesised sounds transformed with digital signal processing.
- Importance of contrast (even if it was expected that sound sounds would appear too strange for most listeners).

examples

Testing stage 1: private testing on myself

- Environmental emulation
- Loudspeaker that will be used in the control room
- Combinations / permutations
- Repetition and patterns

Result: short list

Testing stage 2: Test set-up

- Testing with real listeners in a work environment: four / five people on different shifts.
- How to 'rate' the alarms? statistical approaches e.g. pairwise comparisons are problematic without a large number of listeners and special Bayesian approaches to test for ‘self-contradictions’.
- Ask listeners to explain why they liked one sound more than another using their own words.
- Use a dB meter to ensure an approximately correct listening level.

NATASHA BARRETT
sound designer
sound artist
composer

Results

Listener comments:

- Like or dislike of what a listener associated the sound with.
- Suggestion of the sound's implied priority.
- Description of how stressful / relaxed the sound felt.
- Description of parts of the sound that were liked or disliked (and what it made the listener feel).
- Whether the sound was simply pleasant to hear, irritating, or unpleasant.
- How well the sound contrasted or fitted with the other sounds in the work place.

Results

- Less ‘real-world’ sounds were more successful.
- The following simpler adjustments changed the results:
  - Listening volume: morphology allowed reduced volume.
  - EQ (spectral brightness): tuned for the speakers and acoustic.
  - Repetition speed implying urgency and its connection to stress.

Second test set

- Reduced list of sounds.
- New results: some contradiction to the first results for the same sound presented in a new way to the same listeners.
- Sound-pause sequences where not only about urgency, but about ‘sustainability’.
- Small changes in duration and morphology were important: i.e. play the duration that is needed to communicate the message.

Final set of four sounds

NATASHA BARRETT
sound designer
sound artist
composer

Future potential

Shared control rooms with unique alarms.

A control station audio fingerprint.

Alarms could sound simultaneously and not lead to confusion or stress.