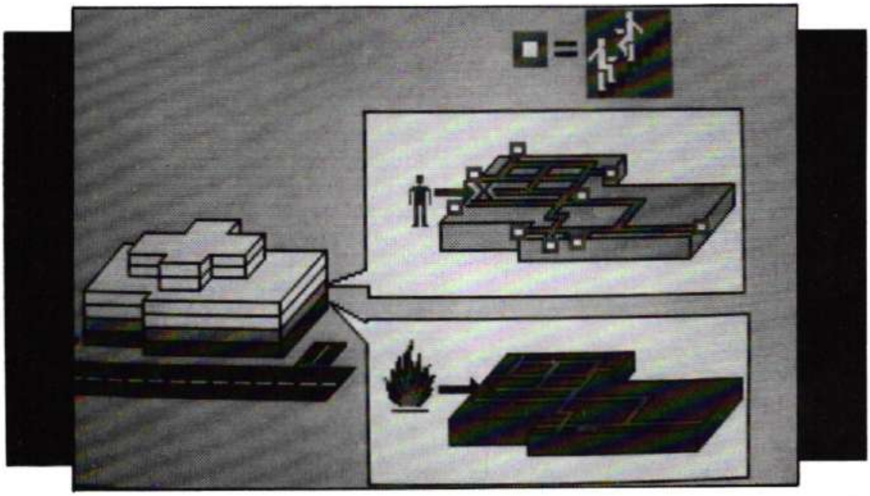
INFORMATIVE FIRE WARNING SYSTEMS:



A STUDY OF THEIR EFFECTIVENESS

by Dr. Linda Bellamy, Human Factors Unit, Technica Ltd.

This article describes some of the work that Technica carried out for the Building Research Establishment. The purpose was to evaluate the effectiveness of informative fire warning systems (IFWSs) for motivating fast evacuation of the public from buildings.

The importance of developing Informative Fire Warning Systems (IFWS) has been highlighted in a study by Tong and Canter[1]. Only 14 per cent of people he interviewed reported interpreting the most recent conventional alarm that they had heard as a genuine fire emergency and only 11 per cent said that they had left the building in response to the alarm. Sime[2] emphasises the problem of getting people to take fire warning information seriously:

"In fires we studied ranging from domestic fires in buildings of one or two storeys, to large-scale multiple-occupancy fires, the early stage of recognition was often characterised by ambiguous information cues. In a number of cases there was a serious delay in people taking these cues seriously before they realised that there was a fire."

The time delay has become known as the "gathering phase" where people try to gain enough information to confirm the existence of a fire threat. The aim of an IFWS is to provide information in order to reduce this delay in commencing evacuation and increase the number of people whose first decision is to evacuate.

To see how IFWS can meet the objective, Technica Ltd, on behalf of the Building Research Establishment, studied the effectiveness of different modes of information presentation and information content. The following modes were investigated:

1. Computer generated colour graphic displays of mimic diagrams of building floor plans.
2. Sixteen character LCD displays (the Building Research Establishment's BRESENS system).
3. Computer generated speech.
4. Computer generated text displays.
5. Computer generated warbling alarm.
6. Conventional fire tone alarm.
7. Various combinations of modes of information presentation (*e.g.* graphics and

speech).

In addition, the effect of incorporating into the computer generated speech warning — "This is an intelligent fire warning system" — was examined.

The general aim of the study was to provide some indication of:

1. The best components of an IFWS for motivating fast evacuation.
2. The expected time between the occurrence of an IFW and the decision to evacuate.
3. The proportion of people likely to make the decision to evacuate in response to an IFWS.

This article discusses, in outline, the way the study was conducted and the most important results. Details can be obtained from the Technica report[3] to the BRE.

METHOD OF STUDY

It was decided to conduct the whole study as a simulation. For this purpose the whole experimental programme was run under computer control using an Amiga PC model 1081.

Two hundred and twelve members of the public took part in the experiments. They were told that they were testing out a new computer system, therefore they had no idea that the experiment involved an examination of fire warnings. In order to simulate the effects of being in a building, each person tested was given a description of a scenario in which they had to imagine themselves. For example:

"We would like you to imagine that you have just booked into a hotel that you have never stayed in before. You are, therefore, unfamiliar with the layout of the hotel. You are on the first floor going to your room when you see this computer screen set into the wall in the corridor. The computer shows an information display or generates a spoken message. We are interested in what you think this information means and what is the first action you might take in this situation. It is important that you really try to imagine yourself in the hotel . . ."

Before the start of an experiment, each person was allocated to either of two conditions of familiarity with a building. Half of those tested were familiarised with building plans until they were able to demonstrate that they "knew" their way around the building. The other half were given no familiarisation exercises.

In generating displays, real building plans were used for the following building types:

— Residential block (used for trial runs)
— Hotel
— Hospital
— Department store
— Office block

The simulation of the warning and evacuation process was achieved by presenting each person ("subject") with a particular type of fire warning and allowing them to select from realistic (but not all correct) alternative interpretations of the warning and alternative actions that they would take. These are shown in Table 1.

The generation of each fire warning was under computer control. Subjects' key presses on the keyboard controlled the length of time the warning information was displayed, and the selections from the interpretation and action lists. In

Table 1: Possible warning interpretations and actions from which the subjects could choose

WARNING INTERPRETATIONS	ACTIONS
1. This has nothing to do with me	1. Ignore-carry on as before
2. Paging system	2. Get more information
3. Practical joke	3. See what others are doing
4. There is a fire above me*	4. Leave the building immediately*
5. There is a fire below me*	5. Collect personal belongings and leave
6. Equipment test	6. Try to find the fire
7. Fire drill	7. Phone fire brigade
8. Burglar alarm	8. Organise others
9. RETURN TO DISPLAY	

**Correct choices in the context of the experiment.*

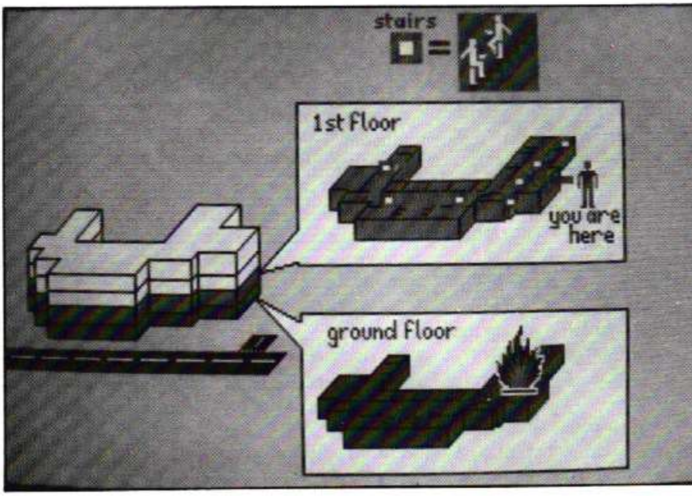


Figure 1: Example of a 3D graphic display

this way the following could be measured automatically without subjects' knowledge:

1. How often different interpretations and actions were selected for each type of warning.
2. How long subjects spent looking at or listening to warnings, how long they spent deciding on an interpretation and how long to decide on an action.

Therefore, for each warning type, it was possible to determine how accurately warnings were interpreted, how often they motivated people to evacuate immediately, and how long before they made their decision from the moment the warning was presented.

Two sets of experiments were carried out. In the first, fire warnings were presented as single mode displays, *i.e.* speech message alone, graphic design alone *etc.* In the second, combination displays of two or three modes were used. In both experiments the conventional fire tone was used on its own as a benchmark against which to compare other modes; in the second experiment, the AMIGA generated alarm was presented both alone and in combination with other modes of display.

Each person tested was only presented with one type of fire warning, but this was carried out for each of the building types.

FIRE WARNINGS EXAMINED

Graphics

For graphic displays, 2D and 3D isometric colour floor plans and buildings elevations were generated. An example of a 3D display is shown in Figure 1. The display shows the location of the person, the fire, the stairs, and the orientation of the building.

The person was always located on the first floor with the fire being either on the ground floor (high perceived threat condition) or third floor (low perceived threat condition). A pilot study on fire threat perception had initially been carried out to establish these locations. Half of those tested were allocated to the high threat condition and half to the low threat condition.

Text

Text messages were generated using two BRESENS display systems. These BRESENS "nodes" are small red boxes each with a 16 character LCD display. The messages were:

1. Low Threat Condition:

— 3rd Floor — FIRE —
— EVACUATE — Now —

2. High Threat Condition:

— Ground Floor — FIRE —
— EVACUATE — Now —

Messages were also generated on the AMIGA screen. They were:

1. Low Threat Condition:

ATTENTION!
FIRE above you
on the 3rd Floor
EVACUATE NOW!

2. High Threat Condition:

ATTENTION!
FIRE below you
on the Ground Floor
EVACUATE NOW!

Speech
In the first experiment that was carried out, computer generated speech was used which gave the same message as the Amiga text warning. In the second experiment the message was modified to be: "Attention. This is an intelligent fire warning system. There is a fire below you on the ground floor." This was termed "IFWS speech".

Alarm Sound
In the first experiment, only a conventional fire tone was used. In the second experiment a warbling tone was also generated using the Amiga. Both were presented at around 90dB(a).

Combined Displays
In the second experiment 3D graphic displays were combined with the Amiga speech message and also with the modified message ("IFWS speech"). BRESENS were also combined with IFWS speech. Two three-mode combinations were used. One used 3D/IFWS speech/Amiga alarm, where the alarm sound alternated with the speech message during the display of the graphic warning. The other was exactly the same except that text labels (*e.g.* "You are here") had been added to the 3D display to resolve ambiguities that had been reported in the first experiment.

RESULTS
The results are shown in Figures 2 and 3 for the two experiments.

Experiment 1
Looking at Figure 2 it can be seen that, although graphic displays are looked at for longer than the other displays are read or listened to (warning acquisition time), they produced the highest percentage of correct interpretations as a genuine fire warning. 3D graphics produced the highest percentage of choices to evacuate immediately.

Eighty-one per cent of interpretations of the 3D display were for a genuine fire warning, compared with 13 per cent for the conventional fire tone. However, it was quite clear that a correct interpretation did not result in immediate evacuation. For 3D graphic display 64 per cent chose to evacuate immediately compared with 11 per cent in the fire tone mode. In fact, all the informative modes produced better intrerpretation and action results than the conventional fire tone. For the fire tone, the most frequent interpretation was that it was an equipment test (28 per cent of interpretations).

Looking at other action choices, uncertainty reduction dominated. This was reflected in the choices to either seek more information or to see what others were doing. By combining these two information gathering categories, it was found that 53 per cent chose these for the fire tone, but only 8 per cent for 3D graphic displays and 21 per cent for Amiga speech.

Overall, only 8 per cent chose to collect personal belongings before leaving. However, 25 per cent ignored the fire tone warning altogether compared with no more than 5 per cent for the IFW modes.

Looking at the total time taken to make a decision, this is made up from the three components of warning acquisition time, interpretation time and action decision time. Although there were some differences between modes for these components, the differences for total times were not significant. The mean response time was 43 seconds with the majority of those tested falling in the range of 19-67 seconds (*i.e.* standard deviation of 24 seconds).

Familiarity with a building significantly improved fire warning interpretations but had no effect on the decision to evacuate. It also had no effect on response times.

Fire threat level had no significant effect.

Experiment 2
The results for the second experiment are shown in Figure 3. In general, the combined modes showed improvements over the single modes for interpretations as a genuine fire warning apart from the combination using modified 3D displays. Interpretation accuracy ranged from 77-92 per cent for the informative fire warnings. Only the two-mode combinations which contained the IFWS speech message were comparable or better than 3D alone for movitivating evacuation. BRESENS/IFWS speech led to immediate evacuation 63 per cent of the time, with 77 per cent for 3D/IFWS speech.

Of all the combined modes, modified 3D/IFWS speech/alarm was the worst, generating only 42 per cent immediate evacuations. This could well have been due to information overload. However, all informative modes were better than both the fire tone and the Amiga alarm which generated only 8 per cent and 23 per cent immediate evacuations respectively.

The most frequent response to the fire tone was to ignore it (33 per cent) whereas for the Amiga

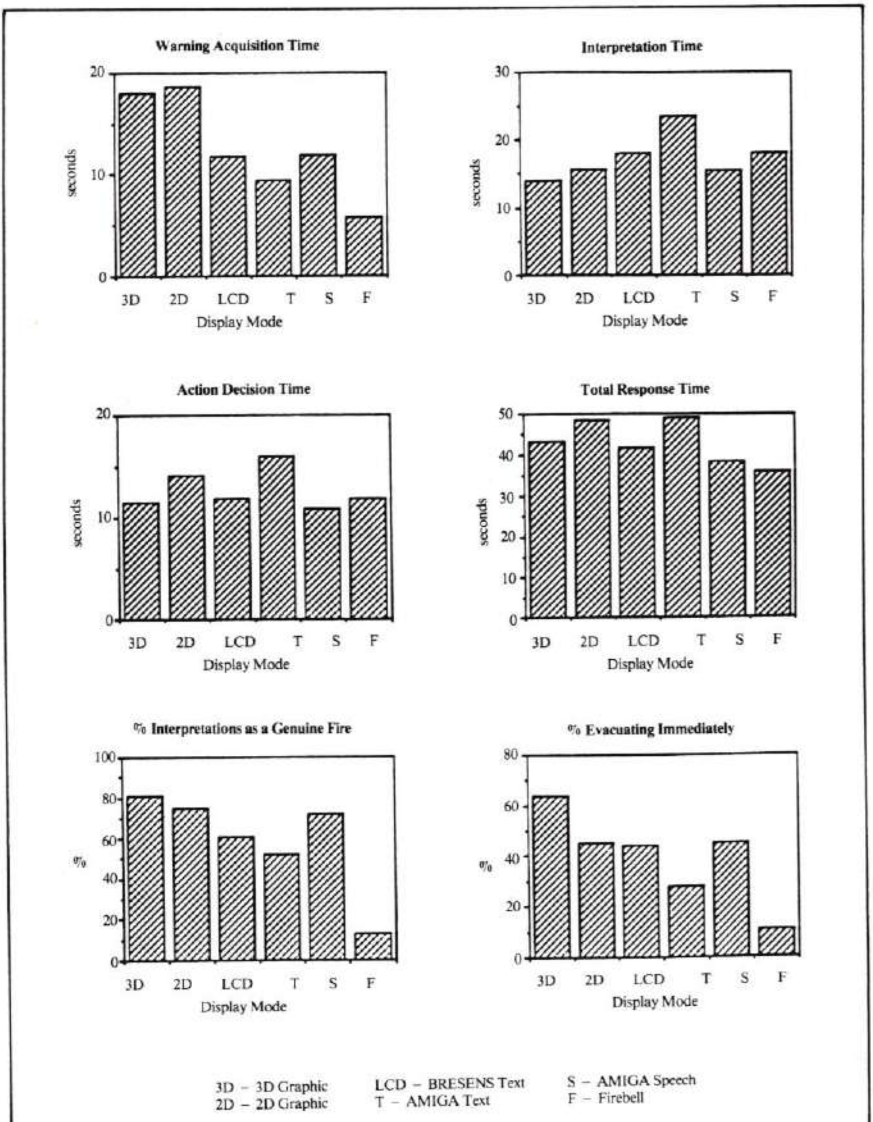


Figure 2: Summary graphs for results of Experiment 1

alarm it was to get more information (25 per cent).

Looking at total times before a decision was made, the mean was 38 seconds with most people falling in the range 24-52 seconds (standard deviation of 14 seconds). Mode had a significant effect on total times. The shortest was for 3D/speech (31 seconds), the longest for modified 3D/IFWS speech/alarm (50 seconds).

CONCLUSIONS

This study demonstrated the potential of Informative Fire Warning Systems for motivating immediate evacuation of the public from buildings. The best IFW modes of presentation provided as much as a six-fold increase in the numbers choosing to evacuate immediately when compared with a conventional fire alarm.

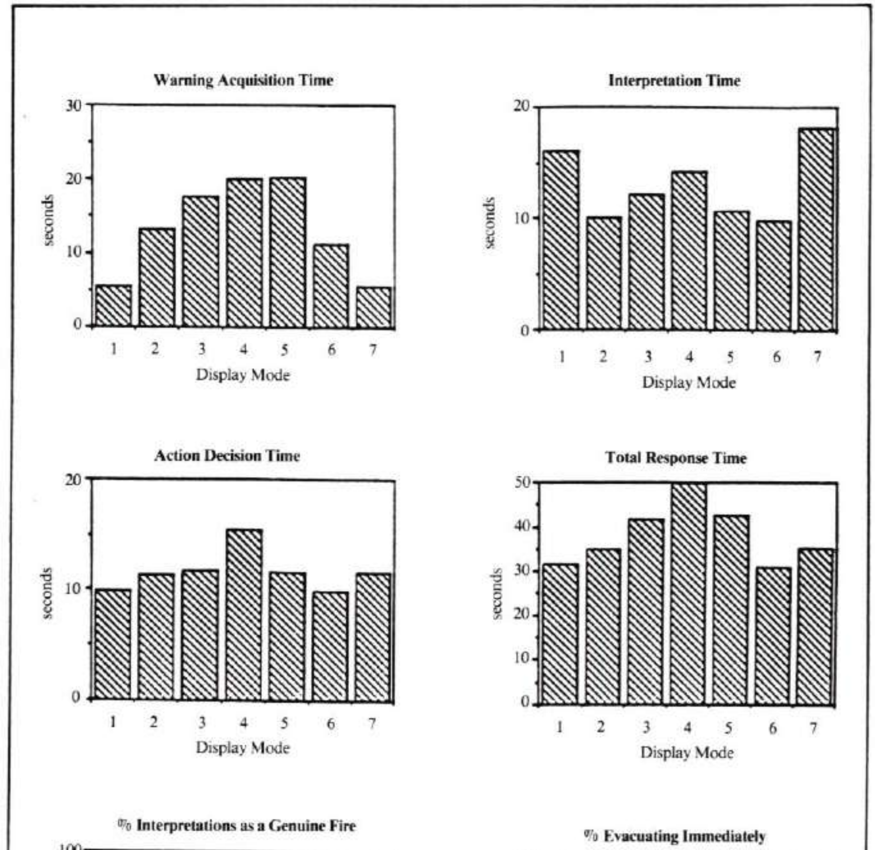


Figure 3: Summary graphs for results of experiment 2

The poor response to the fire tone and the Amiga alarms indicate the weakness of conventional systems; inaccurate interpretations of these alarms demonstrate their ambiguity in conveying information. On the other hand, 100 per cent success was not achieved with IFWSs, although the 60-80 per cent immediate evacuations obtained with some modes indicates the powerful effect of providing people with information that they can use to make judgements.

The fact that a correct interpretation of a warning as a genuine fire does not always motivate immediate evacuation suggests a problem in the education of the public regarding quick responding to fire alarms. The perceived reliability and authoritativeness of the IFWS may play an important role in getting people to respond as directed, but that is not wholly sufficient in obtaining the desired effect. People still choose further information seeking. The best mode of warning was a combination of 3D graphics and a spoken message which also said: "This is an intelligent fire warning system." This spoken message combined with the BRESENS system was also very effective.

In terms of the time taken to arrive at an action decision, this is fairly short. Most people took up to one minute to decide to evacuate. On the other hand, this time is comparatively long relative to measured evacuation times. The effect of mode of warning presentation on the overall times to arrive at a decision was very small.

L. J. BELLAMY

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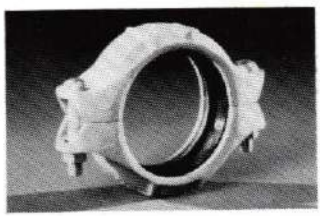

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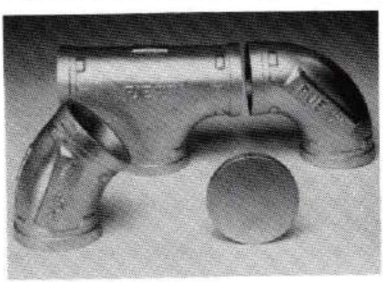

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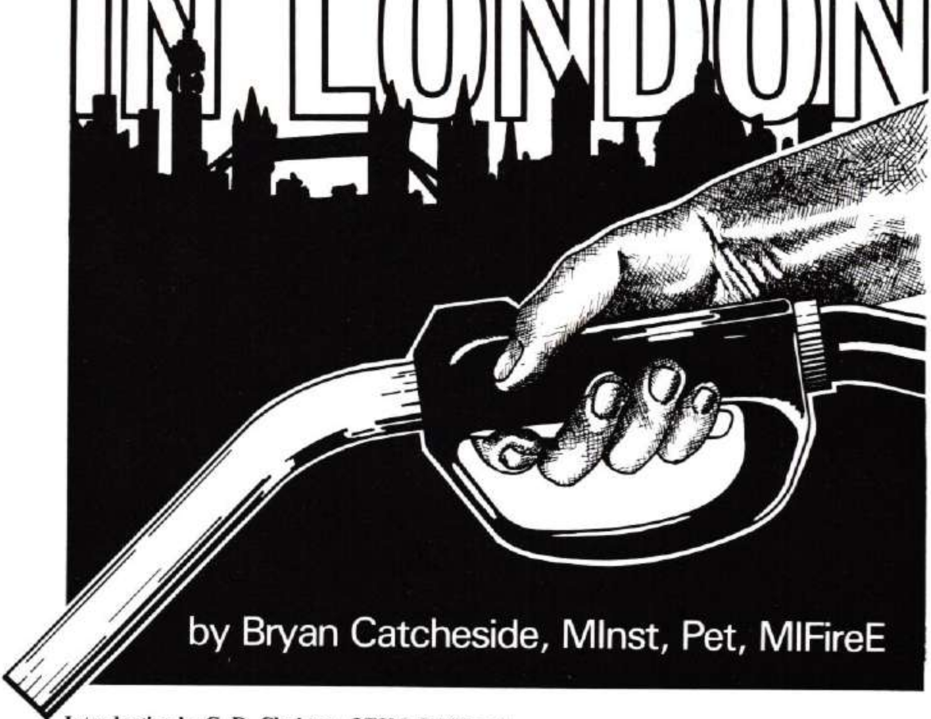

by Bryan Catcheside, MInst, Pet, MIFireE

Introduction by G. D. Clarkson, QFSM, BA(Hons),
Chief Fire Officer & Chief Executive, London Fire & Civil Defence Authority

As the petroleum licensing authority for the whole of the Greater London area, the London Fire & Civil Defence Authority, along with its predecessors, has adopted a pioneering role in the formulation of licensing and safety standards in the U.K.

In the following detailed article, the Authority's Senior Petroleum Inspector, Mr. Bryan Catcheside, M.Inst. Pet, MIFreE, discusses the policies and looks at present and future developments in the responsibilities of the Authority's Petroleum Inspectorate.

Mr. Catcheside is a highly respected authority in his field and I endorse his sound and able analysis of the current situation.