Train Protection and Warning System - Audible alerts
T902 - September 2010

Overview

The Train Protection and Warning System (TPWS) is a primary safety system in use on the railways in Great Britain (GB). TPWS reduces the risk from trains passing signals at danger (or signal passed at danger - SPAD). After the Ladbroke Grove train crash in 1999, in which two passenger trains collided following a SPAD, the fitment of TPWS to the rail infrastructure in Britain was accelerated. However, since TPWS was rolled out there have been 31 occasions (at the time of writing) where a train has passed a signal at danger, been successfully brought to a stand by TPWS, but then the driver reset the train equipment and continued the journey without the signaller’s authority. These incidents are known as ‘reset and continue’ events. The ability of the driver to be able to release the train brakes following a SPAD and the design of the TPWS driver machine interface (DMI) have been identified as causal factors for reset and continue.

An RSSB research project (T725 Justifications of TPWS modifications identified in reset and continue research) trialled a range of new TPWS DMIs. The new DMIs incorporated an improved user interface to support drivers in working out the cause of a brake application. The new designs also prevent a driver from releasing the train brakes by powering down the driver’s desk.

Figure 1 - ‘3 indicator’ TPWS DMI
The rail industry chose to implement the ‘3 Indicator’ TPWS DMI for new trains (Figure 1). The specification for the 3 indicator DMI is detailed in Railway Group Standard GE/RT8030 Issue 3 (Requirements for the Train Protection and Warning System).

This research project designed the audible alerts for the 3 indicator TPWS DMI. The audible alerts consist of three speech messages, the first two of which are preceded by the same, short, ‘priming tone’. The speech messages were as follows:

1. 'SPAD alert, contact the signaller'
2. 'Overspeed, contact the signaller'
3. 'TPWS and AWS operational'

The design and delivery of the audible alerts was undertaken by the University of Plymouth.

Aim

The aim of this project was to design the audible alerts for the ‘3 indicator’ TPWS DMI. The alerts were designed to be resistant to masking by other noises in the train cab, be distinct from other cab alerts and to not startle train drivers.

Method

Selection of priming tone

The priming tone was selected by first reviewing existing alerts within the train cab and then selecting a design that is distinctive from other alerts. A set of eight candidates for the priming tone were presented to a project steering group from which it was deduced that frequency modulated style tones were preferred. Four variants of the frequency-modulated tone were presented to the steering group for consideration. The tones were presented in a paired comparisons experimental design in which each tone was compared with each other tone once, from which the preferred tone could be chosen.

Selection of speech message

A two-stage process determined first the speaker to be used and then the style in which the messages would be delivered.

In the first stage, four female speakers were selected and asked to speak each of the three messages. The speakers were asked to deliver the messages evenly, clearly, impersonally and without unnecessary urgency.

Samples of each of the four speakers speaking the same message were presented to the steering group. On the basis of
a paired comparison study and subsequent discussion, a preferred speaker was identified.

In the second stage, the preferred speaker was asked to speak each of the three messages several times, varying the stress, patterning and urgency. Four versions of each of the three messages were presented in a paired comparisons study from which a preferred style of speaking was chosen.

Findings

The priming tone selected was a 3-pulse tone with a fundamental frequency of 440Hz, with regular harmonics at 880, 1320, 1760 and 2220Hz. The tones were frequency-modulated at a speed of 20Hz and a depth of 15Hz. Each of the pulses was 300ms in length with no time intervals between them, resulting in a length of 900 ms for the complete priming tone. In order to avoid a startle response, each pulse was subject to an ASDR amplitude envelope.

A female voice was chosen for the speech messages because the female voice is more suitable where there is considerable low-frequency noise, which is the case for train cabs. The study indicated that a non-urgent, relatively monotic style with no particular stress on any words, evenly paced syllables and clear enunciation was preferred.

Deliverables

This project delivered the audible alerts for the '3 indicator' TPWS DMI as .wav files recorded at CD quality sampling rate.

The audible alerts consist of three speech messages, the first two of which are preceded by the same, short, 'priming tone'. Both mono and stereo versions of the recordings were made.

- 1a Priming tone plus SPAD alert in stereo
- 1b Priming tone plus SPAD alert in mono
- 2a Priming tone plus Overspeed alert in stereo
- 2b Priming tone plus Overspeed alert in mono
- 3a TPWS and AWS operational in stereo
- 3b TPWS and AWS operational in mono

Also available are the SPAD and Overspeed voice messages only and the Priming Tone only, as individual files.

- 1c SPAD alert message only in stereo
- 1d SPAD alert message only in mono
- 2c Overspeed alert message only in stereo
- 2d Overspeed alert message only in mono
- 4a Priming tone only in stereo
- 4b Priming tone only in mono
The links above will allow you to play, or download, each of the files individually. Alternatively, you can download a Zip file containing the complete set of priming tones and speech alerts from: http://www.rssb.co.uk/sitecollectiondocuments/pdf/research-toolkits/T902/TPWS_AudibleAlerts.zip

Stakeholders’ experience

The TPWS suppliers were involved in the development of the audible alerts to ensure that the deliverables of the project could be implemented smoothly. Train operators were consulted during the project to check that the alerts would be acceptable by train drivers.

Next steps

The TPWS audible alerts will be distributed to the TPWS suppliers in CD format. The alerts will also be incorporated into the forthcoming Railway Group Standard GE8075 'AWS, TPWS and Train stop interface requirements' (which will replace GE/RT8030 Issue 3 'Requirements for the Train Protection and Warning System'). Consultation on this new standard will be initiated by the Control Command Signalling Standards Committee and is expected to take place in December 2010.

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