Results of a Survey on Audio and Visual Warning Systems for Military Helicopters

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Introduction

The Defence Research Establishment, Valcartier, (DREV) of the Department of National Defence (DND) is presently developing an Eye-safe Laser-Based Obstacle Warning System (ELBOWS). It is intended to mount this system on one or more Canadian Forces' (CF) helicopters to provide advance warning of obstacles in the flight path of the aircraft. The Defence and Civil Institute of Environmental Medicine (DCIEM), DND's center of excellence in human factors, has been tasked to develop a display for the new warning system.

Aircraft used in the military environment contain numerous warning systems to assist the crew in monitoring the state of their equipment and flight path. For example, the CH-146 Griffon helicopter contains more than 60 warning and indicator lights, and five or six auditory alerts. The auditory alerts provide notification of conditions ranging from routine to critical. For example, one routine alert is a sound similar in nature to the ringing of a telephone, which tells the crew they are being contacted on high-frequency (HF) radio. However, another audio alert indicates that rotor speed has decreased to the point where the helicopter is in immediate danger of losing lift; this critical warning sound is backed up by warning lights in both pilots' primary field of view.

Requirements for the ELBOWS Display

Much is known about warning systems and displays. Basic issues relevant to the ELBOWS system were discussed in a previous report [1]. As a result of this literature review and analysis, it was decided that the system should identify and classify obstacles. Furthermore, the critical nature of avoiding obstacles with little warning time appears to justify an additional audio alert. Other researchers have determined that up to ten audio alarms can be distinctly identified in military helicopters [2]. Laboratory research has implied that the use of spatial, or three-dimensional audio, may provide a reaction time advantage over non-directional audio [3].

However, the literature review left some issues unresolved. For example, what level of tolerance will the crew have for false alarms? Is there any confusion interpreting existing audio alarms? Should the new warning have a cancel feature? Do the air crew want to have a backup to the primary warning? To address these and other questions, it was decided to design and administer an attitude questionnaire on the subject of audio and visual warning systems in military helicopters.

Questionnaire Design

The selected audience for the questionnaire was current regular and reserve force helicopter air crew. The questionnaire was designed to solicit two types of answers: descriptive answers to supply background information and detailed descriptions of warning systems issues; and scaled questions amenable to statistical analysis. The final questionnaire contained 42 items, and was organized into four major sections:

- relevant information about the respondent, to be used for factor analysis;
- general questions on warning systems, to determine the general level of knowledge and attitudes of the respondents towards warning systems;
- specific questions about audio warnings, to investigate specific design issues and operator attitudes toward audio warnings; and
- questions relating to the specific functionality of the proposed obstacle warning system.

In addition to the four main sections of the questionnaire, respondents were asked to indicate whether they had experienced a near miss with wires.

A pilot trial of the questionnaire was performed at a CF helicopter squadron and responses were received from five volunteers. Two of the questionnaires were completed in the presence of the experimenters; three other forms were completed and returned by mail. Several changes were made to the formatting as a result of the pilot trial, and two new questions were added.

Survey Administration

The final version of the questionnaire was administered at two CF helicopter units, - a search and rescue (SAR) squadron and a tactical helicopter squadron. These two operational communities were sampled because of the very different nature of their missions. Additionally, the SAR squadron flies a large twin-rotor helicopter and the tactical helicopter squadron flies the smaller, single-rotor CH-146 Griffon.

Both squadrons were visited by the survey administrators with the intention of getting all surveys completed during the three or four-day visits. The population of helicopter air crew at the SAR squadron was considerably smaller than at the tactical helicopter squadron (less than 20 at the former vs. about 75 at the latter). However, the response rates at the two units were significantly different, resulting in approximately the same number of responses from the SAR and tactical samples.

Results

Thirty completed questionnaires were received. All of the surveys from the SAR air crew were completed and returned to the administrators during the squadron visit; some of the surveys from the tactical squadron were returned by mail.

The personal data section of questionnaire asked for information concerning number and type of flying hours, crew position, years of service and type of service (regular or reserve). However, because of the relatively small sample sizes, the only factor that appeared to be significant in the grouping of responses was whether the respondent was from a tactical or a SAR squadron.

Of all the respondents, one-half answered 'it depends' when asked whether audio or visual warnings are more likely to get their attention. Forty percent replied that audio warnings were more likely to get their attention, and ten percent stated that visual warnings were preferred. Only two of thirty people had experienced confusion while interpreting audio alarms; the response rate was similar for visual alarm confusion.

No one thought that there are too many audio alarms in the two CF helicopters under study. We also asked whether current alarms are too quiet, just right, or too loud, using a word-anchored, seven-point scale. Twenty-four out of twenty-eight replies to this question indicated that the volume of current audio warnings is 'just right'.

In two different questions, the air crew were asked to list the most important warnings and those of secondary importance in the two helicopters. While the individual lists varied somewhat, there was general agreement that the most important warning list includes:

- master caution light (visual)
- radar altimeter (audio)
- fire (visual)
- low rotor speed (audio and visual)

The secondary warning list was much longer, and no item was listed by more than six respondents. Two audio alerts appeared in the secondary list: the emergency locator transmitter alert, and the HF radio notification.

The survey also addressed the cancellation and switching-off of alarms. A cancel function resets the alarm without corrective action being required; a subsequent warning condition will reactivate the alarm. Switching off an alarm means that no warning will be issued. Respondents were asked whether current auditory alerts could be cancelled or switched off. While there was some misinterpretation of this question (some respondents felt that pulling a circuit breaker was a valid way to switch off an alarm), it was possible to determine that some critical auditory alerts can be cancelled and/or turned off. When asked whether the new system should have a cancel function, all respondents answered in the affirmative. Six respondents said the system should not have an on/off function, while the remainder said that it should.

A sensor-based obstacle warning system will generate some false alarms. The tolerance of air crew to false alarms is a subject of great concern in the design of the display: too many false alarms and the air crew will distrust the system. We asked how often current warning systems provide false alarms, and twenty-six of twenty-eight replies indicated rarely, occasionally, or sometimes (one to three on a five-point word-anchored scale.) We asked respondents to rate the degree of acceptability of false alarms on a seven-point, word-anchored scale. One-half of the answers were unacceptable in all or most systems; only one person said false alarms were acceptable in most systems. Air crew were asked whether false alarms could result in incorrect actions, and 27 of 30 agreed to some extent. Most respondents also agreed that multiple false alarms could cause a subsequent valid alarm to be ignored.

The questionnaire provided six possible options for the new warning system display: voice directions, tone only, tone and voice, light only, light and visual direction, and tone and visual direction. The only definite conclusion from the responses is that no one preferred the light only option. Thirty of thirty-nine answers (some respondents indicated multiple choices were acceptable) included audio, and the remaining nine preferred a light and a visual direction.

The last question asked whether the air crew had experienced a near miss. More than one-third of the respondents indicated they had been involved in such a situation, providing strong support for the new warning system.

Conclusions

The results of the survey have provided some valuable and insightful input into the process of display design for the new system. The need for the system is supported by the significant number of near misses reported by the air crew.

Questions related to the use of audio vs. visual alarms tended to favour the use of an audio alert. However, several respondents also indicated visual only preferences. False alarms are a great concern for the operators and the new system will need to be robust against them.

The completion of the survey represents the end of the second of three stages of requirements capture. In the third and final stage, experimental work will be undertaken to verify the nature of the warning display, e.g. tone vs. voice vs. light, etc.

References

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