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Auditory Demands on Canadian Forces Aircrew

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Auditory Demands on Canadian Forces Aircrew

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ABSTRACT

Situations of high demands placed on the auditory channel of Canadian Forces (CF) aircrew are reviewed in this paper. High auditory demands resulting from periods of intense radio communication often occur in military aviation which may degrade crew performance by interfering with internal communications and cognitive tasks. Additionally, auditory warnings may be presented through the same channels, resulting in loud, strident auditory warnings that often disrupt thought as well as verbal communication among aircrew members. It is also recognized that the visual channel is heavily loaded and investigations are underway, exploring the use of vocal commands to control aircraft systems. Combined, these issues will require new means to manage auditory workload in CF cockpits. This paper documents some cases of high auditory demand and notes three emerging technologies that will affect auditory demands for aircrew.

INTRODUCTION

Linde and Shively (1988) reported that 30-50% of flight time in police helicopters involves communications. A field investigation of low level military helicopter operations (Shaffer et al., 1998; Youngson, 1988) found crews engaged in 2 to 6 messages per minute spanning 20 to 30% of the mission. This does not include passive monitoring of radio channels, critical for developing situational awareness, since such scenarios typically involve numerous, dispersed operators. Thus, communication consumes a significant amount of aircrew time and attention with current systems.

Auditory warnings are used to alert aircrew to dangerous or potentially dangerous conditions. Since the auditory sense usually cannot be "turned off", it is often regarded as the primary choice for presentation of warnings or important messages that must be attended to immediately. The omnipresent nature of audition further recommends sound as the mode of choice for drawing attention to critical situations. Moreover, reaction time to auditory signals has been found to be superior to visual signals during high acceleration or g-stress (Canfield, Comrey & Wilson 1949).

The use of auditory warning signals has been recommended to assist in the reduction of the pilot's visual workload, increasing both the probability and the speed with which one might react to emergency situations (Doll & Folds 1985). Unfortunately, the spare auditory capacity that is available in flight crews is not known; increasing auditory demands coupled with low signal/noise ratios, clipped messages, low information redundancy or low feedback can all lead to misinterpretation or erroneous fulfilment of expectations. Pilots claim present auditory warnings lack a sense of priority – every alert is

urgent. Many of the existing warnings are described as being too loud, insistent, startling, and distracting, disrupting thought and communication, and viewed by pilots as being annoying rather than helpful (Patterson 1982).

EXAMPLES OF INCIDENTS AND ACCIDENTS IN THE CF

CF aircrew have experienced problems in attending to and interpreting auditory information. Several types of problems have been identified, including missed alerts, misinterpreted alerts, insufficient or incorrect communication between aircraft, and ignored alerts. A few examples involving design, training and human factors issues, from CF Directorate of Flight Safety files are reported here:

- An experienced fast jet pilot landed his aircraft with the gear up, destroying the aircraft. The pilot stated that he had ignored the auditory "gear unsafe" warning because of several false alarms experienced previously in the same aircraft.
- A fighter aircraft engaged in an air-to-air combat training mission descended below the minimum safe altitude. The pilot had set the system to alert at the correct altitude, however, the aircraft was engaged in a high-G manoeuvre when it passed this altitude, and the pilot did not comprehend the alert.
- A student on approach realized that he was too low, too soon. He added power to the aircraft to extend the approach to the correct position. The resulting high engine noise in the cockpit prevented the student from hearing the "gear unsafe" warning horn.
- Two CF-18 fighters were part of a combat training exercise. The pilots had calculated and briefed their minimum fuel load for the exercise. One pilot failed to correctly arm the "low fuel" warning system, and the other pilot missed the low fuel voice warning while performing a combat manoeuvre.
- A CF helicopter was operating at low level at night. The two pilots had set different limits on their altitude warning system. The system activated only for the higher altitude; when the aircraft descended below the lower altitude setting, no warning was given. The aircraft subsequently crashed and was destroyed.

SOME TECHNOLOGIES AFFECTING AUDITORY DEMANDS

DCIEM is investigating some technologies that show promise in alleviating the demands placed on pilots. While many modern developments have obvious advantages, there may be undesirable or unrecognized side-effects. Human factors assessments are in progress, but the true cost and benefit of each technology will require considerable additional work.

Active Noise Reduction

Military aircrew are often subjected to potentially hazardous noise levels during flight. This situation results from the combination of cabin noise permeating the flight helmet and the reception of communications traffic at high volume necessary to promote adequate intelligibility. Lack of low-frequency attenuation available from conventional flight helmets, resulting in "bass-heavy" sound at the ear, contributes to forward masking: the capability of intense low-frequency noise to mask or cover desirable higher frequency

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None of the commercial devices tested at DCIEM to date is considered entirely suitable for the CF although several have the potential to be so, pending certain modifications. For example, effective fitting is pivotal to adequate ANR performance, a process that is difficult both to achieve and maintain with current systems.

While it is known that background noise can cause fatigue or hearing damage as well as mask important messages, it is rarely acknowledged that expert operators make use of some of this stimulus for feedback on their environment. Thus, while technologies such as ANR have potential to address the primary problem, care must be taken that they do not also obscure the beneficial noise in the process.

Direct Voice Input

An exploratory study of human factors issues associated with the use of direct voice input (DVI), a technology that makes use of automatic speech recognition to control systems, is in progress at DCIEM. While alleviating some demands, DVI will place a further load on a busy auditory channel and thus requires study to assess its usefulness.

Military helicopter pilots flew a moderate fidelity simulator in which they adjusted the radios either manually or using DVI. As expected, subjects preferred DVI to manual radio control when either the visual and psychomotor demands of flying the simulator were manipulated. Further, preliminary data analysis indicates that subjects were able to correctly acknowledge the occurrence of a simple spoken auditory pattern in a tertiary task while using either DVI or manual control. Flying and radio task performance were unaffected by this simple auditory load, but it remains to be seen whether these results will hold with more complex auditory patterns, particularly when similarities exist between target and distracter stimuli. Interestingly, manual control performed better than DVI when a concurrent auditory/cognitive tertiary task was present, as DVI promoted greater confusion and more errors both in the radio task and in the tertiary task of memorizing and subsequent repeating of spoken call-signs.

Baber (1996) has also reported on a number of human factors issues with DVI arising from high workload and time-critical external demands. Increased workload can cause delays in speech production, increased speech rate, and reversion to well learned structures, such as colloquial jargon, resulting in misinterpretation. In high workload environments, feedback is treated as a more general indicator, often being taken as a sign of successful transmission, regardless of the intended message.

Three-Dimensional Audio

The use of directional auditory cueing via a three-dimensional (3D) audio display could alleviate pilot's visual demands without necessarily increasing auditory demands significantly. It has been proposed that a 3D auditory display can support improved situation awareness and spatial orientation by providing veridical spatial cues to the positions of targets, threats and beacons (Doll 1986). In order to synthesize the location of a sound in virtual auditory space over headphones, digital filters called head-related transfer functions (HRTFs) have been measured from humans or acoustic mannequins for many sound source positions in the free-field.

DCIEM has recently completed a study which examined the effects of stimulus bandwidths and differing HRTFs on auditory localization in the horizontal plane. A preliminary analysis of the data suggests that localization performance measured by percent correct, type of reversal (e.g., front/back, left/right, and diagonal), and response time was not significantly affected by the choice of HRTF or stimulus. This suggests that limited bandwidth in the communication system of CF aircraft may not be a factor for presenting directional cues over headphones in the horizontal plane. Extension to include audio cueing in the vertical plane may require a bandwidth that exceeds current hardware capabilities.

It was reported that a 3D audio display decreased target acquisition time, increased communication capability, increased situation awareness, and decreased visual workload (McKinley and Ericson 1997). It has been observed though, performance will be worse than unaided search if 3D auditory localization errors are sufficiently large (K. Hendy, DCIEM, personal communication).

SUMMARY

Aircrew depend on communications and auditory warnings in order to successfully complete their jobs. As shown above, warnings sometimes fail to be effective and have the potential to interfere with essential communications. Some errors occur because the systems do not perform as expected, reflecting problems in system design or training procedures; some systems perform exactly as intended, and the operators still fail to take the proper corrective action. These examples highlight the need for further research on the subject of audio demands in CF aircraft.

Ongoing research and development at DCIEM is attempting to deal with some of the current problems in the use of auditory information in CF aircraft, extending laboratory studies into the field. The development of ANR headsets is continuing, enhancing performance through digital signal processing. DVI technology will be integrated into a CF helicopter for field research within the next year and its domain of usefulness needs to be established. An experiment is being planned to verify the advantages of 3D audio using a moving-base CF helicopter simulator. The use of new technology and the "smarter" use of existing technology show great promise for increasing the effectiveness of aircrew in the CF environment.

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RÉSUMÉ

Cet article révise les situations qui imposent de fortes demandes auditives sur le personnel navigant des Forces Canadiennes de l'air. Ces demandes auditives élevées résultent de périodes constituées d'intenses communications radio, communes en milieu militaire aérien, pouvant contribuer à la dégradation de la performance de l'équipage en interférant aux communications internes ainsi qu'aux tâches cognitives. De plus, plusieurs avertisseurs sonores peuvent être transmis à travers les mêmes réseaux de communication générant de ce fait de forts bruits ainsi que de stridents avertisseurs qui habituellement perturbent les pensées des membres tout comme les échanges verbaux parmi l'équipage. Il est également reconnu que l'appareil visuel s'avère être fortement surchargé et plusieurs études sont présentement en cours afin d'explorer l'utilisation de commandes vocales dans le but de contrôler les systèmes avioniques. Ces aspects problématiques requièrent de nouveaux moyens permettant la gestion de tâches auditives dans les cabines de pilotage des Forces Canadiennes. Cet article énumère quelques cas impliquant de fortes demandes auditives et présentent trois avances technologiques qui affecteront les demandes auditive pour l'équipage navigant.

by directing visual attention through audio cues without. DCIEM has recently completed a study which examined the effects of stimulus bandwidths and different head-related transfer functions (HRTFs), the filters that encode binaural and spectral cues, on auditory localization in the horizontal plane. A preliminary analysis of the data suggests that localization performance measured by percent correct, type of reversal (e.g., front/back, left/right, and diagonal), and response time was not significantly affected by the choice of HRTF or stimulus. This suggests that limited bandwidth in the communication system of CF aircraft may not be a factor for presenting directional cues over headphones in the horizontal plane.

While many modern developments have obvious advantages, there may be undesirable or unrecognized side-effects. Human Factors assessments are in progress, but the true cost and benefit of each technology will require considerable additional work. The above examples highlight the need for further research on the subject of audio demands in CF aircraft. Ongoing research and development at DCIEM is attempting to deal with some of the current problems in the use of auditory information in CF aircraft.

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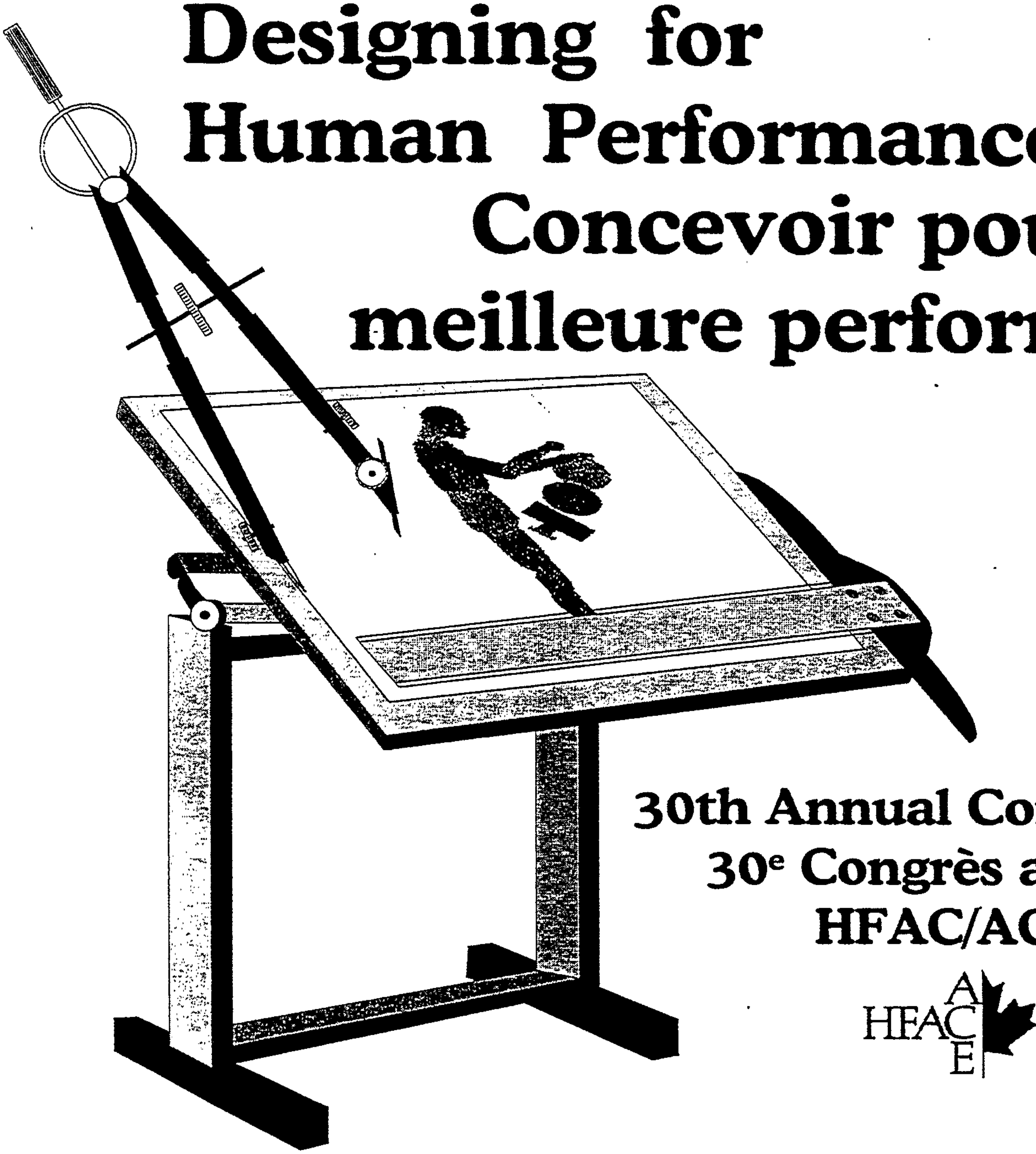

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