ANY OTHER BUSINESS

Report on effects of auditory warning types on response time and accuracy in Integrated Bridge System

Submitted by the Republic of Korea

SUMMARY

Executive summary: This document provides the result of a research project on the Integrated Ship Bridge Alarm System and it is expected to contribute to discussion on the Bridge Alert Management which is one of the major modules of Integrated Bridge System (IBS)

Strategic direction: 5.2

High-level action: 5.2.4

Planned output: 5.2.4.2

Action to be taken: Paragraph 6

Related documents: NAV 55/4, NAV 55/INF.3, NAV 55/INF.5 and NAV 55/21

Introduction

1 At the request of the Maritime Safety Committee (MSC), the Sub-Committee on the Safety of Navigation (NAV) agreed to establish a Correspondence Group in order to review the revised performance standards for both an Integrated Navigation System (INS) and an Integrated Bridge System (IBS) at its fiftieth session. A Correspondence Group coordinated by Germany, involving fourteen Member Governments (Finland, France, Japan, Norway, Poland, Republic of Korea, etc.) and six non-governmental organizations (IEC, ISO, etc.), have worked on the aforementioned systems.

2 The Republic of Korea provided the information (NAV 55/INF.3) on the results of a research project on the Integrated Ship Bridge Alarm System, and Japan provided the information (NAV 55/INF.5) on their experiences of developing industrial standards for voice alarm/control system, based on Japanese Industrial Standards (JIS F 0062). The Technical Working Group finalized the draft MSC resolution (NAV 55/21, annex 7) and the Maritime Safety Committee adopted resolution MSC.302(87) on Performance Standards for Bridge Alert Management, set out in annex 21.
3 Although there are a lot of auditory warning sounds in the ship’s bridge, there is not enough research on the operator’s ability to recognize and interpret those warnings. Therefore, the Republic of Korea carried out the groundwork for effects of different auditory warning types on response time and accuracy in ship bridges.

4 In this experiment, subjective preference on the type of auditory warnings was also of a primary concern. Twenty-five subjects were asked to select an appropriate button for the warning sound presented with three types of auditory warning (abstract sound, auditory icon, and voice alarm) and five levels of warning situation (fire, steering failure, collision, engine failure and low power).

5 The results showed that the response time and accuracy was significantly affected by the types of auditory warning. The voice alarm resulted in a higher accuracy and subjective preference, as compared to the auditory icon and abstract sound. Regarding the response time, auditory icons and voice alarms were equivalent and superior to abstract sounds. In the upcoming future, the result of this research should be reflected in reviewing the guideline of Integrated Bridge System (IBS) as appropriate.

**Action requested of the Sub-Committee**

6 The Sub-Committee is invited to note the information provided.

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ANNEX

REPORT ON EFFECTS OF AUDITORY WARNING TYPES ON RESPONSE TIME AND ACCURACY IN INTEGRATED BRIDGE SYSTEM

1 Introduction

The various kinds of indication equipments are used for delivering detailed information at the bridge and these indication equipments should be designed to deliver the information for deck officers as quickly and exactly. In the bridge of the vessel, visual display is mostly used in a general information delivery, but auditory display is mainly used in emergency situation information delivery. Auditory display can be more effective means than visual display in the following cases; message is simple or short; it doesn't need to refer for the future; it contains the information only at the time when it delivers; and it is a message or warning that demands immediate action (Sanders and McCormick, 1987).

Auditory icon is a warning sound that uses an environmental sound in other words, a natural sound (Ballas etc., 1987; Gaver, 1986). For example, it is the way to warn fire warning situation by presenting firewood crackling sound. Auditory icon is a sound of different type with abstract sound and voice alarm and has a potentiality that can be used for the effective auditory warning. Auditory icon shares benefits of abstract sound and is different with it because a kind to be learned is not limited. Leung (2001) made voice alarm, abstract sound and auditory icon on certain circumstances and measured respectively the number of total performance times and the number of error until subjects answered it correctly. As a result, he reported that there was no significant difference of error rate between voice alarm and auditory icon but abstract sound had a significant difference with voice alarm and auditory icon.

Generally, in the bridge, there is a working circumstance that actual verbal communication that needs for working performance, various auditory signals and unwanted noises co-exist. But the study that analyzes synthetically an effect on human recognition ability caused by warning sounds is insufficient. And these sounds are divided broadly into voice alarm, abstract sound and auditory icon depending on each different warning situation in this circumstance. This study is conducted to recognize how human respond accuracy, respond time and subjective satisfaction level change depending on the type of warning situation and auditory warning sound in the bridge working circumstance.

2 How to do the experiment

2.1 Subjects

25 persons in 1 - 3 class COC holding deck officers joined the experiment, which were normal in their eyesight and hearing and had personal computer using experience. Seagoing year of subjects was average 7.6 years and their age was average 40.6 years.

2.2 Experiment equipment

For the experiment PC (P-4 1.8GHz), LCD colour monitor (17 inches, Resolution 1024×768), Mouse, Head-set (SHS-100V), MFC (Microsoft Foundation Class Library) and simple calculation question papers were used. PC and monitor including mouse were used for subjects to input their information and to respond to choose warning situation at which they recognize during experiment and head-set were used to block the subjects from ambient noise and to present experiment-used warning sound and VHF between vessels to them.
2.3 Experiment plan

Independent variable for the experiment was processed as three levels of warning sound type and five levels of warning situation and then was measured repeatedly in total fifteen (3 x 5) combination conditions. Three types of warning sound type meant three kinds of sound presented to the subjects and were consist of abstract sound, auditory icon and voice alarm as mentioned in the introduction. Five levels of warning situation indicated breakdown, dangerous situation namely what contents of information was and were processed as fire, steering, electricity, collision, and engine. <Table 1> shows how to embody three types of warning sound type depending on each five levels of warning situation. Abstract sound used a recording of representative warning sound used in actual bridge as a sound source and auditory icon and voice alarm used an extract from the KORDI (Korea Ocean R&D Institute) data as a sound source.

Dependent variable was collected the data on the basis of response accuracy, response time and subjective satisfaction level.

Response accuracy was computed from the ratio that subjects choose correctly and respond on each presenting warning sound type and warning situation. Response time was measured by the time required until the subjects pushed a suitable warning situation button displaying on the monitor at each experiment conditions after hearing warning sound. Subjective preference level was measured with 7 point scale in subjects’ total preference level to warning sound type immediately after carrying out experiment and getting closer to point 1 means "extremely dissatisfied" and getting closer to point 7 means "very satisfied".

Table 1: Level and the way of embodying warning sound type and situation

<table>
<thead>
<tr>
<th>Warning sound type</th>
<th>abstract sound</th>
<th>auditory icon</th>
<th>voice alarm</th>
</tr>
</thead>
<tbody>
<tr>
<td>fire</td>
<td>The sound of wood burning</td>
<td>Fire</td>
<td></td>
</tr>
<tr>
<td>steering</td>
<td>The sound of manipulate a rusty steering</td>
<td>Steering failure</td>
<td></td>
</tr>
<tr>
<td>electricity</td>
<td>The sound of machine lost electric power</td>
<td>Low power</td>
<td></td>
</tr>
<tr>
<td>collision</td>
<td>The sound of strong waves</td>
<td>Warning collision</td>
<td></td>
</tr>
<tr>
<td>engine</td>
<td>The sound of the engine is turned off slowly</td>
<td>Engine failure</td>
<td></td>
</tr>
</tbody>
</table>

3 Experiment result

To analyze experiment result, it carried out analysis of variable (ANOVA) to data that measured response accuracy, response time and subjective satisfaction level by using Statview(5.0). In result of ANOVA, it carried out Tukey/Kramer's multiple comparisons to the significant factors. It set up statistical significance level as totally 5%.

3.1 Response accuracy

In result of carrying out ANOVA to response accuracy, it showed that main effect of warning sound type ($F_{2, 360} = 27.841, p < 0.0001$) and main effect of warning situation ($F_{4, 360} = 6.369, p < 0.0001$) were significant at 5% significance level. And it was analyzed that interaction of warning sound type x warning situation was not significant ($F_{8, 360} = 1.223, p = 0.2841$). <Figure 1> shows average accuracy of warning sound type (unit: percentage) at each level.
According to the figure, it can be understood that response accuracy is most excellent as average 0.824 (82.4%) when using voice alarm and accuracy lowers in order of auditory icon 0.64 (64%), abstract sound 0.408 (40.8%). According to Tukey/Kramer analysis result, accuracies at these three levels have statistically significant differences. (See <Table 3>).

![Figure 1: Average response accuracy at each level of warning sound type](image)

### 3.2 Response Time

In result of carrying out ANOVA to response time, it showed that main effect to warning sound type ($F_2, 218 = 4.849$, $p = 0.0087$) and main effect to warning situation ($F_4, 218 = 6.393$, $p < 0.0001$) were significant at 5% significance level. And it was analyzed that interaction of alarm type x alarm situation was not significant ($F_8, 218 = 0.137$, $p = 0.9975$).

![Figure 2: Average response time at each level of warning sound type](image)

### 3.3 Subjective Preference Level

Subjective preference level is a data that subjects evaluated their subjective preference level to three level of warning type, that is, abstract sound, auditory icon and voice alarm with 7 points scale. In result of ANOVA to preference level, main effect of warning sound type was significant ($F_2, 72 = 25.32$, $p < 0.0001$). <Figure 3> shows average preference level according to warning sound type. In result of Tukey/Kramer's multiple comparison, preference level to voice alarm (Ave. = 6.04) was significantly higher than preference level to abstract sound (Ave. = 3.16) and to auditory icon (Ave. = 3.08). However, there was no significant difference of preference level between abstract sound and auditory icon.
4 Discussion and Conclusion

This study was conducted to analyze synthetically the effects of the auditory warning sound types that are either in use or under consideration for use in various warning situations in ship's bridge of ship system. Auditory warning sound type includes abstract sound that is mainly used in present Korean ship, auditory icon and voice alarm that are considered as alternatives in experiment study and integrated bridge design. And the effects of warning sound type were analyzed by the measure of response accuracy, response time and subjective preference level.

In synthetic view of the experiment result, it is judged that voice alarm is the most excellent auditory warning sound type. Voice alarm demonstrates superior results in the aspect of response accuracy and subjective preference level against auditory icon and abstract sound. And it also does not demonstrate significant response time difference in comparison with auditory icon that is shortest.

Auditory icon that shows shortest response time also has a possibility to be considered as an alternative of auditory warning in ship bridge. Lower subjective preference level and response accuracy in comparison with voice alarm may be due to a limited training time before experiment. Hereafter, it demands an additional study that offers sufficient training time to be familiar with auditory icon and analyzes a change of response time and accuracy according to training time.

This study simply individually compared and analyzed three warning sound types. Hereafter it is judged to need a study about new warning sound type that presents these three warning sound type compositively in order or repetitively.

5 References


