ROLE OF THE HUMAN ELEMENT

Seafarer Fatigue – Outcome of Project HORIZON

Submitted by the United Kingdom

SUMMARY

Executive summary: This document provides a summary of Project HORIZON, which was the first study on seafarer fatigue to use empirical evidence and seek to replicate, to the extent practicable, shipboard conditions. It provides a scientifically robust understanding of the effect of different watchkeeping patterns on seafarer cognitive performance. It has enabled the development of a mathematically robust Fatigue Management Toolkit (FMT) and also provides valuable data for consideration of alternative approaches to conventional watchkeeping patterns.

Strategic direction: 5.4

High-level action: 5.4.1

Planned output: 5.4.1.1

Action to be taken: Paragraph 11

Related documents: None

Introduction

1. This document, submitted by the United Kingdom on behalf of the Project HORIZON partners listed in annex 1, provides a summary of Project HORIZON, which was the first study on seafarer fatigue to use empirical evidence and seek to replicate, to the extent practicable, shipboard conditions.

2. Fatigue has been estimated to be a contributory factor in around one-third of maritime incidents. Project HORIZON aimed to build upon the growing body of evidence about seafarer fatigue and add to our knowledge about its causes, effects and the potential for its mitigation. It aimed to improve safety at sea by developing a Fatigue Management Toolkit (FMT), to include guidance to individual seafarers, a fatigue prediction model, as well as recommendations for improving work patterns at sea.
3 Project HORIZON was a major multi-partner European research study involving eleven academic and shipping industry organizations with the aim of delivering empirical data to enable better understanding of the way fatigue can affect ships’ watchkeepers. Its aims, methodology and detailed outcomes are explained in annex 2.

Results

4 Project HORIZON has taken knowledge to a new level and has demonstrated conclusively the connection between certain patterns of work and performance degradation. The results are scientifically and statistically robust and can be used to support the development of safer working patterns at sea. The detailed outcomes and findings are set out in annex 3.

5 A further practical outcome of HORIZON was the development of a Fatigue Management Toolkit (FMT). It contains recommendations for seafarers, shipping companies and regulators, with findings that will help identify, mitigate and avoid the effects of sleepiness in watchkeeping. In addition, fatigue prediction software has now been adapted using the maritime parameters provided by HORIZON. This prototype fatigue prediction model is known as "MARTHA" and is freely downloadable from the HORIZON website. Users are encouraged to provide feedback of the prototype using the evaluation form available, which can be sent to the e-mail address given.

6 Data from Project HORIZON has also provided valuable information for discussion regarding scheduling hours of work and rest and possible alternative approaches to current watchkeeping patterns. For instance, a more flexible approach to duty rosters enabling closer alignment to natural human biological rhythms may enable fatigue to be managed more effectively.

7 More detailed information regarding Project HORIZON, its conclusions and findings together with information about the Fatigue Management Toolkit and fatigue prediction software is available from the Project HORIZON report "Project Horizon – a wake-up call", and the Project HORIZON website: www.project-horizon.eu.

8 It is intended that a copy of "Project Horizon – a wake-up call" will be distributed to each delegation during the STW 44.

Recommendations

9 The Project HORIZON partners are pleased to present the findings of the project to the STW Sub-Committee with a view to further discussion and evaluation of fatigue and fatigue mitigation practices, in the Human Element Working Group.

10 Shipping organizations are encouraged to take note of the findings, participate in the evaluation of the Fatigue Prediction Tool (MARTHA) and provide feedback to the Project HORIZON Team.

Action requested of the Sub-Committee

11 The Sub-Committee is invited to:

.1 note the information in this document and take action, as requested in paragraph 9 above; and

.2 through IMO Member States and Organizations, bring the findings of Project HORIZON to the attention of the maritime industry.

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ANNEX 1

PROJECT HORIZON PARTNERS

1   Southampton Solent University
2   Bureau Veritas
3   Chalmers Tekniska Hoegskola AB
4   European Transport Workers' Federation
5   Stockholms Universitet
6   The Standard P&I Club
7   European Community Shipowners Associations
8   European Harbour Masters Committee
9   International Association of Independent Tanker Owners
10  UK Marine Accident Investigation Branch
11  UK Maritime and Coastguard Agency

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ANNEX 2

PROJECT HORIZON – AIMS, METHODOLOGY AND OUTCOMES

1 In particular, Project HORIZON is set out to:

.1 define and undertake scientific methods for measurement of fatigue in various realistic seagoing scenarios using bridge, engine-room and cargo simulators;

.2 determine the effects of watch systems and components of watch systems on fatigue;

.3 capture empirical data on the cognitive performance of watchkeepers working within the realistic scenarios;

.4 assess the impact of fatigue on decision-making performance;

.5 develop a tool for evaluating potential fatigue risk of different watch systems using mathematical models; and

.6 determine arrangements for minimizing risks to ships and their cargos, seafarers, passengers and the marine environment.

2 A total of ninety deck and engineer officer volunteers participated in rigorous tests at Chalmers University of Technology in Gothenburg, Sweden, and at Warsash Maritime Academy in Southampton, United Kingdom. All were appropriately qualified officers with a mix of nationalities and gender that provided a representative cross section of the industry. They lived as close to a shipboard life style as possible.

3 The project examined the effects of the two most common watchkeeping patterns:

.1 six hours on, six hours off; and

.2 four hours on, eight hours off.

4 To reflect real life on board, for example, port calls, drills and emergencies were included. In one experiment on the six hours on, six hours off watchkeeping pattern, an interrupted off watch period was also included to study the effects of disturbed rest periods on fatigue. Each volunteer took part for a week. Total working hours were 64 hours for those on four hours on, eight hours off and 90 hours for those on six hours on, six hours off watchkeeping patterns.

Data collection

5 Data was collected using a combination of objective and subjective techniques:

.1 objective data was collected through:

.1 activity measurement devices;

.2 computer-based vigilance and performance tests; and

.3 electrodes recording brain activity.
.2 subjective data was collected through participants keeping:
  .1 sleep diaries;
  .2 work diaries; and
  .3 wake diaries.

6 In order to provide a realistic balance of workload activity, the missions were constructed to include a wide and representative mixture of tasks including:
  .1 keeping the ship's logbook;
  .2 marking positions on a chart;
  .3 exchanging information at the end of a watch;
  .4 radiocommunications;
  .5 close quarters encounters with non-compliant vessels;
  .6 crossing, overtaking and fishing vessels;
  .7 man overboard on other vessel in crowded waters;
  .8 gyro compass error;
  .9 monitoring machinery; and
  .10 alarms and technical breakdowns.

Outcomes

7 Project HORIZON succeeded in achieving its core aim of delivering a more informed and scientifically rigorous understanding of the way different watchkeeping patterns at sea affect the performance of ships' officers. The range of measurements and the high degree of realism obtained has provided detailed and robust data on which to assess and analyse effects. Data obtained is sufficiently robust to enable input to marine validated mathematical fatigue prediction models within a fatigue risk management system.

8 In both watchkeeping patterns studied there was evidence of officers falling asleep. Sleep on watch mostly occurred during the night and early morning watches, but there were also surprisingly high levels of sleep at other times. Participants in all groups reported high degrees of subjective sleepiness, close to levels considered dangerous for car drivers.

9 The participants found it difficult to get enough sleep during the study. Varying degrees of sleep loss were observed with differences between the watch systems. Those on a 4-on/8-off system had a relatively normal sleep pattern. However, those on 6-on/6-off system were found to get markedly less sleep than those on 4-on/8-off system.

10 Degradation in performance was noticeable with reaction times showing clear evidence of deterioration towards the end of a watch. The 6-on/6-off system was found to be more tiring than 4-on/8-off system and disturbed off watch periods produced significantly high levels of tiredness. Evidence suggested that routine procedural tasks showed little effect of degradation, but the ability to deal with novel incidents that required thought deteriorated throughout the study period. There was also a decline in the quality of watch handover throughout the study.
ANNEX 3

PROJECT HORIZON – SUMMARY OF FINDINGS FOR CONSIDERATION BY OWNERS, OPERATORS, SHORE BASED MANAGEMENT AND CREW WHEN DETERMINING WORKING PATTERNS, ROSTERS AND MANNING LEVELS

1  Fatigue causing factors
   .1 lack of sleep, or poor quality of sleep;
   .2 working at times of low alertness (circadian rhythms);
   .3 long working hours and prolonged work periods;
   .4 insufficient rest between work periods;
   .5 the impact of watchkeeping patterns, notably 6-on/6-off;
   .6 frequent port calls and associated cargo work;
   .7 stress and excessive workloads;
   .8 tour lengths; and
   .9 noise, vibration, motion and medical conditions.

2  Reported sleepiness

   Sleepiness ratings were reported by participants and validated against EEG measurements:
   .1 overall, more sleepiness was recorded during the first watch of the day, especially among deck teams;
   .2 sleepiness was found to increase with time on watch;
   .3 off-watch disturbance instantly increased sleepiness;
   .4 on the whole sleepiness levels were higher on the 6-on/6-off system than in the 4-on/8-off system;
   .5 sleepiness levels did not differ significantly between deck and engine-room;
   .6 sleepiness levels consistently peaked between 0400 and 0800; and
   .7 alertness levels consistently peaked between 1400 and 1800.

3  Wake diary

   General health and wellbeing feelings were reported by participants during their last period of wakefulness:
   .1 participants indicated better time off following the first watch of the day with rest and recuperation rated more efficient with less negative symptoms such as tension;
   .2 reported wellbeing got worse during the week;
the disturbed free watch had adverse effects in both 6-on/6-off and 4-on/8-off watch systems;

overall, more negative outcomes were reported in the 6-on/6-off system than the 4-on/8-off system; and

no differences were observed between the deck and engine-room.

4 Stress

Stress ratings were provided by participants at regular intervals:

stress levels were found to vary, and differences were found between the watch systems and between deck and engine-room teams;

overall, stress levels remained fairly low;

the disturbed off-watch period resulted in an immediate increase in stress levels;

stress levels were higher in the engine-room than on the bridge; and

stress levels did not differ between the two watch systems.

5 Sleep on duty

Data provided by analysis of EEG recordings and visual observation of participants:

the percentage of participants showing sleep while working on the bridge were unexpectedly high;

more participants fell asleep during the night/morning watches than day/early evening watches;

a disturbed off-watch period was found to result in more sleep during the subsequent watch;

more sleep was found to occur on watch in the 6-on/6-off system than in the 4-on/8-off system; and

no significant differences were observed between the bridge and the engine-room.

6 Diurnal performance peaks and troughs

Data provided by analysis of a number of performance tests:

watchkeepers were found to be most tired at night and in the afternoon (circadian rhythms);

sleepiness levels were found to peak towards the end of the night watches;

slowest reaction times were found at the end of night watches;

incidents of sleep on watch mainly occurred during the night and early morning watches;
.5 the 6-on/6-off regime was found to be more tiring than 4-on/8-off;

.6 the onset of tiredness on 6-on/6-off occurred over a shorter time frame than predicted;

.7 "disturbed" off-watch periods produce significantly high levels of tiredness; and

.8 participants on 6-on/6-off rotas were found to get markedly less sleep than those on 4-on/6-off.

7 Special attention needs to be paid to the following:

.1 the risks in passages through difficult waters in combination with the 6-on/6-off watch system (because of sleep loss);

.2 night watches;

.3 the last portion of most watches (especially night watches);

.4 watches after reduced sleep opportunity;

.5 individual susceptibility to fatigue also needs to be considered; and

8 The Special Attention above may involve, but not be limited to:

.1 alarm systems to alert crew before important changes of course;

.2 alerting devices;

.3 encouragement not to use chairs on the bridge at night;

.4 additional crew;

.5 special protection of sleep periods; and

.6 no work apart from watchkeeping.