Maritime & Coastguard Agency

MARINE INFORMATION NOTE

MIN 452 (M)

Seafarer Fatigue - Project HORIZON

Notice to all Ship Owners, Operators, Shore Based Management, Masters, Officers and Crew

This notice should be read with MSN 1767, MSN 1808 and MGN 211
This MIN expires 1 / 3 / 2014

Summary

Project HORIZON was the first study on seafarer fatigue to use empirical evidence and seek to replicate, to the extent practicable, shipboard conditions. It was a EU-funded multi-partner research programme designed to investigate seafarer fatigue using scientifically robust methodology. It used simulator based experiments to examine and identify the effect of different watchkeeping patterns on seafarer cognitive performance using realistic scenarios, and has enabled the development of a mathematically robust Fatigue Management Toolkit (FMT).

The UK Maritime and Coastguard Agency is committed to reducing the serious problem of fatigue amongst seafarers which has a major impact on maritime safety. The information contained in this MIN provides a summary of the HORIZON project together with its findings. It also provides links to further information about HORIZON.

Owners, operators and crew are recommended to take note of the findings when determining working patterns, rosters and manning levels.

1. Introduction

1.1 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) as well as recommendations for improving work patterns at sea.

2. Methodology

2.1 Project HORIZON was a major multi-partner European research study involving 11 academic and shipping industry organisations (Annex A) with the aim of delivering empirical data to enable better understanding of the way fatigue can affect ships' watchkeepers.

2.2 In particular, it set out to:

a) Define and undertake scientific methods for measurement of fatigue in various realistic seagoing scenarios using bridge, engine room and cargo simulators

b) Determine the effects of watch systems and components of watch systems on fatigue

c) Capture empirical data on the cognitive performance of watchkeepers working within the realistic scenarios

d) Assess the impact of fatigue on decision-making performance

e) Develop a tool for evaluating potential fatigue risk of different watch systems using mathematical models

f) Determine arrangements for minimising risks to ships and their cargos, seafarers, passengers and the marine environment

2.3 A total of 90 deck and engineer officer volunteers participated in rigorous tests at Chalmers University of Technology in Gothenburg, Sweden, and at Warsash Maritime Academy in Southampton, UK. 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 ship board life style as possible.

2.4 The project examined the effects of the two most common Watchkeeping patterns

a) six hours on, six hours off, and

b) four hours on, eight hours off

2.5 To reflect real life on board, eg port calls, drills and emergencies, missions were constructed to include an interrupted off watch period. Each volunteer took part for a week. Total working hours were 64 hours for those on 4-on/8-off and 90 hours for those on 6-on/6-off.

3. Data Collection

3.1 Data was collected using a combination of objective and subjective techniques. Objective data was collected through

a) activity measurement devices

b) computer based vigilance and performance tests

c) electrodes recording brain activity

3.2 Subjective data was collected through participants keeping

a) sleep diaries

b) work diaries

c) wake diaries

3.3 In order to provide a realistic balance of workload activity the missions were constructed to include a wide and representative mixture of tasks including

a) keeping the ship's log book

b) marking positions on a chart

c) exchanging information at the end of a watch

d) radio communications

e) close quarters encounters with non-compliant vessels

f) crossing, overtaking and fishing vessels

g) man overboard

h) gyro compass error

i) monitoring machinery

k) alarms and technical breakdowns

4. Outcomes

4.1 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.

4.2 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.

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

4.4 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 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.

5. Guidance for Owners, Operators, Shore Based Management and Crew

5.1 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.

5.2 A 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 watch-keeping. In addition, fatigue prediction software has now been adapted using the maritime parameters provided by Horizon. This is known as ”Martha” and is freely available 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 on the web site.

5.3 More detailed information regarding Project HORIZON, its conclusions and findings together with information about the FMT and fatigue prediction software is available from the Project HORIZON website

www.project-horizon.eu

5.4 The key findings are summarised in Annex B. Owners, operators, shore based management and crew are recommended to familiarise themselves with the work and findings of Project HORIZON and fully consider the findings and implications for safety when planning working patterns, rosters and manning levels: - for instance, the significance of the body’s natural times of low alertness (circadian rhythms) in combination with other fatigue causing factors to degrade performance particularly on novel, difficult, or thought requiring tasks.

6. Further Work

6.1 HORIZON has provided invaluable evidence towards enabling the reduction of fatigue amongst watchkeepers. However, we recognise that we still do not have the full picture and much scope remains for further investigation for instance, alternative watchkeeping patterns, tour lengths, innovative alternative approaches, validation and refinement of the FMT.

More Information

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An executive agency of the Department for **Transport**

Annex A

Project HORIZON Partners

Southampton Solent University

Bureau Veritas

Chalmers Tekniska Hoegskola AB

European Transport Workers' Federation

Stockholms Universitet

The Standard P&I Club

European Community Shipowners Associations

European harbour Masters Committee

International Association of Independent Tanker Owners

UK Marine Accident Investigation Branch

UK Maritime and Coastguard Agency

Annex B

Project HORIZON – Summary Of Findings For Consideration By Owners, Operators, Shore Based Management and Crew When Determining Working Patterns, Rosters and Manning Levels

Fatigue Causing Factors

Lack of sleep, or poor quality of sleep

Working at times of low alertness (circadian rhythms)

Long working hours and prolonged work periods

Insufficient rest between work periods

The impact of watchkeeping patterns, notably 6-on/6-off

Frequent port calls and associated cargo work

Stress and excessive workloads

Tour lengths

Noise, vibration, motion and medical conditions

Reported Sleepiness
Sleepiness ratings were reported by participants and validated against EEG measurements

Overall, more sleepiness was recorded during the first watch of the day, especially among deck teams

Sleepiness was found to increase with time on watch

Off-watch disturbance instantly increased sleepiness

On the whole sleepiness levels were higher on the 6-on/6-off system than in the 4-on/8-off system

Sleepiness levels did not differ significantly between deck and engine room

Sleepiness levels consistently peaked between 0400 and 0800

Alertness levels consistently peaked between 1400 and 1800

Wake Diary
General health and wellbeing feelings were reported by participants during their last period of wakefulness

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

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

No differences were observed between the deck and engine room

Stress
Stress ratings were provided by participants at regular intervals

Stress levels were found to vary, but the axis along which it varied differed 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

Stress levels did not differ between the two watch systems

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

No significant differences were observed between the bridge and the engine room

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

The 6-on/6-off regime was found to be more tiring than 4-on/8-off

The onset of tiredness on 6-on/6-off occurred over a shorter timeframe than predicted

“Disturbed” off-watch periods produce significantly high levels of tiredness

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

Special Attention Needs To Be Paid To The Following

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

Night watches

The last portion of most watches (especially night watches)

Watches after reduced sleep opportunity

Individual susceptibility to fatigue also needs to be considered

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

Alarm systems to alert crew before important changes of course

Alerting devices

Encouragement not to use chairs on the bridge at night

Additional crew

Special protection of sleep periods

No work apart from watchkeeping