Institution: Southampton Solent University

Unit of Assessment: Uoa15 – General Engineering

Title of case study: Project HORIZON: Seafarer fatigue and its effect on cognitive performance

1. Summary of the impact

Seafarer fatigue is a major issue for the safety and economics of shipping and the protection of the marine environment. Estimates suggest that 25% of marine casualties are caused by fatigue.

Project HORIZON demonstrated that sleepiness levels for some watch-keeping regimes are high, and actual sleep can occur. The main outcome of the project was a fatigue prediction model for use by voyage planners to ease workloads on ships' crews.

The introduction of such fatigue risk mitigation measures will potentially save lives, have an impact on the competitive success of global shipping companies, and bring significant economic and environmental benefit.

2. Underpinning research

Project HORIZON was an EU FP7 international collaborative project led by researchers at Southampton Solent University (SSU) to investigate the effects of fatigue on the cognitive performance of ships' watch-keeping officers, using a range of simulators and under different watch patterns and workload conditions. The other main partners in the project came from Chalmers University and the world-renowned Stress Research Institute at Stockholm University, both in Sweden. The project ran from June 2009 to January 2012.

This was the first time that scientific sleep research had ever been conducted on linked marine simulators over an extended period. Experiments were focused on two watch patterns – the conventional 4 hours on/8 hours off regime, and the more arduous 6on/6off pattern. A total of 90 officers undertook the experiments on simulators at both Chalmers University and at the UK Warsash Maritime Academy. Chalmers conducted experiments on the 4on/8off watch and the Warsash experiments studied a 6on/6off regime, in which participants undertook their watch-keeping duties without any deliberate disturbance of their rest periods.

At Warsash, 10 identical simulator-based "voyages" took place, involving 20 deck officers and 20 engineers in linked bridge, engine room and cargo simulators. The participants undertook normal watch keeping duties for 7 days. During that period, measurements were taken of their watch keeping performance and levels of alertness. Measurement included EEG recordings, for two 24-hour continuous periods, at the beginning and end of the week.

The key researchers at Southampton Solent University were Professor Mike Barnett, Head of Maritime Research since 1991, who led the research team, Dr David Gatfield and Associate Professor Claire Pekcan, Senior Lecturers since 1996. They were supported by a team of 20 staff.

The key findings were:

- Subjects actually fell sleep on watch, both on the bridge and in the engine room. In the Warsash experiment, 20% of watch keepers fell asleep during midnight to 0600 watches. (R2)
- Sleepiness and neurobehavioral performance, as measured by EEG, are particularly affected towards the end of the 0000-0600 watch. Performance as measured by reaction time also deteriorates over the watch and during the week.(R2)

- The data supports previous research on shore-based shift workers. Marine watch keepers are most tired during night watches and show signs of tiredness in the afternoon. There is a gradual increase of fatigue during the work periods, as the week progresses. (R1)
- The 6on/6off watch regime is more tiring than 4on/8off, and there are more incidents of falling asleep. The onset of tiredness on 6on/6off was apparent over a shorter timeframe than predicted by previous research; (R3)
- The total amount of sleep afforded watch keepers on 6on/6off is less than normally required for full rest. Watch keepers averaged 6.5 hours in total, split into two sessions: the main one during the "night" time, followed by a "nap" during the other period of rest. This is an original finding not observed empirically before. (R5)

A fatigue management "toolbox" was produced, which included recommendations to individuals and industry on risk mitigation, and a software fatigue prediction model.

3. References to the research

The HORIZON consortium agreed a policy which reserved the publication of original scientific data for the highest rated journals in the field of sleep science. Major papers are forthcoming and the first is represented here by R3. The policy allowed other papers describing methodology and concepts to be published in peer-reviewed international conferences in maritime subjects, and are represented by R1,R2 and R4. All these contributions reflect the original and unique nature of the research and its findings. R4 looks forward to the implementation of the results and its likely impact on international regulatory regimes in shipping.

R1 Maurier, P., Barnett, M., Pekcan, C., Gatfield, D., Corrignan, P., and Clarke, G. (2011). *Fatigue and Performance in Bridge and Engine Control Room Watchkeeping on a 6on / 6off Watch Regime".* Royal Institute of Naval Architects, Proceedings of International Conference on Human Factors in Ship Design. London, November, 2011
http://ssudl.solent.ac.uk/2300/

R2 Barnett, M., Pekcan, C., and Gatfield, D. (2012). *The Use of Linked Simulators in Project "HORIZON": Research into Seafarer Fatigue.* MARSIM, Proceedings of MARSIM conference. Singapore, April 2012
http://ssudl.solent.ac.uk/2302/

This peer reviewed paper at an international conference on marine simulation describes this novel and unique methodology for sleep research, using three linked marine simulators, to create a sustainable and realistic voyage experience, from which the original data could be collected. MARSIM is the leading international conference for all marine simulator operators and designers in the world and is held every four years.

R3 van Leeuwen, W., Kircher, A., Dahlgren, A., Lützhöft, M., Barnett, M., Kecklund, G., Åkerstedt, T. *"Sleep, sleepiness, and neurobehavioral performance while on watch in a simulated 4 hours on/8 hours off maritime watch system"*

This peer reviewed paper is to be published in Chronobiology International in 2013, Chronobiology International is a highly regarded journal in sleep science.

R4 Barnett, M., Pekcan, C., and Gatfield, D. *"Fatigue Management: Self Regulatory Activities in Shipping"*

Published in Proc 2nd Int Conference on Maritime Incidents and Near Miss Reporting (IMISS2013) Kotka, Finalnd 11-12 June 2013)

Other references:

R5 The HORIZON final report may be found at: http://www.project-horizon.eu

Grant Funding:
Awarded to consortium, lead partner: Southampton Solent University (SSU)
Principal Investigator at SSU: Professor Mike Barnett
Grant title: HORIZON
Grant Agreement No: 234000
Sponsor: European commission
Period of Grant: 01 June 2009 to 31 January 2012
Value of the grant: 3.8 mill Euros

4. Details of the impact

According to the seminal report[1] by the United Kingdom's Marine Accident Investigation Branch (MAIB), fatigue is a major causal factor in collisions and groundings. It suggested that the factors which probably contribute to collisions and groundings include, *inter-alia*, watch-keeping patterns, working hours and sleep problems. The report concluded that the majority of the groundings occurred between 0000 and 0600 and that they involved solo watch-keeping officers following a 6 hours on and 6 hours off working pattern for significant periods.

HORIZON[2] has successfully achieved the first-ever sets of experimentally based and wide-ranging data on fatigue and cognitive performance in the maritime field, and provided novel methodologies and data to inform future research. From a quantitative point of view, the potential impact of implementing the results of HORIZON is considerable. From the MAIB report alone, the casualty figures for UK Flag ships or accidents in UK waters, studied from 1993 to 2003, revealed that 66 accidents occurred involving 75 large vessels. Of these, one third was caused, or contributed to, by human fatigue. High-profile casualties, such as the *Shen Neng 1* grounding on the Australian Barrier Reef have had major impacts in financial terms and on the destruction of the environment. Such accidents continue to cause concern, and fatigue remains a significant risk factor in maritime safety[3].

One major achievement of HORIZON is the production of a prototype fatigue prediction model (MARTHA) for use in operations on all types of ship, including cruise ships and tankers. MARTHA is based on a theoretical model of fatigue, and incorporates data from other industries to produce algorithms, which predict the levels of sleepiness of shift workers. HORIZON has also introduced original data on off-watch sleep patterns and has developed the basic model to create a version which is valid for marine use. It is envisaged that MARTHA will be used by voyage planners to check fatigue levels of crews in areas of high risk and workload, such as port turn rounds. Tiredness and risk of falling asleep can be calculated for six weeks in advance, giving management time to plan and implement options for mitigating the risk of personal accident and ship casualty through fatigue.

Although studies[4] have been made of the operational life of the seafarer before, including assessment of the fatigue experienced by seafarers and others working in safety-critical industries, through the use of questionnaires and sleep diaries, none of these studies produced experimentally based data, and the shipping industry has been slow to take up any self-regulatory

[1] MAIB (2004): "*Bridge Watch-keeping Safety Study"* Safety Study, 1/2004 Southampton, MAIB,
[2] "HORIZON: Research into the effects of fatigue on the cognitive performance of maritime watch-keepers under different watch patterns, using ship's bridge, engine and liquid cargo handling simulators. FP7 project 234000
[3] ATSB (2013) "*Identifying Risks in transport: safety Issues from ATSB occurrence investigations."* Australian Transport Safety Bureau, Canberra March 2013. ISBN 978-1-74251-314-0 www.atsb.gov.au/publications/2012/xr-2012-001.aspx

[4] Centre for Occupational and Health Psychology (2006): "*Seafarer Fatigue: The Cardiff Research Programme"*

measures.

Project HORIZON included stakeholder partners representing key international associations in the shipping industry and knowledge transfer through these bodies and influential individuals has led to active encouragement of shipping companies to evaluate MARTHA. One high-speed ferry company is using it regularly to check roster schedules and a newly funded project called MARTHA is currently scientifically evaluating the software at sea. Other international research teams, companies and navies are also conducting studies to evaluate and implement such models. The impact of MARTHA could lead to a reduction in environmental clean-up costs alone of millions of dollars, and lower insurance premiums for those who successfully implement such fatigue prediction models.

The working hours and the hours of rest of 2 million seafarers, and the conditions they work under for long periods of time, are issues which remain continuously under the microscope. In addition, with the advent of maritime governance issues, new approaches are emerging to change the safety culture of the industry through self-regulation, to provide both competitive advantage for companies and, at the same time, the improved health and wellbeing of employees and their families.

A new externally funded project is now providing a pathway to raise awareness of these issues. All these aspects of fatigue management at sea will benefit from the impact of implementing the findings from HORIZON and the application of the MARTHA software. These outcomes may also have a wider application to any shift working industry ashore and could provide further significant and long-term impacts. (see R4)

5. Sources to corroborate the impact

Several feature articles have appeared in shipping press and maritime periodicals, including Lloyds List, Fairplay, Seatrade, Tanker Operator and the "Telegraph"

Articles may be viewed on the project website: www.project-horizon.eu

Reports:

C1. Paper submitted by UK Government to IMO STW44: Role of the Human Element: Seafarer fatigue Project HORIZON April 2013. Commended by several national delegations at this United Nations Agency meeting.
C2. MGN Notice by UK MCA: "Preventing Fatigue: Guidance on Good Practice" (Notices are promulgated to all UK ships, companies and available internationally)

Examples of articles:

C3. News Analysis feature on seafarer fatigue, Lloyds List July 09 2012
C4. Brain probes used in battle against fatigue, Maritime IT and Electronics, IMarEst, April/May edition 2012
C5. Fairplay editorial and article, 09 February 2012

Individual users:

C6. Brian Simpson, MEP Chair of the European Parliament Transport Committee
C7. Mrs Theresa Crossley, Deputy Head, European Maritime Safety Agency (EMSA)
C8. Capt Steve Clinch, Head of the UK Maritime Accident Investigation Board (MAIB)
C10. Mr T Abrahamsson, Chair Social Sectoral Dialogue Committee, European Commission, Brussels (membership includes ETF (European Transport Federation) and ECSA (European Ship Owners Association)
C11. Capt Kuba Symanski, Secretary General, InterManager (the International Shipmanagers Association)