Institution: University of Chichester

Unit of Assessment: Sport and Exercise Sciences, Leisure and Tourism

Title of case study: High Speed Marine Craft benefits to users and industry.

1. Summary of the impact

Government funded research into the design of high-speed marine craft from a human factors perspective has achieved significant international impact for organisations and personnel including the UK MOD, US Department of Defense, Canadian, Dutch, and Australian Defence Forces, US Coastguard and the Royal National Lifeboat Institute (RNLI). The research was instrumental in the launch of a marine consultancy and a commercial training organisation; the latter delivering research led training courses worldwide. Moreover, the research contributed to improved working conditions for military and RNLI personnel through changes in work practices, equipment design and procurement and the revising of an international whole-body vibration standard.

2. Underpinning research

The main research programme leading to the impact described was carried out by a multi-disciplinary team at the University of Chichester (Professor Terry McMorris, Drs Rosemary Dyson, Trevor Dobbins, Stephen Myers), with additional industry expertise (Drs Tom Gunston, SIG-SCP; Sharon Holmes, Stuart King, QinetiQ Ltd) from 01 March 2005 to 29 February 2008 supported by EPSRC funding (Design of High-Performance Marine Craft from a Human Factors Perspective, EP/C525744/1). The research has had a direct impact on the design and practical usage of Marine High Speed Craft (HSC) by measuring the effects that the high shock and impact environment had on crew and passengers. The programme was driven by widespread anecdotal reports of fatigue following transits in HSC. A secondary driver was the EU Physical Agents (Vibration) Directive, for which 8-hour action and limit values are mandated, using whole-body vibration (WBV) data, recorded primarily on terrestrial vehicles.

Prior to the research programme, no representative data existed describing either the HSC environment, or its effect in the physical and cognitive performance of passengers/crew. Acceleration data collected in open rigid inflatable boats (RIB) demonstrated that WBV and shock/impact levels were far in excess of those experienced in any other form of transport and the EU Limit Value was often exceeded within minutes of normal operation. These data suggested that the EU mandated values and the current WBV evaluation standard (ISO 2631-5:2004) were incompatible with HSC operations and resulted in an international committee being formed to revise the latter, on which Dr Gunston represents the UK.

The acceleration data confirmed it was not possible to simulate HSC conditions, which necessitated the development of methodologies and equipment for sea-based trials to reliably assess their effect on physical and cognitive performance. It was also necessary to use participants for who HSC transits followed by high intensity activity formed part of their role. Over 100 specialised military personnel participated in 14 trials conducted in Poole, Plymouth, Faslane and Panama City covering a range of sea conditions. These trials were supported through extensive in-kind support (MOD, UK Special Forces, Royal Marines) covering personnel and equipment. Initial trials conducted with the Special Forces team responsible for UK maritime security, demonstrated reduced running performance (-15%), following 2-hour high-speed RIB transits in calm/moderate seas. This confirmed the importance of the issue and the need to identify the underlying causes and ways to mitigate it. Further sea-trials were conducted with a Royal Marine maritime protection unit over a range of sea conditions. These reported reduced physical performance post-transit of 20-25%. Measurements were also made of muscle activity and metabolic rate during sea-transits, which indicated low aerobic demand, but high muscle activity, however both were reduced when a commercial suspension seat was used. Suggesting that localised muscle fatigue resulting from absorbing shocks, as a possible cause of the performance decrements. This was supported by results of two trials where suspension and standard seats were tested side-by-side. Those in the suspension seats maintained their physical and cognitive performance at pre-transit levels, whilst the others suffered decrements of 15 and 25% for calm and rough sea-conditions, respectively.

3. References to the research

The research was supported by an EPSRC grant (EP/C525744/1; see below) and was disseminated widely through peer reviewed journal articles and industry-focused conference papers (e.g. UK Conference on Human Response to Vibration) and research reports to specialist bodies (e.g. American, British, Canadian and Dutch Working Group on Human Performance at Sea). Research output underpinning the research includes:

1. McMorris, T, **Myers, S**. Dobbins, T. Hall, B. Dyson, R. (2009). Seating type and cognitive performance after 3 hours travel by high-speed boat in sea states 2-3. Aviation Space Environmental Medicine 2009; 80 (1): 24-28 10.3357/ASEM.2405.2009
2. **Myers, S**. Dobbins, T. King, S. Hall, B. Holmes, SR. Gunston, T. & Dyson, R. (2012). Effectiveness of suspension seats in maintaining performance following military high-speed boat transits. *Human Factors, 54: (2): 264-276*. 10.1177/0018720811436201
3. **Myers, S**. Dobbins, T. King, S. Hall, B. Ayling, R. Holmes S.R., Gunston, T. & Dyson, R. (2011) Physiological consequences of military high-speed boat transits. European Journal of Applied Physiology 11(9): 2041-2049. 10.1007/s00421-010-1765-3.
4. Dobbins, TD. **Myers, SD**. Dyson, R. Gunston, T. Pierce, E. Blankenship, J. LaBreque, G. (2008). Discrepancies between the perceived comfort of experienced high-speed craft operators and current standards. The 43rd UK Conference on Human Response to Vibration, Leicester, UK. This paper was the output from a joint UK-US study (Pierce, Blankenship and LaBreque – Naval Special Warfare (NSW) Systems, Naval Surface Warfare Center, Panama City Division, USA) supported by UK Special Forces.
5. **Myers, SD**. Dobbins, TD. & Dyson, R. (2006). Motion induced fatigue following exposure to whole body vibration in a 28ft rigid inflatable boat (RIB). The American, British, Canadian and Dutch Working Group on Human Performance at Sea Symposium Influence of Ship Motions on Biomechanics and Fatigue, San Diego, USA. This was the first report to confirm the existence of motion induced fatigue on small high speed boats and phenomenon only previously measured on large ships.

The University's original research was funded by the UK Ministry of Defence, and then supported by a combination of governmental and commercial funding (Defence Procurement Agency (now DE&S), Dstl, Office of Naval Research Global, US Navy, Engineering and Physical Sciences Research Council and QinetiQ Ltd, Ullman Dynamics Sweden) and in-kind support (Royal Marines, UK Special Forces, US NSW, RNLI).
EPSRC Reference: EP/C525744/1
Title: Design of High-Performance Marine Craft from a Human Factors Perspective
Principal Investigator: Dr R. Dyson (University of Chichester)
Other Investigators: Professor T McMorris (University of Chichester)
Researcher Co-investigators: Dr T Dobbins (University of Chichester)
Research assistant: Dr S Myers (University of Chichester)
Project Partners: Lloyd's Register of Shipping (Naval), Royal National Lifeboat Institution, Seaspeed Technology Ltd, VT Halmatic Ltd
Started: 01 March 2005 **Ended:** 29 February 2008; **Value**: £341,718

4. Details of the impact

The research carried out by Dr Myers and high-speed craft (HSC) research team (Professor McMorris, Drs Dyson, Dobbins, University of Chichester (UoC); Dr Tom Gunston, SIG-SCP; Drs Sharon Holmes, Stuart King, QinetiQ Ltd), has achieved significant impact across the globe for individuals and organisations that use high speed marine craft. The principal pathways for impact are:

- Uptake of research by civil and military organisations leading to change in guidelines and/or working practices including procurement and training;
- Launch of commercial ventures drawing on the findings of the research;
- Development and delivery of training materials based on outcomes from the research delivered to users/operators of high speed craft;
- Improved boat operative experience and performance through reduced exposure to vibration and shock resulting from better designed craft and/or working practices.

Creation and revision of international standards and guidance

Longer-term impact stemming from the UoC work arises from High Speed Craft Human

Factors Engineering Design Guide written by Dobbins with two co-authors from industry (Ergonomist and Naval Architect) (ABCD-TR-08-01; 2008). The guide was funded by the MOD and is issued by the ABCD Working Group and draws heavily on those measurements made by the HSC Team; it is open-access and has become the default Human Factors reference document of many nations (e.g. UK, Canada, Australia, USA, Netherlands) for high-speed marine craft procurement. The guide is also given as a recommended reference source in a number of guidance documents (e.g. Department of Transport Small Passenger Craft High Speed Experience Rides Guidance). The guide was also awarded the Innovations Showcase Award for 'Vessel Design & Construction' at Seawork 2008 the UKs premier high speed craft trade show. The research also contributed to the formation of an international committee (date) to revise the whole-body vibration standard ISO 2631-5:2004, with HSC team member Dr Gunston representing the UK. This was driven by the HSC group's research highlighting the current vibration evaluation standards inability to effectively report those accelerations experienced by users (Dobbins 2006; Gunston 2006; Dobbins 2008a,b; Myers 2012). The findings of the HSC group also contributed the setting up of working groups by the MOD and the RNLI to address how shock and vibration can be dealt with and how the EU Physical Agents (Vibration) Directive regulations might be met. Members of the HSC team (Drs Myers, Dobbins, Gunston) continue to contribute to both these groups.
Furthermore, the published findings and accompanying technical reports were used by the Ministry of Defence (MOD) to help retrospectively justify the equipping in 2007 of the Royal Marines' fleet of ORC with the same type of commercial suspension seats. The move away from the conventional fixed seat (unit cost ~£100) to a suspension seat (unit cost ~£1,200) represented a significant financial investment, with a minimum of eight required per ORC in a fleet of around 50 craft (representing an additional investment in excess of £4.5M). Widespread dissemination of the research including evaluation of the suspension seat amongst the high speed craft/maritime/vibration industry/academic community (see section 5) created a context for the decision made by KNRM the Dutch equivalent to the RNLI to fit the same seat evaluated by Myers et al in their new NHN1816 lifeboat (12/13). Incidentally, the number of companies supplying suspension seats has risen dramatically from around 5 when the research commenced in 2005 to over 20 in 2013.

Commercial impacts and impacts arising from commercial deliver of specialist training
The research enabled directly to the creation of two commercial ventures STResearch and FRC International. The novel nature of those data collected by Myers and colleagues highlighted the need for further research and for the continued dissemination of information to educate end-users, managers, employers, legislators and procurers. A commercial consultancy STResearch Ltd (www.str.eu.com), was formed (in 2005) by one of the team members Dr Dobbins to continue supporting the research need, supply high-speed craft Human Factors support and solutions for a number of government and commercial clients in the UK and overseas (US Navy, RNLI, Maritime Investigation Branch (MAIB), MOD, RNLI). Drs Myers, Dobbins and Gunston on the invitation of the HSE presented to them on the challenges the maritime environment presents to users and those trying to enforce legislation. Similar meetings were held over the period 2006-2008 with the MOD, RNLI and UK Maritime Coastguard Agency (MCA). These meetings highlighted the need for this information to be disseminated more widely and were instrumental in the setting up FRC International Ltd ((formed 2010) (www.frc-int.com)) which Dr Dobbins is a Director along with John Haynes and Jon Hill, the latter who worked closely with the Chi team before he retired from the Royal Marines, who deliver education and training courses to organisations worldwide including the Police Service of Northern Ireland, Canadian Navy, UK Environment Agency, MCA, UK Maritime Accident Investigation Branch reaching hundreds of individuals across these organisations (87 listed online). Both of these companies make direct use of the findings of the University's research in this area and Dr Myers continues to contribute to STR's consultancy activity and the training given by FRC. In addition, QinetiQ Ltd a world leading defence technology and security company (with 9000 employees worldwide) and partner on the EPSRC funded project have directly benefited through first hand access to data and analysis from the human factors research which they have subsequently utilised in their operations, for example in the demonstrator PASCAT landing craft developed for the MoD (2010).

Change to training procedures and working practices

On the basis of the levels of fatigue and acceleration reported by the HSC team the RNLI amended their training operations to reduce their trainers' exposure; the small training team is responsible for training hundreds of RNLI volunteers. It is highly probable that the MOD's adoption of a suspension seat along with the findings of the HSC team and its dissemination through academic conference and journal papers, lay articles, and industry and government briefings (Defence and Equipment Supplies, Health and safety Executive, Maritime Coastguard Agency etc.) and its membership of the American, Australian, British, Canadian and Dutch (ABCD) Working group on Human Performance at Sea, have increased the number of organisations who have modified working practices or adopted shock mitigation solutions for their craft, although evidence has not been collected to support this claim.

Benefits to end users of HSC in military, civil and leisure contexts

Evaluation of the benefits accrued by the end-users due to the changes in working practices and conditions arising directly out of primary engagement with the research or mediated by adherence to the high speed craft design guide is still underway. Nevertheless, the physiological data collected in the research show that those end users whose craft or practices/conditions have changed, i.e. specialist military and civil personnel in the UK and overseas (see above for list of organisations) and non-professional passengers (e.g. thrill rides) are now better protected from the reported acute and chronic effects of repeated shocks (Ensign et al., 2000; Hodgdon et al., 2003) increasing working life and long-term wellbeing.

5. Sources to corroborate the impact

High speed craft human factors engineering design guide:

- **Dobbins, T.D.**, Rowley, I. and Campbell, L. (2008). High speed craft human factors engineering design guide. ABCD-TR-08-01 v1.0, Human Sciences & Engineering Ltd, Chichester. http://www.highspeedcraft.org/HSC_HFE_Design_Guide_v1.0.pdf

Dissemination to military and civil operators of high speed marine craft:

- **Dobbins, T**. **Myers, SD**. & Gunston, T. (2010). The development of a repeated shock transfer function for a high speed craft suspended jockey seat. The 45th UK Conference on Human Response to Vibration, Alverstoke, UK.
- Hill, J. **Dobbins, T.** & **Myers, S**. (2009). Advanced high-speed craft coxswain training. RINA – SURV 7 Surveillance of Search & Rescue Craft, Poole, UK.
- Gunston, T. **Dobbins, T.** & **Myers, S**. (2006). Acceptance trial requirements for high speed marine craft seats. The 41st United Kingdom Group Meeting On Human responses to vibration, Farnborough, UK.
- **Dobbins, T. Myers, S**. & Hill, J. (2006). Multi-axis shocks during high speed marine craft transits. The 41st United Kingdom Group Meeting on Human Responses to Vibration, Farnborough, UK.
- **Dobbins, T. Myers, SD**. Stark, J. & Mantzouris, G. (2011). Modeling human performance in maritime interdiction operations. NATO RTA Human modeling for military application (RTO-MP-HFM-202), Amsterdam, NL.
- **Dobbins, TD. Myers, SD. Dyson, R**. (2009). High speed craft coxswain workload. RINA – SURV 7 Surveillance of Search & Rescue Craft, Poole, UK.
- **Dobbins, TD. Myers, SD. Dyson**, R. Withey, WR. Gunston, T. & King, S. (2009). Impact count index for high speed craft motion assessment. RINA – SURV 7 Surveillance of Search & rescue Craft, Poole, UK.
- Ensign, W., Hodgdon, J.A., Prusaczyk, W.K., Ahlers, S., Shapiro, D. and Lipton, M., (2000). A Survey of Self-Reported Injuries Among Special Boat Operators. Tech Report 00-48, Naval Health Research Centre, San Diego.
- Hodgdon, J.A., Walsh, B.J. and Hackney, A.C., (2003). Biomechanical markers of musculoskeletal status associated with shock loading on special operations craft, 74th Shock and Vibration Symposium. SAVIAC, San Diego, pp. 250-262.
- Indicative list of companies whose employees have attended FRC Training sessions (BAE Systems, British Columbia Ferry Services, Canadian Coast Guard, Canadian Navy, De Wolf Maritime Safety, Dutch Workboats, Environment Agency, Garmin, German Maritime SAR Service, Kent Police, Netherlands Marine Corps, Royal Netherlands Navy, Swedish Maritime Administration, UK Border Agency, United States Coast Guard.