Institution: University of Southampton

Unit of Assessment: 15 General Engineering

Title of case study: 15-15 Engineering excellence in performance sport

1. Summary of the impact

A total of 34 British Olympic Gold medal triumphs in Beijing (2008), Vancouver (2010) and London (2012), [redact 14 words] relied to a greater or lesser extent on research in fluid dynamics, instrumentation and [redact 4 words] originating from the University of Southampton's Performance Sport Engineering Laboratory (PSEL). Global media coverage of the science behind these victories has raised the profile of British engineering. PSEL was awarded a 2012 Queen's Anniversary Prize for its sustained contribution to the competitiveness of the UK's sailing and motorsport industries worldwide through its research, specialist consultancy services and its high-quality engineering graduates.

2. Underpinning research

The margins of victory in elite cycling, [redact 3 words], skeleton or in the race for pole position in F1 can be as little as a hundredth of a second. As such, the sustained research of the Performance Sports Engineering Laboratory (PSEL) has centred on ensuring that athletes, coaches, and designers have available [redact 11 words]. The primary area where these performance gains originate is from PSEL's research into the complex, often unsteady, flow regime around yachts, vehicles and cyclists from the early 1990's onwards. [redact 21 words].

PSEL is a collaboration of academics directed by Turnock, Professor of Maritime Fluid Dynamics (UoS PhD '93) who was an employed researcher (R) '88 onwards, appointed a Lecturer (L) in '94, Airbus Professor of Aircraft Engineering Zhang L '93, Professor of Ship Dynamics, Wilson L '75, Senior Lecturers Drs Hudson(UoS PhD'99) R'94-, L '99-, Forrester (UoS PhD '03) R'03-,L'07, and Dr Taunton (UoS PhD'04) R'06-,RCUKF '08-, L'11. Longstanding Research Director Claughton, and in post since completing their doctorates research engineers Prince (UoS PhD '99), Wright (UoS PhD '00) and Scarponi (Perugia/UoS PhD, '06) are part of the UoS's Wolfson Unit (WU) for marine technology and industrial aerodynamics.

The underpinning research of the academic team, with related funds from EPSRC of £1.16 milllion, all completed prior to 2008 was that of Zhang (PI GR/M2156), *Unsteady flowfield and noise radiation from high-lift devices*; Turnock (CI GL11687), *Prototype integrated electric thrusters for work class underwater vehicles thrusters*, (PI GL32279), *Convective cell approach for free surface flow around moored offshore structures*, and (CI GJ73193) *Enhanced ship manoeuvring performance estimates through effective design of rudder-propeller systems*; Wilson (PI GR/N16471) *Ships' wash impact management*; and Hudson (CI EP/C525728) *Design of High-Performance Marine Craft from a Human Factors Perspective*.

This background fluids research contributed to Zhang's pioneering wind tunnel research into diffusers, wheel interactions and other subtle flow control influences of F1 car design [3.1, prior to 2003] allowing greater insight into the opportunities to maximise car performance throughout the race. The work of Turnock on improved design of control surfaces [3.2, 1995-2006], and with Zhang understanding bluff body flow using experimental and Computational Fluid Dynamics (CFD) [3.3, 3.4, 1999-2005] and Wilson and Taunton's work on wave resistance of high performance hulls[3.5, 1998-2004], all gave the necessary insight into unsteady fluid dynamics and the ability to make precise and repeatable measurements. Whereas the work of Scarponi and Turnock [3.6, 2003-2007] developed a vital understanding of how human decision making can be included in race performance analysis.

There has been on-going research in competitive sail craft at UoS since the 1950s. For example WU has had a continuous involvement (Claughton) with Team New Zealand's since their first successful America's Cup (AC) campaign of 1995. Wind tunnel tests on sails, keels and bulbs as well as hull development through towing tank tests were carried out giving them further victories in 2000 as well as runners up again in 32nd AC in 2007. In this competition WU gave research support to seven of the competing teams (Claughton, Wright, Prince).

This excellent track record in uncovering small fluid dynamic based performance margins led to a

partnership with UKSport from 2005, with Southampton's WU one of eight organisations awarded Innovation Partner status. Initial research drew on PSEL's expertise to seek aerodynamic improvements for track cycling and bob skeleton, and aero/hydrodynamic gains [redact 12 words] where fluid dynamic drag is of importance.

PSEL's research into performance gains is a unique expertise [redact 31 words] Using the UK's largest University-sector wind tunnel, from 2005 onwards, the PSEL team developed [redact 44 words] The computational simulation of fluid dynamics to measure drag [3.3] was applied to vehicles and equipment using Southampton's parallel supercomputer Iridis 3. [redact 39 words]

In 2010 they developed a novel winch system for evaluating the hydrodynamics of swimmers, in which a line pulls the swimmer through the water as academics analyse stroke technique through synchronised video and a network of wireless motion sensors. Based on research into these and similar instrumentation techniques from 2006 onwards the PSEL team created a system [redact 11 words]. This was used by Turnock's EngD student Rachel Blackburn to [redact 6 words] design a new sled, 'Arthur', [redact 38 words].

3. References to the research (the best 3 indicating quality of research are starred)

[3.1]* Ruhrmann, A. and Zhang, X (2003) Influence of diffuser angle on a bluff body in ground effect. Journal of Fluids Engineering, Transactions of the ASME, 125, (2), 332-338. (doi:10.1115/1.1537252)

[3.2] Molland, A.F., and Turnock S.R., 2007, Marine Rudders and Control Surfaces: principles, data and design, Butterworth Heineman,414pp.

[3.3]* Pattenden, R.J., Bressloff, N.W., Turnock, S.R., and Zhang, X , 2007, Unsteady simulations of the flow around a short surface-mounted cylinder, Intl, Journal of Numerical Methods in Fluids, 53:895-914; DOI: 10.1002/fld.1309.

[3.4]* Pattenden, R.J., Turnock, S.R. and Zhang, X., 2005, Measurements of the flow over a low aspect ratio cylinder mounted on a ground plane. Experiments in Fluids, 39(1) 10-21.

[3.5] Molland, A.F., Wilson, P.A., Taunton, D.J., Chandraprabha, S. and Ghani, P.A. (2004) Resistance and wash measurements on a series of high speed displacement monohull and catamaran forms in shallow water. International Journal of Maritime Engineering, 146, (2), 19-38. (doi:10.3940/rina.ijme.2004.a2.3604).

[3.6] Scarponi, M, Conti, P, Shenoi, R.A. and Turnock, S.R. (2008) Interactions between yacht-crew systems and racing scenarios combining behavioural models with VPPS. Transactions of the Royal Institution of Naval Architects Part B: International Journal of Small Craft Technology, 150, (B1), 11-18.

4. Details of the impact

PSEL research into [redact 2 words] fluid dynamic interactions has uncovered crucial performance gains that contributed directly to widespread British sporting success in all the Olympic games from 2008 onwards, raising the international profile of British engineering excellence and helping inspire greater public interest in sport.

Dr's Wright and Prince are founding member's of British Cycling's (BC) 'secret squirrel club ' and led the wind tunnel testing recommending changes that achieved significant performance gains when first rolled out in 2008 and then again in a more challenging 2012 Olympics. BC's Brailsford stating '*We have done a huge amount of work with the wind tunnel in Southampton and have come up with some cool stuff'* [5.1,5.2]. BC won 14 gold medals in 11 days of Olympic competition in 2008 and 2012. BC Head of Research and Development praised Southampton [5.3] for *'Their world leading experimental capabilities, innovation and technical expertise in the area of cycling aerodynamics and engineering are outstanding* '. [redact 106 words] [5.4].

PSEL research informed the design, by two of Turnock's doctoral students of 'Arthur', the sled used by skeleton racer Amy Williams in the 2010 Winter Olympics in Vancouver. The sled and the students' use of the wind tunnel was the major contributing factor to Williams becoming the first British individual gold medallist at a Winter Games for 30 years [5.5].

Research techniques honed through PSEL's expertise in maritime engineering underpinned the design of the systems used to test 38 of the 45-strong British Swimming team for London 2012. [redact 29 words]. British Swimming's lead technical advisor, ex. World Champion Jonty Skinner confirmed that '*its really educated people'* [5.6]. Similar interventions by PSEL in a diverse range of sports including sailing, rowing, and kayaking made contributions to sports that helped win 34 Olympic Gold medals in the 2008, 2010 and 2012 games. [redact 21 words].

All of PSEL's work with elite British Olympic athletes came under an "innovation partnership" with UK Sport. In 2012 PSEL was awarded a prestigious Queen's Anniversary Prize for Higher and Further Education, prompting Dr Scott Drawer, UKSport's Head of Research and Innovation to describe PSEL's work as '*critical*'[5.7, 5.8] and that '*I wish to congratulate the University of Southampton for the fantastic work they have done in the field of sports engineering, in particular with our Olympic athletes'* [5.8].

British Olympic success led to global media coverage of PSEL's engineering expertise [5.9, 5.10], reaching both NBC in the USA and Russian TV enhancing the reputation of British engineering at home and overseas. The design of Amy Williams' skeleton sled in the aftermath of her victory in 2010 followed the world's press interview of Blackburn at Williams's post-race press conference[5.11-5.14]. In 2012, media coverage of the swimming research [5.9, 5.10] had reached an estimated audience of 3.5 million people worldwide. This positive publicity serves to attract UK school students to study engineering at university with typically 50% of Southampton's Mechanical, Aerospace and Ship Science UCAS applicants citing Formula 1, sailing and cycling as motivations for applying. Through his links with PSEL Olympian of 2004 and now cycling commentator, Chris Boardman gave an inspirational lecture at the University in May 2012 to 300 17-year-olds from schools less likely to send students to university.

Longstanding research at Southampton has upheld the outstanding reputation of British engineering in the worlds of sailing and motorsport, benefiting the UK economy. The research engineers at the WU (Claughton, Prince, Wright, Scarponi) provide consultancy services worldwide, achieving a turnover of [redact 1 word] from 2008 to 2013. They optimised the sloop *Kokomo*, which in 2010 won the award for best sailing superyacht at the International Superyacht Society awards. In 2009, the engineers contributed to the successes of the top three finishers in the Jacques Vabre transatlantic race and assisted the Challengers, Defender and Race Management in the run-up to the 34th America's Cup in 2013.

The University supplies the sailing and motorsport industries with high-quality graduates. There are 40,000 skilled jobs in the UK motor sport industry and its supporting industries, including 25,000 engineers, with a turnover of £7 bn per year. A UoS graduate [5.15] leads the Red Bull racing team that won the F1 championship in 2010, 2011 and 2012 states '*The University of Southampton continues to produce graduates of the highest quality that are amongst the best new young talent coming into this highly competitive industry'*. And. '*I recognise the quality of Southampton's engineering graduates, the facilities provided, the broad and the world-leading research undertaken by your academics in areas related to aerodynamics and performance'.*

5. Sources to corroborate the impact

[5.1] Sir David Brailsford, quoted in Guardian in 2008 in run up to 2008 games and discusses secret squirrel club in 2012. http://www.guardian.co.uk/sport/2008/apr/01/cycling.sport

[5.2]http://www.dailymail.co.uk/sport/olympics/article-2160746/London-2012-Olympics-Dave-Brailsford-plots-cycling-glory.html.

[5.3] [redact 29 words].

[5.4] Chris Boardman's six ITV4 pieces filmed for the 2013 Tour de France Highlight Programme in the RJMitchell Wind Tunnel, with links to first five at end of http://www.itv.com/tourdefrance/features/feature-cycling-aerodynamics-part-6-ned-chris-forming-the-complete-package/ with Dr's Prince and Wright playing a silent role throughout. Southampton referred to as the 'home of the secret squirrel club'.

[5.5]. The Engineer interviews EngD student Blackburn http://www.theengineer.co.uk/awards/project-blackroc-the-gold-medal-winning-skeleton-

bob/1006337.article [redact 4 words] both Dr's Blackburn and Roche employed by McLaren [redact 10 words].

[5.6] Jonty Skinner World Class Technical Advisor to British Swimming quoted in an article in The Times in which Dr Hudson also interviewed.
http://www.timesonline.co.uk/tol/sport/more_sport/article6853003.ece

[5.7] [redact 12 words].

[5.8] UKSport press release after QAA to PSEL http://www.uksport.gov.uk/news/university-of-southampton-awarded-queens-anniversary-prize-281111

Two examples of swimming media coverage with link to Ben Fogle's piece on NBC broadcast throughout USA during primetime

[5.9] http://archives.nbclearn.com/portal/site/k-12/flatview?cuecard=60008

[5.10]http://www.independent.co.uk/sport/general/others/swimming-second-wave-seek-a-fitting-stage-7534709.html

Example of the many items of Skeleton media coverage:

[5.11]http://www.guardian.co.uk/sport/2010/feb/22/amy-williams-winter-olympics-skeleton

[5.12]http://www.telegraph.co.uk/sport/othersports/winter-olympics/7286622/Winter-Olympics-2010-Amy-Williams-slowly-realises-that-life-wont-be-the-same-again.html

and see insert 'A rather unique..' in article on Research Impact by HEFCE(2012).

[5.13] http://www.researchtrends.com/issue-27-march-2012/research-impact-in-the-broadest-sense-ref-14/ pointing to press release by EPSRC

[5.14]http://www.epsrc.ac.uk/newsevents/news/2010/Pages/gold-winningsled.aspx

[5.15] [redact 13 words].