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Dear Dr Julie Soden,

We are pleased to enclose the final Warwick Innovative Manufacturing Research Centre report.

If you require further copies please email me at: c.m.shepherd@warwick.ac.uk or alternatively call 02476 151667.

Kind regards,

[Signature]

Carla Shepherd  
Administrative Co-ordinator  
Warwick IMRC
Impact through Multidisciplinary Research

Warwick Innovative Manufacturing Research Centre

Final Report - November 2011
Featured Project - World First Racing

Budget & Timescale
The project received funding of £198k from WMRC and ran from April 2008 to June 2009.

Project Goal
To create the world’s first environmentally friendly racing car and in doing so demonstrate the potential for using sustainable materials and fuels in high performance, high quality, technically advanced products.

Relevance of the Research
Motor sport contributes £85 billion to the UK economy every year and the UK motorsport cluster is widely acknowledged as world leading. The UK motorsport industry is thriving with 4000 companies and 2500 skilled engineers innovating at a pace not seen in any other industry. However, motorsport faces criticism from environmental campaigners that it is disconnected from the changing world in that it is doing little to reduce fuel consumption and no longer generates innovations that are relevant to mainstream automotive developments. In the past motorsport innovations, such as disc brakes, regularly filtered down into everyday car designs. Having consulted with leading members of the motorsport industry the project team identified that motorsport could make itself more relevant by leading the adoption of sustainable technologies and in particular providing a high profile platform to showcase novel lightweight sustainable materials and fuels.

The Approach
The work was focussed on delivering the following objectives:
- To implement a sustainable racing car based on a recognised competitive racing formula specification so that it would be potentially possible to race the car against conventional versions of the formula.
- To partner with a suitable motorsport car manufacturer to implement a working vehicle.
- To bring in a network of motorsport supply companies and Universities to contribute materials, knowhow and credibility to the project.
- To evaluate the performance of the car and its constituent sustainable elements on race tracks and demonstrate the fitness for purpose of sustainable technologies.
- To generate research questions for future projects to answer.
- To achieve strong public engagement.

The Team
The Sustainable Materials Group at WMG comprises a number of academics and PhD students. Disciplines range from engineering, through chemistry to economics. The multidisciplinary nature of the group enabled the team to draw in expertise from across the university including Warwick HRI (the horticultural department) and Chemistry. Furthermore, 20 external partners contributed to the project in a number of ways. Some, like the wiring loom provider Yazaki, simply donated and fitted their custom designed loom. Others, like Green Fuels and Scott Racing were heavily involved in providing fuel and engine mapping capabilities. The project was conceived and directed by three key individuals:
- Kerry Kirwan and Steve Maggs, the Principal Investigators (WMG).
- James Meredith, the Project Manager (WMG).

Partner Involvement
The following companies donated engineering resources and materials to the project with an estimated value in excess of £200,000 - Lola; Life Agency; Place; BASF; Yazaki; Koni; Scott Racing; Crop & Food Research NZ; AP Racing; Bioreins; euCellucomp; Sogefi; Filtration; Lear; Fuchs; University of Ulster; Bosch; Mitted Carbon; Green Fuels; Hewland; DMS. The project could not have been completed without their invaluable assistance.

Project Outputs
- The WorldFirst Racing car was based on a Lola B05/30 Formula 3 chassis. Only non-safety critical parts were replaced with environmentally friendly alternatives. Hence the monocoque, nose box and rear crash structure all remained as standard.
- The engine was a heavily modified BMW two-litre turbo diesel, chosen because of its inherent efficiency advantages over gasoline as well as the reduced noise levels, since this is an ongoing issue for many UK race tracks. The engine was tuned to run on bio-diesel which was manufactured from a variety of waste streams, including vegetable oil and cocoa butter from waste chocolate. The gearbox and engine were lubricated with vegetable oils. The standard copper wiring loom was replaced with a much lighter recycled aluminium wiring loom which has a much better weight to conductivity ratio.
- A number of environmentally friendly technologies were incorporated including a catalytic coating on the radiators to convert atmospheric ozone to oxygen, seat foam made from soybeans rather than petroleum extracts and rear view mirrors made from Potatopak water-resistant starch packaging material, derived from the waste liquid starch produced in the manufacture of potato crisps.
- Several bodywork components contained natural materials. The flax reinforced epoxy used to manufacture the bib on WPR F3 has mechanical properties which match glass fibre but with improved vibration absorption and reduced environmental footprint. One of the partners, Airplus in Valencia, Spain, successfully produced a front wing flap using a woven jute fabric combined with an epoxidised soy bean resin. The bargeboards on the car used three dimensional (3D) weaving carried out at the University of Ulster to produce a multiple-layer woven flax preform. The steering wheel was fabricated from Curran, derived from carrots, rather than carbon fibre - Curran is already commercially used for high performance fishing rods.
- To complement the natural fibres, sustainable resins were employed in the manufacture of the sidepods. The resin contained recycled PET derived from drinks bottles and other plastic waste.

Notable Impacts
- The car was competitive on track and achieved 0 to 60mph in 3.5 seconds, with a top speed of 148mph and a fuel consumption of 18 mpg under racing conditions (compared to Bmg's for a standard gasoline F3 car).
- The project has featured in countless TV, Radio and Newspaper articles across the globe and has been widely covered online.
- The car was named in Time Magazine's Top 50 Inventions of 2009 and was the showcase exhibit at the MIT Energy Conference in March 2010.
- Interest from the Mayor of Indianapolis led to the project team visiting Indiana in May 2010 to meet with a number of Indy Car race teams and local Universities. Discussions on possible joint research in sustainable materials and motor sport technologies are continuing with Purdue University and IUPUI (Indiana University Purdue University at Indianapolis).
- Dr Steve Maggs was awarded the Rowbotham Medal from the Institute of Materials Mining and Minerals for contribution to the development or innovative use of materials for automotive applications.
- Dr Kirwan was awarded the Thornton Medal by the Institute of Materials, Minerals and Mining (IOM3) in recognition of Dr Kirwan's talk 'Lean, Mean and Green: The World’s First Environmentally Friendly Racing Car'. Dr Kirwan was also awarded the Iambard Kingdom Brunel award 2009 from the British Science association.
- The project team was shortlisted for the Times Higher Education awards 2010 for Outstanding Research Team of the Year and was 'highly commended'.
- The use of motorsport demonstrations has been widely acknowledged as an effective way of promoting new ideas and technologies.

Next Steps
The project has spawned a number of research activities in WMG, including work on natural fibres and recycled carbon fibres in crash structures. WMG has joined Lola Cars and Drayson Racing Technologies in a consortium that will fast-track the development of a range of next generation technologies including an all-electric drive train and sustainably sourced composite parts for the Lola-Drayson B12/69EV car.

Interested?
For further information and to discuss possible future collaboration please contact Kerry Kirwan, Head of Sustainable Materials, WMG, University of Warwick, CV4 7AL. Email: kerry.kirwan@warwick.ac.uk

www.wmg.org.uk kerry.kirwan@warwick.ac.uk
Thank You to Our Private and Public Sector Partners

Warwick Innovative Manufacturing Research Centre (WIMRC) could not have implemented its ambitious research strategy and achieved the outputs reported in this document without the support and encouragement of our industrial and public sector partners and the research grant provided by the Engineering and Physical Sciences Research Council (EPSRC). WIMRC, WMG and the University of Warwick acknowledge and thank all our partners and in particular EPSRC for its generous funding of Warwick IMRC from October 2001 to December 2011 inclusive.

Our partners during Phase 1 (October 2001 to September 2006) and Phase 2 (October 2006 to December 2011) are represented by their organisational logos in the following montages.

Phase 1

Phase 2

www.wimrc.org.uk