

Impact case study (REF3b)

<p>Institution: Oxford Brookes University</p>
<p>Unit of Assessment: 15 – General Engineering</p>
<p>Title of case study: AVERT Project (Adaptation of Vehicle Environmental performance by Remote sensing and Telematics) a FORESIGHT Vehicle Programme</p>
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Implementing measures that can maintain, as well as improve air quality is a constant challenge faced by local authorities, especially in metropolitan cities. The AVERT, EPSRC/DTI link project, led by Samuel and Morrey of Oxford Brookes University, were tasked at identifying and proposing a new strategy to limit the amount of pollutants from vehicles dynamically using remote sensing and telematics. Firstly, it established the magnitude of real-world emission levels from modern passenger vehicles using a newly developed drive-cycle. Secondly, it demonstrated a broad framework and limitations for using existing on-board computer diagnostic systems (OBD) and remote sensing schemes for the identification of gross polluting vehicles. Finally, it provided a strategy for controlling the vehicle to meet air pollution requirements. The outcomes had direct impact on Government policy on “Cars of the Future”, roadside emission monitoring, and the business strategies for both the Go-Ahead Group and Oxonica Ltd.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>The Advanced Engines, Propulsion and Vehicles group (AEPV) has been active for nearly three decades under various guises, carrying out research in the area of vehicle emissions and fuel economy. Most of the research work has been directly linked to automotive industry in the area of combustion and emissions, and alternative fuels. Notable work during the 90’s included production of alternative fuels from locally available oil seeds in Nepal and combustion and optimization of a gasoline engine to run on natural gases for BOC.</p> <p>In 2000, AEPV was chosen [1] as one of the partners in AVERT Project with main researchers Denise Morrey [1-6] and Stephen Samuel [2-6]. The main task was to develop novel engine and vehicle emission control strategies especially for highly congested metropolitan cities. The other members of the project were tasked with developing a representative drive cycle (TRG of Southampton) [3-4], evaluating the strategy developed by Oxford Brookes (Transport Research Laboratory (TRL)) [3-4], providing vehicle test facilities (MIRA) [2-6], and supplying engine hardware to Oxford Brookes (Daewoo Motors), and to give expert advice regarding on-road diagnostic systems and roadside measurement systems for the identification of gross polluting vehicles (Golden River Transport). The work focussed on finding an answer to three major questions using experimental as well as powertrain modelling tools; Is there any significant difference between real-world emission levels and legislative emission levels? [2,3]; Which is the most significant vehicle operating parameter responsible for real-world emission levels? [4]; and, Is there any significant difference in the performance of catalytic converters for real-world drive cycles and the legislative drive cycle?[5] The answers to these questions were to enable AVERT to implement remote sensing in order to identify gross polluting vehicles, and also to switch the engine management system to lower tailpipe-out emission modes when entering lower emission zones.</p> <p>With experimental and numerical work this project identified that: Real-world emission levels measured using chassis dynamometer tests were significantly higher than legislative emission levels; and, no single vehicle operating parameter was found to be entirely responsible for real-world emission levels. It was found, however, that the engine performance map has two zones- a “clean” zone that supported the legislative drive cycle and an “unclean” zone that was outside the boundary of the clean zone and was responsible for real-world emission levels [4, 5]. It was also found that the conversion efficiency of the catalytic converter for real-world drive cycles was significantly lower than that for the legislative drive cycle, and was found to oscillate depending on the emission loading of the catalytic converter. Under heavy emission loading due to events such as sudden acceleration, the conversion efficiency of the catalytic converters will be close to zero due to the oscillating nature of chemical reactions. Therefore, under these conditions, the tailpipe-out emission levels from even newer modern vehicles will be equivalent to that of pre-1990 vehicles. If the emission levels are continuously monitored by the OBD system, or snapshot measurements are carried out by road-side monitoring systems, a new vehicle could be identified</p>

as a gross polluting vehicle under these circumstances, Hence, this project highlighted that the application of remote sensing and OBD to determine the gross polluting vehicles would lead to difficulties unless the entire engine operating map, i.e clean and unclean regions together, was brought under the legislative test regime. This work also provided a strategy to identify localised emission hot-spots for a given driving route [6].

3. References to the research (indicative maximum of six references)

Selected peer-reviewed publications in the area of Real world Emission Levels and Fuel economy / combustion and emissions

- [1] **Key grants:** EPSRC Grant No GR/M86811/01, Adaptation of Vehicle Environmental Performance by Telematics (AVERT), Principal Investigator, Dr D Morrey, 4 Jan 2000 to 03 Jan 2003, Value, £84,625
- [2] Samuel S, Austin L, Morrey D. "Automotive test drive cycles for emission measurement and real –world emission levels- A Review", Journal of Automotive Engineering, the Proceedings of IMechE Part D,. Engrs, Vol 216, No 7, 2002, pp 555-564. doi: 10.1243/095440702760178587.

Submitted to RAE2008, Oxford Brookes University, UoA25-General Engineering and Mineral & Mining Engineering, RA2, S Samuel, Output 4.

- [3] Samuel S, Morrey D, Fowkes M, Taylor DHC, Austin L, Feslthead T, Latham S. "Real-world fuel economy and emission levels of a typical Euro-IV passenger vehicle", Journal of Automobile Engineering, Proc. IMechE Part D, Vol 219, No 6, 2005, pp 833-842, doi: 10.1243/095440705X28277.

Submitted to RAE2008, Oxford Brookes University, UoA25-General Engineering and Mineral & Mining Engineering, RA2, S Samuel, Output 1.

- [4] Samuel S, Morrey D, Fowkes M, Taylor D H C, Austin L, Felstead T, Latham S. "The most Significant Vehicle Operating parameter for real-world emission levels", SAE 2004 Transactions, Journal of Fuel and Lubricants, Paper No. 2004-01-0636.

Submitted to RAE2008, Oxford Brookes University, UoA25-General Engineering and Mineral & Mining Engineering, RA2, D Morrey, Output 2.

- [5] Samuel S, Morrey D, Fowkes M, Taylor D H C, Garner CP, Austin L. "Real-world performance of catalytic converters", Journal of Automobile Engineering, Proc. IMechE Part D, Vol 219 No 7, 2005, pp 881-888, doi: 10.1243/095440705X28349.

Submitted to RAE2008, Oxford Brookes University, UoA25-General Engineering and Mineral & Mining Engineering, RA2, S Samuel, Output 2.

- [6] Samuel S, Morrey D, Garner C P, Taylor DHC, Fowkes M, Austin L. "Deriving on-Road spatial vehicle emission profiles from chassis dynamometer experiments" Journal of Automobile Engineering, IMechE Part D, Vol. 220, No, 2006, pp 77-87, doi: 10.1243/095440705X69678.

Submitted to RAE2008, Oxford Brookes University, UoA25-General Engineering and Mineral & Mining Engineering, RA2, S Samuel, Output 3.

4. Details of the impact (indicative maximum 750 words)

The outcome of the AVERT project enabled us to support local industries to develop products and strategies for improving fuel economy and emission performance of bus fleets and other vehicles equipped with heavy duty internal combustion engines. Some selected examples are:

a. Development of vehicle Operating Strategy for Sustainable transport for Regenattec

Specific insight gained from AVERT was used to develop a vehicle operating strategy for a dual fuel vehicle, implementation by Regenattec in new sustainable buses operating in Milton Park, Oxfordshire, for improved fuel economy and lower emissions levels [7]. A consultancy project was also carried out to evaluate the required operating temperature and combustion characteristics of various plant oils in order to develop a suitable operating strategy that can be implemented for dual fuel engines in North Sea trawlers. It was successfully completed and implemented by Regenattec Ltd [8]. The annual fuel consumption per year for these types of vessels is about 260,000 litres and with this new strategy the savings per vessel per year is between £26,000 and £39,000 [8].

b. Development of fuel borne additive for combustion control

Knowledge gained from the AVERT project by Samuel and Morrey was used to carry out research and consultancy work with Oxonica, an Oxford based company developing nano-scale additives. One of the main products, Envirox™ [9,10] a fuel borne additive for diesel combustion was developed and optimised to achieve improved fuel economy and lower emission levels in heavy duty diesel engines for typical bus operation. These additives are used in operation by Stagecoach buses which has a 15% share of the tendered London bus market [11], and these have been successfully implemented across 10 depots in London and have achieved an overall improvement of 5% in fuel economy for the past 8 years [11,12]. Similar work has continued through research and consultancy work for developing a fuel specific operating strategy with Energenics Ltd, a Singapore based company for fuel additives. Envirox™ has now been sold by Energenics to London Stagecoach buses [12]. Recently, Stagecoach has announced that the savings due to the use of Envirox over 8 years was 188,000 tonnes of CO₂. It has also signed a new 3 year supply agreement with Energenics for the additives. Envirox™ is currently used by 8,300 buses and coaches in the UK and North America [12].

c. **Fuel economy for bus fleets**

The research outcomes disseminated through journal publications were used by the automotive industry. As a result we have received invitations from Metrobus, Transport for London (TFL), and Jaguar Land Rover to share the results of these findings with their research and development engineers [13], and to educate their customers regarding the impact of driving patterns on fuel economy and emissions. A KTP application through Metrobus was developed specifically to implement the optimum fuel economy strategy on Metrobus London for the Route 10 Gatwick Fastway [13].

d. **Hybrid Fuel economy for Transport for London**

Recently Samuel et al with WSP, a leading consultancy in the realm of public transport, were chosen by TFL to evaluate the fuel economy benefit of the Hybrid bus fleet in London, and to study the effect of the topology of the routes [14]. The knowledge gained from the AVERT project is being used in the current project to evaluate the fuel economy and emission performance of a number of Hybrid Bus fleets in London. The project is also developing a strategy that will be proposed for improving the fuel economy and emission performance of current and future Hybrid fleets in London. This work will provide scientific background to TFL for choosing appropriate routes for future hybrid fleets and also the optimisation of hybrid routes for minimising the creation of localised emission hotspots.

e. **Professional training**

The outcome of this project created further interest in the Automotive Industry; BMW Oxford wanted to train their engineers in the area of fuel economy and emissions and therefore, enabled Oxford Brookes to install their engines and emission monitoring systems in the Advanced Engines Lab. A routine training programme for 20 of their engineers has been run by Samuel in the lab since 2008. Recently one of the BMW engineers in partnership with our group developed a tool that can use sensed inputs from the vehicle, for real-world driving conditions, to assess the health of the engine for optimum operating conditions.

f. **Policy**

The findings of this FORESIGHT vehicle initiative directly influenced the policy of “Cars of the Future” relating to real-world emission levels from modern passenger vehicles and were also incorporated into the Foresight Intelligent Infrastructure Systems Project commissioned by the Office of Science and Technology review [15].TRL(UK), is using the data developed by the AVERT Project to improve the instantaneous emission models used by the Highway Authority to target mitigating measures for reducing pollutant concentrations close to road networks [16].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[7] Barrett Byrd, ‘Accord strives for carbon neutrality’, Transportation Professional, The magazine of the Institution of Highways and Transportation, Jan/Feb 2007, pp16-20, ISSN: 1478-4467.

[8] Biofuels for the Fishing Industry: ‘An investigation into the use of Pure Plant Oil as a Replacement for Marine Diesel’, Report by Regenattec, Release 1.5, February 2008. http://www.seafish.org/media/Publications/Biofuels_for_the_Fishing_Industry_An_Investigation_into_the_Use_of_Pure_Plant_Oil.pdf

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- [9] Barry Park, Roger Scattergood and Chris Harris, (Oxonica Ltd, UK), Geoff Goddard and Stephen Samuel, (Oxford Brookes University), 'Mechanistic Studies on the Action of a Cerium Based Diesel Fuel Additive', Additives 2005-Optimizing Automotive Power trains, 5-7 April 2005, Dublin, Ireland, organised by Royal Society of Chemistry, London.
- [10] Gareth Wakefield, Xiaoping Wu, Martin Gardener, Barry Park and Stuart Anderson, 'Envirox™ fuel-borne catalyst: Developing and launching a nano-fuel Additive', Technology Analysis & Strategic Management, <http://dx.doi.org/10.1080/09537320701726825>
- [11] 'Fuel saving additives returns to Stagecoach London Business', by Passenger Transport, 15 Sep 2011, <http://www.passengertransport.co.uk/2011/09/fuel-saving-additive-returns-to-stagecoach-london-business/> [Web Accessed] 11 Sep 13.
- [12] News Release: 'Stagecoach Cuts Carbon Emissions Through Innovative Fuel Saving Additive', <http://www.energenics.co.uk/news/news-release-stagecoach-cuts-carbon-emissions-through-innovative-fuel-saving-additive/> [web Accessed] 12 Sep 13.
- [13] Corroborating statement author 1. Letter from Managing Director of Metro Bus, 17 July 2006.
- [14] Transport for London, 'Hybrid fuel consumption study', Data gathering and Analysis- Technical Submission, Bid No. 50400567, dated 4 Oct 2012.
- [15] 'Cars of the Future', House of Commons Transport Committee report, Seventeenth Report of Session, 2003–04, Vol II, oral and Written evidence, HC319-II, published on 15 July 2005, pp Ev140. <http://www.publications.parliament.uk/pa/cm200304/cmselect/cmtran/319/319ii.pdf>
- [16] Barlow, TJ, Boulter PG and McCrae, I S, An Evaluation of instantaneous emission models, TRL report PPR 268, Framework Contract no 3/323-R041 to Highway Agency, 2007, pp11-13.