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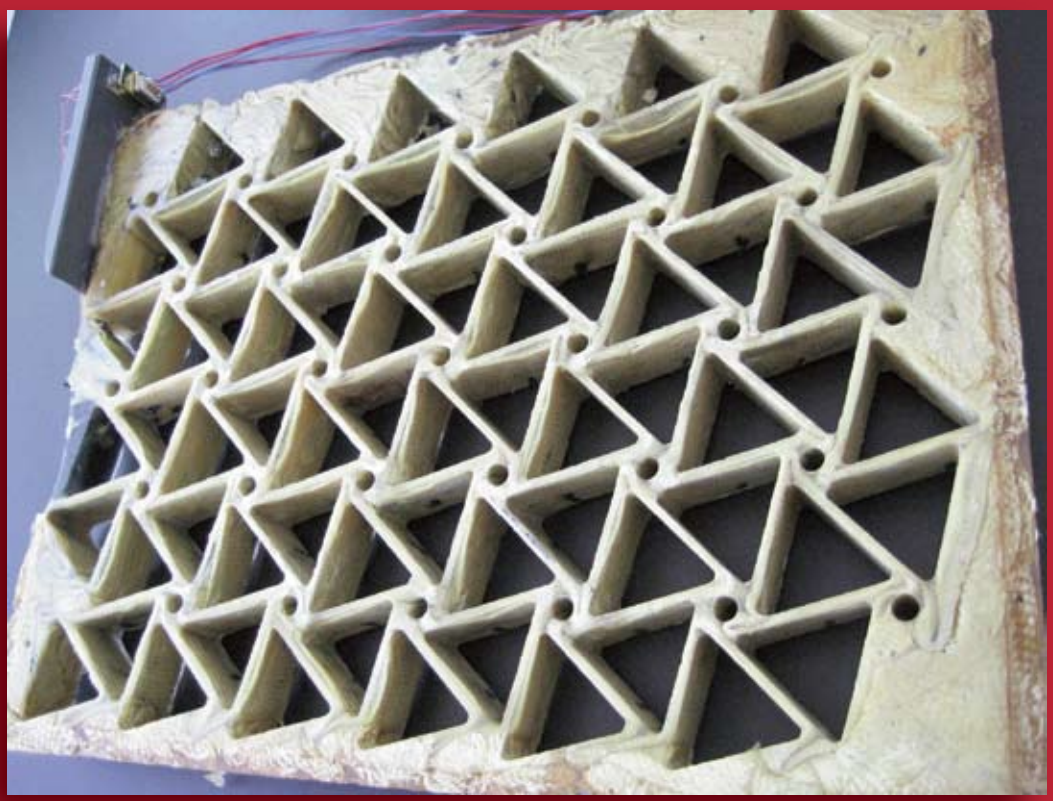
MARCH 2009

JOURNAL OF THE ENGINEERING INTEGRITY SOCIETY

ENGINEERING INTEGRITY



papers on:

- A survey study of steering wheel vibration and sound in automobiles at idle
- Russian market road load data collection exercise to identify the potential customer usage envelope compared to the engineering durability standard

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EIS Secretariat :
Engineering Integrity Society
18 Oak Close, Bedworth,
Warwickshire, CV12 9AJ
Tel & Fax: +44 (0)2476 730126
E-mail: eis@e-i-s.org.uk
WWW: http://www.e-i-s.org.uk

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Photographic contributions for the front cover are welcomed.

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PRINCIPAL ACTIVITY OF THE

ENGINEERING INTEGRITY SOCIETY

The principal activity of the Engineering Integrity Society, is the arrangement of conferences, seminars, exhibitions and workshops to advance the education of persons working in the field of engineering. This is achieved by providing a forum for the interchange of ideas and information on engineering practice. The Society is particularly committed to promoting projects which support professional development and attract young people into the profession.

'Engineering Integrity', the Journal of the Engineering Integrity Society is published twice a year.

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Front cover: Smart chiral truss panel with integrated SHM capabilities
(Fraunhofer Institute IPA, Dresden - CHISMATECH s.a, Catania, Italy)

Editorial

The months since the last issue have been interesting on many fronts. Over shadowing most things is the slide from credit crunch to full blown recession and it is no surprise that the world's economic woes find their way into many of our regular columns. The automotive sector is being particularly hard hit with redundancies, pay cuts and factory shutdowns abounding – those at Bentley caught my eye particularly as my first meeting with the EIS committee was hosted at their Crewe factory.

At times like these it is particularly important that Government gets the best possible advice and it is good to see that the engineering institutes are pushing for more formal input from an engineering perspective into policy making (Industry News). Perhaps with the current economic downturn and the hope that the knowledge economy might lead us out of it in mind, the Government are in turn increasing the emphasis they place on knowledge transfer from the research they fund through the research councils. EPSRC have recently announced that they will be requiring a two page 'impact plan' for all proposals from April. This should hold no fears for anyone working closely with industry, but we should be wary of focussing too much on short term impact at the expense of more fundamental research whose impact will only be felt in the longer term.

While the recession is currently hitting the automotive sector from mass market manufacturers to Formula 1, Formula Student is having no difficulty attracting teams, with places filling in two hours. Also in the News from Formula Student column is a look at some longer term challenges for the car industry. In particular ambitious goals for reducing vehicle emissions by up to 50% that are to be discussed at 'Low Carbon Vehicles 2009'.

Continuing with the automotive theme, the two technical papers in this issue concern noise and vibration in automotives and a durability study comparing existing manufacturer sign off procedures with in service conditions in emerging markets, notably Russia.

Although there seems to be little to cheer about on the industrial side, academics may look to at least one silver lining: economic downturns often encourage sixth formers to apply to university rather than face a hostile job market. This has proved to be a double edged sword in the past with insufficient funding following the students – many of the funding problems facing the sector for the last decade stem from the spectacular rise in student numbers in the early nineties. Taking academic minds off the economy in December was the release of the RAE results. It was a relief to see that the engineering panels chose to acknowledge the quality of the research done around the country and avoided the academic tendency to stab their colleagues and their subject in the back. We all now await the announcement of the all important funding formulae that determine how the money follows the grades.

The battle to attract students to study STEM subjects continues with several projects being highlighted in the Industry News column, in particular the GET AHEAD WITH STEM! programme which aims to take this message to 'hard to reach' low participation groups and has recently attracted in excess of a million pounds worth of funding from the Government. Having been involved in similar projects myself for several years, I can attest to their success, not only in raising the profile of engineering, but also in attracting students to study engineering at university.

Finally, the various groups within the EIS are organizing several events for us this coming year, including 'testing and failure in orthopaedic medical devices', 'rapid prototyping', 'living with aging plant' and 'Multiplexed Digital Information for Test and Development'. It is however a shame to see one of our groups being forced into hibernation by the current economic situation. Hopefully this economic winter will not last too long and they will be fully functioning again in the not too distant future.

Karen Perkins
Honorary Editor

Diary of events

Wedneday 13 May 2009

'Testing and Failure in
Orthopaedic Medical Devices'

Devonshire Hall, University of Leeds

Wednesday 20 May 2009

'Multiplexed Digital Information for Test
& Development'

MIRA Ltd, Nuneaton

ANDREW MIDDLETON

I wish to propose a vote of thanks for the work that Andrew has put into the running of the NVHP group for what must be close on ten years.

Andrew has decided to stand down and take a well earned rest but before we let him go I think we should review the contribution that Andrew has made to our society and the field of noise & vibration.

Andrew graduated in 1958 and as a first job went to work in the development department of Rolls Royce Motor cars in Crewe.

As with many engineers this first job shaped the rest of Andrew's professional life. Firstly he became both interested in and proficient at NVH engineering and secondly he met and became a lifelong friend of Tony Best.

Like many of us Andrew's feet began to itch after a few years and so in the late 1960's he set off for ISVR at Southampton to further sharpen his NVH skills and as time passed he rose to become the Head of the Wolfson Consulting Unit.

A love of the sea and of sailing has been a continuing theme for at least the last 35 years and being based in Southampton allowed Andrew to become a keen dinghy sailor at Weston Sailing Club.

It was while at ISVR in the mid 1970's that I first met Andrew and many of the other young engineers including Frank Fahy and Bob White who have made significant contributions to the science of Noise and Vibration.

Tony stayed within the motor industry, working with Alex Moulton on suspensions. Tony eventually, in 1982, decided that he wanted to start his own company. A pressing need was soon identified as being the generation of sales and so he decided it was time to visit all his old contacts.

When Tony reached Andrew at ISVR he got a result, but not the one he was expecting, rather than getting a project from ISVR he got a partner in Andrew. Andrew's feet had started to itch again, he had decided that he had been long enough at ISVR and it was time for a change and so he asked Tony if he could join him and become a share holder and Director in the Anthony Best Dynamics Company. As always when starting a business some sacrifices had to be made and for Andrew the sale of his beloved Bentley was necessary to raise the share capital.

Tony was more than pleased to welcome Andrew as a partner and so in 1983 Andrew joined ABD and together they have built up a successful engineering company designing, developing and building specialist dynamic testing machines and software systems, including NVH for the motor industry. Initially ABD found customers for its products and services in the UK but as the design function reduced so the need to look abroad for customers became apparent. Andrew started to travel and in particular visited the USA, India and China where sales for the large scale suspension and steering machines technically known as Kinematics and Compliance machines have been successful.

The EIS was formed around 1986 with ABD becoming an early member increasingly represented by Andrew who became more and more involved when the NVH group was formed. Andrew has been supporting the NVH group's events for more than twenty years organising and often presenting papers. When Bernard Challen, the early Chairman of the NVH, stood down Andrew was the obvious and preferred choice as successor and he continued to Chair the Group until December 2008.

We wish Andrew a long and enjoyable retirement and we will always be pleased to see him at any of our meetings.

Alan Bennetts
Bay Systems Ltd

OBITUARY - DAVID COOPER

We are sad to report that David Cooper one of the founder members of the EIS died on 1 December aged 67. David was an early chairman of the Ground Vehicle Instrumentation Group and his contribution was immense. He took the idea of the GVIG from an initial dream to a highly successful reality, with single-minded determination and sheer and sustained hard work. David also gave considerable support both to the running of the successful weekend conferences held in the early days of the society and to the Instrumentation exhibition which is still an annual EIS event today.

After his retirement from GKN Technology David set up his own business, Clear Visibility, an audio visual company and many will remember his considerable input to the three Rail Conferences held jointly with British Rail in the early 1980's.

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Technical Paper

A survey study of steering wheel vibration and sound in automobiles at idle

M. Ajovalasit and J. Giacomin, School of Engineering and Design, Brunel University, Uxbridge, Middlesex, UB8 3PH, UK

1 Introduction

In city traffic automobiles typically consume 30% of their fuel while at idle (Jurden, 1995). Decreasing the engine idle speed (600-840 rpm) is considered a means of reducing fuel consumption, however, lower-speed operation degrades the idle stability and increases engine idle oscillations. Even slight fluctuations of engine idle can cause unpleasant vibration and sound emissions leading to lower customer satisfaction (Hoard and Rehagen, 1997). Further, under idle conditions, the engine can be considered to represent the major source of vibration and sound which is transmitted to the driver within the vehicle cabin. Studies of the idle comfort of passenger cars (Stout et al., 2003) report that the overall perception of vehicle idle quality is mostly correlated to the level of satisfaction a customer has with the vehicle's engine. In this respect, modern diesel engine technologies are sought which reach levels of refinement compatible with their gasoline-powered counterparts (Ivaldi *et al*. 2004), providing a more stable diesel engine combustion process due to the use of high pressure direct fuel injection.

When investigating what aspects of engine idle vibration and sound are important towards the driver's judgment of vehicle quality, consideration must be given to the role of the fuel type, the engine technology design, the engine mounting system design, and the other intermediate mechanical structures which are found between the emission source at the engine and the points of contact with the human body (Ajovalasit and Giacomin, 2005, Alt et al., 1999). Of the car/driver interfaces, the steering wheel (Pak *et al*., 1991) is the fundamental subsystem in the case of idle vibration due to the sensitivity of the skin tactile receptors of the hand (Bolanowski Jr and Gescheider, 1988) and due to the lack of intermediate structures such as shoes and clothing which can act to attenuate vibration stimuli.

The research presented in this paper describes a field survey of steering wheel vibration and interior car sound in automobiles at idle. The primary objective of the research was to quantify the magnitude of the two stimuli in terms of the most commonly used human perception metrics. The steering wheel vibration stimuli were summarised in terms of the un-weighted root-mean-square (r.m.s.) acceleration, the ISO 5349-1 W_h-weighted r.m.s. and the W_s-weighted r.m.s. (Giacomin et al. 2004). The sound stimuli were summarised in terms of the un-weighted sound pressure level in decibels, the A-weighted sound pressure level in decibels and the Zwicker loudness in sones. The secondary objective was to verify whether the steering wheel idle vibration and the sound at the ear were significantly different between diesel and gasoline powered automobiles.

2 Experimental Idle Tests

2.1 Automobile test population sample

The steering wheel vibration and interior car sound data were measured from a sample of 24 European automobiles which consisted of 12 diesel-powered automobiles and 12 gasoline-powered automobiles. All were equipped with 4-cylinder engines. The decision to focus the research on 4-cylinder engines was taken due to the popularity of this configuration. In order to introduce statistical variation into the data, the automobiles had substantially different engine characteristics. The diesel engines differed with respect to their fuel injection system which consisted of either an indirect injection (IDI) system, a direct injection (DI) system or a common rail turbocharged direct injection (CDTI) system. All gasoline powered automobiles had instead a multi-point injection system since this typology is the most popular among gasoline engines. Table 1 lists the specifications of the 24 automobiles used in this study.

2.2 Test Measurements and Operating Conditions

The steering wheel vibration and sound data were measured using a SVANTEK portable field analyser model SVAN 947. The analyser had built-in functions which allow the reading of both the sound and vibration stimuli. Besides recording the time histories, the SVAN 947 was used to determine the unweighted r.m.s., the ISO 5349-1 W_h-weighted r.m.s. for hand-arm vibration exposure and the W_s-weighted r.m.s. developed for steering wheel rotational vibration exposure (Giacomin et al. 2004). The unit was also used to determine the un-weighted sound pressure level in decibels, the A-weighted sound pressure level in decibels and the Zwicker loudness in sones. The W_h frequency weighting of the SVAN 947 is based on ISO standard 5349 -1, the acoustical A-weighting is based on IEC 60651, and the Zwicker loudness methods is based on ISO standard 532. In addition, the unit was programmed to implement a user-defined function to calculate the W_s frequency weighting for steering wheel rotational vibration following the frequency specifications and tolerances outlined by Giacomin et al. (2004). The meter conforms to the Type 1 specification for sound level meters (IEC 60651, 1979). Table 2 lists the steering wheel idle vibration and sound metrics which were measured for the 24 automobiles used in this study.

Table 1. Specifications of the 24 automobiles which were tested

Car Number	Brand and Model	Capacity (cm^3)	Engine type	Turbocharged	No. of cylinders	Power (Hp)	Registration Date (year)	Age (km)
1	Ford Escort	1800	Diesel IDI	No	4	60	2002	108800
2	Citroen C1	1400	Diesel DI	No	4	55	2006	3640
3	Seat Leon	1900	Diesel DI	No	4	105	2006	7713
4	Ford Focus	1800	Diesel DI	No	4	90	2006	70
5	Vauxhal Agila	1300	Diesel CDTI	Yes	4	70	2004	44179
6	Alfa Romeo 156	1900	Diesel CDTI	Yes	4	115	2005	12474
7	Volkswagen Golf	1900	Diesel CDTI	Yes	4	105	2006	9337
8	Ford Mondeo	2200	Diesel CDTI	Yes	4	155	2006	15790
9	Toyota Avensis	2200	Diesel CDTI	Yes	4	150	2005	32656
10	Toyota Avensis	2200	Diesel CDTI	Yes	4	150	2005	7508
11	Jaguar X-Type	2200	Diesel CDTI	Yes	4	155	2005	14250
12	Peugeot 607	2200	Diesel CDTI	Yes	4	170	2002	12450
13	Nissan Micra	1200	Gasoline MultiPoint	No	4	89	2005	17344
14	Renault Clio	1400	Gasoline MultiPoint	No	4	98	2003	14375
15	Ford Fiesta	1400	Gasoline MultiPoint	No	4	80	2006	4700
16	Renault Megan C	1600	Gasoline MultiPoint	No	4	111	2006	19250
17	Vauxhall Meriva	1600	Gasoline MultiPoint	No	4	105	2006	23845
18	Seat Leon	1600	Gasoline MultiPoint	No	4	105	2001	55504
19	Ford Focus	1800	Gasoline MultiPoint	No	4	125	2006	1640
20	Vauxhall Astra	1800	Gasoline MultiPoint	No	4	125	2006	6163
21	Vauxhall Zafira	1800	Gasoline MultiPoint	No	4	140	2006	5805
22	Alfa Romeo156	1800	Gasoline MultiPoint	No	4	144	1998	149811
23	Alfa Romeo 156	2000	Gasoline MultiPoint	No	4	165	1999	67326
24	SAAB 900	2000	Gasoline MultiPoint	Yes	4	175	1995	199411

Table 2. Steering wheel idle vibration and interior car sound metrics of the 24 automobiles which were tested

				Steering wheel idle vibration metrics			Interior car idle sound metrics		
Car Number	Brand and Model	Capacity (cm^3)	Engine type	Un-weighted rms [m/s^2]	rms (Wh) [m/s^2]	rms (Ws) [m/s^2]	SPL [dB]	SPL [dBA]	Zwicker Loudness [sones]
1	Ford Escort	1800	Diesel IDI	0.36	0.16	0.12	90.7	55.3	10.0
2	Citroen C1	1400	Diesel DI	0.16	0.10	0.05	77.8	52.2	7.8
3	Seat Leon	1900	Diesel DI	0.11	0.05	0.02	73.4	47.5	6.0
4	Ford Focus	1800	Diesel DI	0.21	0.12	0.05	83.6	54.3	10.3
5	Vauxhal Agila	1300	Diesel CDTI	0.37	0.24	0.10	83.4	49.4	6.6
6	Alfa Romeo 156	1900	Diesel CDTI	0.97	0.55	0.20	91.7	54.2	9.1
7	Volkswagen Golf	1900	Diesel CDTI	0.11	0.05	0.02	81.5	50.7	6.7
8	Ford Mondeo	2200	Diesel CDTI	0.17	0.05	0.03	85.2	50.2	6.7
9	Toyota Avensis	2200	Diesel CDTI	0.85	0.52	0.21	85.4	45.5	4.3
10	Toyota Avensis	2200	Diesel CDTI	0.37	0.22	0.09	91.2	48.6	5.2
11	Jaguar X-Type	2200	Diesel CDTI	0.45	0.26	0.11	81.7	47.5	5.5
12	Peugeot 607	2200	Diesel CDTI	0.36	0.22	0.09	87.5	51.3	8.6
13	Nissan Micra	1200	Gasoline MultiPoint	0.08	0.04	0.03	70.6	41.4	3.6
14	Renault Clio	1400	Gasoline MultiPoint	0.07	0.03	0.02	73.4	40.3	3.3
15	Ford Fiesta	1400	Gasoline MultiPoint	0.13	0.08	0.03	68.5	44.5	4.4
16	Renault Megan C	1600	Gasoline MultiPoint	0.09	0.04	0.03	79.4	41.9	3.6
17	Vauxhall Meriva	1600	Gasoline MultiPoint	0.07	0.05	0.02	69.0	39.8	3.1
18	Seat Leon	1600	Gasoline MultiPoint	0.10	0.06	0.03	71.1	43.5	3.7
19	Ford Focus	1800	Gasoline MultiPoint	0.11	0.06	0.02	80.5	39.1	2.8
20	Vauxhall Astra	1800	Gasoline MultiPoint	0.36	0.22	0.09	72.0	44.6	4.0
21	Vauxhall Zafira	1800	Gasoline MultiPoint	0.18	0.10	0.04	75.9	43.2	3.5
22	Alfa Romeo156	1800	Gasoline MultiPoint	0.79	0.42	0.18	81.8	46.8	5.0
23	Alfa Romeo 156	2000	Gasoline MultiPoint	0.69	0.36	0.14	75.8	42.8	3.8
24	SAAB 900	2000	Gasoline MultiPoint	0.27	0.16	0.06	80.1	48	5.4

A laptop PC was used to store the time histories of both stimuli for post-processing analysis. Both the analyser and laptop were run using a DC battery to eliminate electronic noise from vehicle systems. The sampling frequency of the SVAN 947 unit was 48 kHz. The recorded signals were post-processed in the laboratory by means of a LMS CADA-X 3.5BE software.

The vibration measurements consisted of acceleration data which were recorded at the steering wheel. The measurement point was taken on the surface of the steering wheel at the clockwise 60° position with respect to top centre. This location coincides about with the two o'clock hand grip position which drivers typically assume when holding an automotive steering wheel (Giacomin and Gnanasekaran, 2005). The direction of measurement for the steering wheel acceleration was taken tangential to the wheel. A single accelerometer was mounted rigidly to the steering wheel by means of a mounting clamp which guaranteed adequate coupling stiffness to frequencies in excess of 300 Hz. While the single accelerometer did not differentiate the rotational and the translational components of the steering acceleration, the approximation was made in the current study to associate the acceleration time history with the wheel rotational axis. Though non-negligible, the error implicit in this choice was considered acceptable for purposes of relative comparison.

The sound measurements consisted of sound pressure levels which were measured at the driver's ear at the centreline of the vehicle cabin. In order to obtain accurate and comparable sound measurements across different automobiles, the direction of measurement and the microphone position were taken in accordance with the guidelines of the British Standard BS 6086 (1981) which define the method of measurement of noise inside motor vehicles. The microphone position was taken with respect to the driver's seat which was occupied by the experimenter during the tests. The vertical co-ordinate of the microphone was at 0.7 ± 0.05 m above the intersection of the seat surface and the surface of the back of the seat. The horizontal co-ordinate was taken at 0.2 ± 0.02 m to the left of the vehicle from the middle plane of the seat. The microphone was mounted by means of a tripod which was secured to the unoccupied passenger seat. The microphone was oriented horizontally, pointing towards the windscreen.

In order to stabilise engine temperature and injection conditions, each automobile was left to idle for approximately 10 minutes before any recordings. After the 10 minute warm-up, the steering wheel vibration and sound were acquired for a duration of 1 minute for each idle condition. The test site was chosen to be in an open car park within the campus of Brunel University. An open space was chosen such that the sound inside the automobile cabin did not contain energy from reflections with surrounding buildings and structures. The distance of the automobiles from the nearest large buildings exceeded 20 m. In order to provide accurate sound measurements the level of background noise was measured in each test condition. With the engine off, the environmental background noise level measured outside the automobile was 60 dB on average, and 54 dB when measured inside the automobile cabin, including the inherent noise of the measuring equipment. With the engine idling the interior car sound was found to be 72 dB. Following British Standard BS 6086 (1981) which specifies a limit difference value of 10 dB between the sound pressure level of the interior car sound and that of the background noise, in this survey any automobile which achieved less than 10 dB was not included in the analysis. The vibration and sound signals were measured for each automobile in the following test conditions:

- automobile stationary with the engine idling;
- transmission in neutral gear;
- same experimenter sitting at the driver's seat during the test
- no human subject holding the steering wheel;
- approximately 20 ºC environmental temperature and 40% humidity.

3 Results

Figure 1 presents the steering wheel rotational idle vibration time histories and frequency spectra for two representative diesel-powered automobiles. Figures 1a and 1b present the data measured for car 4 which is a diesel-powered automobile equipped with a direct injection system (DI) and mechanical rotary fuel pump, while Figures 1c and 1d present the data for car 9 which is a diesel-powered automobile equipped with a common rail turbocharged direct injection system (CDTI). As can be seen, the steering wheel idle vibration occurring in diesel-powered automobiles is characterised by low-frequency components with significant vibrational energy occurring between 5 and 80 Hz. The harmonic components occur at multiples or sub-multiples of the engine rotational frequency H_1 (10-14Hz). The second-order engine harmonic H_2 (20-28 Hz), which for a 4-cylider engine corresponds to the firing frequency of consecutive cylinders, was found to account for most of the energy of the steering wheel. Further, it can be seen that large amplitude modulation sidebands occur at frequencies above and below the second-order engine harmonic H_2, separated from the harmonic H_2 by the half-order engine harmonic $H_{1/2}$ (5-7 Hz). The data of Figure 1 suggest that the steering wheel idle waveform of the common rail CDTI technology is characterised by less amplitude modulation of the second-order engine harmonic H_2 than in the case of the indirect injection DI.

Figure 2 presents the steering wheel rotational idle vibration time histories and frequency spectra for two representative

gasoline-powered automobiles. Figures 2a and 2b present the data measured for car 13 while Figures 2c and 2d present the data for car 17. As can be seen from Figure 2, the steering wheel idle vibration occurring in gasoline powered automobiles is also characterised by low-frequency harmonics occurring between 5 and 80 Hz, with the second-order engine harmonic accounting for most of the spectral energy. The presence of modulation sidebands was found to be a characteristic of the steering wheel vibration signature also in the case of the gasoline powered automobiles.

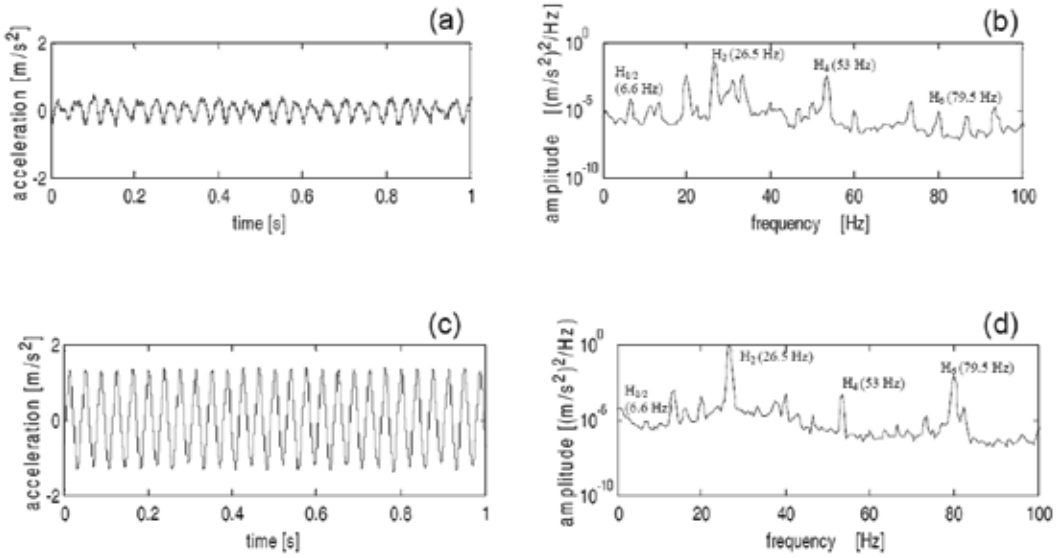

Figure 1. Steering wheel idle acceleration time histories and power spectral densities for two representative diesel-powered automobiles:
(a) and (b) car 4 - Ford Focus 1.8 L Diesel DI.
(c) and (d) car 9 - Toyota Avensis 2.2 L Diesel CDTI

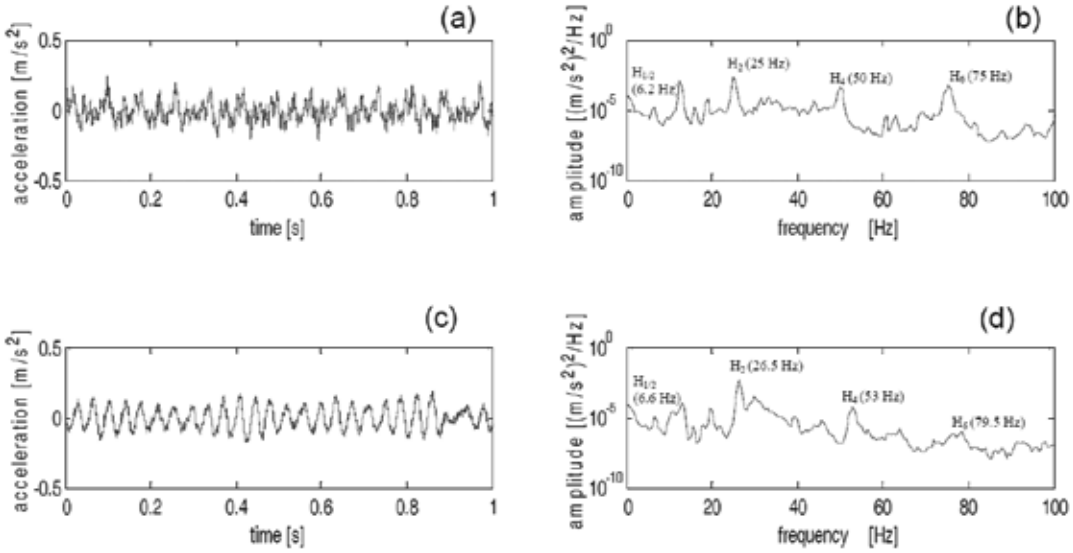

Figure 2. Steering wheel idle acceleration time histories and power spectral densities for two representative gasoline-powered automobiles:
(a) and (b) car 13 - Nissan Micra 1.6 L Gasoline Multi point injection
(c) and (d) car 17 - Vauxall Meriva 1.6 L Gasoline Multi point injection

Figure 3 presents the mean unweighted, the mean W_h-weighted and the mean W_s-weighted r.m.s acceleration amplitudes which were determined across the group of twelve automobiles from each of the two engine technologies reported in Table 2. The steering wheel idle vibration magnitude for the diesel-powered automobiles (0.44 m/s^2 r.m.s.) was found to be higher than for the gasoline-powered automobiles (0.24 m/s^2 r.m.s.), however, the differences were not found to be statistically significant at a 5% significance level when evaluated by means of a single factor ANOVA test (Hinton, 1999) for each of the three vibration magnitude metrics.

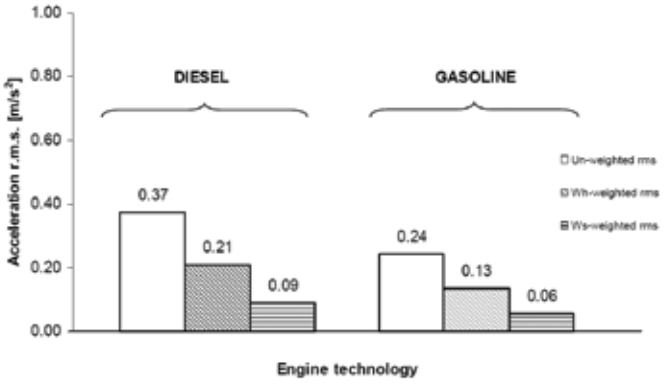

Figure 3. Mean idle steering wheel acceleration r.m.s. values determined for the group of twelve diesel-powered and the group of twelve gasoline-powered automobiles

Figure 4 presents the idle sound pressure data for two representative diesel-powered automobiles. Figures 4a and 4b present the data for car 4 while Figures 4c and 4d present the data for car 9. As can be seen, the diesel idle sound is characterised by significant spectral energy at the second-order engine harmonic. Figure 5 presents the idle sound pressure data for two representative gasoline-powered automobiles. Figures 5a and 5b present the data for car 13 while Figures 5c and 5d present the data for car 17. Gasoline idle sound was also characterised by the second-order engine harmonic and by multiple and sub-multiple harmonic components. From Figures 4 and 5 it can be seen that for both the diesel and the gasoline-powered automobiles the interior car sound was characterised by engine order harmonics and modulation sidebands of the second-order engine harmonic H_2 with significant sound energy occurring mostly in the frequency range from about 10 to 80 Hz, depending on the engine rotational frequency.

Table 3 presents the mean un-weighted SPL in decibels, the mean A-weighted SPL in decibels and the mean Zwicker loudness in sones, which were determined across the group of twelve automobiles from each of the two engine technologies. The mean idle sound magnitude for the group of the diesel-powered automobiles (84.4 dB) was found to be higher than for the gasoline-powered automobiles (74.85 dB). The difference was found to be statistically significant at a 1% significance level when evaluated by means of a single factor ANOVA test for each of the three sound magnitude metrics.

Table 3. Mean idle sound magnitude metrics determined for the group of twelve diesel-powered and the group of twelve gasoline-powered automobiles

Engine technology	Sound pressure level [dB]	A-weighted sound pressure level [dBA]	Zwicker loudness [sone]
Diesel	84.4	50.6	7.2
Gasoline	74.9	43.0	3.9

Figures 6 and 7 present plots of sound magnitude metrics versus vibration magnitude metrics for all 24 automobiles listed in Table 2. Figure 6 presents the diagram of the un-weighted sound pressure level in decibels as a function of un-weighted r.m.s. acceleration amplitudes, while Figure 7 presents the diagram of the Zwicker loudness in sones as a function of the W_s-weighted r.m.s acceleration amplitudes. In both Figures the mean values determined across the set of the diesel and the gasoline powered automobiles are also presented as a group centroid. While the number of automobiles tested is not sufficient for a rigorous statistical analysis for each subgroup of engine injection system, the data distribution does suggest that the interior sound pressure level and loudness is non-monotonically related to the vibration level at the steering wheel. Further the data points also suggest the possibility that for diesel-powered automobiles the steering wheel vibration depends greatly on the type of engine injection system. For example, the data of Figure 6 suggests that lower steering wheel acceleration amplitudes were measured for the diesel-powered automobiles which were equipped with direct injection (DI) than for the common rail (CDTI) or the indirect injection (IDI) systems. Further, the data of both Figures suggest the possibility that for the gasoline-powered automobiles the steering wheel vibration depends greatly, instead, on the vehicle model, meaning the mechanical characteristics of the vehicle structures. For example the data of Table 2 and Figure 6 suggest that the highest steering wheel acceleration amplitudes were obtained in the case of the gasoline-powered automobiles for cars 22 and 23, which are both Alfa Romeo 156 models, and in the case of the diesel-powered automobiles for car 6 which is also an Alfa Romeo 156 model. The data from the current study suggest thus the possibility that the design of the steering system and chassis is highly influential towards determining the

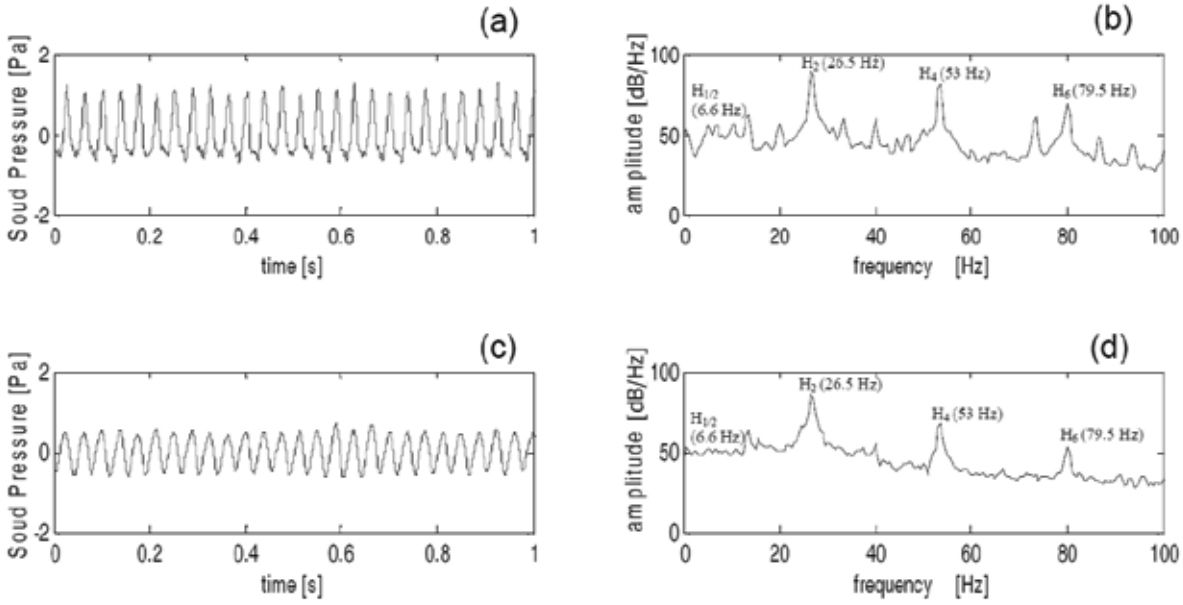

Figure 4. Interior idle sound pressure time histories and power spectral densities for two representative diesel-powered automobiles
(a) and (b) car 4 - Ford Focus 1.8 L Diesel DI.
(c) and (d) car 9 - Toyota Avensis 2.2 L Diesel CDTI

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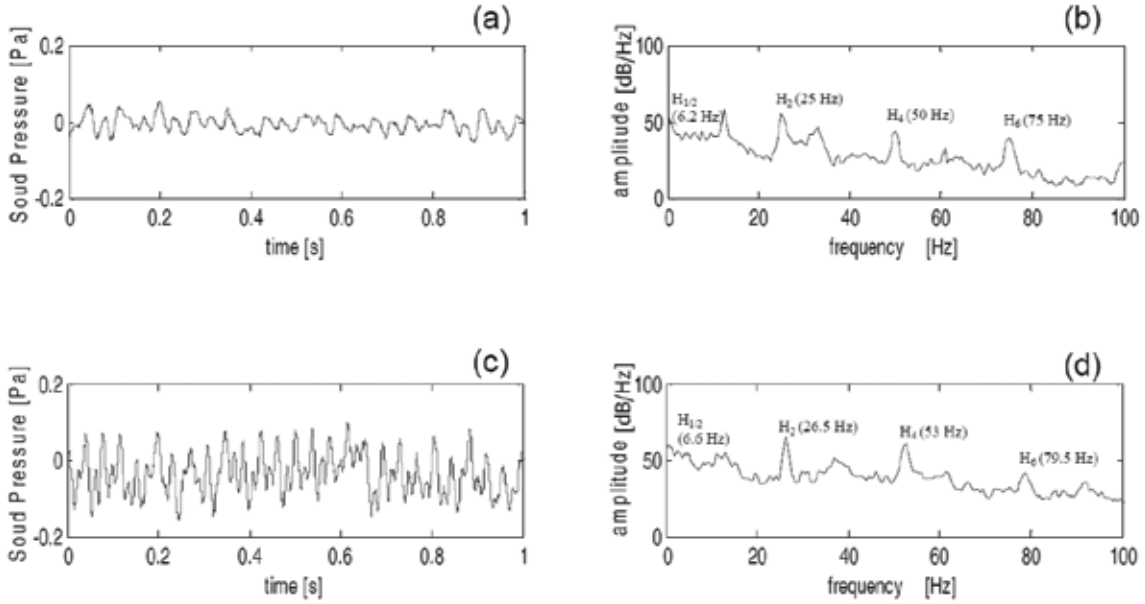

Figure 5. Interior idle sound pressure time histories and power spectral densities for two representative gasoline-powered automobiles:
(a) and (b) car 13 - Nissan Micra 1.6 L Gasoline Multi point injection
(c) and (d) car 17 - Vauxall Meriva 1.6 L Gasoline Multi point injection

vibration content at the steering wheel, as much so as the design of the engine injection system.

Figures 6 and 7 also suggest that, on average, the diesel-powered automobiles were characterised by higher steering wheel vibration magnitudes than the gasoline-powered automobiles. However, the difference between the two engine technologies was not found to be significant by means of an ANOVA test at a 5% significance level. Figures 6 and 7 also suggest that, on average, the diesel-powered automobiles were characterised by significantly higher sound magnitude values than the gasoline-powered automobiles as confirmed by an ANOVA test at a 1% significance level.

The results of the current study also suggest that the choice of the statistical metric used to represent human perception has important implications towards the findings. For example, the data of Table 2 and Figure 7 suggest that when the steering wheel vibration is expressed in terms of the W_s-weighted r.m.s. acceleration rather than un-weighted r.m.s. acceleration, the difference between cars was either greatly reduced, as in the case of the vibration difference between the gasoline-powered car 22 and the common rail direct injection (CDTI) diesel-powered car 6, or greatly increased, as in the case between the indirect injection (IDI) system diesel-powered car 1 and the common rail direct injection (CDTI) diesel-powered car 10, or even reversed in sign, as in the case between the common rail direct injection (CDTI) diesel-powered car 6 and car 9. A possible explanation of the differences is the large amount of vibrational energy found in the spectrum of each automobile condition at frequencies below about 8 Hz, where the W_s frequency weighting attenuates less.

Moreover, the data of Table 2 and Figure 7 also suggest that when the idle sound is measured in terms of the Zwicker loudness metric, the difference in sound magnitude between cars is greatly reduced. The data of Figure 6 suggests that a difference of about 10 dB, which is greater than the well-known just-noticeable difference value of approximately 1 dB (Zwicker and Fastl, 1990), occurs among the gasoline-powered cars 13 to 18. However, when the sound is quantified using the more sophisticated Zwicker loudness method, as shown in Figure 7, a difference of less than the just-noticeable difference value of approximately 0.5 sone for loudness detection (Jeon et al., 2006) was obtained for the same cars.

Further laboratory tests of human subjective response to steering wheel vibration and sound stimuli are required in order to establish which human perception metric correlates best with the subjective judgments of sound and vibration. Nevertheless, psychoacoustical research provides evidence that the use of the popular acoustical A-weighting underestimates the loudness of perceived sound due to its inability to represent the nonlinear response characteristics of the human ear (Quinlan, 1994). Automotive research (Auken and Zellner, 1998) has also suggested that Zwicker loudness correlates best with the subjective evaluations of automobile interior sound due to its ability to correctly represent frequency and temporal auditory masking. The results of the current study suggest that when comparing the Zwicker loudness values with the A-weighted SPL values calculated for each of the 24 automobiles, presented in Figure 8, the two acoustical metrics are highly linearly related (R^2=0.92). However, the vertical distances of the data points from the regression line appear to be more than the just-noticeable difference value of approximately 0.5 sone for loudness. The result suggests thus that the more sophisticated Zwicker loudness in sones would not be directly derived from the A-weighted SPL despite the high degree of linear correlation found in this study between the two sound metrics.

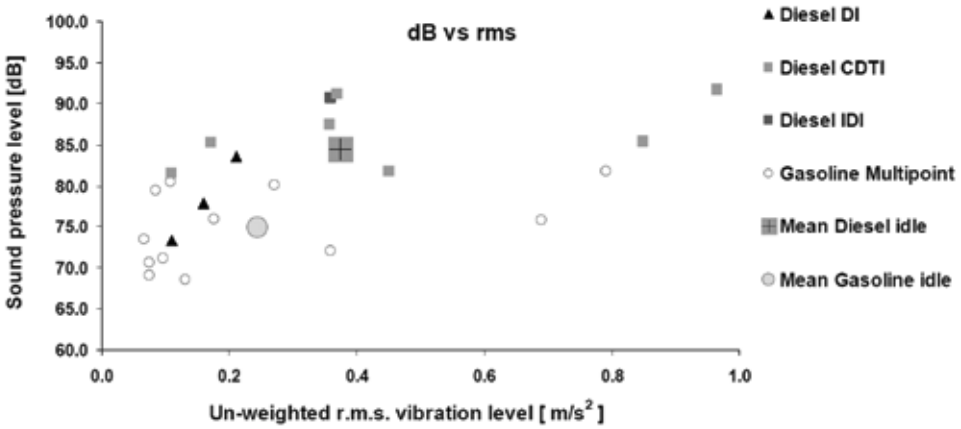

Figure 6. Plot of un-weighted sound pressure level in decibels versus un-weighted steering wheel r.m.s. acceleration for the 24 automobiles

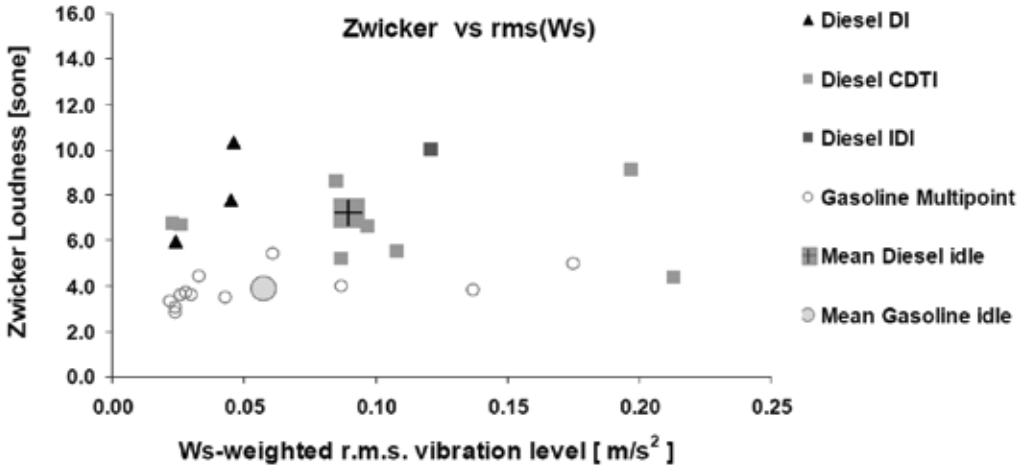

Figure 7. Plot of Zwicker loudness in sones versus the W_s-weighted steering wheel r.m.s. acceleration for the 24 automobiles

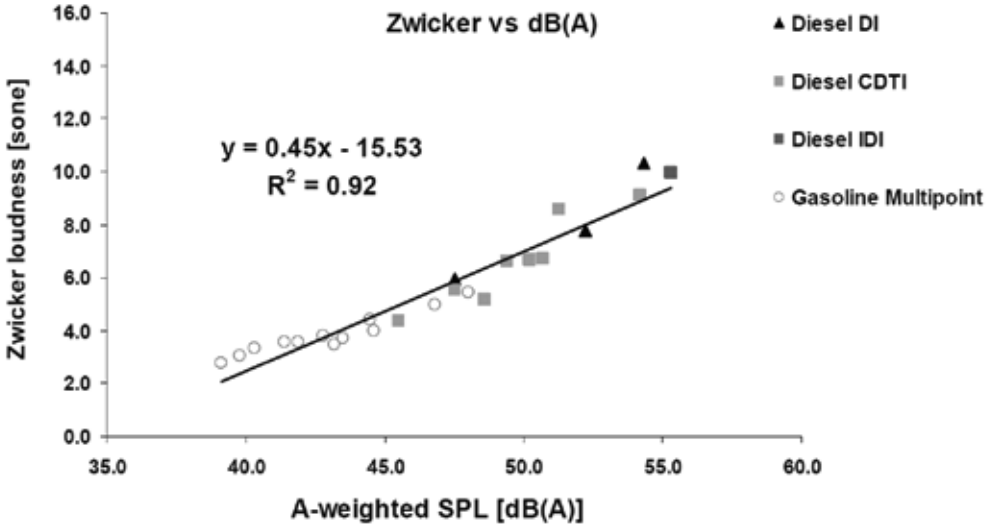

Figure 8. Plot of Zwicker loudness in sones as a function of the A-weighted sound pressure level in decibels for the 24 automobiles

4 Conclusions

Steering wheel idle vibration and sound were measured in field tests of 12 diesel-powered automobiles and 12 gasoline-powered automobiles. The steering wheel acceleration time histories were analysed in terms of the un-weighted r.m.s., the W_h-weighted r.m.s. and the W_s-weighted r.m.s. The sound pressure time histories were analysed in terms of the un-weighted sound pressure level in decibels, the A-weighted sound pressure level in decibels and the Zwicker loudness in sones. Both the steering wheel idle vibration and sound were found to be characterised by low-frequency harmonic components in the range from 6 to 40 Hz. The difference in steering wheel idle vibration magnitude between the diesel-powered automobiles and the gasoline-powered automobiles was not found to be statistically significant at a 5% confidence level. The difference in idle sound magnitude between the diesel-powered automobiles and the gasoline-powered automobiles was instead found to be statistically significant at a 1% confidence level. The results of the current study support the hypothesis that the design of the steering system and chassis is highly influential towards determining the vibration content at the steering wheel and the hypothesis

that the sound at the human ear is highly dependent on the design of the engine combustion system.

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Technical paper

Russian market road load data collection exercise to identify the potential customer usage envelope compared to the engineering durability standard

Stephen Cook, Andrew Giles, Richard Winder, Jaguar Land Rover Product Development, Gaydon, UK.

Abstract

To enable a durability customer correlation exercise between existing manufacturer sign off procedure and the Russian market, a Land Rover vehicle was instrumented to measure various suspension loads. As this data was to be collected on public roads, wheel force transducers could not be used. Therefore various vehicle components were strain gauged and calibrated for load, such as ball joints, dampers and major suspension components. This vehicle then collected data from the JLR (Jaguar Land Rover) Global structural sign off, and from the Russian environment. The Russian environment collection included a cross section of Motorway, "A" class road, "B" class road and city driving.

A comparative analysis using fatigue damage analysis based on "rainflow" cycle counting, mean correction and Miners' rule reduction was then carried out. This compared the JLR worldwide structural sign off test for 4X4's with 240,000km of the Russian environment for a severe and extreme customer. The analysis was based on both fatigue damage and a peak load analysis. The severe and extreme customer profiles used were sanctioned by the JLR Russian after sales team and the JLR Vehicle Capability and Robustness (VCR) department with a combination of warranty data and the customer / dealer relationship used to target regions that resulted in vehicle issues.

For each of the components measured, the fatigue damage ratio between the JLR Global Structural sign off test and the Russian market data was calculated. This analysis was split into lateral, longitudinal and vertical loading inputs with the results plotted on bar charts. The JLR Global structural sign off tests for customer vehicles driven in this market was found to be adequate for a customer in this environment.

Introduction

Protecting the customer against strength and endurance failures of automotive components is a largely unnoticed, but extremely important area of automotive engineering. Vehicle durability testing ensures the vehicle remains fit for purpose throughout its life, and that safety related failures do not occur. The level to which this testing takes place is governed by a combination of sound historical knowledge of the market place, customer correlation activities and component fatigue correlation, guaranteeing the market environment envelope is exceeded for the vast majority of customers.

A new challenge for automotive manufacturers is born from the rapid economic growth in the BRIC (Brazil, Russia, India, China) markets. This has meant that the demand for vehicles, including premium products, is rapidly expanding. However this is also a market place where historical durability data is incomplete. This is necessitating customer correlation between these markets and existing manufacturer testing.

Customer correlation can be carried out in many different ways, for example, customer surveys or warranty information. However these methods can take a considerable time to gather and to interpret the data, in which time the customer may not be protected in their home market. This is bad for the customer, whose vehicle could suffer premature failure, and bad for the manufacturer, whose image would be tarnished and whose warranty costs would increase.

The following piece of work highlights a methodology to rapidly evaluate an emerging market place, in this case Russia. It explores the limitations of collecting such information on public roads and continues with an explanation of the fatigue damage calculations used to correlate the data into useful comparative information. This evaluates whether the manufacturer tests are adequate for the market, or if alterations are required.

Methodology

In order to access the structural integrity of JLR vehicles in the Russian market environment a Land Rover 4X4 vehicle was instrumented to measure a range of parameters as shown in table 1.

The loads were measured by fitting strain gauges to actual vehicle components and the selection of parameters was made to cover the three orthogonal directions of loading (Longitudinal, Lateral & Vertical) with a mixture of parameters covering each direction. The parameters "sensitive" to each of the loading directions is shown more clearly in table 2.

It is commonplace within the engineering data collections to use wheel force transducers to give load time histories at the wheel centre. While these provide truly orthogonal axes which are characteristic to the inputs into the vehicle they can only be used on proving grounds. This is because they protrude from the vehicle and provide an unsafe condition for pedestrians and other road users. Furthermore they can be insensitive to the dynamic full bump and full rebound excursions, which in this vehicle design are located within

Table 1

Parameter No.	Description
1	Lefthand Front Damper Piston Rod Force
2	Righthand Front Damper Piston Rod Force
3	Lefthand Rear Damper Piston Rod Force
4	Righthand Rear Damper Piston Rod Force
5	Lefthand Front Ball Joint Longitudinal Force
6	Righthand Front Ball Joint Longitudinal Force
7	Lefthand Front Ball Joint Lateral Force
8	Righthand Front Ball Joint Lateral Force
9	Lefthand Rear Trailing Link Force
10	Righthand Rear Trailing Link Force
11	Lefthand Rear Lateral Link Force
12	Righthand Rear Lateral Link Force
13	Lefthand Rear Second Lateral Link Force
14	Righthand Rear Second Lateral Link Force
15	Lefthand Front Stabiliser Link Force
16	Righthand Front Stabiliser Link Force
17	Lefthand Rear Stabiliser Link Force
18	Righthand Rear Stabiliser Link Force
19	Lefthand Front Track Rod Axial Force
20	Righthand Front Track Rod Axial Force
28	Lefthand Front Spring Vertical Force
29	Righthand Front Spring Vertical Force
30	Lefthand Rear Spring Vertical Force
31	Righthand Rear Spring Vertical Force

the spring-damper module and thus vital for understanding the performance of these components and those in the same load path such as the vehicle body. It was expected that issues around full bump and rebound may be found within the Russian market and, even if wheel force transducers had been usable, inboard load channels would still have been used in the vertical load path to ensure these forces were captured directly.

To validate the parameters used for their relationship to the directions of loading specified (and only those) of the vehicle, they were compared to the wheel force transducer load. A 200 second combined brake, acceleration, cornering and

Table 2

Parameter No	Load Measured
1 to 4 and 28 to 31	Vertical load, vertical rebound load
5,6,9,10	Longitudinal load, braking load
7,8 and 11 to 14	Lateral load, cornering load
15 to 18	Vertical anti-phase load, cornering load
19,20	Steering load

bump collection was carried out on a vehicle with both wheel force transducers and the internal load sensors. The internal load sensors were then plotted against the wheel force loads to check for direct relationships. This was done as a single time series such that each parameter would show up influences from all types of event and hence enable the team to ensure that each sensor only measured one axis of loading. Some examples of this are shown opposite which demonstrates that the sensor locations chosen were only sensitive to single directions of loading in a direct relationship.

The vehicle then collected time history data from the appropriate JLR sign off tests and also from the Russian environment using HBM MGC+ data acquisition equipment. Collecting time history data meant that additional part related warranty correlation work could be completed. The Russian collection was taken over a thousand kilometres of road which included a selection of Motorways, “A” class roads, “B” class roads (which includes roads with and without asphalt surfaces) and city routes which were then scaled to replicate 240,000km of a “severe” and “extreme” Russian user based on the ratio’s shown in table 3 below:-

Table 3

Road Type	Severe Customer (km)	Extreme Customer (km)
Motorway	48,000	24,000
“A” Class Road	36,000	36,000
“B” Class Road	12,000	36,000
City Roads	144,000	144,000
Total	240,000	240,000

These ratios were approved as representative by the JLR Russian after sales team and the JLR Vehicle Capability and Robustness (VCR) department. It should be noted however that these represent the harsher (higher percentile) users with the majority of users falling below these levels. The “severe” and “extreme” differentiation is a function of the distance the customer drives on the different roads. Both contain the same types of road but the extreme customer is biased towards the less well maintained and

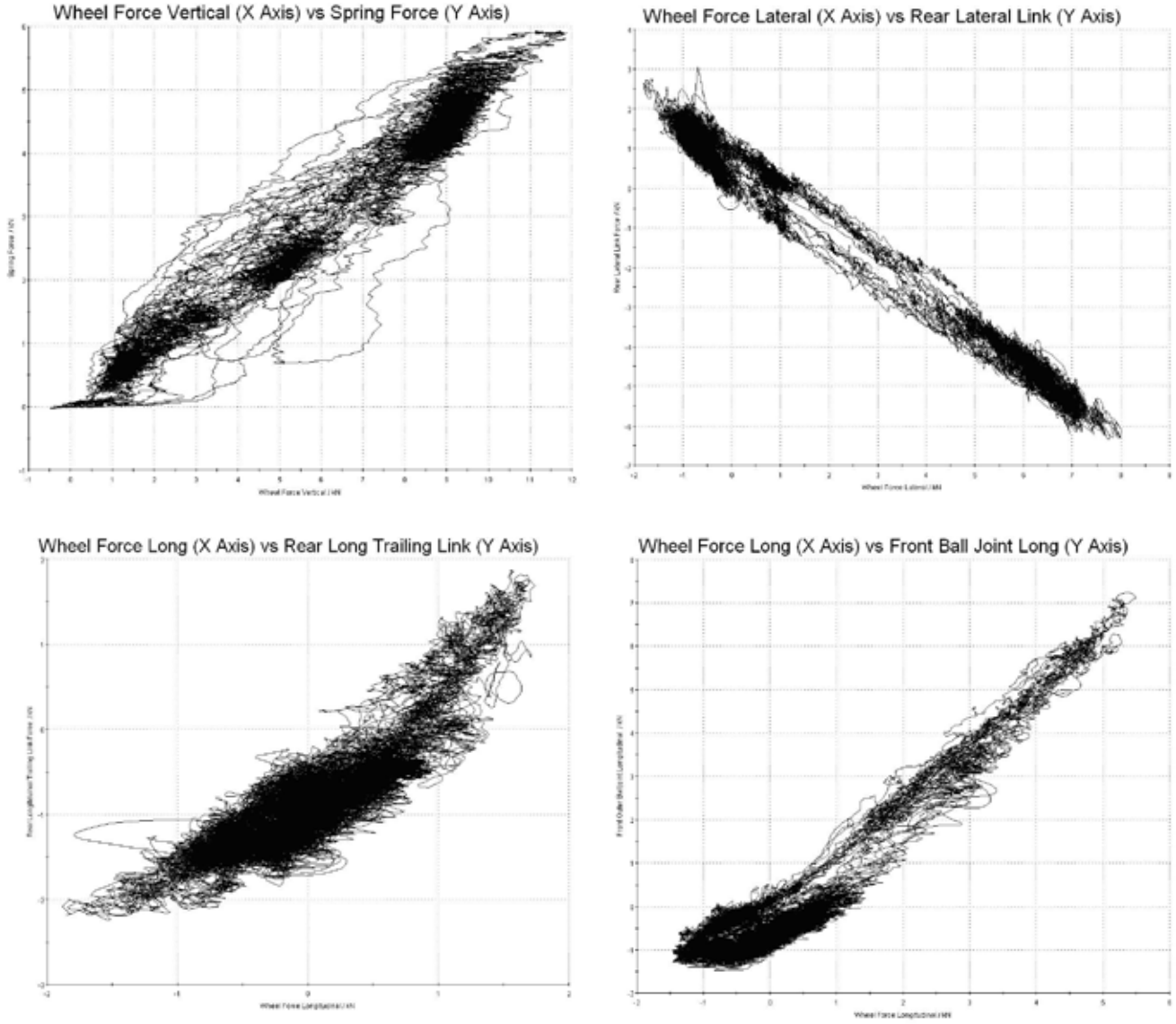

Figure 1

rougher “B” class roads in lieu of motorways. The “B” classification of roads also includes un-surfaced tracks which may be termed “off road”.

The statistical basis for the exercise was to utilise warranty data to encompass the entire population, and that this information, by its nature, results in a targeted data collection of extreme customers. This captures more appropriately the population outliers of a niche product. Using the customer / local dealer relationship, targeted roads were driven in an appropriate manner and vehicle loading using local drivers. This has the advantage that large quantities of road load data from many vehicles did not need to be collected. Although this did not give the population, it did indicate the extreme user. It should be noted that possible errors can come from inaccurate information from dealers or a misunderstanding between customer and dealer.

Typical road conditions are shown in the photographs over the page.

Analysis Procedure

The data collected was integrity checked for any spurious spikes or other anomalies and corrected as necessary. It was then filtered to remove any static offset and drift corrected where required to leave a dynamic signal which could be compared between data sets.

The cycles contained within the data sets were then classified into their appropriate range and mean using the “rainflow” and Miner’s Rule technique (described in detail below). This was then used as an input to a comparative damage analysis which reduced the fatigue damage in each data set, to an equivalent number of constant amplitude

Figure 2. Typical Motorway

Figure 3. Typical "A" Class Road

Figure 4. Typical "B" Class Road

Figure 5. Typical City Road (Moscow)

cycles based on a constant fatigue slope (K) value. Once each data set had been reduced to its damage equivalent it could then be multiplied by the appropriate factor to give the damage contained in the equivalent mileage shown in table 2. Thus the total fatigue damage contained in the Russian environment and the Land Rover Structural sign off test could be assessed by means of a ratio of the content of one to the content of the other.

Analytical Techniques Employed

The core comparison of the two signals, the sign-off test and the market, uses a range-mean "rainflow" analysis to generate a matrix of the cyclic content of the data. A set of data bins is created, with *N* bins in amplitude and *M* in mean. The load time history is then processed using MTS Corporation's RPC3 "Rainflow" tool to extract the cycles and then place them into one of the bins. For any given bin, where *n* and *m* are any number from 0 to *N* and *M* respectively, of the matrix there is a number of cycles $C_{n,m}$ and obviously its amplitude $A_{n,m}$ and mean $M_{n,m}$ are known.

Each cell in this matrix is reduced in mean using a technique developed from several sources [1], [2], to a zero mean equivalent, $A0_{n,m}$ using equation 1 as shown;

$$A0_{n,m} = \sqrt{A_{n,m}{}^2 + A_{n,m} \times M_{n,m}} \quad (1)$$

Finally a Miner's rule summation using an appropriate slope (*k*) is used to equate this to a single amplitude load. If the single amplitude test load is *TL* then the number of cycles *CTL* which are equivalent to the cycles contained with matrix element *(n,m)* is calculated using equation 2;

$$CTL_{n,m} = C_{n,m} \times \left(\frac{ATL}{A0_{n,m}} \right)^k \quad (2)$$

Figure 6. Typical City Road (Outside Moscow)

The total content of the signal can be expressed as a number of cycles C_{tot} at the test load TL which is the summation of the individual elements cycles as shown in equation 3;

$$C_{tot} = \sum_{n=0}^{N} \sum_{m=o}^{M} CTL_{n,m} \quad (3)$$

This technique has been used for a number of years in Land Rover and has shown good correlation with physical testing. The Test Load amplitudes chosen will be those of the design load cases which will allow a direct comparison of the content of these to the whole vehicle durability tests at the differing customer duty requirements. The chosen test load can be set on a mean if required and this corrected back using the same mathematics used in equations one to three to give a zero mean comparator as required.

The choice of slope *k* depends upon the analysis being used. Typical values of this inverse miner's rule slope are 5 for base steels and 3.5 for welded parts. Specific values of measured materials can be used if they are known to be relevant for a sizeable portion of the structure. A useful guide as to whether the approximations used in this method are appropriate is that the test load should be in the region of the majority of the cycles being reduced. In the case of giving a view of the market using a single car we have not used exact values for the *k* factors as these will obviously be different for different vehicles as each uses a different set of materials.

As this is a mathematical method wholly negative values cannot be calculated; cycles whose negative mean is greater than their amplitude. In the actual data collection sign and zero point are merely a function of where the transducer set up is performed. This is different to the genuine tensile and compressive load which is the true application of the Miner's rule summation. For this reason the analysis is run in positive and negative direction of the measured data. For many of the transducers there is a more significant direction of loading, and as such the ratios chosen, if there is a significant difference, can be aligned to that direction. For instance, at the front the longitudinal load backwards in the vehicle is much higher than that forward in the car. The ratio therefore of the two rearward loads (market loads divided by engineering standard) is much more significant than the ratio of the forward loads, it being calculated from dividing a small number by another small number which can give misleading results.

Results

The results from the above damage analysis are contained in Figure 7.

Discussion of Results

The Land Rover Engineering Structural Test includes a wide spectrum of surfaces. High quality asphalt is used for limit cornering and braking and the content extends through to rough asphalt, graded stone, un-graded stone and more severe off road type surfaces. The structure and suspension of the vehicles is not market specific and neither is the Engineering Standard. The mass of the vehicle is also varied during this procedure to ensure that all types of suspension loading are generated, e.g. bump interaction at high payload and rebound stop interaction at low payload. The Engineering Standard has been developed to encompass the structural requirements of our traditional markets and their customer base.

The result plots confirm that for lateral loads the Land Rover Global Engineering Structural Test for 4X4's exceeds the Russian severe and extreme customer by a significant margin. This damage ratio varies from less than 0.1 on the front ball joints (i.e 10% of the damage contained in the sign off test) to a maximum of 0.4 on the rear lateral links. Values such as these indicate that the Russian market does not contain a significant handling input compared with the Structural Engineering Test and hence we are comparing fundamentally different data sets. This is confirmed by the steering track rod and stabiliser link loads which all display a high safety margin confirming that the Russian market has little cornering input. Therefore from a lateral perspective the Structural Engineering Test provides a robust structural sign off in terms of fatigue damage. For longitudinal inputs the situation is similar with Engineering Test Requirement adequately covering the fatigue damage produced by a severe and extreme Russian customer with a damage ratio of 0.3 - 0.4 for SUVs. As in the lateral case, the peak loads are adequately covered and so again Engineering Test Requirement gives a robust sign off.

In the vertical case the sign off from Engineering Test

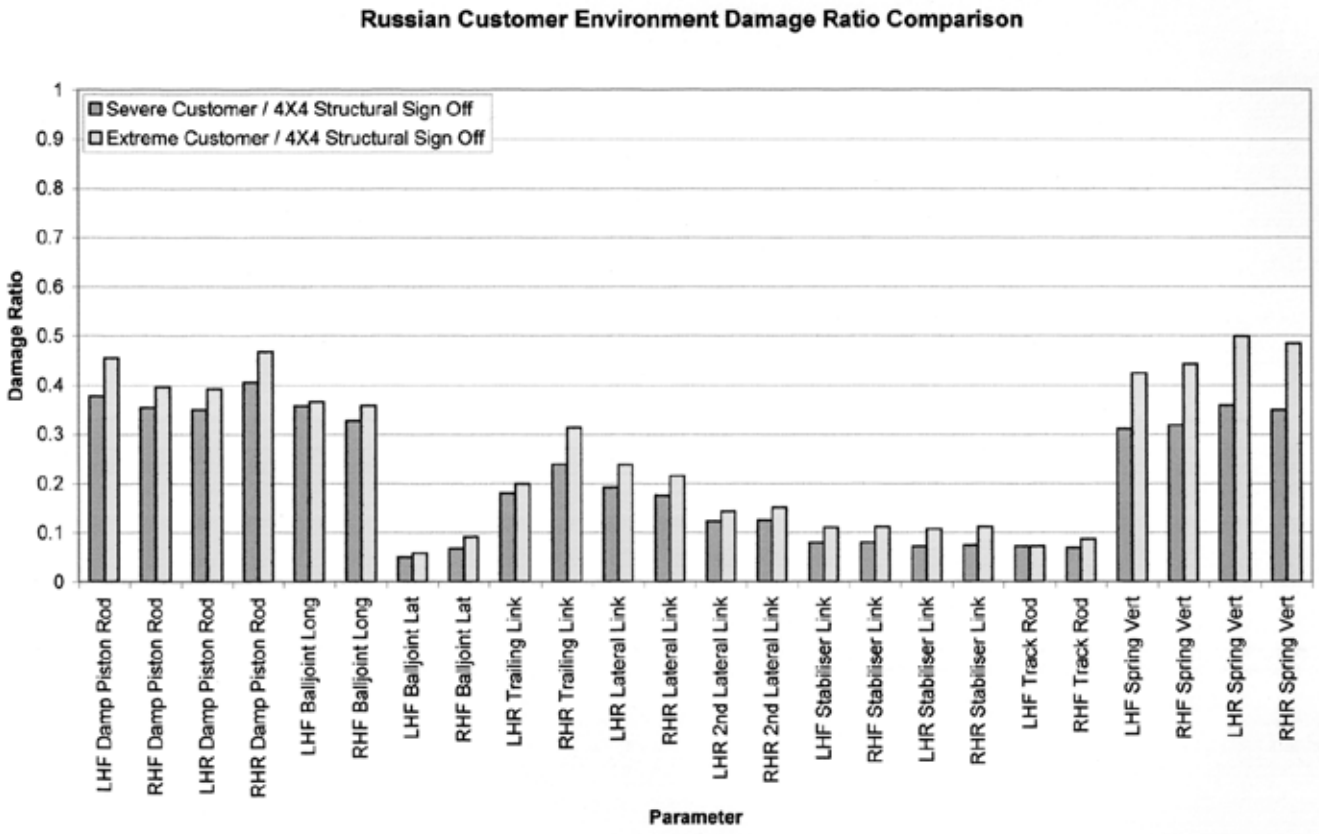

Figure 7

Requirement is closer to the market demand. For the SUV measured, the fatigue damage produced for the damper rebound and road springs is covered by the Engineering Test Requirement. It should be remembered that the market collections were only based upon road driving and do not include un-metalled road mileages which are common in other markets. Land Rover expects to be engineering to cover for the extreme customer in market, though obviously each market is not necessarily worst case for all inputs. The Russian market is predominately severe in the vertical which is also why it is not conducive to high cornering loads.

An important factor in understanding the proving ground vs. real world comparison of data is the appropriate choice of sign off test. Jaguar Land Rover has different durability sign off standards for 4x4's and cars due to the very different duty cycles that these two types of vehicle will experience in the hands of the customer. As the benchmark vehicle was a 4x4 product a damage comparison for the Russian market and the cars durability sign off test could not be carried out in this case. This is because features on the proving ground tuned for cars would lead to inappropriately low vehicle responses due to the suspension travel differences, and a correspondingly unrealistic damage comparison result. The exercise was therefore limited to a Russia market 4x4 accelerated durability test comparison.

The data collection in Russia also highlighted some severe single event loading. These were one off load cases that could not have the multipliers for vehicle whole life mileages applied to the data as their statistical invalidity would have skewed the damage comparison results. These results were compared with the Jaguar Land Rover extreme strength events load cases to ensure that the design envelope was met.

Conclusions

The vehicle was carefully chosen such that sufficient load measurements could be taken from existing components to adequately represent load paths through the suspension structure. It was also a vehicle with a long history of road load data measurement where the component load paths were understood.

The fatigue damage indicates that for all lateral and steering based inputs, the JLR Global structural sign off test standard greatly exceeds the Russian environment for both the severe and extreme customer. This is as expected as the Russian environment does not generally contain twisting, winding roads run at higher speed that would induce lateral inputs.

For longitudinal inputs the JLR structural sign off test

standard encompasses the severe and extreme Russian market user by an adequate margin for 4X4's, with the braking and longitudinal inputs covering for the fatigue damage and generating higher peak loads than those found in the Russian environment. Also vertically for the 4X4 case with a severe and extreme customer the fatigue damage is covered.

Like for like comparison of sign off test to customer usage profile was found to be important due to the vehicle type specific nature of the accelerated durability sign off test. Additionally due to multipliers being used to equate recorded data to whole life usage mileages, careful consideration of the number of actual events recorded was required to ensure there were sufficient events of a given magnitude to give a valid damage comparison result.

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[2] The Fatigue Design Handbook (Second Edition), Various Editors, The *Society of Automotive Engineers*, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

Positive actions during recession

We are in the middle of a recession, and it seems reasonable to ask what effect this may be having on R&D and what opportunities are presented in this peculiar situation.

Of course, money is going to be tight, but should we just sit and wait and then get ready to take up again where we left off? That would be the view of a conservative thinker, but this assumes that the post-recession world will be exactly like it was before. There is no guarantee this will be the case. It is pretty sure that products will have to be even more attractive and competitive in the future as the market has diminished. One major company has a policy of investing in R&D during a recession so that they can offer something really exciting as the market picks up. This attitude is commendable, but is not the general rule.

This is a time for evaluating the worth of what we do and reviewing processes and procedures. R&D spending has always been seen (wrongly) as a cost to business, and so we should be prepared to do more with less. It is often the case that procedures and processes grow in complication over time, and become inefficient during the easy times. It's a natural progression that more is added, and things are seldom deleted even if they are no longer required or sensible. In a mature organisation there is always some scope for improvement in efficiency without sacrificing effectiveness.

Add to this the changing requirements of product design and development that are taking place, and you will find that there is a real need for re-aligning the R&D activity to the business. Even though it may be recognised that systems and processes need to be changed, there is usually no time to do it when everyone is busy.

This was demonstrated by a company processing data collected on the proving ground. The channel count on this job was around 150 and the tests were scheduled to take two weeks. A problem was identified during the collection which meant that the data was suspect. All attempts to fix it failed leaving only half of the channels. A discussion about which measurements could be sacrificed resulted in an eventual channel count of 70. With only two days left to repeat all of the data collection, a difficult discussion followed which centred on which tests would be done. The rest of the data collection went along without incident and the data brought back to base. As a priority, the last two days worth of data was processed immediately and passed on to the users of the data, both test and CAE. Time was then made available to attempt to retrieve the problem data. It was then found that almost all of the data could be recovered and would be reliable. It transpired that there was now no urgency at all to do this since the users found that the reduced data set was adequate for their needs.

This situation is not unique, and the tendency has been to collect more and more data "just to be on the safe side". There has been little willingness to restrain this, but as resources become scarcer it is important to establish what is really necessary.

Along with an assessment of procedures, it is important to review the skills and capabilities of the team. People become despondent and de-motivated in times of recession. If roles are reviewed and aspirations are taken into account, updating and enhancing skills will help motivation people towards a brighter future. Flexibility will definitely become a requirement of most roles to enable quick response to changing conditions. All of this can be done in-house, although some external training may be needed. Employees are usually keen to take on new skills that enhance employability/value and are transferable.

Companies that survive and thrive in the next five years will be leaner and fitter, with more efficient processes and well trained and motivated staff. They will deploy efficient hardware and software tools. There will always be a market for quality in products and services.

Robert M Pirsig, the author (Ref.1 below) taught us that "Quality" is a concept that is hard to define and yet we all can recognise it when we see it. Similarly, if we are involved in the delivery of "quality" we respond positively and give it our best. Now is the time to review what we do in terms of quality rather than quantity, which has been the prevailing tendency of what will become known as "the wasteful years".

Geoff Rowlands
Product Life Associates
Limited. February 2009.

Ref 1. "Zen and the art of Motorcycle Maintenance", Robert M Pirsig. 1974 Published by William Morrow and Company.

Call for papers

Multiplexed Digital Information for Test & Development

MIRA Ltd, Nuneaton, UK

Wednesday 20th May 2009

This one day working seminar at MIRA in Nuneaton follows the successful event held in 2005 where speakers' highlighted recent progress and pitfalls in the use of data from on-vehicle digital systems. See previous programme: http://www.e-i-s.org.uk/events.htm

The forthcoming second event is aimed at practising engineers involved with the collection, installation or use of data from vehicle for development or design work and will cover a variety of aspects of this technology. It focuses on advances in the on-board digital systems, external data collection and interpretation, problems that can arise and more importantly the 'integrity' of any data collected via these methods.

In particular, the event aims to bring new developments and experiences in the methods and technologies to new users and experienced data collectors and analysts alike.

Abstracts to arrive no later than 30th April 2009, by email to:

Lisa Mansfield - lmansfield@e-i-s.org.uk
Contact: 02476 730 126
http://www.e-i-s.org.uk

The forum will be informal and will concentrate on practical issues along side wide ranging discussion groups. We are especially encouraging speakers from emerging technologies as well as from established areas.

Speakers selected for presentation will be able to attend for the whole day of their presentation free of charge.

A short introduction/abstract of no more than 500 words is invited in all aspects relevant to design, development or research – there will be no publication of official papers, speakers are free to provide hand-outs or other documents as they wish. Only up to 8 contributions will be selected for presentation and abstracts and/or presentations published in the EIS Journal.

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Industry news

Welcome to the Industry News section of the journal. Thank you to everyone for their submissions, of which we received around 400 e-mails and a few paper press releases. The nominal limit for entry is 200 words, which should be sent to eis@amberinstruments.com or posted to EIS, c/o Amber Instruments Ltd, Dunston House, Dunston Road, Chesterfield, S41 9QD. We would appreciate you not sending entries by fax.

Paul Armstrong

POWER UP FOR BATTERIES REGULATION SAYS ENVIRONMENT AGENCY

Businesses that make, import or sell batteries and battery-operated equipment from torches to toys should start planning now so they are ready to comply with new regulations aimed at reducing the environmental impact of batteries, the Environment Agency said today.

Around 700 million batteries, which can contain a number of substances harmful to the environment such as cadmium, are landfilled in the UK each year - and just 3% of the 30,000 tonnes of portable batteries that are sold onto the UK market annually are recycled.

But the Batteries Directive sets strict targets and by 2012 a quarter of all end-of-life portable batteries in Britain, some 7,500 tonnes, must be recycled rather than discarded – a figure already being exceeded in several European countries including Belgium and the Netherlands.

Bob Mead, Batteries Project Manager at the Environment Agency, which will regulate battery producers in England and Wales, said: "Some details of how this legislation will be implemented in the UK are currently being consulted on. But, we do know that it will cover all the types of batteries we are familiar with - from AAA cells and mobile phone batteries to the button cells used in hearing aids and watches - and impact on lots of firms."

ENGINEERS WITHOUT BORDERS UK

EWB-UK is an emerging charity that aims to remove barriers to development using engineering throughout the developing world. The charity is mainly student-run but its members include both students and professionals who are involved through 20 university based branches and a professional network of academics, researchers and graduates.

The charity's work involves training members in development engineering techniques, researching new technologies and techniques; educating non-members and school children and funding volunteers to assist NGO's on placements overseas. In 2007-08 EWB-UK was able to fund 39 of these placements in locations across Europe, Africa, Asia and South America.

Highlights for 2007-08 include:

- The Department for International Development awarded EWB-UK £175,000 for training and research.
- EWB-UK set up its first permanent office with three staff members.
- Members benefitted from 1,200 training days.
- EWB-UK contributed £67,000 for young volunteers to get directly involved with international development projects.
- EWB-UK ran a pilot scheme for Britain's first ever education programme raising awareness of global water and sanitation issues in three secondary schools.

(EWB-UK, website: www.ewb-uk.org).

EUROPE'S BIGGEST STUDENT MOTORSPORT EVENT IS A SELL OUT IN ONE DAY

The race to register was on as places were filled in just over two hours, with 88 teams signed up for the event. The teams registered include students from universities around the world, such as India, Romania, Iran, Canada, Sweden, Switzerland, Germany, France, Austria, Italy, Portugal, Finland and Spain. Over 20 teams from the UK universities have entered, including Cambridge, Glasgow and Cardiff.

Last year – for the first time in the competition's 12 year history – FS launched Class 1A, challenging students to design and build alternative fuelled cars, using power sources such as hydrogen and hybrid. Three teams entered the category, which was won by Hertfordshire University and five teams have registered this year.

FS is run by the IMechE to challenge the next generation of engineers to design, build and drive a single-seater racing car from scratch. The aim of the competition is to help students develop academic, vocational and practical engineering skills and the training it provides is considered essential by industry experts for students hoping to pursue a career in F1 or motorsport. Registration for Formula Student closes on 27 March 2009. For further information please visit www.formulastudent.com or contact Kate Jones on (020) 7973 1287.

GOVERNMENT AWARDS THE SMALLPEICE TRUST FUNDING FOR NEW COURSES

Young people from low-income families, ethnic minorities and girls are being given a financial helping hand by the Government to encourage them into engineering. The Smallpeice Trust has been awarded funding from the Children, Young People and Families Grant Programme to support new courses. The £1.1m grant will enable The Smallpeice Trust, in partnership with STEMNET and the WISE Campaign to promote the importance of Science, Technology, Engineering and Maths (STEM) subjects to 8000 school children from disadvantaged backgrounds over two consecutive years. The courses will specifically target 'hard to reach' groups.

The new programme is called GET AHEAD WITH STEM! Starting in April 2009, The Smallpeice Trust will deliver

160 STEM days – half or one day in-school sessions – and 8 residential courses over a two year period. Each STEM day will introduce 50 pupils to the challenges of a hands-on design-and-make project, to increase their understanding of the importance of STEM subjects and develop transferable skills such as teamwork, creativity, problem solving and time management. Participants for the residential courses will be selected from STEM day attendees, with each course giving 100 pupils the opportunity to gain an even deeper insight into engineering plus a taste of university life.

OPEN UNIVERSITY ENGINEERING DEGREES GAIN FURTHER OFFICIAL RECOGNITION

The Open University's Engineering programme has gained further official recognition recently with another four separate engineering bodies recognising the Open University's Bachelor of Engineering (BEng Hons) and Master of Engineering (MEng) degrees.

The Chartered Institute of Building Services Engineers (CIBSE); The Royal Institution of Naval Architects (RINA); The Institute of Highway Incorporated Engineers (IHIE) and The Institution of Gas Engineers & Managers (IGEM) have all agreed to recognise the qualifications for professional registration. They join the Institution of Engineering Designers (IED) who were the first body to recognise the OU's engineering programme in August 2008.

http://www.open.ac.uk/recession

ENGINEERING ADVICE FOR GOVERNMENT

The Innovation, Universities, Science and Skills (IUSS) Committee held its first evidence gathering session on 'Engineering in Government' towards the end of last month. Government departments presently enjoy the benefit of 'science' advice when they need it but 'engineering' does not appear to have quite the same degree of representation in the corridors of power. That imbalance is now being addressed, as the institutions representing the engineering professions were given the opportunity to air their concerns at this initial hearing.

The Institution of Engineering & Technology (IET) was represented by deputy president, Professor Christopher Snowden, who claims that the presentations made to the Committee clearly demonstrated the value that the institutions, the Royal Academy of Engineering (RAE) and the profession at large can add to the development of government policies, in addition to the delivery of government projects and programmes.

In its written evidence, the IET said that it considered the government's use of engineering advice and, in particular, its use of resources like the professional engineering institutions was "ad hoc and uncoordinated in nature". The IET believes the government does not formally acknowledge the role of engineering in policy making and may even be unaware of the resources available to it.

INAUGURAL BIG BANG FAIR TO CELEBRATE UK SCIENCE AND ENGINEERING TALENT AND INSPIRE FUTURE GENERATIONS

Over three days at the QEII centre in London from the 4th – 6th March, nearly nine thousand young people, teachers and members of the public will witness the UK's biggest and boldest celebration of UK science and engineering. The Big Bang will demonstrate the excitement and opportunities of the sector, and encourage greater take-up of careers in science and engineering. It will feature compelling and engaging shows, workshops and presentations across the entire science and engineering spectrum; displays and demonstrations of leading-edge UK technology from sponsor companies including Shell and BAE Systems; and exhibition stands to showcase further inspirational projects.

One of the highlights of The Big Bang will be the newly established National Science Competition, to identify the first UK Young Scientist and UK Young Technologist of the Year. The competition is open to all 13-19 year olds including regional finalists from the BA (British Association for the Advancement of Science) CREST Awards, and Young Engineer for Britain Competition. Each winner will receive a personal cash prize of £5000, a once in a lifetime international science or technology trip, a trophy and opportunities to represent youth science at events across the UK and beyond over the following year.

Through the range of exhibits, workshops and events at The Big Bang, young people will discover the huge range of opportunities that exist for those with science and engineering qualifications in the UK.

CRANFIELD LAUNCHES HI-TECH VEHICLE HEALTH RESEARCH FACILITY

Cranfield University has officially opened a multi-million pound IVHM Centre (Integrated Vehicle Health Management Centre), to lead revolutionary research in vehicle condition monitoring and management for aircraft, ships, high-speed trains, high-performance cars and energy applications.

The Centre – jointly funded by the East of England Development Agency – will now become home to this developing field of research which aims to advance existing concepts of vehicle management, offering a total health check for high-tech, high-value assets.

IVHM works through a network of sensors that are distributed on the vehicle. Each sensor collects data on the condition of the vehicle's components and subsystems. This data is then read by on-board processors which, through complex algorithms, assess the vehicle's health, predicts its future life and any possible deterioration.

It is hoped that the results can be used

to avoid potential component malfunctions, reduce operating costs, increase competitiveness and allow companies to assess the effectiveness of their fleets.

BAE Systems, Rolls-Royce, Thales UK and Meggitt PLC have each committed £1 million over five years to IVHM research jointly launched by Cranfield University and The Boeing Company in late 2007. The world-class facility is also benefiting from a £3 million investment from EEDA and £500,000 from EPSRC (Engineering and Physical Sciences Research Council) money in conjunction with Cranfield's PSS (Product Service Solutions) project.
http://www.cranfield.ac.uk/ivhm

MOOG ACQUIRES WIND ENERGY FIRM INSENSYS

East Aurora, N.Y., February 6, 2009 – Moog Inc. (NYSE: MOG.A and MOG.B) has acquired 70 percent of the stock of Insensys Ltd. for US$15.7 million in cash. As part of the transaction, Moog has an option to purchase the remaining 30 percent within one year. Insensys is a leading supplier of pitch control and rotor blade monitoring systems for wind turbines.

nCODE MERGED WITH HBM

On 1st January 2009 nCode merged with HBM to become HBM United Kingdom Limited, following the acquisition of nCode International by the leading test and measurement company, HBM on 1st August 2008.

The company will operate within HBM and retain the prestigious brands of nCode for analysis and CAE software as well as SoMat for rugged mobile data acquisition systems. In doing so, HBM strongly underlines its commitment to the continuity and growth of nCode's and SoMat´s products and services.

nCode's head office near Sheffield and Somat's in Urbana, USA are recognised centres of excellence within the HBM company and existing support staff, hotlines and websites are unchanged.

HBM's head office is in Darmstadt, Germany, but are owned by Spectris PLC based in the UK. Spectris also own B&K and as of late 2008 also own LDS – all sponsor members of the EIS.

THE SCIENCE BEHIND BUILDING CROSSRAIL'S TUNNELS

The latest methods of tunnelling will ensure that London's Crossrail scheme can be safely constructed without damage to the buildings above ground according to a public lecture given at the Royal Society. Leading geotechnical engineer, Professor Robert Mair FREng FRS of Cambridge University, spoke on the major advances that have been made to allow large tunnels to be safely built in the soft ground beneath cities.

Work on the Crossrail scheme which will connect Maidenhead in Berkshire to Shenfield in Essex via Heathrow airport and London began in mid-January and the new line is due to open in 2018. The project will involve major new tunnels and stations, including the new Tottenham Court Road Station, constructed beneath many buildings in central London. The tunnels and stations will be considerably larger than a typical London Underground station and so extra care will need to be taken to protect the buildings already standing above ground.

According to Mair, engineers will use an innovative technique called compensation grouting to protect certain key buildings during construction of the tunnels. Before tunnelling, steel tubes known as 'tube a manchettes' will be installed in the ground between the tunnel and the buildings above. During tunnelling grout (liquid cement) will be injected from any one of a large number of holes in the steel tubes into the ground to compensate for the ground movements being caused by the tunnel excavation. The result is that the building experiences only a slight settlement, compared with what might have been a severe settlement if no compensation grouting had been undertaken.

COMPAIR ACQUISITION COMPLETED

The acquisition of leading compressor manufacturer CompAir has been completed for £200 million, with the whole of the CompAir Group, including Hydrovane & Reavell, now being part of Gardner Denver, a US based global manufacturer of compressor and vacuum products and fluid transfer systems.

Illinois-based Garner Denver has operations in over 30 countries, a turnover of around $2.3 billion (£1.4 billion) and employs 6,200 staff worldwide. The acquisition of CompAir will enable Gardner Denver to extend its global compressor business using CompAir's strong brands, technologically advanced products and complementary routes to market.

2009 – NAFEMS

The International Association for the Engineering Analysis Community, has announced an impressive line-up of invited speakers for its World Congress, to be held in Crete, Greece, on June 16th-19th 2009.

This, the 12th International Conference organized by NAFEMS, brings together a wide range of leading industrial experts and academic researchers, to provide a unique insight into current best practice and future state-of-the-art in FEA and CFD.

The confirmed keynote speakers are: Erich Schelkle - Porsche AG and Automotive Simulation Center Stuttgart, Germany, Tsuyoshi Yasuki - Toyota Motor Corporation, Japan, Martin Wiedemann - DLR German Aerospace Center, Germany, Jacek Marczyk - Ontonix, Italy, Louis Komzsik - Siemens PLM Software, USA, François Besnier - Principia RD, France.
http://www.nafems.org/congress

Neil C Hay
Napier University

Targets

Recent events in world finance have prompted a reflection on the topic of targets. As engineers, we are well placed to consider targets because we successfully continue to meet the target of improving structural integrity. The same cannot be said of 'the city' where targets have generated problems such as toxic debts, credit crunch, market meltdown, and, worst of all, a multitude of metaphors. It appears that setting targets has a detrimental influence on behaviour, which makes real targets elusive, or, once achieved, out of date and irrelevant.

Before commenting on financial targets let us consider targets nearer to home, e.g. the impossible task of defining customer usage[1]. One approach is to fit a data acquisition system to a customer's car. Does the customer ever drive the same way again and therefore is the resulting target valid? Another aspect of targets is that achievement may have unforeseen consequences. For example, thickening the A pillar in vehicles has met the target of improving occupant safety in a crash but the blind spot created by this pillar has significantly expanded and this may have the reverse effect on safety by increasing the number of accidents.

Although I am not qualified to comment on banking and finance, surely the circumstances of 2008 might have been foreseen by those who are. Clearly, financial experts did not anticipate the interaction of targets and human nature. The overall target in the world of finance, greatly encouraged by the philosophy of the 1990's, is to make much money. This has lured some away from traditional banking into wonderful new strategies of derivatives, hedge funds, short selling, unlocking assets, and 'ninja' loans[2]. Fundamentally, financial institutions make money from lending and more debt means more money. Until the recent reversal of fortune, the bank's shareholder targets were achieved, trader's, derivative and hedge fund manager's targets were achieved and the television was awash with adverts offering the general public credit cards, loans and the release of capital locked up in homes. Bonuses were paid and all could have more money provided the economy, i.e. debt, was growing. Inappropriate targets or strategies corrupted good sense throughout the whole system resulting in bailouts and recession.

No area escapes the effect of targets. Consider education where we might infer that the next generation of engineers will be geniuses because targets in mathematics and physics are exceeded year on year. The previous year's pass rate sets the target for the next year which must be met else there is an enquiry into falling standards or, alternatively into 'dumbing' down.[3] The unforeseen consequence of education target inflation is that learning is often forgotten.

In engineering projects, targets are a necessity otherwise nothing is achieved. As soon as a project commences, goals and milestones are set. The alternative is to rely on serendipity where fortunate events are expected to happen by accident. This may lead to a more interesting life and generate new ideas but more probably the result is derailment of a project and subsequent disaster. Of course, well managed projects with clear targets can also fail, possibly because the target was wrong or obscured by other considerations. Alternatively, failure may occur when the route to a target is necessarily indirect to circumvent obstructions. In making the detour, alternative targets can arise that are more attractive than the original. Other causes of failure are due to alternative strategies which compete and hinder progress. These strategies are generally influenced by external circumstances or interesting new technological developments that divert attention and drain productive effort. In projects of long duration, targets may change, develop or become unclear. As projects progress, the target may be recognised as unobtainable or, on completion, the level of achievement can be debateable or immeasurable.

Immeasurable targets return us to our gatherer of customer usage data. It is clear from improved durability that manufacturers have a successful customer usage specification. However, several acquaintances, who recently suffered suspension spring failure, question whether the target has moved. Currently, in Edinburgh, we have unprecedented levels of road works for gas and water mains and the installation of a tramway system. These and a spreading rash of speed bumps have surely redefined the specification of the service environment. Despite such changing circumstances, strategies have adapted and durability targets are still achieved. Maybe it is in the definition of the engineer, 'to plan, manage and put through by skilful acts or contrivance'[4] that gives a clue to our success in achieving seemingly impossible targets. Should not our skills be applied to setting targets and strategy for 'the city' to ensure that there is investment in productive activity where real wealth is generated?

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[1] Grubisic, V., Detemination of load spectra for design and testing, *Int. J. of Vehicle Design* Vol **15** Nos 1 / 2 1994.

[2] 'Ninja' loans explode on sub-prime frontline, Edmund Conway, San Francisco, 22 Sep 2008. http://www.telegraph.co.uk/finance/economics/2785403/'Ninja'-loans-explode-on-sub-prime-frontline.html.

[3] Keep it stupid, simple by John Gill 23 October 2008. http://www.timeshighereducation.co.uk/story.asp?sectioncode=26&storycode=404042&c=1

[4] http://www.thefreedictionary.com/engineer

News from Formula Student

Richard Folkson Chairman of Institution of Mechanical Engineers' Automobile Division

Reducing our country's carbon emissions has been at top of the Government's agenda ever since the words 'climate change' became second nature to the media and public alike. So it came as no surprise when Transport Secretary Geoff Hoon announced a £250m package of measures to promote ultra-low emission cars in January this year, with the aim of bringing them to mass market more quickly. But in spite of the Government's commitment to low carbon vehicles – and public enthusiasm to go green – the industry is not without its challenges.

The obstacles of many alternative fuel sources used in road vehicles can pose serious challenges, as can the short lifespan of a battery used in an electric car. One of the organisations trying to overcome such challenges is the Institution of Mechanical Engineers (IMechE), whose key themes include both Transport and the Environment.

In May this year, the IMechE is holding an event on Low Carbon Vehicles, at which companies are invited to demonstrate how new technologies will address vehicle emissions and, as a result, tackle climate change. It is imperative that we focus on influencing the mass market because without wide-spread appeal, using low carbon vehicles as a way to reduce harmful emissions will have little impact. There is no single solution and lots of different technologies are needed to start achieving a significant reduction. Today's cars produce an average 160g per km of C02 and the UK Government has set a target of 100g per km by 2020. Although it is a difficult task to achieve, the target itself may still not be enough to stabilise climate change. We should be aiming for 70g/km, or maybe even reduce to 40g/km. This reduction of more than 50% is clearly an incredible challenge for engineers to undertake, but it is not impossible.

One of the topics that will be addressed is whether battery-powered electric vehicles really do have a positive effect on the environment. They will be powered largely by electricity from coal-fired power stations and many people assume this is no better than burning fossil fuels directly in a car engine. However this source of energy can produce less CO2 than diesel cars, although obviously green electricity from a renewable source is the long term goal. Challenges presented to electric cars include competing against the less expensive purchase cost of diesel and petrol vehicles and attracting consumers put off by lengthy charge times.

Hydrogen and fuel cell vehicles offer a longer-term alternative to battery electric cars – provided cheap hydrogen can be produced from renewable sources. It is a more expensive option and is not as energy efficient as some, but if these challenges can be overcome a mass market vehicle powered by hydrogen could become available in around 20-30 years.

Today's hybrid cars are more expensive than those that run on diesel for similar fuel efficiency, but it will be worthwhile developing different types which make better use of the available energy dependant on vehicle use. Hybrid vehicles use the same electric motors found in electric cars and hybrid power is especially suited to city vehicles which regularly stop and start or for urban goods delivery.

Moving away from fossil fuels is an important factor and using biofuels as a source of power is a good way of storing fuel energy. Biofuels can be produced by growing plants that contain high amounts of vegetable oil and when these oils are heated, their stickiness is reduced so they can be burned directly in a diesel engine. Growing crops help to mitigate climate change by capturing and storing C02, so that net CO2 emitted by road transport when the fuel is burnt is significantly less than that from fossil fuel. However, biofuels are beneficial to low carbon cars only as long as they do not replace food crops, which can be achieved by the production of second generation biofuels from waste bio-mass or land which cannot be used for food production.

Some people are unaware that diesel is beneficial for reducing C02 in comparison with petrol because diesel engines actually have a higher thermal efficiency to make better use of the energy. This fact is not widely accepted in the USA where people place more importance on refinement and were put off by earlier diesel engines introduced during the first oil shock in the 1970's. Modern diesel engines can address all the concerns of US customers if we can overcome these old prejudices.

The event will also cover a new hybrid vehicle technology being developed by Flybrid Systems. The company has produced an entirely mechanical high-speed flywheel based energy storage and recovery system which meets the 2009 Formula One regulations but which is also suitable for road vehicles. This technology makes it possible to store energy during braking or hill descents. Computer simulations suggest that fuel consumption savings of around 50% are possible for vehicles making frequent stop-starts and the promise of big reductions in CO2 emissions have already attracted vehicle development programmes with several major car makers.

The conference also relates to the Formula Student event, in which university students are required to design, build and race a single-seater racing car. In 2007 the competition introduced its Class 1A category (1A stands for Alternative Fuels), inviting teams to produce and enter a low carbon car using alternative fuel for power. The class places more emphasis on the environmental impact of racing.

It is clear from the technology and areas discussed that there is no simple solution to bringing low carbon cars to the mass market. A lot of research still needs to be done. It is a challenging area, with many exciting technological opportunities for those working in the industry. Companies designing low carbon vehicles vary in their opinions of what works best, with some favouring fuel cell and others opting for hydrogen internal combustion engines or hybrids. The way forward is to continue evolving technology that will appeal to mass market consumers and provide long term personal mobility in affordable and exciting vehicles.

IMechE will be hosting Low Carbon Vehicles 2009 on 20th and 21st May in partnership with the Technology Strategy Board. For further information on this event please contact Louise McKenna on 020 7973 1316 or email l_mckenna@imeche.org

www.imeche.org

News from the Universities

Joseph Giacomin
Brunel University

The great credit crunch is worrying. There is real pain being felt, and while manufacturing appears to be among the hardest hit sectors, no place of work is immune from the problems, not even the ivory towers of academia.

For the universities the current situation presents a mixed picture. Some academics are relatively optimistic about the prospects, pointing to recent announcements from both businesses and government about new investment in technology and infrastructure. Some movement away from financial services is expected, and areas such as biomedical, digital media and advanced manufacturing may be the beneficiaries. Other academics are more pessimistic, citing instead cutbacks in long term investment. The picture is far from clear.

The fuzziness is in part due to academia's moving in yearly cycles, rather than monthly or weekly cycles. The effects of the credit crunch will take some time to filter through the system, thus current estimates may be wildly out of date by the start of the new academic year in October. Things are also not helped by the mixed bag of recent news, where one can find both the good and the bad, if not the outright ugly.

First the good news. Recent statistics from the *Universities and Colleges Admissions Service* suggest that student admissions will be up this year. With jobs in short supply, and possible periods of inactivity on the horizon, many people are seeing higher education as a useful investment. Many current undergraduates are continuing on to complete masters or even PhD study in order to make good use of the available time. For professionals already in work, restrictions to career progression or fears of redundancy play a role. The downturn is leading many to enter into higher education in order to raise their professional profile for when rosier times return.

More good news comes from the area of international admissions. Foreign student numbers are still, by and large, on the up. A recent survey found that the needs of the growing middle classes in many countries around the world are not being met by their local educational systems, thus many of these young people are coming to the UK for their training. The recent drop in the value of Sterling has also added some impetus to this trend, making UK education more competitive than it has been in recent years.

The student accommodation market is also proving resilient, with demand still far exceeding supply. Given the strong demand, universities are managing their estates, or outsourcing their provision, in such a way as to achieve a healthy income stream. Where the traditional halls of residence were once a burden, the same halls are now a major part of the overall business model as security, social and lifestyle expectations grow.

And now the bad news. To start with, there are fears that government funding will be cut as the recession bites. A £400 million hole in next year's budget for the sector has been predicted based on the reduced teaching and research support outlined in a recent grant letter from the *Higher Education Funding Council*. Such a move is widely expected to push a number of UK universities into the red. Redundancies are expected, and there is even talk of more than one institution being at risk of bankruptcy.

More bad news emerges from the most obvious effects of the banking crisis. When the Icelandic banks collapsed, universities such as Exeter and Manchester Metropolitan were among the investors who lost their money. In addition to default losses, there is also growing concern about the sector's reliance on investment equity for the funding of major infrastructure. A number of high profile building projects have been scrapped and many more are being reconsidered. And it is not just building works which are being affected, since several high profile IT projects have also been either redefined, postponed or scrapped altogether. Considering how the current recession may develop over the longer period, there are also concerns about university pension schemes, with more than one analyst claiming that several of them will soon be struggling to meet their commitments.

Bad news is also coming in from university HR and finance offices as difficulties build in the area of staff recruitment. While relatively junior posts appear to be benefiting from a greater number of applicants due to the perceived stability of the sector, some senior posts are remaining unfilled as falling house prices and uncompetitive mortgage offerings make it difficult to relocate. Inflationary pressure on salaries appears to be growing for some posts.

Finally, alarm bells are also ringing at research and knowledge transfer offices as private sector sponsors cut back investment due to the need to plug gaps in their balance sheets. Despite efforts by both the CBI and government to stimulate investment, many businesses are finding themselves obliged to redirect investment away from training or research so as to stabilise their revenue streams.

Overall, the situation at UK universities is not dissimilar from that of other sectors of the economy, in both the good and the bad. Surprisingly, perhaps, the outlook is more like that of business than it has ever been in the past. Globalisation and governmental reforms have closed some of the gap between universities and their business partners. If the economic crisis is teaching us anything at all, it is that the destinies of all countries and of all people are now intertwined. While many may still take amusement from the common stereotype of the academic as a person far removed from the stresses of everyday life, many of my colleagues are suffering restless nights as they feed their PCs a steady diet of financial simulations, searching increasingly desperately through a bewildering number of scenarios for the holy grail of a balanced budget.

News on Smart Materials and Structures

Fabrizio Scarpa
University of Bristol

Welcome to our column on Smart Materials. Well, since the last time I wrote in this journal, the economy has gone through what unfortunately we all well know, and the general mood is quite sombre. However, as all the experts and policy makers say, this is the very time that investments on innovation and new technologies are needed. Let us hope that their appeals are really followed, because the world of smart materials and structures is going through a paradigmatic change at this time, with plenty of opportunities for new concepts of smart structures to be developed.

As I wrote last time, the world of smart materials and structures is using more and more nanotechnologies to develop the next generation of "intelligent" solids for sensors and actuators. Moreover, there is a growing emphasis on designing multifunctional materials for energy conversion and sustainability. In terms of energy production, a recent development at the University of Notre Dame in 2008 (http://tinyurl.com/blpwfs) has been the design of specific quantum dots for smart solar cells, able to absorb tuneable light wavelengths. Quantum dots are semiconductor crystals having diameters in the range of 1 – 10 nanometres, and are quite well known for their fine-tuned absorption wavelength and quantum conversion energy above 100 % due to multiple exciton generation. Furthermore, they can easily be manufactured using the existing self-assembling techniques. The researchers at Notre Dame managed to combine different sizes of cadmium selenide quantum dots into thin nanofilms and nanotubes of titanium dioxide. The quantum dots absorbed light at different wavelengths, injecting electrons in the titanium oxide structures acting as collectors to the electrode. In theory, smart cells with quantum dots could reach conversion efficiency higher than 30 % against the current 15 – 20 % of silicon-based photovoltaic panels. What is more, quantum dots could also be produced into flexible sheets or put in liquid form, which is also relatively inexpensive compared to bulk silicon semiconductor materials and thin films.

During the last four to five years, several US, UK and EU programmes have funded research activities on wireless sensors systems for aerospace and transport applications. Magnetoelastic sensors for pressure, temperature, density and liquid viscosity have in this context received some attention, in particular iron-boron films, although for the latter it has always been difficult to produce films with desired target performance. However, very recently a group from Auburn University has managed to identify a method, by which iron-boron films of any desired composition can be made with controllable properties, using separated cathodes for the iron and boron targets, and differentiating the cathode power between the elements (http://tinyurl.com/bdz8lt). I think that this new manufacturing layout could allow the design of a new generation of position sensors based on magnetoelastic effect, as well as very interesting applications in biosensing technologies, where already magnetoelastic films are considered.

Continuing on the line of using nanostructures for smart materials and structures applications, graphene is very much on the agenda. Graphene is a single sheet (one atom thickness) of specifically bonded carbon atoms packed as a classical regular hexagonal honeycomb. What makes graphene a very special nanostructure is the high response to perpendicular electric field, which is therefore able to generate interesting field-effect transistors for NEMS (Nano Electro mechanical Systems). Moreover, its extremely high surface area to mass ratio makes it an ideal material for supercapacitors, and mass sensors for adsorbed molecules. In addition, the mechanical properties are outstanding. In a recent paper with colleagues from Swansea University and British Columbia (http://tinyurl.com/djv8sy) we have identified in-plane stiffness of the order of 2 – 3 TPa for graphene sheets with different dimensions and loading conditions, and also unusual deformation mechanisms. Those values put single layer graphene as the strongest material available, and also suggest potential applications to produce enhanced nanocomposite where functionalized graphene would constitute the inclusions. Manchester and Exeter Universities have secured substantial funding from EPSRC to develop graphene technologies – a sure indicator of the trust that the TSB bodies put in this promising nanostructure.

At the recent Conference on Auxetics and Related Systems in Bristol (14 – 17 September 2008), there were some interesting presentations from the smart materials point of view. Exeter University presented, to the best of my knowledge, the first composite honeycomb with auxetic characteristics and with an integrated sensing infrastructure with structural capability inside the core. The honeycomb could sense flexural propagating waves generated by low kinetic energy impacts on micro fibre composites, and transmit the data through the core to an external data acquisition card. The work has been developed under the FP6 project CHISMACOMB (CHIral SMArt honeyCOMB), with the collaboration of Bristol University, Fraunhofer Institute in Stuttgart and Technion Institute of Israel. Two other presentations related to metamaterials to be used in sound absorption or, even more futuristically, "sound cloaking"- how to wrap from the acoustic point of view an object in such a way that the acoustic wave passes through the object itself with no mutual interference. The idea was introduced by Professor Graeme Milton from the University of Utah, and it is based on superlensing techniques developed for negative refractive index materials in optics. The talk was fascinating, yet futuristic – Professor Milton was identifying the mathematical conditions required to provide the existence of those effects, but no indication on how to make such materials, although some of the microstructures proposed could be very inspiring for engineering applications. Another interesting talk was presented by the group from Industrial Research Limited in New Zealand on multiple scattering and negative mass effects for tailored sound absorption applications. The group has developed composites with heavy mass inclusions to produce multiple scattering effects due to the resonance of the inclusions in the soft matrix. The multiple scattering and reflections cause an equivalent increase of the acoustic

News from the British Standards

Brian Griffiths
Brunel University

Over the last several issues, I've been telling you about the progress of standards in the 'Design for Manufacture' area and in particular end-of-life processing; firstly because of its importance and secondly because of the interest it generates for design. However, there are many 'product design' committees and in future articles I intend to tell you something about their work. But, before we get into detail, it is appropriate in this article to take an overview of the work of TDW4 – the suite of committees concerned with product design. This TDW/4 suite is one of the largest in the BSI and has direct connections with many ISO committees.

The parent committee is TDW/4, Technical product realization. To give an idea of the extent of its work, it is currently responsible for fifty-four ISO standards alone development!

Sub-committee 1, called TDW/4/1, is concerned with General drawing principles, conventions and related documentation. It mirrors the work of ISO/TC 10, including technical drawings, manually produced or computer based for technical purposes throughout the product life cycle, to facilitate preparation, management, storage, retrieval, reproduction, exchange and use. The current work items/issues are the revision of national limits and fits series - the BS 1916 series, BS 4500 series.

Sub-committee 2 is TDW/4/2, Drawing media. It is responsible for a two part national standard on pen caps (BS 7272) and feeds into ISO/TC 10's newly established working group 18 on drawing and writing instruments.

TDW/4/3 is concerned with technical product verification, including the properties and metrology of surfaces. It feeds into the work of a number of ISO/TC 213 working groups, particularly WG 15 on GPS extraction and filtration techniques, WG 16 on Areal and profile surface texture, and mathematical support. It is also responsible for the national standard BS 8889, Technical product verification – inspection of size, form and surface texture in relation to function, currently in development.

TDW/4/4 is concerned with gauging and measurement equipment. It has been recently reactivated to deal with a series of revisions of national measuring equipment standards. Feeds into ISO/TC 213 WG6 - general requirements for geometrical product specification (GPS) measuring equipment.

TDW/4/5 is responsible for Design for Manufacture. It considers manufacturing, assembly, disassembly and end of life processing. Work is currently focussing on terms and definitions in disassembly and end of life processing aspects and sustainable design. It is also responsible for the national standard BS 8887.

TDW/4/6 is responsible for education and training strategy. It promotes increased awareness and use of TPR standards through the development and provision of learning, coaching and mentoring resources for engineering practices.

TDW/4/7 is concerned with digital product definition. It is the e–panel for Electronic Technical Specification covering international standards on 3D modelling and feeds into ISO/TC 10 WG16.

TDW/4/8 is responsible for the major national framework standard BS 8888, Technical product specification, and related standards and products. Current work items are the just published 2008 edition of BS 8888 (November 2008).

TDW/4/10 is concerned with diagrams and symbols. It feeds into ISO/TC 10's SC6 on Mechanical engineering documentation and SC10 on Process plant documentation and TPD-symbols.

If the reader has any questions concerning the work of any of these sub-committees, they are welcome to contact this author through the EIS editor. Future articles with be devoted to the TDW/4 work programmes of significance to readers.

Brian Griffiths
Chair of the TDW/4/5 – The BSI
'Design for Manufacture'
sub-committee

Smart Materials and Structures continued .....

absorption of the material. We are also working on similar concepts here, and the overall challenge is to identify the correct mass/stiffness ratios of the inclusions and matrix at different frequencies. However, the work of the New Zealand research centre was remarkable, including the amount of experimental data obtained considering the initial stage of their research.

I would like to close with some references to conferences on smart materials and structures in the months to come. The ICCM-17 in Edinburgh (www.iccm17.org) will have some dedicated sessions on multifunctional materials and smart structures. The 17th AIAA/ASME/AHS Conference in Adaptive Structures (http://tinyurl.com/c293zo) will be held in Palm Springs between the 4th and the 7th of May. Apart from the classical SPIE Conference in San Diego (www.spie.org), I would also like to alert readers to the events that the SmartMat network of Materials KTN (www.smartmat.org) puts in place to facilitate knowledge exchange between academia, industry and third parties.

Group News

Durability & Fatigue Group

The group has been working on three topics in late 2008 and for 2009. Following our successful wind and marine power seminar in 2006, we ran a second one in November 2008. Once again it was well attended and it was good to see progress in two ways. Firstly some of the presenters from 2006, who showed prototypes or products in final assembly, can now claim that they are generating electricity (both wave and tidal) – we wish them every success. Secondly there are new devices being developed and research undertaken to improve the performance of existing ones – in both wind and marine applications. It was particularly good to see a presentation by E.ON – a UK power generating company with a significant (and growing) investment in wind energy. They were able to show us some of the problems that they face in operating and maintaining modern wind turbines; larger machines pose new challenges compared to the machines which have been operating for a decade. Clearly there is more work to be done and a need for cooperation between all parties; the EIS is well placed to provide a forum for this.

A seminar entitled "Testing and Failure in Orthopaedic Medical Devices" to be held at Leeds University is now scheduled for May, and we are working with various partners on this – both medical and engineering.

A related topic is that of using Rapid Prototyping materials and processes in low to medium volume production. They were originally proposed as working mock-ups or simply to assist understanding in product development meetings. Nowadays they are used for a variety of components (including replacement hip joints) in service and their long-term structural integrity is becoming increasingly important. The Rapid Prototyping event is being organised with the assistance of Wolverhampton University and will be on their Telford campus.

These are trying economic times, so I'd particularly like to thank all those who still manage to support us: presenters, committee members and those who attend our technical meetings.

Robert Cawte

Noise Vibration & Human Perception Group

The Group has been more or less in limbo for last few months. The Group relies on support from industry but this has been sadly lacking recently. It is entirely understandable with the credit crunch and the financial difficulties of the automotive industry, so there is little choice but to go into hibernation for a while.

Andrew Middleton has resigned as Chairman. He has been threatening to do this for about two years, feeling that a younger person should take on the position. Andrew has been in retirement for two years now and it is very noticeable how quickly ones contacts melt away in that time. It is essential that the chairman of the group is in close contact with the movers and shakers of the industry. John Wilkinson has kindly agreed to take over as Chairman while the group is in hibernation, with a view to restarting activities when the situation recovers. Its a pity we had to take the decision to hibernate because we had some interesting events in the early stages of planning. Let's hope for a successful reawakening before too long.

Andrew Middleton

Simulation, Test & Measurement Group

By the time you read this the 26th Instrumentation, Analysis and Testing Exhibition will have taken place at the International Media Centre, Silverstone Race Track on 24th February. A report on this will be published in the next edition of the EIS Journal, but in the meantime may I express my thanks to Lisa Mansfield, Bernard Steeples, Ray Pountney, Norman Thornton and Trevor Margereson for organising this event.

Future Events

A one day event entitled "Living with Ageing Plant" is being planned for 2009 focusing on the challenges and solutions in monitoring and extending manufacturing and process plant life.

In the current economic climate, plant life extension is increasingly seen as an operational necessity not an option. The requirement to quantifiably and safely extend the productive life of existing infrastructure and plant demands action based on measured operational data and predictive analysis tools rather than simply relying on the conservatism built into the codes used for the original design to justify continued operation when the design life has been reached.

Companies with these problems such as oil/gas, petrochemical, pharma and power generation will be invited to make presentations on the problem and companies such as IDEAS, nCode, TWI etc will be invited to present some potential solutions.

An open forum will be advocated to stimulate appropriate directions for further investigation.

At present it is planned to hold the event in North East England, dates and a possible venue are being investigated. Further details on all this event will be published on the EIS website when more information is available.

Data from On-Vehicle Digital Systems working group

During the past year or two there have been various ad hoc meetings and discussions to establish this working groups goals. It transpires that what is really needed is a general set of seminars / workshops from the 'how to do it' and 'pitfalls' point of view. This has culminated in a plan to run a series of short seminars.

The first event is the previously postponed 'Multiplexed Digital Information for Test and Development' seminar. This event will be held on Wednesday, 20th May 2009 at MIRA, Nuneaton and will cover the use and abuse of information from on vehicle digital systems such as Control Area Network (CANbus) and OBD (On Board Diagnostics) as well as other instrumentation sources.

There will be introductory presentations covering state-of-the-art methods, problems, pitfalls and equipment used. Speakers are expected from industry, research, academia and suppliers. This will be interlaced with informal discussion sessions to network and investigate the subject in depth with other experts. A call for papers has been included in this issue of the EIS Journal.

Richard Hobson

Committee members

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Trevor Margereson, Engineering Consultant 07881 802410
Treasurer
Khaled Owais, TRaC Environmental & Analysis 01926 478614
Company Secretary
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EIS Secretariat
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Communications Sub Committee – 'Engineering Integrity' Journal of the EIS
Honorary Editor
Karen Perkins, Swansea University 01792 295666
Managing Editor
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Durability & Fatigue Group

Chairman
Robert Cawte, HBM United Kingdom..... 0121 733 1837
Secretary
Khaled Owais, TRaC Environmental & Analysis 01926 478614
Members
John Atkinson, Sheffield Hallam University 0114 2252014
Martin Bache, Swansea University 01792 295287
Peter Blackmore, Jaguar Land Rover 01926 646757
Feargal Brennan, Cranfield University 01234 758249
Emanuele Cannizzaro, Atkins Aerospace..... 01454 284242
John Draper, Safe Technology 0114 255 5919
Steve Hughes, Bodycote 01524 841070
Karl Johnson, Zwick Roell Group 0777957 8913
Davood Sarchamy, British Aerospace Airbus 0117 936 861
Giora Shatil, Darwind..... +31 (0)30 6623987
Frank Sherratt, Engineering Consultant 01788 832059
James Trainor, TRW Conekt Engineering Services 0121 627 4244
John Yates, University of Sheffield 0114 222 7748

Noise Vibration & Human Perception Group

Acting Chairman
John Wilkinson, Millbrook Proving Ground 01525 408239
Members
Marco Ajovalasit, Brunel University 01895 267 134
Alan Bennetts, Bay Systems 01458 860393
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Peter Clark, Proscon Environmental 01489 891853
Richard Cornish, University of Central England in Birmingham 0121 331 5416
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Chairman
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Dave Ensor, MIRA 02476 355295
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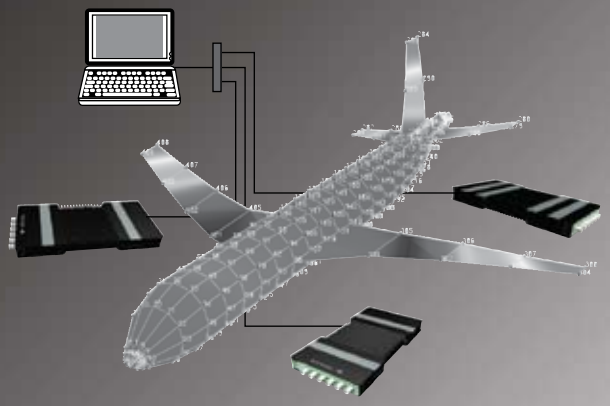

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Bedford House · Rutherford Close · Stevenage · Hertfordshire · SG1 2ND
Telephone: 01438 739 000 · Fax: 01438 739 099
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