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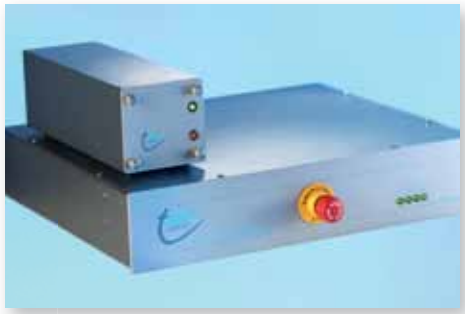

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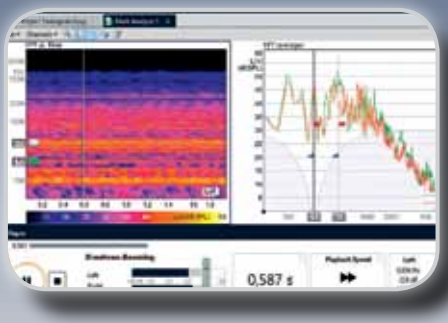

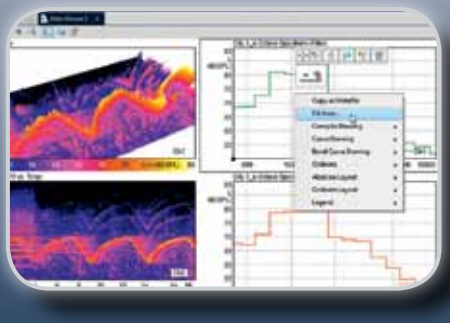

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Front Cover: Courtesy of Downing College, Cambridge. Venue for Fatigue 2017, 3-5 July 2017.

EDITORIAL POLICY

Engineering Integrity contains various items of information of interest to, or directly generated by, the Engineering Integrity Society. The items of information can be approximately subdivided into three general categories: technical papers, topical discussion pieces and news items. The items labelled in the journal as technical papers are peer reviewed by a minimum of two reviewers in the normal manner of academic journals, following a standard protocol. The items of information labelled as topical discussions and the news items have been reviewed by the journal editorial staff and found to conform to the legal and professional standards of the Engineering Integrity Society.

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.

'Engineering Integrity' is lodged with the Agency for the Legal Deposit Libraries on behalf of the Bodleian Library Oxford University, the Cambridge University Library, National Library of Scotland, National Library of Wales and Trinity College Dublin.

Editorial

Another editorial, another surprise from the electorate, albeit on the other side of the Atlantic. 2016 was certainly not a good year for the opinion pollsters - a reminder to us all of the importance of representative data sets.

While public opinion may be fickle, we can only hope that policy in matters technological are at least influenced by the underlying science. The sudden transition of the diesel engine from climate change saviour to air pollution villain is a heady cocktail of industrial misdeeds and political/media over simplification. When an issue has multiple competing facets, in this case CO_2, NO_x and particulate emissions, any sensible discussion is inherently quantitative. As financial issues are the only ones that seem to get any sort of quantitative treatment in the main stream media, it falls to experts to make the case. When those experts are associated with a particular industry, their credibility rests on the perceived integrity of that industry. One company falsifying data leads to the suspicion that everyone does it, so no numbers are believable and decisions are made in a data vacuum. It is ironic that the fundamental scientific principle of reproducibility is forgotten - the very claims that can be verified or rebutted are ignored because a subset of them were repudiated.

While the diesel car drivers around me are waiting for a lynch mob around the next corner, I'm trying to adjust to the efficiency measure of an electric car. While mpg is a headline figure for petrol and diesel engines, I had to hunt for my miles per kWh figure - range seems to be the key performance indicator in this sector. Not only are the KPI's different, but regenerative braking turns the traditional urban, extra urban efficiency concept on its head – fighting wind resistance on the motorway becomes the real power drain. Environmentally of course the electricity has to come from somewhere. At 4 mpkWh a domestic solar PV installation covers typically annual mileage. On a much grander scale tidal power schemes are still making headlines with renewed support for an experimental lagoon in Swansea bay – I might get to watch the power to get me home being generated!

In a break from tradition, but following the Society's goal of promoting the development of young engineers, the technical papers in this edition have been produced by students. If you have students, please encourage them to contribute their work.

Our first paper entitled 'Failure analysis of a bearing cap on a piston connecting rod' is a topic close to my own interests, where a picture really can tell a thousand words. It reminded me of my first failure investigation - an LP turbine blade on a brand new marine engine, 8 hours into its maiden voyage, leading to a catastrophic failure of several last stage blades. The fractography was spectacular.

The second paper entitled 'Bicycle design for improvements in aerodynamic design', offers an insight into the time savings that can be obtained with correct choice of bicycle frame shape. Having sat through many stages of the tour de France and watched bike changes between mountain stages and time trials, I now have a better appreciation of what all the fuss is about – I do wonder what would happen to this once you put a rider on top and how much ultimately comes down to rider position…

This time last year we were contemplating the disappearance of the UK's capability to produce steel. Twelve months on the outlook seems much brighter, with Tata investing a billion pounds in its plants across the UK. While there are bound to be some interesting times ahead across industry and academia as the UK changes its relationship with the EU, Tata's investment in a key sector can only be good news - at least until someone decides to reinstate Offa's Dyke.

Karen Perkins
Honorary Editor

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Technical Articles by Young Engineers

One of the aims of the Engineering Integrity Society is to support younger engineers with their professional development. With this in mind the society has offered final year engineering students the opportunity to submit a short paper to the journal. The articles below are the first in a series of these papers and we will be publishing more from time to time.

We wish to encourage young engineers to become more involved with the society. With their broad-ranging expertise our members have a wealth of knowledge to offer to young engineers as they move into employment. The society has already held the first in a series of Young Engineers seminars at Birmingham University in December and a report can be read on page 20.

Failure Analysis of a Bearing Cap on a Piston Connecting Rod

Supervisor: Dr. S.W. Stafford at The University of Texas at El Paso
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Abstract

A bearing cap on a piston connecting rod failed while in service which led to a failure analysis investigation. Metallographic analysis revealed a microstructure of pearlite in a proeutectoid ferrite matrix along with manganese sulfide inclusions and carbides present throughout. Fractographic analysis of the failed specimen showed classic brittle fracture, evidenced by secondary cracking, transgranular cleavage and river patterns. Brittle fracture of the bearing cap is believed to be caused by the underlying manufacturing method of intentionally fracturing the bearing cap bolt mating surfaces, as they are sites of high stress concentration.

Keywords—Non Destructive Examination, Optical Microscopy, Scanning Electron Microscopy, Fractography, Secondary Transgranular Cracking, Transgranular Cleavage, River Patterns, Brittle Fracture.

I. BACKGROUND

A bearing cap of a piston connecting rod assembly failed during service. It was a part of a Ford F-150 series, 4-stroke engine from a 2006 - 2008 model. Based on manufacturing processes from this time frame, the bearing cap process consisted of intentionally fracturing the cap and fastening the sections with bolts, known as an intentional fracture rod.

II. FAILURE ANALYSIS & INVESTIGATION

A. As-Received Condition

Initially, a failure analysis investigation begins with documentation of the as-received condition without making assumptions. This includes measurements, documentation of unordinary findings and photographic evidence.

Figure 1 (a) is a front facing view of the bearing cap on a piston connecting rod. The base of the piston is measured approximately 3.25 inches in diameter. It is visible along the bearing cap, there are two bolts on the outer rim where separation is present. The length of the piston connecting rod assembly is approximately 11.75 inches. Figure 1 (b) illustrates a fracture surface along the bearing cap near one of the bolt mating surfaces; it is measured at 90° relative to the base of the piston. Figure 2 is a magnified view of the piston rim. It is observed at the 'top' of the rim, there is significant damage where material has been lost. The diameter of the piston rim is measured approximately 1.675 inches.

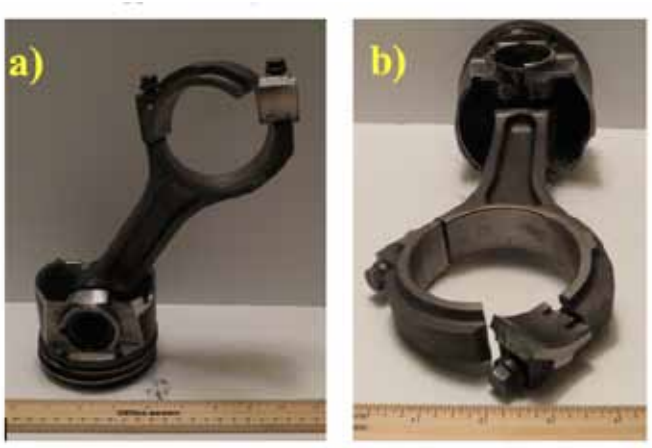


Figure 1. As-received documentation of the piston connecting rod assembly: a) front facing view; b) longitudinal top view

Figure 2. Magnified view of piston rim with noticeable damage

B. Non-Destructive Examination

Non-destructive examination (NDE) is an evaluation technique which utilizes a variety of tests to identify underlying issues of the component, if any. X-Ray fluorescence (XRF) was performed on the base of the bearing cap to determine the chemical composition of the component. A Niton XL2 GOLDD XRF gun was used to perform the analysis. Table 1 is an average reading. It outlines primary elements of the chemical composition indicating the bearing cap contains an iron (Fe) content of 92.78% wt.

Table 1. Chemical composition using X-ray fluorescence

Element	% wt.	+/-
Fe	92.78	0.17
Cu	4.14	0.05
S	0.98	0.01
Al	0.94	0.07
Si	0.54	0.02
P	0.371	0.008
Mn	0.26	0.01
Cr	0.037	0.007

Wet Fluorescent Magnetic Particle (WFMP) testing was performed on the entirety of the bearing cap. This method of non-destructive testing was performed to identify, if any, surface discontinuities which may have induced failure. Prior to testing, the surface was cleaned to remove residual grease and/or lubricant. The bearing cap was then magnetized in three directions: 90°, 180°, and 45°, separately by a standard horseshoe magnet from First4Magnets. Once magnetized, the bearing cap was sprayed with magnetic particles and held under a black light to highlight surface discontinuities. MAGNAGLO WB-655 water-oil based particles were used. During the inspection, of all three directions, the bearing cap was free from surface discontinuities on the outer rim, inner rim and surface near the fracture surface of the bearing cap.

C. Chemical Analysis

Following NDE, further chemical analysis was required. As a result of the limitations of XRF readings which do not read elements above aluminum, carbon is not read in the chemical composition. Because carbon is a crucial element in determining the type of steel, optical emission spectroscopy (OES) was used. A TEST-MASTER Pro OES machine by Oxford Instruments was utilized to perform the various scans. OES was performed after NDE because it is a semi-destructive test leaving behind circular burns on the surface where the composition is read. Table 2 is a compilation of the various scans which were taken. It is observed that the carbon content ranges from 0.328 – 0.365% wt.

Table 2. Chemical composition using Optical Emission Spectroscopy

Element	Burn 1	Burn 2
Fe	93.3	93.5
C	0.328	0.365
Si	0.732	0.928
Mn	0.661	0.706
Cr	0.0144	0.0189
Al	0.0042	0.0137

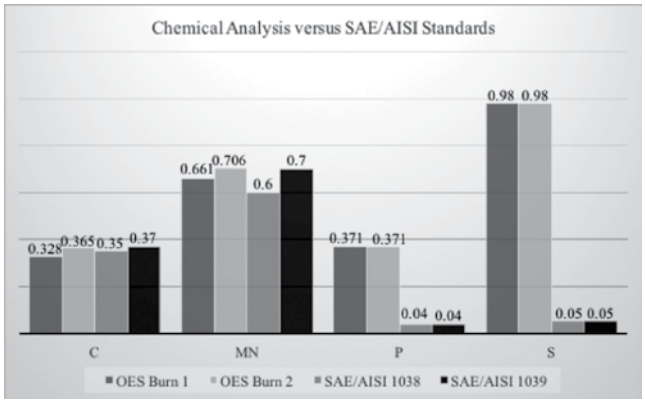
Table 3 specifies the standard chemical composition for automotive parts of 1038 and 1039 steel. The Society for Automotive Engineers (SAE) has established standards for specific operating conditions, in which, the steel that is required must attain a chemical composition within the ranges specified. It is shown in Table 3 that the maximum sulfur content should not be greater than 0.05% wt. and carbon content should be maintained within the ranges 0.35 – 0.42% wt. and 0.37 – 0.44% wt. for J403 – 1038 and 1039 steel grades, respectively. Graph 1 is a representation of the data collected from Table 2 and Table 3. It is observed that the carbon content for both OES burn scan 1 and burn scan 2, are well within range for SAE standards. The manganese content from the OES burn scans 1 and 2 are 0.661 and 0.706 % wt., respectively, which is within range from SAE standards. As for the phosphorus and sulfur content, the maximum content is exceeded well above the SAE standards for J403 – 1038 and 1039 steel grades.

Table 3. Chemical composition of SAE standards 1038 and 1039 steel

	C	Mn	P	S
SAE Standards (J403) 1038	0.35–0.42	0.60–0.90	Max 0.04	Max 0.05
SAE Standards (J403) 1039	0.37–0.44	0.60–0.90	Max 0.04	Max 0.05

D. Surface Cleaning

The as-received samples were minimally oxidized. In order to clean the fracture surface without damaging the fracture surface and maintaining the part integrity, the bolts were removed to separate both the fracture surfaces, from the bearing cap. Once removed, the fracture surfaces were cleaned using an ultrasonic bath which was a RS Pro Ultrasonic Cleaning Tank 100W, 3L with lid. Alconox is a concentrated anionic detergent; it was diluted with water and



Graph 1. Chemical composition of OES scans compared to SAE standards

both sides of the fracture surfaces were ultrasonicated for 10 minutes, separately. By using an ultrasonic bath, oxide particles were removed to make the fracture surface more visible for macroscopic evaluation.

E. Macroscopic Analysis

Once the fracture surfaces were separated from the bearing cap and cleaned, they were observed macroscopically. It is evident from Figure 3, the fracture surfaces are shiny and granular in appearance. Figure 3 (a) is referred to as the 'top' fracture surface while Figure 3 (b) is referred to as the 'bottom' fracture surface. Observed macroscopically are markings on the outer rim diameter of the bearing cap, indicated by the arrows. The arrows in Figure 3 (a) highlight the intrusions on the top fracture surface while the arrows in Figure 3 (b) highlight the protrusions on the bottom fracture surface.

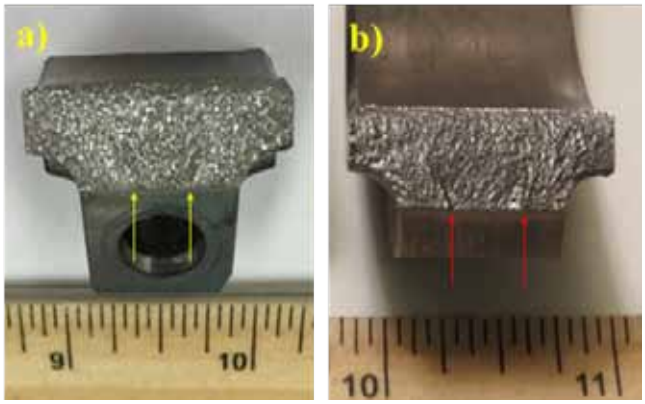


Figure 3. Macroscopic evaluation of the fracture surfaces: a) top fracture surface; b) bottom fracture surface

F. Sectioning

Following macroscopic evaluation, sections were initially made transversely. This transverse section was made on the top fracture surface to evaluate the microstructure beneath the fracture surface as seen in Figure 4 (a). By doing this, it provides insight into the microstructural integrity of the fracture surface, under the assumption that the microstructure is the same at the fracture surface. Figure 4 (b) depicts an axial section which was made near the protrusion. The axial section was made to determine if secondary cracking into the microstructure was evident.

*** It should be noted, the axial section was not made until fractographic analysis was observed on both, top and bottom, fracture surfaces.

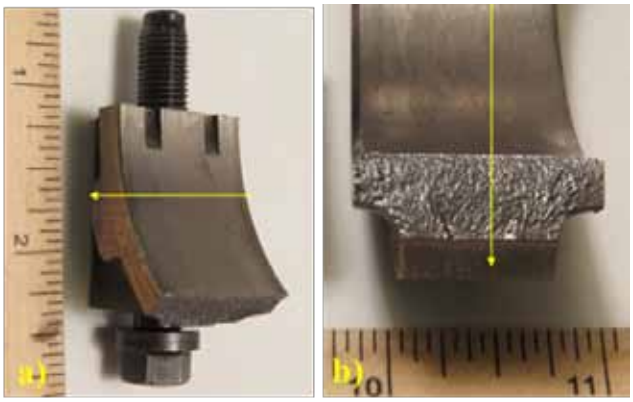


Figure 4. Schematic of sections made at/near the fracture surface(s): a) transverse section of the top fracture surface; b) axial section of the bottom fracture surface

G. Metallographical Evaluation

Following sectioning, the samples were polished with a series of grit paper to remove fine scratches on the surface and produce a mirror-like finish. Initial grinding utilizing the various grit paper which follows an order as such: 50, 60, 80, 120, 150, 180, 220, 240, 280, 320, 400 and 600, 1200. Once polished using the grit paper up to 1200, a fine grit, the sample was further polished with a microfiber polishing cloth and lubricated with alumina powder, KEMET – Alpha Alumina powder: 1.0µm, 0.3µm and finally 0.05µm. The samples were polished using METPOL 1V Metallographic Grinder by MetLab Corporation.

Once the samples were polished and attained a mirror-like finish, 2% Nital was used to etch the surface to reveal the microstructure using an AmScope B120C Siedentopf Binocular Compound Microscope. A series of etches were done by dipping the sample face down into the solution for 2 seconds followed by subsequent immersion for 5 seconds. A total of 7 seconds produced a sufficient etch revealing the microstructure with minimal areas of over etching.

Figure 5 (a) is a micrograph of the transverse section of the top fracture surface. The evidence reveals a microstructure of a proeutectoid ferrite matrix with colonies of pearlite. This

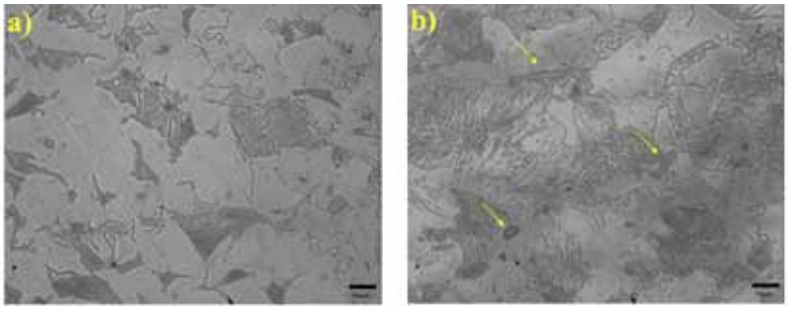


Figure 5. Micrograph of the transverse section: a) microstructure near the surface of the outer rim of the bearing cap; b) microstructure at/near the center of the sample.

micrograph was taken near the surface, placing it at/near the outer rim of the bearing cap. As indicated by the micrograph, there are few pearlitic colonies throughout the ferrite matrix. Figure 5 (b) is a micrograph of the transverse section of the top fracture surface, at/near the center of the sample which places the microstructure in the mid-section of the bearing cap. Similarly to Figure 5 (a), the microstructure consists of a ferrite matrix with colonies of pearlite with a slight variation in the density of pearlitic colonies. It is evidenced, near the center of the sample, there is a wide distribution of pearlite colonies. As highlighted by the arrows in Figure 5 (b), there is a small distribution of inclusions present in the microstructure. Figure 6 is a micrograph of the axial section which was made near the protrusion of the bottom fracture surface.

Figure 6 (a) depicts a rigid fracture surface and secondary cracking originating off a ridge; this is highlighted by the box. Figure 6 (b) is a magnified view of the area highlighted in Figure 6 (a). As seen, the crack originates off the fracture surface and runs through the grain boundaries.

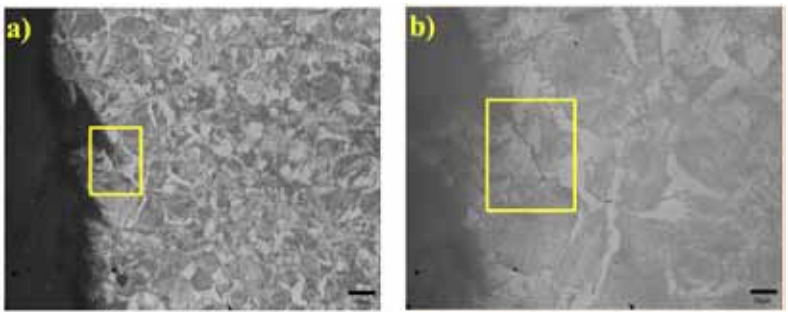


Figure 6. Micrograph of the axial section on the bottom fracture surface: a) microstructure at the fracture surface; b) magnified view of the fracture surface showing secondary cracking.

H. Fractographic Evaluation

Fractographic analysis was performed using a HITACHI Ultra-High Resolution Scanning Electron Microscope SU9000. These analyses were completed in tandem with metallographic optical microscopy. Figure 7 is a fractograph of the top fracture surface. It is seen in Figure 7 (a) there is an abundance of mechanical damage surrounding the intrusion taken at 20,000 volts at 30x magnification. Figure 7 (b) shows fracture evidence of transgranular cleavage. Within the transgranular cleavage, there are cleavage facets and river patterns indicating the direction of fracture. On the outer edges of the fractograph, Figure 7 (b), mechanical damage is still present.

Figure 8 is a fractograph of the bottom fracture surface of the bearing cap near the visible protrusion. Figure 8 (a) was taken at 20,000 volts at 30x magnification; there is an abundance of mechanical damage, limiting the view of the fracture evidence. The area highlighted by the yellow box, is the area Figure 8 (b) was taken. Near the protrusion, at 20,000 volts and 800x magnification, transgranular secondary cracking through the cleavage facets is evidenced.

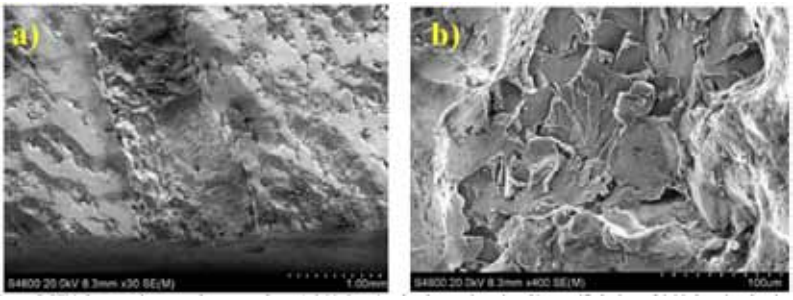


Figure 7. SEM fractography - top fracture surface: a) initiation site showing an intrusion; b) magnified view of initiation site showing transgranular cleavage.

III. RESULTS

Throughout the investigation, the background information which was obtained gave insight into the processing of the bearing cap. The bearing cap on the piston connecting rod is an intentional fracture rod where the bolts were used to mate these surfaces on the bearing cap.

At the time of receiving the piston connecting rod assembly, the fracture surface - which is 90° relative to the base of the piston, were mated. However, during photographic documentation,

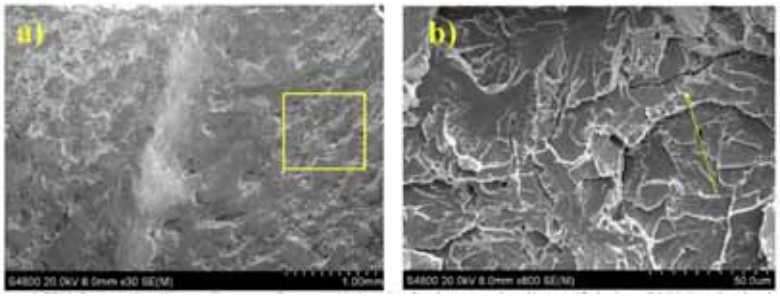


Figure 8. SEM fractography - bottom fracture surface: a) initiation site showing protrusion; b) magnified view of initiation site showing secondary cracking

the fracture surfaces were never mated and kept apart to minimize mechanical damage. During NDE, wet fluorescent magnetic particle testing did not reveal surface discontinuities near the fracture surface, indicating fracture did not occur from an external source.

The chemical composition obtained through XRF and OES were consistent with one another and to that of a hypoeutectoid steel. The iron content was approximately 92.78% wt. with a carbon content within the range of 0.328 – 0.365% wt. Based on the chemical composition from the OES burn scans relative to the SAE standards, the phosphorus and sulfur content is out of range. Because of this, it is detrimental to the mechanical properties of the bearing cap due to increased susceptibility to formation of inclusions and competition sites formed at the grain boundaries. It is evidenced by the microstructures seen during metallographic evaluation.

As seen in the micrographs, there is a depletion of pearlite at/near the surface of the bearing cap which reduces the strength. Near the center of the sample, it is shown that there is an abundance of pearlite which maintains its strength; however, the presence of inclusions will have a counteracting effect on the mechanical properties. Based on the chemical composition and electro dispersive spectroscopy, the inclusions were observed to be MnS – manganese sulfide – inclusions.

The fractographic analysis using scanning electron microscopy, showed classic brittle fracture evidenced by transgranular cleavage, cleavage facets and transgranular secondary cracking. An axial section of the bottom fracture surface was made near the protrusion after secondary cracking was observed in the SEM. The metallographic evaluation of the axial section supported the evidence of secondary cracking, showing that secondary cracking originated off the fracture surface, leading into the microstructure.

IV. CONCLUSIONS

Based on the evidence throughout this failure analysis investigation, it is evident that the bearing cap on the piston connecting rod assembly failed as a brittle fracture. From metallographic and fractographic analysis, the evidence revealed classic brittle fracture evidence, to include transgranular cleavage, river patterns and secondary cracking. Although little background information was able to be obtained, it is proven that the bearing cap failed in a brittle manner induced by stress concentration at the machined sites near the fracture surface.

ACKNOWLEDGMENT

The author gratefully acknowledges the support from the Department of Metallurgical and Materials Engineering at the University of Texas at El Paso.

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Diary of Events

Instrumentation, Analysis & Testing Exhibition
Silverstone
14 March 2017

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Downing College, Cambridge
3-5 July 2017

Young Engineers Seminar - date to be arranged

Supported Events:

IMechE – Non Destructive Testing
21-22 March 2017, Sheffield

IMechE - Late Life Care of Ageing Assets
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Bicycle design for improvements in aerodynamic properties

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Abstract— The main force cyclists have to overcome is air resistance. As bicycles have evolved and developed more focus has been made into the refinement of their design, with more aerodynamic profiles being utilised to cheat the wind. The research conducted aims to analyse the effect of these different profiles on the structural properties of the frame and each of their effects on aerodynamic efficiency. Aerodynamic analysis of both frame and 3D profiles will be conducted. Computational Fluid Dynamics in SolidWorks will be used to simulate the frames and profiles at wind yaw angles of 0, 5, 10, 15, 20 degrees.

Keywords—Cycling, Bicycle Design, Computational Fluid Dynamics, Performance, Kamm Tail, Aerofoil, Truncated Aerofoil.

I. INTRODUCTION

Cyclists, both professional and amateur face continual opposition to forward movement by four main forces; frictional resistance of the drive-chain, rolling resistance, gravity and finally air resistance. Since the bicycle was conceived as a transportation device, continual refinement of the design has taken place. This has not been solely constrained to individual components but an integration of the system, a synergy of rider and machine to create the most efficient method of movement in history. The sport of professional cycling has evolved from being quirky and niche, to one that is now truly global with hundreds of millions of euros being spent in the top tier of the sport. As the sport has grown, the need for lighter, stiffer, and ultimately faster machines and components has driven the bicycle industry into € 1.05 billion industry in the UK alone (2015) [1]. Almost all bicycle companies now produce a whole variety of machines for these different purposes. Since the Cervelo Soloist was launched in 2001 [2], the equivalent of an arms race in the bicycle industry has ensued to produce the most efficient and fastest racing machines possible [3].

The research conducted herein will be based upon a Cannondale CAAD10 size 56cm racing frame. This is a widely used aluminium frame, which is considered a benchmark for design and performance. The frame will be unchanged apart from the alteration of the 'down tube', which will be altered from the standard round tube to three different aerodynamic shapes. The three shapes to be analysed are a standard symmetric NACA0010 aerofoil, this will be then altered to form a kamm tail and a truncated aerofoil shape with a trip feature. These profiles are all common throughout the bicycle industry with varying claims made about their efficiency made by numerous manufacturers.

A. Research Objectives

This paper will investigate how the optimisation for more aerodynamically efficient bicycles alters aerodynamic efficiency of the frame. All testing for the frame, will be undertaken on a frame as a single unit, without wheels or fork to solely test the various tubes shapes. These will be conducted according to both the International Cycling Association (UCI), and the European Standards for Racing Bicycles [4]. Three completely different aerodynamic profiles will be examined. The profiles used are common within the bicycle industry. A direct comparison between all four profiles, including a round tube, has not been investigated before. Thus, this paper will allow for a direct comparison of the effect that these four tube profiles have upon the frame.

Aerodynamic modelling is to be conducted using SolidWorks Flow Simulation Computational Fluid Dynamics (CFD) package, with transient flow analysis. The scenario for testing the frame is based upon typical race speeds. Depending on terrain this varies from 32 to 48 kph [5]. Subsequent aerodynamic testing uses a velocity of 43kph, a typical speed for flat stages, or time trial events where aerodynamic forces are dominant. This equates to 12m/s, at standard air conditions (20°C, 1atm) through various yaw angles; 0, 5, 10, 15, 20 degrees. These conditions are taken from sources within the industry, specifically various conditions and situations that bicycle manufacturers use to analyse their frames.

II. COMPUTATIONAL METHODOLOGY

A. Frame and aerodynamic profiles

For experimental computational modelling to be undertaken, a three-dimensional model of the frame must be made. For this SolidWorks design software will be utilised. As previously stated a Cannondale CAAD10 racing frame will be used as the basic model, with three additional iterations of the frame, each with a different down tube aerodynamic profile. Figure 1 details the geometry of the frame, specifically the 56cm size. The SolidWorks model takes dimensions from this, so that the frame is an exact representation of a CAAD10. The only alteration from this design is the enlargement of the base of the seat tube, notation 'B', from internal radius 15.6mm to 20mm to accommodate a wider junction that is required for the thicker aerodynamic profiles. This is an important adaptation in order for all four frame to be identical, apart from the obvious profile change in the down tube.

The governing body for professional cycling, the International

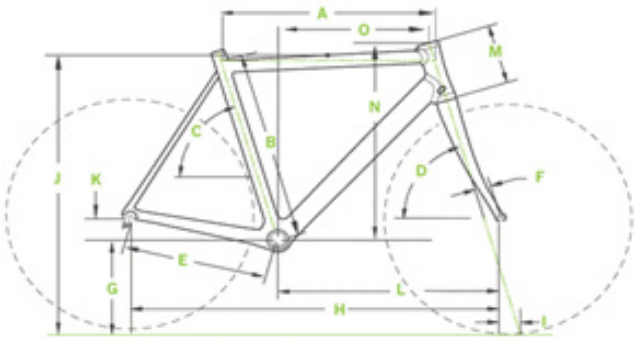


Figure 1 - Cannondale CAAD10 Geometry [6]

Cycling Association (UCI) dictates how bicycles are designed and manufactured [4]. The rule which is most relevant for this study is the 3:1 ratio. This dictates that 'the length of an element must not exceed three times the width' (Article 1.3.021) for the design of each structural member of the frame. If a bicycle manufacturer does not comply with these regulations, then the component, frame, wheels or handlebars, cannot be used in competition, therefore rendering the product unusable by professionals. As design within the sport is driven by racing, consumer products are usually exactly the same, thus if a product is not UCI compliant time and money will not be spent developing it. In order for the frame to be compliant with the UCI regulations, no alterations were required for the existing frame design as this already holds a UCI certification. However, the 3:1 ratio rule must be applied when considering the various aerodynamic shapes.

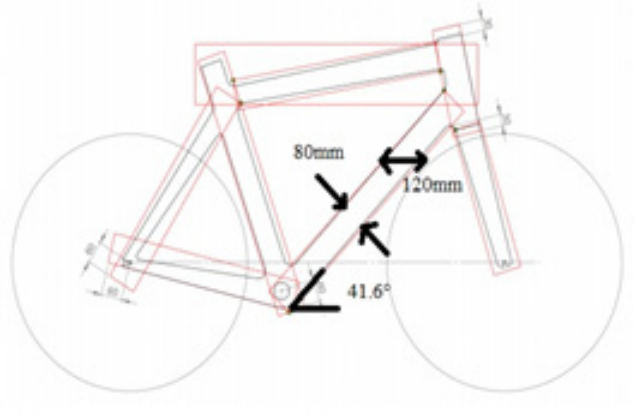


Figure 2. UCI Frame Regulation 1.3.020 [4]

UCI rule 1.3.020 [4] dictates that tube profiles cannot exceed the given 80mm box, for which they must be retained within, Figure 2. This rule stems from the UCI's desire to keep bicycle frame design in keeping with the traditional double triangle shape and without excessive aerodynamic profiles. This means that due to the geometry of the CAAD10 the longest possible profile for an aerofoil or similar, is 120mm.

B. Aerodynamic Tube Profiles

Within the bicycle industry numerous tube profiles are used, with different shapes and sizes being utilised to provide different levels of aerodynamic efficiency and stiffness, all of which are dependent on the area of the frame where they are applied. The most common profile is a standard symmetric aerofoil as it is generally considered to be the most efficient shape. For this study the NACA0010 will be used. As this is deemed to be the most efficient shape, its profile will be maximised to the upper limit allowed by the UCI, specifically the 3:1 ratio. Exact dimension are shown in Table 1.

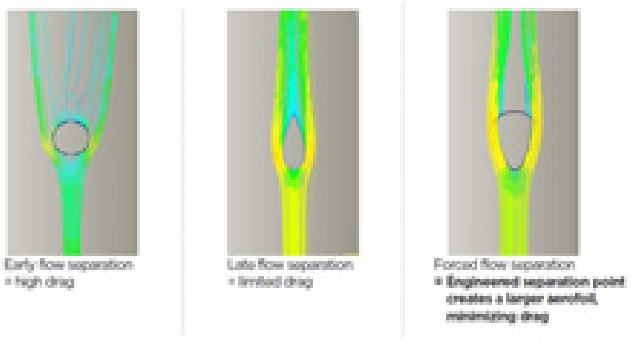


Figure 3. Profile Streamline Flow Variations [7]

The kamm tail design uses an aerofoil with the rear section cut off, usually around the thirty to forty percentage of chord. The theory behind the profile is that the separation point is engineered in such a way that it creates a large 'virtual' tail, which according to manufacturers vastly improves efficiency, especially at increased yaw angles, whilst still maintaining high tube stiffness, as observed in Figure 3 [7]. Sizing for the kamm tail is taken from the Scott Foil bicycle.

Finally, a truncated aerofoil shape with a trip feature will be analysed. This profile has become popular with one company in particular, BMC of Switzerland. They state that 'the trip features create a small amount of turbulence over the surface of the frame that prologues flow separation' improving aerodynamic efficiency [8]. Figure 4 details the formation of this turbulent layer.

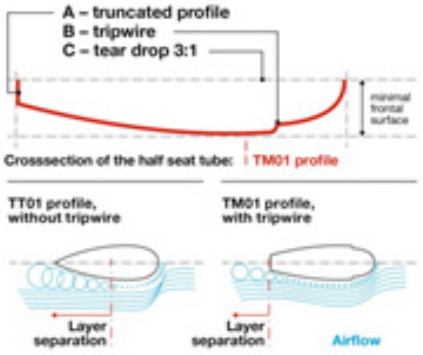
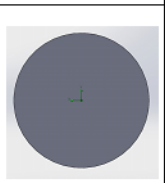
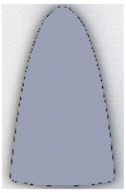


Figure 4. Truncated aerofoil [8]

Both kamm tail and truncated profiles are also claimed to have the advantage of reducing material required whilst

maintaining an apparent aerodynamic advantage. They are also said to greatly increase the stiffness compared to a standard aerofoil shape. The following methods will be used to investigate these claims and draw conclusions on what is generally perceived as marketing hype.

Table 1. Tube Profiles (not to scale)

Round	Kamm tail	Truncated	Aero
Diameter: 52.2	Length:70mm Width:36mm	Length:120mm Width: 40mm	Length:120mm Width: 40mm
			

III. COMPUTATION FLUID DYNAMICS

A. Methodology

Unlike other CFD tools SolidWorks has an embedded and essentially automated software package to allow for ease of use and for computation of complex flow structures. The SolidWorks CFD simulation package uses a revised k-Ɛ turbulence model, with inclusion of rotational and shear flow, along with its immersed Cartesian meshing method to solve 3D steady Reynolds averaged Navier-Stokes equations. This allows for simulation of various turbulent flow scenarios whilst maintaining a low mesh density to reduce computation requirements and time [10]. To compute fully turbulent flow without the use of a super computer would be practically impossible; however, using this flow simulation software with an added time-step function transient fluid flow can be achieved, resulting in accurate drag values.

The following simulations are all run at 12m/s, and through yaw angles; 0, 5, 10, 15, 20 degrees. This is a standard procedure for bicycle wind tunnel testing, to simulate variations in drag with wind direction at average riding speeds. In a real world scenario the variations in wind velocity, direction and turbulence are continually changing as a rider progresses along a road. To simulate this accurately without spending thousands of hours collecting real world data is impractical. Instead, the scenario is simplified to in essence a straight road, with constant wind speed with varying yaw angle, or angle upon which it acts on the bike changes. This allows for analysis through various wind condition, although without the complex natural wind turbulence.

B. Flow Simulation Procedure

Simulation for transient flow predictions is undertaken by selecting external analysis of the frame with time dependence set with total analysis time of 10 seconds with an output time step of 1/24 seconds. Initial conditions are set at standard sea level conditions, 20°, 1 atmosphere (101.325 kPa) with air as the operating median. Laminar and turbulent flow characteristics are set with default values, as embedded within SolidWorks flow simulation, with adiabatic wall, roughness zero. This allows for development of turbulent flow throughout the time domain, whilst having no interference from the computational domain. The computational domain is set with the following dimensions, as seen in Figure 5, to minimise interference that will reduce the accuracy of results. An additional refinement in the calculation using control options, refinement properties, means that the solver will refine the mesh between iterations to better capture flow structures, especially areas where vortices form.

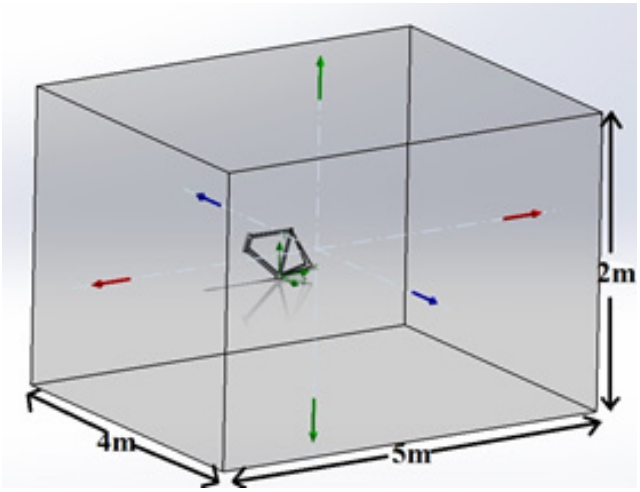


Figure 5. Computational testing domain (wind tunnel)

A global mesh must be determined that is able to fulfil accuracy requirements by being fine enough whilst, also allowing for reasonable processing time and not overloading the processing power of the computer. Too fine a mesh has caused a complete computer shutdown numerous times. The global mesh used in all simulations uses an initial mesh value of 5 and mesh refinement of 5, out of a possible 10. This allows, firstly for the computer to run the simulation with an appropriate simulation length, whilst providing accurate results, where more complex flow patterns are observed. The mesh density can be seen in Figure 6, note that the mesh density increases significantly around the frame due to the requirement for a finer mesh set in this region.

This study is primarily concerned with the drag created by changing the down tubes, for the simulation a global goal for drag in the X plane is allocated. As the yaw angles

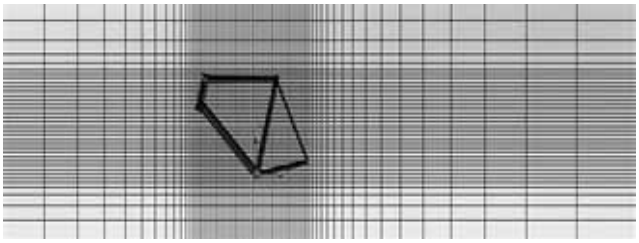


Figure 6. Mesh density

increase the effective drag force created by the frame alters through the X and Z components within the model. The rider is expected to lean and hold the bike to oppose the Z component so only the X component of drag is considered as this is the main force effecting forward movement. Initial calculations calculated changed in velocity as well, however, due to the increased time this required they were subsequently scrapped.

Following completion of initial set-up procedure and alterations for time dependency, the simulation is commenced.

Convergence of global goal plots determined the ceasing of the simulation. Usual running time for simulations is 1 hour 45 minutes and 2 hours, taking between 325 and 380 iterations. Figure 7 shows how a typical plot converges, although it appears to fully converge at around 70 iterations, the value continues to decrease until 325 in this instance.

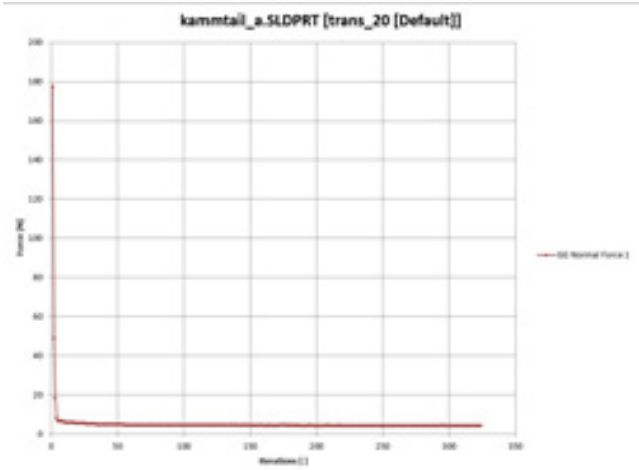


Figure 7. Convergence of goal plots

C. Flow Simulation Results

Simulation results taken from global goal plots are compiled where graphical representation of the drag variation across the various yaw angles are visualised. Flow plots and cut plots allow further investigation into the flow properties, especially whether turbulence is accurately predicted. Raw data from each of the simulations is shown in Table 2.

Significant figures are kept to a reasonable level to provide accuracy, usually this level would not be required however, and due to the small values it is important.

Table 2. CFD drag force data

Frame Type	Force (N)							
	Yaw Angle (degrees)							
	0	5	6	8	10	12	15	20
Round	2.5446	2.9052	2.9815	3.0996	3.1960	3.4893	3.9293	4.3220
Kamm tail	2.5105	2.6833	2.77615	2.9876	3.2364	3.3681	3.7516	4.4425
Truncated	2.4559	2.6745			3.3487		4.0097	4.5227
Aerofoil	2.3711	2.7428			3.0372		3.8068	4.4141

Figure 8 illustrates how the drag increases as the yaw angle becomes greater. When the wind is head on to the frame, the drag is highest for the round tube and kamm tail profiles, causes are due to the relatively early flow separation compared to the more aerodynamic shapes and the bluff body nature - especially for the round profile. At zero yaw the aerofoil is by far the most aerodynamic, producing 7% less drag. When yaw is increased to 5 degrees, the truncated aerofoil becomes the most efficient, albeit only marginally less than the kamm tail. As the yaw increases further, the truncated profile produces the most drag. Analysis will be undertaken with 2D models to determine whether the trip features are working effectively. As yaw increases to 20 degrees, the round profile produces the least amount of drag, the aerofoil and kamm tail produce very similar values while the truncated profile produces the most. Further scrutiny of streamlines show how the larger profiles act as a barrier to airflow creating more drag, whilst the kamm tail simply produces a larger turbulent wake than the round profile.

D. Quantifiable Savings

For real world analysis of what the results collated means for a rider, taking the power produced by a rider over a certain distance, the time saved can be calculated. For these calculations the power produced by the rider is taken at an average value of 300 Watts over a distance of 40km. This is a typical test conducted by numerous manufacturers, including Specialized and Trek Bicycle Corporations [5].

$$Power\ (W) = \frac{Force\ (N) * Distance\ (m)}{Time\ (s)} \quad (1)$$

$$Time\ (s) = \frac{Force\ (N) * Distance\ (m)}{Power\ (W)} \quad (2)$$

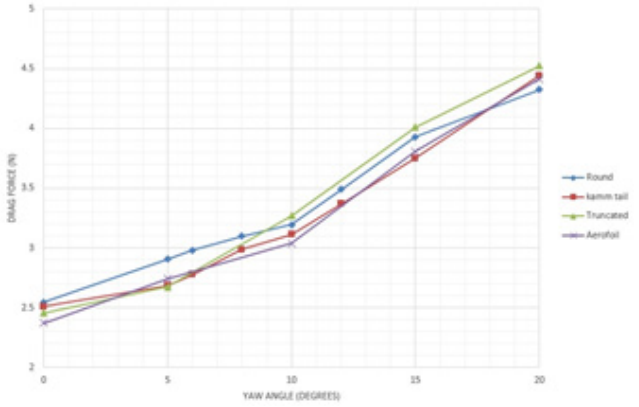


Figure 8. Drag versus yaw

The time element calculated for each profile is then compared to the data for the round profile, as this is taken as the benchmark for performance. The difference in time between the various profiles is calculated, giving data for time saved or lost, against the round tube through the various yaw angles. The results for this are shown diagrammatically in Figure 9. These savings, although small provide a huge gain for a rider, savings of 20 to 30 seconds are the difference between finishing 1st, or holding off a chasing pack instead of being caught on the line.

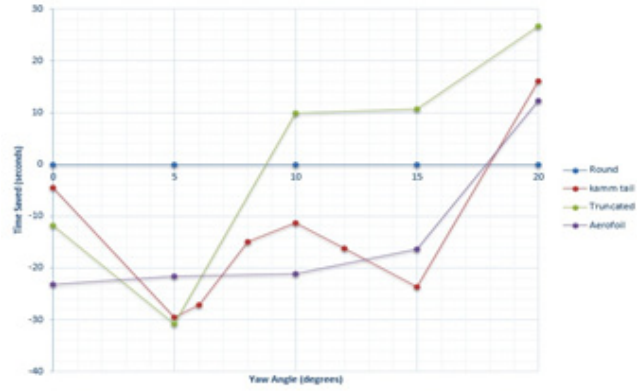


Figure 9. Time saved compared to round tube frame

From the frame alone, at an angle of zero yaw a rider will save 23 seconds by using the aerofoil, as the yaw angle increases to 5 degrees, the kamm tail and truncated profile provide the most savings at 30 seconds. This could be due to the ability of both profiles being able to shape the airflow and as manufactures claim, trip the airflow to allow for small amounts of turbulence, creating a movable 'virtual' tail to the profile [7][8]. The efficiency of the kamm tail and truncated profile drop significantly after the 5 degrees of yaw. The truncated profile becomes so inefficient that it concedes firstly 10 and then 27 seconds to the round profile. Analysis of the 2D profile will investigate the effectiveness of the trip features to further understand why this occurs. The aerofoil maintains an almost consistent advantage over the round tube until yaw angles exceed 15 degrees, where the time saved drops from between 23 and 16 seconds to conceding 12 seconds on the round frame. Based upon numerous claims made by manufactures, this was not expected. The aerofoil typically is very efficient at low yaw angles, but as the yaw angle increases, the profile would be expected to act in a far less efficient manner. With flow separation occurring very early on the leeward side, causing a large area of turbulence. Figure 10 shows how the streamlines interact with the frame, in this case the kamm tail profile. As expected, the joints between the different tubes, where numerous tubes intersect the air flow causes the most interference in the streamlines. The interaction between the air and the more complex features creates large amounts of turbulence. Isolating the exact effect from the tube in the frame becomes more complex, so a 2D simulation is used to analyse the formation of vortexes. This is firstly to confirm that the simulation tools are predicting vortex shedding that would be expected at a certain Reynolds number. Secondly, to provide more understanding of the characteristics of each profile, especially how turbulence forms as yaw is increased.

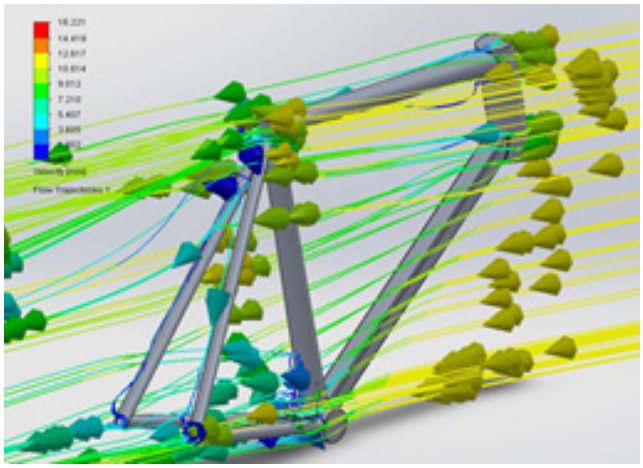


Figure 10. Streamline flows around kamm tail profile

E. Clarification of Transient Flow

To confirm that the simulation undertaken provide transient flow, and turbulent flow characteristics with expected vortex shedding characteristics, two dimensional simulations of each tube profile will be carried out. These simulations will follow the exact methodology and procedure as the frame analysis, albeit with a smaller computation domain for 2 dimensional analysis. The intention of these further tests is to observe Von Karman vortex shedding from the different shapes [11].

The Reynolds number for the simulation on the round tube profile is calculated using equation 3. This predicts that the profile will experience fully developed Von Karman vortex shedding [12].

$$Re = \frac{\rho * V * D}{\mu} = \frac{1.225kg/m^3 * 12m/s * 52.2mm}{1.789x10^{-5}N.s/m^2}$$
$$= 43138.6 \quad (3)$$

Figure 11 shows the sequence of vortex formation on a round tube profile. The development from a pair of vortexes behind the profile into a large developed wake, where one vortex breaks away, followed by the second is as predicted by [11]. The vortexes continue to shed in an asymmetrical manner due to the non-symmetric pressure in the wake of the profile. This suggests that the study does show transient flow, and at the Reynolds number experienced the manner of vortex formation and shedding is what would be expected.

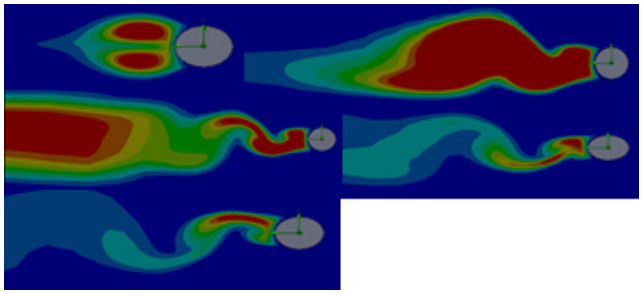


Figure 11. Formation of vortices round profile tube (sequence left → right)

Figure 12 details how vortexes form due to flow over the kamm tail. The Reynolds is again in the region that Von Karman shedding would be expected, the plots for turbulent viscosity clearly detail the development of the wake, and then subsequent asymmetric shedding of vortexes. It is widely published by manufacturers that the kamm tail produces a virtual 'tail'. In essence an area of turbulence that mimics the profile of the aerofoil that has been cut away. This is not witnessed in this study, however, as the flow formation patterns emerge in the first few seconds of the transient flow, a section of flow does appear to create a 'tail'.

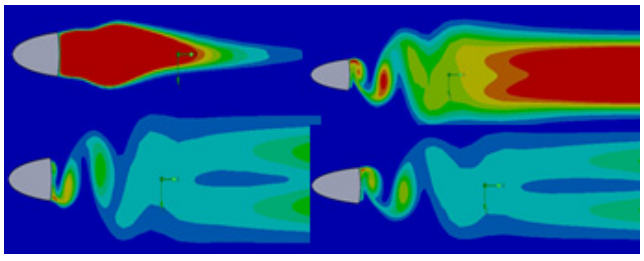


Figure 12. Vortex shedding for Kamm tail profile (left → right)

Figure 13 details how the vortexes are developed at 20 degrees of yaw. Although detailed analysis of exactly how the flow structure is effected, the variation in vortex intensity and size is clear. Both the aerofoil and truncated profile appear to have flow separation at around 50-60% of the chord however, the truncated aerofoil has a less intense vortex perhaps caused by the trip features reducing the drag produced.

The formation of these vortexes confirms the solver is predicting transient flow, and therefore the accuracy and legitimacy of the results is confirmed.

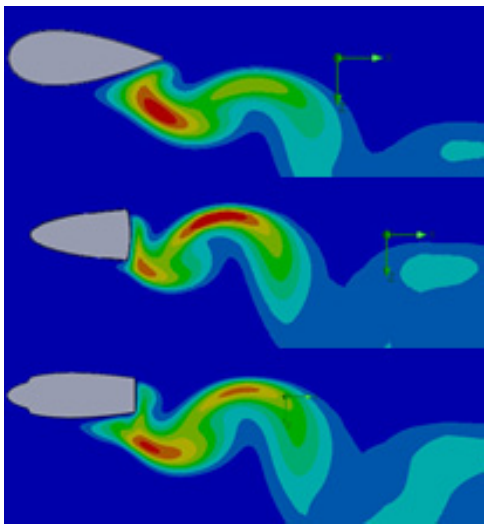


Figure 13. Vortex shedding at 20 degrees yaw

IV. DISCUSSION

A. Comparing the results

In perfect riding conditions with no cross wind the aerofoil as expected is the most aerodynamic profile for the frame, its ability to shift airflow efficiently is clear with over a 10 second advantage to the nearest competitor. However, as the yaw increases to 5 degrees the advantage tips to the kamm tail and truncated profile. As the yaw passes through 10 degrees the efficiency of the aerofoil remains relatively constant with the kamm tail reducing somewhat, in contrast the truncated profile develops incredibly inefficient flow with large areas of turbulence making it the least efficient option. Simulation of the 2D profiles shows how the creation of the large turbulent wakes reduces the efficiency of the truncated and aerofoil profiles while the kamm tail is able to maintain relatively efficient control of the air flow. Finally, as the yaw is increased to the maximum 20 degrees all profiles exhibit a loss compared to the round profile. Although, the results do not determine one particular profile for the optimisation of the frame, they do provide insight into the potential applications and compromises in further design work.

B. Limitations and Improvements

This project was undertaken solely using computation simulation as a means of testing and gathering results. As a results a number of limitations and assumptions have been made, some were intentional to deliberately limit the complexity, allowing more results to be gathered.

Initial simulations for CFD were undertaken with Altair Hyperworks Simulation software. This was deemed to be the most appropriate and accurate software available, a program widely used by Level 3 students in the aerodynamic simulation for their group design projects. However, due to the intricacy of the frames and the interaction between this and the test domain, subsequent simulation times over 8 hours led to the adoption of SolidWorks Flow Simulation software in late February. Simplifications within the SolidWorks flow simulation, primarily the formation of boundary layers and the interaction between tubes means that the results, although a good indication, could be far more accurate.

Firstly, improvements to the accuracy and reliability of the results could be achieved by increasing the computing power available. Time has been spent finding the balance between generating reliable results by using a fine enough mesh, whilst simplifying the model for appropriate simulation length. Current simulations have been run with a personal computer using an Intel i7 processor which used 8GBs of permanent full memory. This appears to have not generated totally accurate and therefore reliable results, and thus future tests would ideally be undertaken with a more powerful computer with large amounts of RAM. This would allow for a finer mesh to be created, which would hopefully allow for boundary layer formation to occur and provide more reliable results.

Secondly, the simplification of the project for analysis of only the frame was decided in order to achieve accurate results for the alteration of the downtube. More processing power would allow for simulations of not only frame, forks, wheels and handlebars, but the addition of the rider. This would naturally create more drag and be a more accurate simulation of real world applications, however, the effect of profile change for the downtube would be lost. If simulations such as this was to be undertaken then optimisation of the placement of certain tubes would mean interaction between rider and bike could be analysed.

Thirdly, the velocity at which the frame is simulated is in the higher regions of race average speeds, typically a speed associated with criterium [5] racing and time trials. Further simulations at a series of lower speeds would enable analysis of time saved in different scenarios to be undertaken.

V. CONCLUSIONS

This research project investigated the optimisation of frame design through the alteration of three different tube profiles, for their aerodynamic efficiency. The analysis focussed upon the creation of drag and subsequent changes in efficiency of the frames at different yaw angles. Aerodynamic simulations performed within provide useful information into the characteristics of the different profiles, and a basis for further investigations into the development of these profiles.

VI. ACKNOWLEDGEMENTS

I would like to thank my tutor, Professor Michael Friswell of Swansea University, for firstly, accepting this project proposal and secondly, for his continual support and guidance throughout the project. This topic is something that I have pondered for many hours whilst in the saddle. Comparing my companions, and competitor's bicycles, as well as my own. I have thoroughly enjoyed this research, understand and exploring real world engineering solutions in a sport that I love.

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Instrumentation, Analysis and Testing Exhibition, 14 March 2017, Silverstone

The 2017 Instrumentation, Analysis and Testing Exhibition will be held on 14 March in the Silverstone Wing. The exhibition will have 70 exhibitor tables covering a wide range of industries including aerospace, automotive, motor-sport, rail, off-highway, mechanical handling, industrial and power generation industries. Entrance to the exhibition and open forums is free and complimentary refreshments will be available. Car parking is also readily available and is free of charge.

A number of open forums will be held throughout the day on a diverse range of topics. The panels will be made up of experts from industry who will give short presentations expanding on the technical developments and take questions from the floor.

Forums

11.00 - 11.45 Techniques for Visualising Strain
Chairman: Norman Thornton (EIS)
Panel: Geoff Calvert (VisEng Ltd), Matthew Clavey (Thermal Vision Research), Rob Wood (GOM), Ian Jones (Airbus)

This forum will review the techniques available for physically visualising strain in components produced in a range of materials, including plastics and composites. Thermoelastic and modern photoelastic techniques will be covered as well as digital image processing.

11.30 - 12.15 Acoustic Challenges of Low Carbon Vehicles
Chairman: John Wilkinson (EIS)
Panel: Steven Dom (Siemens STS), Chris Knowles (JCB), Ian Ramsay (Polytec), Mark Burnett (Horiba-MIRA)

Downsizing internal combustion engines has a positive effect on the vehicle's fuel consumption, but inevitably impacts other performance attributes. Instead of running isolated campaigns targeted at individual attributes generating redundant and sometimes conflicting models and data sets, engineering processes are converging towards a unified testing and modelling methodology to balance multiple attributes in an optimal way.

This presentation will provide an overview of the acoustic and NVH challenges facing automotive manufacturers and outline approaches to co-optimize drivability, NVH, ride comfort and fuel economy, using unified testing and modelling methods.

14.00 - 14.45 Tyres and Road/Runway Interface
Chairman: Norman Thornton (EIS)
Panel: David Woodward (Ulster University), Owen Ardill (Highways England), Paul Philips (Aggregate Industries), David Shaw (Tyre Industry Research), Andrew Blows (JLR)

We will discuss this interface with regard to both the tyre and the road. Factors that affect grip and skid resistance and traffic and weather effects on both will also be explored. The presence of water at this essential interface will be debated. These discussions will relate to both road vehicles and aircraft and will include parameters and how they are measured.

14.15 - 15.00 Data collection and analysis - do it fast, do it cheap, or do it accurately - choose two
Chairman: David Ensor (EIS)
Panel: Andrew Halfpenny (HBM Prenscia), Steve Payne (Horiba-MIRA), Virrinder Kumar (HBM Prenscia)

This forum continues the theme covering practical issues around data collection and data analysis. Data collection engineers have the same constraints as anywhere else, but are also required to provide good quality data fit for purpose. We will discuss some of the best practices and tips in providing useful data, when being pressed for time, resources or unreasonable accuracy.

Exhibitor List

The following companies will be exhibiting:

A&D Europe GmbH
AB Mech Design & Analysis
AcSoft Ltd
ASDEC, University of Leicester
Bruel & Kjaer
CaTs[3]
Daqlog Systems Ltd
Data Acquisition & Testing Services Ltd
Data Physics (UK) Ltd
Datron Technology Ltd
DC White & Partners Ltd
Dewesoft UK Ltd
DJB Instruments
DWE Scientific Ltd
Emmegi Heat Exchanges UK Ltd
Engineering Photonics, Cranfield University
Gantner Instruments
GOM UK Ltd
HBM UK Ltd
Head Acoustics (UK) Ltd
Hydrotechnik UK Ltd
IDT (UK) Ltd
Imetrum Ltd
Instron
Interface Force Measurements
Ixthus Instrumentation
Jaeger
KDP Electronic Systems Ltd
Kemo Ltd
Kistler Instruments Ltd
Lavision UK Ltd
M&P International
Meggitt Sensing Systems
Micro-Epilson
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Nprime Ltd
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PCB Piezotronics Ltd
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Polytec Ltd
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Siemens Simulation & Test Solutions Ltd
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Techni Measure Ltd
Thermal Vision Research
THP Systems
Tiab Ltd
Transmission Dynamics
Vibration Research UK Ltd
Vishay Precision Group - Micro-Measurements
Yokogawa Measurement Technologies Ltd
Zwick Testing Machines Ltd

For more information or to register your attendance, please contact the EIS Secretariat (Sara Atkin): info@e-i-s.org.uk or visit the website www.e-i-s.org.uk

Reports

Launch of EIS Young Engineers Seminars

The end of 2016 saw the launch of a new charitable initiative for the EIS. In recent years members have increasingly commented on the need to develop young engineers' understanding and experience in their day-to-day roles. With a wealth of broad-ranging expertise within the society it was felt that we could fill this gap and provide support to younger engineers in furthering their understanding and knowledge. The society also felt that such an activity would fit well with our remit to support the professional development of young engineers.

We were inundated with requests from recent graduates to attend our first Young Engineers Seminar at Birmingham University in December. Unfortunately, we were unable to accommodate all requests and limited attendance to 20 engineers to enable group activities to run successfully. This also allowed time for the engineers to introduce themselves to the group and discuss their recent experience and aspirations. With engineers attending from a variety of sectors and roles, there was a good mix of delegates from automotive, rail, power generation, aerospace, software and testing facilities which provided opportunities for varied discussions and sharing of common challenges encountered.

The theme of the day was Test & Analysis and presentations were given on Measuring Operational Loads and Introduction to Transducers, Challenges and Best Practice in Industrial Use of FE Simulation, Simulating an Imperfect World and The Myth of Accuracy. In a first for the EIS, Damian Harty of Lucid Motors, presented by Web-Ex from the United States. We would like to thank Damian along with our other presenters: Peter Lavelle (HBM Prenscia), Andrew Buckingham (ABMech Design and Analysis) and David Ensor (Engineering Consultant and EIS Council Member), for their support in running a successful day.

Delegates were enthusiastic and found the day to be both informative and a good opportunity to mix with other engineers from a variety of backgrounds. During the last session of the day we discussed the format and possible topics the engineers would like to cover in future sessions which included site visits and demonstrations.

The feedback from delegates was extremely encouraging and we plan to run further sessions for the group over the coming year. We also hope to be able to offer similar opportunities to recent graduates in 2018.

Advanced Engineering Show, NEC, 2-3 November 2016

Once again the EIS had a stand at the Advanced Engineering Show at the NEC in November. This provided a great opportunity to talk to visitors about the charitable work of the society as well as a chance to publicise future events. Throughout the two days we also spoke to a number of exhibitors, several of whom booked stands at the Instrumentation, Analysis and Testing Exhibition at Silverstone on 14 March 2017.

Forums are run throughout the two days and the society was pleased to be involved in two of the forums. Norman Thornton (EIS Director) and Geoff Calvert (VisEng Ltd) presented on "Visualising Strain" and on the second day

David Ensor (EIS Council Member) ran his forum on "You've Tested it, What have you Proved?". Both forums were well-attended and many delegates visited our stand following the sessions to further discuss these topics.

The society will be attending the 2017 show next November and will be involved again in a number of forums.

Co-sponsored by:

Institution of MECHANICAL ENGINEERS

The Engineering Integrity Society Fatigue 2017

Downing College
Cambridge, UK
3-5 July 2017
www.fatigue2017.com

Leading Sponsor:

Prenscia

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Rolls Royce PLC is pleased to support the Fatigue 2017 conference.

Fatigue 2017

Fatigue 2017 will bring the international fatigue and durability community together to share knowledge, and understand the challenges, in using high performance materials for reliable and cost effective products. The conference builds on the long established philosophy of the Engineering Integrity Society to provide a forum for practising engineers and researchers to exchange ideas and experiences in all aspects of structural integrity. The 3 day conference will focus on the complex interplay between materials and their processing, advanced manufacturing methods, and the subsequent durability and reliability of the products.

Fatigue 2017 will highlight the progress made in fatigue and durability research and its impact on industrial practice.

Keynote presentations from:
Steve Williams, Rolls-Royce
Dr Michael D. Sangid, Assistant Professor, Purdue University
Professor Robert Akid, BP/Royal Academy of Engineering Chair in Corrosion and Materials at the University of Manchester

There will be a strong theme of the relationship between novel manufacturing processes and the durability of the resulting components. Environmental factors, including corrosion and elevated temperatures will also feature, along with developments in testing methods and mathematical modelling.

Venue
The conference will take place at Downing College, University of Cambridge. It is the county town of Cambridgeshire and the seat of one of the oldest universities in the British Isles. Downing College was founded in 1800 through a bequest made by Sir George Downing. The College's beautiful neo-classical buildings are set in spacious and peaceful gardens in the centre of Cambridge.

Exhibition
There will be an accompanying exhibition of material testing systems, durability software tools and engineering services where delegates will have the opportunity to discuss the latest developments in the field of fatigue and durability.

A Special Issue of extended papers selected from the conference will be published in the international journal Fatigue and Fracture of Engineering Materials and Structures.

A selection of conference papers, including those of the Durability Prize winners, will be published in Engineering Integrity, the Journal of the EIS.

Proceedings
The proceedings will be published in CD-ROM format and will be available at the conference.

Accommodation
En-suite accommodation is available at Downing College subject to availability. Please select the accommodation option on the booking form. Prices include bed and breakfast.

Travelling Information
The nearest airports are Stansted and Luton. Cambridge is easily reached by train. Downing College is located about ¾ mile from the railway station and is served by regular buses and taxis.

Liability
EIS as organiser is not liable for any changes in the programme due to circumstances beyond their control. The organisers are not liable for any losses, accidents or injuries to persons or damage to property of any kind. Participants must arrange their own insurance if considered necessary.

Visa
Visa applications must be applied for in your country of origin.

Local Technical Committee
Dr John Yates
Robert Cawte
Paul Roberts
Dr Mark Whittaker
Professor Filippo Berto
Professor Angelo Maligno
Dr Ali Mehmanparast
Dr Peter Bailey
Dr Nicolas Larrosa

International Scientific Committee
Professor Hong Youshi (China)
Professor Filippo Berto (Italy)
Dr Yee Han Tai (UK)
Professor Martin Bache (UK)
Professor Jie Tong (UK)
Professor Luca Susmel (UK)
Professor Ir. Dr. Shahrum Abdullah (Malaysia)

Conference Dinner Address
Professor Lord Robert Mair CBE FREng FRS

Provisional Programme

Monday	
Keynote lecture: Steve Williams, RR plc	
Session 1:Influence of manufacturing processes on fatigue I	
Keynote lecture, Dr Mike Sangid, Purdue University	
Session 2: Mathematical and numerical modelling I	
Session 3: Fatigue of engineering materials I	**Session 4: Fatigue at notches**
Tuesday	
Session 5: Corrosion Fatigue	**Session 6: Fatigue of welds**
Session 7: Mathematical and numerical modelling II	**Session 8: Fatigue of engineering materials II**
Session 9: Influence of manufacturing processes on fatigue II	**Session 10: Multiaxial fatigue**
Session 11: High temperature and thermomechanical fatigue	
Wednesday	
Session 12: Fatigue of composite materials and structures I	**Session 13: Reliability and probability II**
Session 14: Fatigue of composite materials and structures	**Session 15: Advances in experimental methods**
Session 16: Fatigue at welds, notches and manufactured features	

Registration Fees

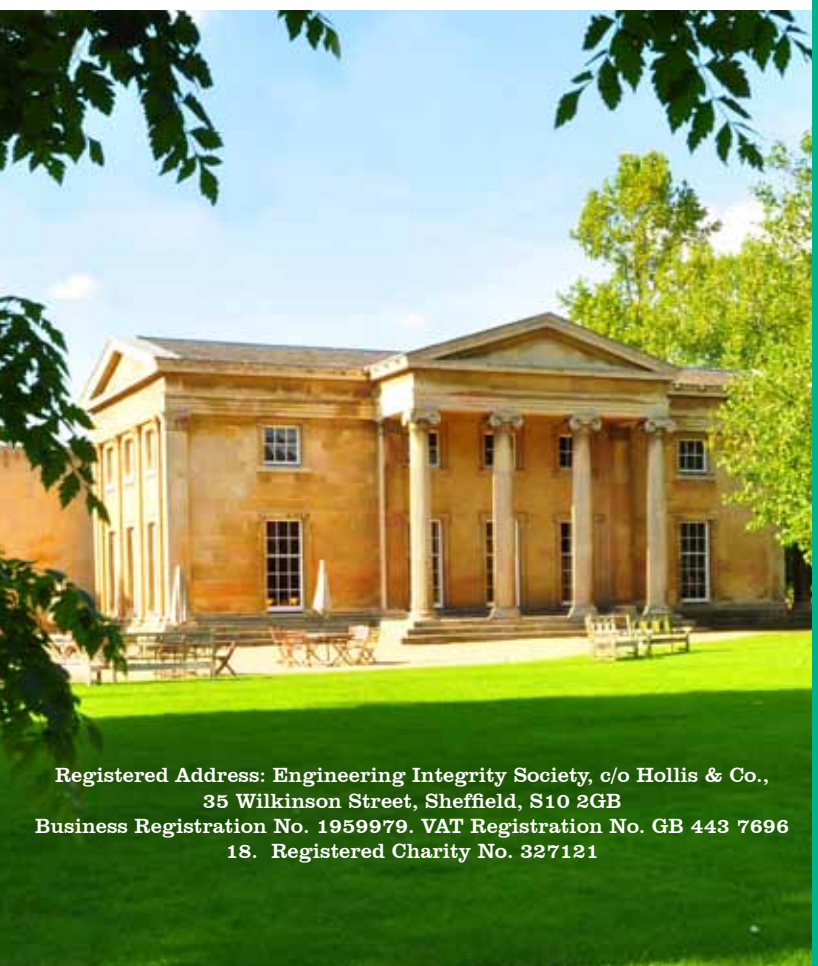
	3 Day	2 Day	1 Day
Presenting Authors (Registration and payment by 28 October 2016)	£450 +VAT	-	-
EIS Members (Registration and payment by 31 January 2017)	£500 + VAT	£380 +VAT	£200 +VAT
Non-Members and Registrations and payments after 31 January 2017	£600 +VAT	£480 +VAT	£250 +VAT
Students and Retired Members (limited places available)	£320 +VAT	-	-

Registration
The booking form should be completed and emailed to the conference secretariat, Sara Atkin: info@e-i-s.org.uk

All payments must be made in Sterling by bank transfer or a cheque drawn on a UK bank account.

Please find all the latest information relating to the conference and details of how to book your place on the Fatigue 2017 website.
www.fatigue2017.com

We look forward to welcoming you to Cambridge.



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Vibration Research
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Industry News

Welcome to the Industry News section of the journal. Thank you to everyone for their submissions. 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.

Making an impact: Lloyd's Register Foundation publishes review on progress in 2015/16

The major grants made by the Foundation during the year were a £10 million commitment to the National University of Singapore (NUS) to establish a world institute with an Asian focus on the public understanding of risk; a grant of £10 million to Ove Arup and Partners International Ltd for a joint programme with the Foundation to build resilience in critical infrastructure; and a £10 million grant as a founding partner of the Alan Turing Institute to develop research and education in the area of data-centric engineering.

The review describes the Foundation's main activities over the year to drive impact and excellence in pursuit of its charitable purpose – to make the world a safer place for the benefit of society. Impacts highlighted in the review include:

- 2,029 copies of our two foresight reviews downloaded or provided in hard copy
- Sophie Damy from Imperial College won an EPSRC £54,000 grant on her LRF-funded PhD research
- Research grants supported 124 PhD students
- Funding trained 283 RNLI lifeboat volunteer crew members from 35 lifeboat stations which launched 4,695 times and saved 4,271 lives
- Grants reached 23 countries, plus there are additional international relationships developed by grant holders.
- Articles written for The Conversation by the Foundation-funded science editor have been read over 6 million times.
- 710 National Coastwatch Institution watchkeepers at 52 UK stations trained for new radio operator's certificate.

Download a copy of the 2016 Review at http://info.lr.org/review-2016-lrf

Renishaw supports UK charity with generous donation

Global engineering technologies company Renishaw has donated £16,500 to Engineers Without Borders — a UK charity that encourages young people to get involved in engineering and use their skills to address global challenges. The donation was in lieu of the usual gift that Renishaw distributes to its employees worldwide to celebrate the company winning a Queen's Award for Enterprise.

In 2015 Renishaw won a Queen's Award for Enterprise in the Innovation category for the development and manufacture of its RESOLUTE™ family of non-contact, optical position feedback devices. This was the eighteenth Queen's Award won by the company.

In the UK, Engineers Without Borders runs a youth outreach initiative, aiming to inspire the next generation of globally responsible engineers. Through a series of workshops with primary and secondary school children, the charity encourages young people to explore human development issues and how they can be part of the solutions by becoming engineers.

The charity also runs the Engineering for People Design Challenge, where undergraduates from 30 UK universities are given a real-life design brief and tasked with creating an engineering solution. Most recently, students have been asked to solve the pressing issue of increased water and sanitation demands in Lobitos, Peru.

Engineers Without Borders also operates in South America, Africa and Asia, offering engineering support to local communities through volunteer work.

Silverstone Metrology Network has Immediate Wow Factor for High-Tech Community

The much anticipated Silverstone Metrology Network has got off to "the best start possible" thanks to a high-profile launch that attracted a quality audience of some of the best brains in high-tech engineering in the area.

The meetings are taking place at the Silverstone Park Metrology Facility, managed by Hexagon Manufacturing Intelligence. The facility is the only dedicated sub-contract inspection metrology centre in Great Britain.

It opened in July inside the Silverstone Park Innovation Centre, the result of a collaboration between the estate's developer MEPC and Hexagon, the world-leader in the science of metrology (precision measuring in engineering).

Among the top names to attend the Network's inaugural event were the Red Bull and Mercedes Formula 1 teams, Delta Motorsport, Design Rule PLM, Diamond Hard Surfaces, IMechE, Kepston Ltd, Lohmann Technologies, Moog Space & Defence Group, Performance Projects, TD Group Ltd, Torotrak, TotalSim and Xaar plc.

New study reveals solidification cracking during welding of steel

University of Leicester researchers offer new insights into important engineering alloy.

New research led by the University of Leicester has made a novel breakthrough in understanding how solidification cracking occurs during the welding of steel, an important engineering alloy.

In a new study, which has been published in the journal Scientific Reports from Nature Research, the team from the University of Leicester Department of Engineering propose that solidification cracks grow by linking micro-porosities in the meshing zone in the solidifying weld pool.

This is the first time that researchers have observed solidification cracking in steel and sheds new light on why the alloy may crack during the process.

The team used synchrotron X-ray beamline at the European Synchrotron Radiation Facility (ESRF) to observe the crack formation at the real time.

With modern advances in synchrotron X-ray and imaging techniques, the team was able to see through metals, providing detailed analysis of the alloy.

The study is part of the team's international EU FP7 project – Mintweld (www.le.ac.uk/mintweld), working with eleven partner originations from 7 EU countries.

The paper 'Initiation and growth kinetics of solidification cracking during welding of steel' published by Nature is available at: http://www.nature.com/articles/srep40255

Images demonstrating the research findings are available at: https://www.dropbox.com/sh/0cwr70l73xegbmi/AACIHtj14v0WoMjXtBJpXLpla?dl=0

New company and website launched to promote Silverstone Technology Cluster

A new company – Silverstone Technology Cluster – has been formed to support the high-tech activity within a one-hour radius of Silverstone Circuit.

The formation of the new company follows a report from independent research and analysis specialists SQW identifying the area around Silverstone as a cluster exceptionally rich in high-tech engineering know-how and capability.

Subsequently Silverstone Park developer MEPC, along with Barclays, EMW, Grant Thornton, Hexagon Manufacturing Intelligence, Aylesbury Vale District Council and Cherwell District and South Northants Council, came together to agree a business plan and set up the membership-based, not-for-profit company.

Brackley companies, TotalSim (computational fluid dynamics) and KW Special Projects (integration of new processes and technologies), will join Silverstone Technology Cluster as the first full members and will advise the Board from a high-growth company perspective.

Silverstone Technology Cluster is the cluster of high-tech companies identified by the SQW report, which was published in the summer. Subsequently, the Cluster has been warmly welcomed by both Government and the finance and business community. SQW is the highly respected economic and social development research firm whose findings first brought the 'Cambridge Phenomenon' – a collection of significant companies working in bioscience, medicine and technology – to public attention.

STC has now launched a distinctive brand identity and new website. For more information on Silverstone Technology Cluster, please visit silverstonetechnologycluster.com.

Nineteen student teams from the UK and three international teams are set to compete to build the best drone

16 January 2017 - Some of the most talented young engineers from the UK and overseas will compete to design and build the best Unmanned Aircraft System (UAS), also known as a drone, as part of the annual competition run by the Institution of Mechanical Engineers.

An unmanned aircraft system is an aircraft without a human pilot on-board. They are predominantly known for their use in military and special operations, such as delivering humanitarian aid.

The competition will see the young engineers develop their drones before taking on other teams in a 'fly-off', where they will be challenged to transport a package as accurately and rapidly as possible.

The universities confirmed to be taking part are:

1. University of Bath
2. Loughborough University
3. University of Nottingham
4. DHA Suffa University, Pakistan
5. University of Sheffield
6. University of Glasgow
7. University College London
8. Swansea University
9. University of Huddersfield
10. Queens University Belfast
11. Istanbul Technical Univ., Turkey
12. University of West England
13. Cranfield University (2 Teams)
14. Sheffield Hallam University
15. University of Surrey
16. Coventry University
17. University of Hertfordshire
18. Univ. of Southampton (2 Teams)
19. University of Dundee
20. Military Technical College, Egypt

Now in its third year, the UAS Challenge is the fourth student engineering challenge event run by the Institution, following Formula Student, the Railway Challenge and the Design Challenge.

British Safety Council launches a special offer to support small organisations and charities

The British Safety Council has launched a free, special one-year 60th Anniversary Supporter offer for small organisations and charities to help them manage health, safety and environmental risks.

Responding to the challenges of time, resources and the shortage of health and safety expertise among the smallest companies, the British Safety Council is inviting small and micro-sized organisations (under 50 employees) and small charities (under 100 employees) from across the world, to join it as Supporters.

Supporters will enjoy a range of services and benefits, free of charge, for 12 months, to help them manage health and safety risks in their organisations. A Supporter will receive:

- A limited-edition Supporter logo, which they can use to show their commitment to health and safety;

- Access to a 24/7 telephone helpline with practical guidance and technical advice;
- Free places for all employees on the British Safety Council's General Health, Safety and Environmental Awareness e-learning course, ideal for inductions;
- Online risk assessment templates that include general risk assessment, fire and manual handling;
- Digital edition of the monthly Safety Management magazine;
- Electronic posters and guides that focus on themes such as stress, lone working and manual handling;
- Hear about opportunities to meet and engage with experts and peers tackling similar issues in their sector at the British Safety Council's events and seminars.

Lloyd's Register and TWI launch two new projects to advance take-up of additive manufacturing

Collaboration aimed at two aspects of additively manufactured (AM) parts: regulatory compliance and joining of AM structures

12 January 2017: Lloyd's Register (LR) and TWI are calling for partners to join two new global collaborative projects focused on two additive manufacturing challenges facing the industrial sector. "Achieving Regulatory and Code Compliance for Additive Manufacturing" and "Joining of Metallic Additively Manufactured Products and Materials" are expected to attract considerable interest from companies worldwide, as these new projects will further explore challenges uncovered from LR and TWI's first joint industry project, "Certification of Laser Powder Additive Manufactured Components for Industrial Adoption in the Energy and Offshore Sectors".

What remains unexplored is the link between additive manufacturing and compliance with standards and regulations that are often used in safety-critical pieces of equipment, such as the American Petroleum Institute code (API), the American Society of Mechanical Engineer's (ASME) Boiler and Pressure Vessel Code, and Europe's Pressure Equipment Directive (PED).

The second project, "Joining of Metallic Additively Manufactured Products and Materials" will concentrate on filling in the real-world gaps (e.g. controls, data, testing, inspection) to enable project sponsors to design, fabricate and put into service structures that are comprised of conventionally made parts welded with additively manufactured parts. Project sponsors will gain the confidence to put parts into service in real-world, challenging operating environments and conditions, which is a significant step forward for industries such as energy, marine and offshore.

Manchester scientists tie the tightest knot ever achieved

Scientists at The University of Manchester have produced the most tightly knotted physical structure ever known – a scientific achievement which has the potential to create a new generation of advanced materials.

The University of Manchester researchers, led by Professor David Leigh in Manchester's School of Chemistry, have developed a way of braiding multiple molecular strands enabling tighter and more complex knots to be made than has previously been possible.

The breakthrough knot has eight crossings in a 192-atom closed loop – which is about 20 nanometres long (ie 20 millionths of a millimeter). Being able to make different types of molecular knots means that scientists should be able to probe how knotting affects strength and elasticity of materials which will enable them to weave polymer strands to generate new types of materials.

Professor David Leigh said he and his team were delighted to have achieved this scientific landmark.

"The eight-crossings molecular knot is the most complex regular woven molecule yet made by scientists."

The research breakthrough was published in the prestigious journal Science on 13 January 2017 in a paper entitled: 'Braiding a molecular knot with eight crossings'.

Scientific breakthrough reveals unprecedented alternative to battery power storage

Major scientific breakthrough research has discovered new materials offering an alternative to battery power and proven to be between 1,000-10,000 times more powerful than the existing battery alternative - a supercapacitor.

The technology could have a seismic impact across a number of industries, including transport, aerospace, energy generation, and household applications such as mobile phones, flat screen electronic devices, and biosensors. It could also revolutionise electric cars, allowing the possibility for them to recharge as quickly as it takes for a regular non-electric car to refuel with petrol – a process that currently takes approximately 6-8 hours to recharge. Imagine, instead of an electric car being limited to a drive from London to Brighton, the new technology could allow the electric car to travel from London to Edinburgh without the need to recharge, but when it did recharge for this operation to take just a few minutes to perform.

Supercapacitor buses are already being used in China, but they have a very limited range whereas this technology could allow them to travel a lot further between recharges. Instead of recharging every 2-3 stops this technology could mean they only need to recharge every 20-30 stops and that will only take a few seconds.

Jim Heathcote, Chief Executive of both Augmented Optics Ltd and Supercapacitor Materials Ltd, said "We are now actively seeking commercial partners in order to supply our polymers and offer assistance to build these ultra high energy density storage devices."

Predictive and Control Capabilities through IoT Rapidly Expand Global Growth Opportunities for Sensors

Intelligent sensors will be critical in the evolution toward a single connected industrial world, finds Frost & Sullivan's Sensors and Instruments team.

December 2, 2016 – Sensors are experiencing large-scale deployment in diverse end-user applications across verticals in standalone, integrated, combined, embedded and, more recently, wearable and ingestibles. Sensors are transforming to be highly intelligent with analytical and decision-making capability at the edge. Driven by the Internet of Things (IoT) revolution, sensors form the cornerstone of Industry/Manufacturing 4.0, an integrated approach to remote connectivity for real-time monitoring and control. Smart sensors are now evolving to be prognostic/ predictive. With up-gradation of contact, non-contact technologies and evolution of hybrid technologies, sensors are proactively enabling new applications. Sensors are at the forefront of digital transformation across diverse industrial markets.

Global Sensor Outlook 2016, part of Frost & Sullivan's Sensors & Instrumentation Growth Partnership Service programme, estimates the global sensors market to generate USD162.36 billion in 2019, with industrial control, smart cities, and eHealth being top revenue contributors. Immediate investment focus will be on developing non-contact technologies, remote connectivity through IoT, 3D printing, and improving 3D vision sensing.

"Wireless sensor networks are the future of connectivity," said Thusu. "Sensor technology will continue to advance in terms of natural user interface, ubiquitous computing, and sensory tracking. By 2025, sensors will not only be intelligent and prognostic, but also autonomous, self-healing and failsafe, paving the way for Industrial IoT (IIoT)."

£60 million boost to strengthen the UK's manufacturing base through six new research hubs

- Six universities across England, Wales and Scotland will share government funding to improve the UK's manufacturing processes
- An additional £87.5 million total contribution from partners, academia and industry
- Key part of the government's Industrial Strategy to further UK economic growth

Six new £10 million research hubs that will explore and improve new manufacturing techniques across fields such as targeted biological medicines, 3D printing, and composite materials have been announced by Universities and Science Minister Jo Johnson.

Funded by government through the Engineering and Physical Sciences Research Council (EPSRC), the hubs will draw together expertise from 17 universities and 200 industrial and academic partners to upgrade the UK's manufacturing capabilities and take greater advantage of the UK's innovative strengths. Through increased collaboration between universities and industry, more products can be developed to meet industry needs and progress from the research lab to market - boosting the UK economy.

The hubs will be led by Cardiff University, the universities of Huddersfield, Nottingham, Sheffield, Strathclyde & University College London.

Announcing this major investment in the UK's manufacturing research base, Universities and Science Minister Jo Johnson said: "Developing new innovative manufacturing techniques will help UK industry create new products, explore more business opportunities and ensure the UK becomes more competitive and productive.

HORIBA MIRA Opens New Vehicle Engineering Facility in Pune, India

Global leader take space within brand new Technical Centre

New facility increases regional capabilities

HORIBA MIRA – a world-leader in advanced engineering, research and product development – has further bolstered its worldwide automotive engineering and testing capabilities with the opening of a facility within the new HORIBA India Private Limited, Technical Centre in Pune, Western India.

The new site increases HORIBA MIRA's presence in India and will provide an in-territory base from which to deliver comprehensive vehicle attribute engineering and testing programmes. Utilising automotive test systems within the HORIBA India Technical Centre, HORIBA MIRA will ultimately provide a suite of emissions testing for vehicle manufacturers, delivering against its global-growth strategy on a regional level.

Since the growth of India's automotive industry, air pollution and safety have become key concerns for leading manufacturers in the region – particularly following the introduction of the country's heightened Bharat Stages (BS) emissions standards. Together with HORIBA's Portable Emissions Measurement System (PEMS) and HORIBA MIRA's engineering capabilities, the new facility will provide vehicle manufacturers with test services to support them to meet BS VI compliance.

The 10,000m^2 HORIBA India Technical Centre opened on November 30 2016. It is situated near a key export base for several European and Indian manufacturers, in an area which is a hub for many auto parts developers and researchers.

For further information o HORIBA MIRA, please visit www.horiba-mira.com.

New id8 decide release strengthens engineering teams' agility to make smarter decisions

Leuven (Belgium), January 2017 – Noesis Solutions, the developer of Optimus and id8, announces a new release of id8 decide. New and improved capabilities within this intuitive-to-use Engineering Data Analytics environment include additional plot types, enhanced data handling, and faster data processing. id8 decide enables development teams to acquire deeper engineering insights faster than ever before. But what will boost user productivity most, are id8 decide's brand new worksheet templates making it easy to deploy fit-for-purpose engineering dashboards across the organization.

This new software release incorporates customer feedback from leading OEMs in automotive, aerospace and other manufacturing industries. Featuring a number of productivity boosters, the new release of id8 decide further increases the pace of the worldwide adoption of this engineering data analytics solution.

id8 decide multiplies the power of Optimus, the industry-leading Process Integration and Design Optimization (PIDO) software platform. Complementing Optimus design space exploration, id8 decide delivers actionable insights and relevant decision metrics to engineering teams - maximizing user productivity while minimizing technology ownership cost.

Noesis Solutions is an engineering innovation partner to manufacturers in engineering-intense industries. Specializing in solutions that enable Objectives Driven Draft-to-Craft Engineering processes, its software products and services help customers adopt a targeted development strategy that resolves their toughest multi-disciplinary engineering challenges.

Noesis Solutions operates through a network of subsidiaries and representatives in key locations around the world. For more information, please visit www.noesissolutions.com.

New Options for In-line Accelerometer Signal Conditioning

DJB Instruments (UK) Ltd are pleased to announce the launch of the QV/04 in-line signal conditioner which joins the QV/02 and replaces the outgoing QV/01. All products in the QV range of in-line converters provide charge/voltage conversion when supplied with a standard IEPE supply current in the range of 4 to 20mA. The low impedance line drive maintains signal integrity even over distances of several hundred metres, requiring minimal configuration to interface with vibration analysers and data acquisition systems.

The QV/04 offers a solution for all applications. Its small size and low mass are ideal for compact multi-channel solutions, both rugged and flexible offering the most compact solution on the market today. This low package size minimises mass effect on cables when installed into the signal cable lines.

Features
- Thick film hybrid charge/voltage converter housed in stainless steel body
- 10/32 UNF microdot connector on input and output
- Suitable for high temperature operation up to 185°C
- Lightweight, weighing only 20gm
- The QV/04 is suited to most applications involving piezoelectric sensors requiring long cables.

The QV/04 is available with a range of gain options to suit a variety of different charge output accelerometers.

Options
- QV/04-0.1 = 0.1mV/pC gain
- QV/04-1 = 1mV/pC gain
- QV/04-10 = 10mV/pC gain

If you have a challenging application or a new requirement looming please get in touch: +44 (0) 1638 712 288 or email sales@djbinstruments.com

New Thermometry Bridge calibration service

NPL is now able to offer calibration of resistance bridges of all types. Resistance bridges are crucial to measuring platinum resistance thermometers with very low uncertainties - but they often operate for many years without having their own performance checked.

Contact: Customer Services tel: +44 20 8943 6315, E-mail: temperature_enquiries@npl.co.uk

New turbochargers from L'Orange promise more power, less fuel, less emissions.

Stuttgart, January 2017 - L'Orange - the leading German manufacturer of injection technology - has introduced a new range of high performance and efficient turbochargers for large industrial diesel engines used in the marine, offshore, power plant and rail sectors.

Users of large diesel engines are constantly looking for reliability, engine efficiency, safety and performance. Here, the introduction of these state-of-the-art L'Orange turbochargers offers customers a comprehensive solution from a single source. The so-called L'Orange ZR turbocharger families fill a significant gap in the market for those needing high performance upgrades for large diesel, gas and dual fuel engines. The new ZR turbocharger families are the result of a collaborative effort between L'Orange and MTU Friedrichshafen and provide high system compatibility saving customers time and money in engine development and ongoing operations.

The L'Orange ZR range turbochargers differ in the size of the compressors and turbine wheels, pressure ratio and volume flows and are specifically targeted at (off-highway applications and power plants) with high-speed diesel, gas and dual fuel engines. Depending on the customer needs, L'Orange offers ZR turbochargers

for engines typically from 500 kW to 10.000 kW. The performance class is sufficient for volume flows from 0.2 m³/s through to 3.5 m³/s.

To cope with conditions at sea and at altitudes of 4,000 meters, as well as at low and extremely high exterior temperatures, the turbo units have sealing and bearing points that are thermally isolated and can also be water-cooled if needed.

Element's aerospace vibration testing for all conditions

December 2016 - Element Materials Technology's Warwick laboratory is one of the few UK test centers to house a high-displacement LDS V8 electrodynamic test system, enabling it to reproduce the extreme vibration conditions of an aircraft facing a fan blade out event.

Classed as a serious safety threat, a fan blade out event occurs when a foreign object - such as a bird - is caught by an aircraft's engine, causing one of the rotor blades to detach. The damage caused is so critical to the engine that it stops producing power, although the engine will continue to rotate due to the incoming airflow, an effect which is known as 'windmilling'. This places high levels of stress on the aircraft's flight systems and the ability of the systems to withstand these conditions must be validated through rigorous tests.

As such extreme conditions are usually outside the capabilities of normal test systems, Element invested in Brüel & Kjær's LDS V8 electrodynamic test system to provide its customers with the certainty that their products would meet the most stringent testing standards.

The V8 is an air-cooled electrodynamic shaker for vibration and mechanical shock testing of large payloads up to 700 kg (1540 lb.). Its combination of large displacement and wide-duration shock pulses matches specific requirements for testing windmilling, making it ideal for Element to test this effect on components such as aircraft engines and fan blades.

More information is available at: https://www.element.com

Morgan Advanced Materials announces prototype capability for custom piezoceramic microtubes

Morgan Advanced Materials has become one of the first materials specialists globally to offer a prototype and development service for piezoceramic microtube components in diameters between 0.4mm to 1.0mm, and lengths of up to 15mm.

The products have been developed following increasing demand for ever smaller piezoelectric components, brought about by the accelerated rate of technological innovation in markets including medical, industrial measurement, and consumer electronics. In certain applications where there is a need to accommodate optical fibres or ultrasound probes, components must be of a specific size to ensure compatibility.

Attempts to produce components of this size which meet the performance demands of their intended applications have, until now, proven difficult due to the sheer intricacy of the geometries required and the materials used. This breakthrough from Morgan makes it the only international supplier that can produce Lead Zirconate Titanate (PZT) microtubes within these exact parameters.

In addition to the diameter of Morgan's piezoceramic microtubes, another aspect of the design which makes the company's offering unique is the fact that the range can be supplied to custom electrode configuration. Morgan's team of ceramic specialists have the capability to laser edge the components, splitting the surface into several external electrodes. This enables the component to bend during operation, opening the door to a variety of new applications.

For further information, please visit: www.morgantechnicalceramics.com/pztmicrotubes

HBM Takes the Strain out of PCB Testing!

HBM – a market leader in the field of test and measurement – is pleased to announce the arrival of its new RF9 miniature rosette strain gauge, which is suitable for measurements on printed circuit boards (PCB), small components or applications with limited space.

Compact in size, the RF9 strain gauge rosette features a three stacked measurement grid which is only 5mm in size, enabling it to determine a biaxial stress state with unknown principal stress direction in confined spaces.

Easy to connect, the RF9 is pre-wired with colour-coded enamelled copper wires, eliminating the need for fiddly soldering on the strain gauge.

When it comes to printed circuit boards of electronic components in automobiles, commercial vehicles, or smart phones in mobile use, even the slightest crack can cause the entire system to fail. As manufacturers increasingly require their suppliers to prove the mechanical safety of PCBs, strain gauges such as the RF9 from HBM enable the mechanical stability of printed circuits boards to be reliably tested.

HBM provides the complete measurement chain for such applications; from its extensive range of strain gauges; through to the QuantumX MX1615 amplifier and Catman® AP software for data acquisition and analysis. HBM also supports its customers with training and contract installation to ensure optimum operational use.

For further information, contact HBM on +44 (0) 20 8515 6000 or via email: info@uk.hbm.co.uk or visit the HBM website at http://www.hbm.com/en/

Inspiring the Next Generation

What a year 2016 turned out to be. I spent around 300 hours on STEM outreach activities ranging from 'The Big Bang' Fair to the Farnborough Airshow. I also supported Girlguiding UK and Scouts at Fundays and even helped with a World Record. During September and October myself and other Rolls-Royce colleagues successfully ran two rocket car events, one in Rolls-Royce as part of a family fun day and one at the Derby Silk Mill Museum as part of the Derby's 'Mini Maker' Faire. Over the course of the two days we fired over 300 rocket cars much to the delight of children, both young and old.

Alongside my STEM outreach work as Rolls-Royce STEM Ambassador I am also a Derby Maker. Derby Makers is a hackspace group comprising mostly of Rolls-Royce employees, who are based at the Silk Mill Museum in Derby. The Silk Mill forms part of a World Heritage group of former mills in Derbyshire, attributed as the World's first factory. The Silk Mill has ambitions through the heritage lottery fund to become a 'museum of making' and is corporately sponsored by Rolls-Royce. Most Thursday evenings you will find me in the workshop teaching people how to laser cut, 3D print or solder electronic components. Members of the public are encouraged to come into the museum and make or create in the name of STEM and the Arts. This incorporation of art into STEM is becoming an ever important aspect to outreach work. By creating STEAM (Science, Technology, Engineering, Arts and Mathematics), not only does this sound a more appealing acronym but it supports the growing belief in the engineering and academic community of encouraging creativity in traditionally scientific subjects.

As advanced manufacturing develops in the UK to include processes such as laser cutting, 6 axis CNC machining and additive manufacturing, innovation will be key to driving further improvements. While the Office for National Statistics has shown an increase in innovation from 2013 to 2015 across all sectors, there are large regional variations across England and in the South West there has actually been a drop in innovation. STEAM is one way to potentially unlock talent which may have initially been overlooked; an idea which has been championed by the Rhode Island School of Design. STEAM aims to target creative thinkers, designers, makers and artistic individuals who may otherwise be overlooked as engineers due to their 'labelling' as artists at an early part of their career by showing them that the subjects can be linked through making in all forms.

The idea of artists becoming engineers is certainly not new. It has been established that Maths and Art are closely aligned as proven by theories like the golden ratio and fractals. Leonardo Da Vinci is among the most famous example of a talented mathematician, craftsman, artist, designer and engineer, demonstrating the blurring of the boundaries between the arts and science.

Sir Geoffrey De Havilland, designer of the Mosquito and Comet aircraft wrote in Sky Fever;

"Although most designers would resent being called an artist and respond that they could not draw well nor paint at all, a designer must have much of the creative artist in him, backed up by a lot of practical engineering experience. A successful designer is born rather than made, and is a rare product. Neither deep knowledge of mathematics nor great theoretical knowledge is necessary."

For advanced manufacturing methods like additive layer manufacturing; organic design is the ultimate aim of the industry. In order to design objects which are as strong as they can be but as light as possible the industry needs designers who can remove as many straight lines as possible. This often requires a more imaginative or innovative thought process.

The work I am involved in at the Silk Mill Museum is designed to help nurture creativity and support people to turn ideas into reality. My own personal experience of the making process has made me a better engineer, as I feel more able to appreciate manufacturing processes, having actually been through the full process myself. Whilst my experience is limited to basic materials at the Silk Mill (typically wood and plastic) many of the principles of laser cutting and 3D printing are applicable in a professional setting, particularly when it comes to thinking of novel ways of approaching tasks.

Over the coming months I will be supporting the Joseph Whitaker School with their attempt to fire a model rocket car at 1000mph, helping at the Big Bang Fair in March and building 12 air rocket launchers for Rolls-Royce to take into schools or support Scout/ Girlguiding events across the UK.

As ever if anyone is interested in knowing more about how they can get involved in STEM please do not hesitate to contact me or your local STEMnet contract holder.

Grant Gibson EngD BEng (Hons) – Capability Acquisition Engineer, Additive Layer Manufacturing Centre of Competency, Rolls-Royce Plc. grant.gibson@rolls-royce.com 07469 375700

News from Women's Engineering Society

Engineering, Technology, Construction I could go on, are all facing the reality that so few women are entering the profession or remaining and there are equally few in the creative sphere of technology. However we make up half of the consumers and often are the decision makers. We hear about 'leaning in' or 'nudging' but the clear and honest truth is that with so few women in these sectors we need more men who are allies. Some people are hiding behind the term Diversity or are saying it is done, but facts and figures don't inspire me with confidence. How can we get more women to enter our sector when often I hear the pool of women is so small? Or is there another factor at play? Yes, fewer women are considering engineering at 16 and when we look at the apprenticeship data this is in the region of 2%. Is it a perception, opportunities or lack of engagement from a variety of events - The Big Bang, Tomorrows Engineer, Your Life, Stemettes - that are all trying to engage young people into becoming an engineer? The Institutions are using projects such as Bloodhound to fire up children's imaginations and the latest piece to engage local London schools is Hackathons. It must be difficult for teachers, students and parents to grasp all of this when there is so much available to engage and immerse the creativity of the young.

However we still see so few entering the sector and women are being made redundant without knowing where to turn. There are a variety of groups – Powerful Women, WES, women's groups in the professional institutions along with Women returners who are focusing on gainful employment for women in corporates. Coaches are mushrooming at every event to which I turn. That's not to say that they are not needed but we need to find a way of getting our workforce to transfer between sectors. WES along with TRS, Prospect and Women in Glass, carried out a survey "Women in STEM: Are you IN or are you OUT?". This 2014 survey received over 5000 responses. 60% of respondents reported barriers which prevented them returning to careers in STEM after a career break. Some solutions were given:

* 43% stated that some sort of training or development would help them to overcome these barriers (with 12% of these stating that sector specific training would be useful);
* 14% stated that more flexible working hours – in particular in managerial roles – would be beneficial (shared maternity/ paternity leave, job sharing, part time hours or condensed hours), and
* 17% said that better careers advice and a bespoke matching service would help them to return.

Also, In terms of membership of Professional Institutions, a huge 46% of respondents were not members of a Professional Institution. More recently, the PEIs themselves reported that the majority of their women members gave up their membership by their mid-40s. So how do we get people back to work?

Returner programmes are a simple idea to help women, and other people who have had to take a career break, back onto the career ladder after an extended break. These are placements or short-term contracts, similar to internships at the start of careers. With these the returner follows a programme of activity designed to bring them up to speed with the work of the company. The company moves them around so that they gain a number of experiences, and monitors and supports their career progression for a few years so they do not become excluded due to the limited network of people they know in the organisation. As with internships, the employee may or may not be employed by the company at the end of the contract, depending on whether a suitable role exists, and also depending on whether the employer is happy with the work of the employee. Maybe we need tax breaks for returners and further incentives or to follow the apprenticeship path. However this doesn't ensure SMEs get involved. If major government led infrastructure starts to measure the proportion of women and progress of women in engineering then there may be some opportunities.

Perhaps I am dreaming. Another method is to entice us all, and I can see this being done through the internet of things, as I see my 10 year old son wanting a 'fitbit' because the other children wear theirs with pride. Luddite as I am I don't want to know 'how many steps I have done for fear of failure' or that Robotics are entering the heath environment as companions for the elderly or sick or of virtual reality, where primary school children talk about it with a sense of knowledge and interest.

I can see all these factors are playing a part in technological development and maybe we will find women getting involved through SME and other ways. However, we all need to play a part here, as engineers, parents, consumers and voters because social media is challenging the norms and our perceptions which the women's engineering society formed after the first world war when women through necessity undertook male dominated roles.

Benita Mehra FIET FWES FIHEEM
CEng BSc MSc MBA President
Women's Engineering Society (WES)

News from British Standards

The evolving series of British Standards, BS 8887, Design for manufacture, assembly, disassembly and end-of-life processing (MADE), is intended to guide the design decisions to be made in order to maximise the investment in materials and energy of a product's original production. Part 2 of the series identified six options for treatment of a product at the end of a life in service. These options are:

* Remanufacture, where the product components are returned to service in the same or better condition than the original.
* Recondition, where any remedial work returns the components to a similar quality to the original.
* Reuse, where components can still be used for a similar product, but at a lower quality.
* Repurpose, takes components for use in a different product.
* Recycle, breaks down components into their constituent materials for reprocessing.
* Disposal, when the materials are of no further use and may be burnt for energy or dumped.

Later this year, BS 8887: Part 3 "Guide to choosing an appropriate end-of-life strategy" (currently in late draft) will help designers take decisions during the original design to aid end-of-life processing.

This will give a product a value at the end of its life, which will encourage users to return the product for reprocessing and give industry a potentially profitable additional business. There is some discussion of the merits of moving to some form of leasing system, rather than simple sales, to ensure an adequate flow of end-of-life products. This is already the norm in much of the automotive and aircraft markets. The overall result should be a more efficient and longer term use of materials and energy benefiting industry and the environment.

Part 3 will set out the reasoning behind the adoption of a reprocessing policy by a company with environmental, business and marketing aspects. The detailed considerations for the designers and manufacturers in enacting such a policy take up the rest of the standard. Clearly there are specific considerations which apply with different industries and companies so the standard will give general guidance, which must be interpreted for the particular circumstances. Even so it has been possible to formulate the guidance in some detail.

A table sets out the options for comparison, with the advantages and disadvantages of each. This leads into a more detailed discussion of the design considerations for each option. These include the possibility of including previously used components, which may be available in sufficient quantity and quality as these policies are adopted more generally. In a complex product, different options may be adopted for the design of different components. This gives maximum flexibility in making the best use of the initial investment in manufacture, both for the materials and energy involved.

This is followed by a review of the manufacturing implications and constraints. These focus on practices which will allow for easier dismantling, inspection and testing, as necessary, of used products to ensure their suitability for further service. Some form of component marking may be necessary to keep track of its use to avoid cumulative damage such as fatigue. Inspection must be undertaken to identify any components which have failed or suffered an extreme event rendering them impossible to put back into service.

As with other British Standards, a Draft for Public Comment will be issued allowing any interested person to contribute to the discussion before publication of the final version.

Colin Ledsome, Chair of BS8887 Part 3 drafting committee

News from the Institution of Mechanical Engineers

New survey: engineers could save NHS money and improve hospital patients' experience

An Institution survey of members found strong support for engineers to have more responsibility in the NHS.

Engineers think that they could help the NHS meet the Government's efficiency savings and give NHS patients a better hospital experience if they were given more responsibility for the procurement, maintenance and calibration of medical equipment, according to a new survey of members of the Institution of Mechanical Engineers.

Of the 200 engineers surveyed, 94% said that the UK should have a Chief Engineer, similar to a Chief Nurse or Chief Medical Officer, to oversee the use of medical equipment in NHS Trusts.

According to the findings, the majority (86%) think that giving engineers more responsibility for the procurement, maintenance and calibration of medical equipment would help the NHS meet the Government's efficiency savings, while 80% said it would ensure NHS patients have a better experience when under hospital care.

Perhaps surprisingly, nearly two thirds of those surveyed (65%) also said that engineers working in the NHS should have more hands-on involvement with front-line patient care.

Dr Helen Meese, Head of Healthcare at the Institution of Mechanical Engineers, said:
"The NHS is facing testing times, with more pressure than ever due to the UK's aging population and stretching targets to find £22 billion in efficiency savings by 2020.

"Giving engineers already working in hospitals more responsibility for medical equipment and being around when it is used would be a step-change in our approach to medical care in the UK. It is also likely to ease the burden on doctors and nurses. Additionally, having Chief Engineers co-ordinating the procurement, maintenance and calibration of equipment could potentially save the NHS millions of pounds a year.

"Technology is set to play a greater role than ever in our hospitals, and in order to make best use of it, we need engineers to have greater control over the way equipment is viewed in the NHS."

The survey of 200 members of the Institution of Mechanical Engineers was carried out in Autumn-Winter 2016.

To find out more about the Institution's healthcare campaign: Healthcare: engineering solutions to the NHS.

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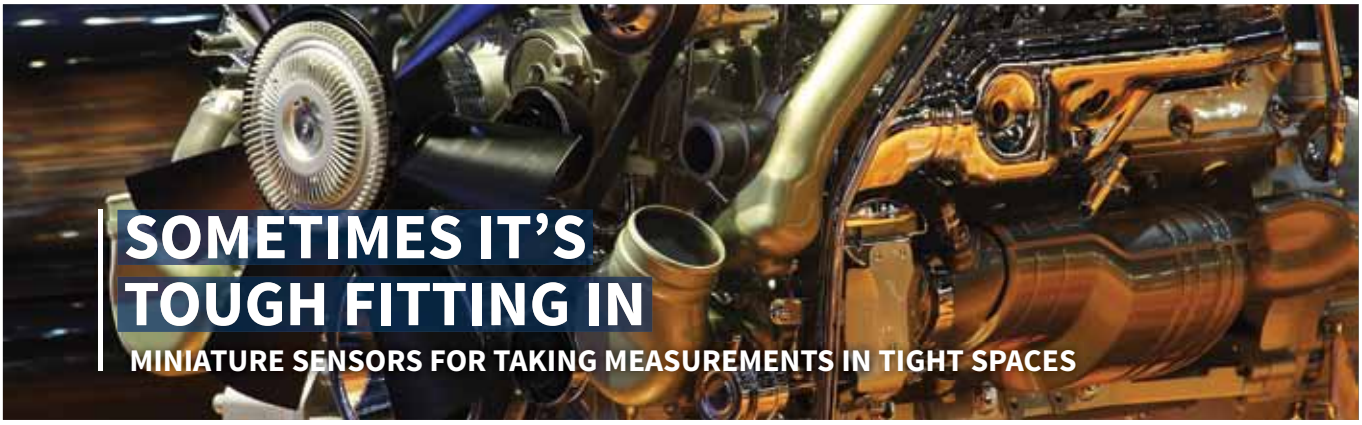

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Group News

Simulation, Test & Measurement Group

It seems it is true that you should always attend meetings lest you are "volunteered" for things. I had to miss the last STMG committee meeting, and so I was duly elected as chairman! Thank you for those that put my name forward.

I would like to introduce myself a little. I have worked in the automotive and allied industries for many years, and for many different companies. This has always been in or around testing and development trying to use the latest technology to enhance the design and development process. As a long-term member of the EIS I have appreciated the company and unselfish help and assistance of the experienced STMG membership. This is a network that I recommend to all engineers in our discipline – especially younger testers wanting to gain experience quickly.

I first attended EIS seminars back in the early 1980's, and contributed papers on the development of on-vehicle data collection, and correlation of customer usage to realistic accelerated durability testing. I think my first technical paper was in 1984 and I have contributed regularly since then.

Anyway, to more recent times, 2016. The last few months continued to be very successful for the STMG. Folllowing the excellent attendance at the Silverstone Exhibition and open forums, we have held a number of other events specifically aimed at passing on the wealth of experience we have in our community. Some of the more notable being the seminars on "Hydraulics: What the Engineer Needs to Know and How to Avoid the Pitfalls" in September, and "The Theory & Practice of Developing Rubber Products with Good Fatigue Life" in October.

We had a very interesting time attending the Advanced Engineering Show at the NEC in November. Sara Atkin bravely withstood the onslaught of visitors on our stand, and two presentations were made to the throng, "Photoelastic Techniques for Strain Measurement on any Material" and "You've Tested It, What Have You Proved?" This produced many enquiries about the technical content, follow up, and the EIS.

Looking forward into 2017, the next event is the Instrumentation, Analysis and Testing Exhibition and associated seminars at Silverstone on 14 March. This looks set to be another great event where you can network, review the latest equipment and techniques, and keep up-to-date via the open forums. This year there will be a superb collection of experts available across four sessions covering practical issues and experiences in: data collection and analysis, "do it fast, cheap, or accurately - choose two", tyre and road interface analysis and measurement, acoustics challenges of low carbon vehicles, and techniques in visualising strain.

I look forward to seeing you at Silverstone, and later at one of our proposed training sessions or forums during 2017. Please come and have a chat.

David Ensor
Chairman

Sound & Vibration Product Perception Group

By the time you read this our one-day Workshop on Structural Dynamics entitled 'Workshop on Structural Dynamics in a World Where Weight Reduction Matters' will have been held on 7th Feb 2017 at AMRC, Sheffield. This is fundamentally a second attempt at running the postponed event – 'Implications of Weight Reduction on Structural Modal Performance' that was to have been held at Coventry University in June 2016, which unfortunately did not attract enough delegates to make it viable. This time we have exceeded our target of 30 delegates, showing that the programme was fundamentally attractive.

The event aims to refresh basic techniques coupled with formal presentations and will feature the following:-

- Educational 'workshop style' sessions to demonstrate the fundamentals of structural testing and analysis
- Technical presentations on a theme of 'Light-weight Structures' and the issues that can be expected
- Exhibition of leading Structural Dynamics measurement and analysis equipment

The SVPP has a Forum session at the EIS Instrumentation Exhibition at Silverstone on 14th March entitled 'Acoustic Challenges of Low Carbon Vehicles' - this will be a 30min presentation followed by a Q&A with a panel comprising some industry specialists.

Summary: This presentation will provide an overview of the acoustic and NVH challenges facing automotive manufacturers and outline approaches to co-optimize drivability, NVH, ride comfort and fuel economy, using unified testing and modelling methods. Downsizing internal combustion engines has a positive effect on the vehicle's fuel consumption, but inevitably impacts other performance attributes. Instead of running isolated campaigns targeted at individual attributes generating redundant and sometimes conflicting models and

data sets, engineering processes are converging towards a unified testing and modelling methodology to balance multiple attributes in an optimal way.

John Wilkinson
Chairman

Durability & Fatigue Group

Reading the last two copies of our journal makes me realise we are beginning to measure things by the generation, not just years. Our Hon Editor and President both commented on nuclear power, one when Berkeley was new and the other about our next generation reactors. Both our President and I joined the society circa 1990, exact date unknown; this is probably because you attend a seminar or two and before you know it you are asked to organise one (Surfaces and Fatigue, 1993 in my case). I hope history will repeat itself with the Young Engineers' seminars; the first one was held in December 2016 and is reported elsewhere in this edition. The audience spanned a range of industries and job titles but they seemed to find a lot in common, which is one of the strengths of the EIS. I very much hope this group will guide itself to events and activities that support career development, and then even a seminar for the Society as a whole; who knows we might have found a future chairman/woman.

Turning to more established members of the EIS, D&FG has been busy planning Fatigue 2017 and reviewing papers, and given the current topics it is a good time to welcome a new member from Sheffield University, Dr Hassan Ghadbeigi.

Finally Dr Peter Blackmore has tendered his resignation from committee work, due to other pressures on his time. Peter is a founding member of the Society and has held many roles, including Chairman. He has presented many papers over the years and shared his expertise at numerous seminars. The EIS Council voted to offer him life membership as a token of our gratitude.

Robert Cawte
Chairman

New Personal Members

Sathya Babu - Hendrickson Internat.
Jim Eason - JCB
James Graham - Bonas
Oliver Greenwood - Rolls Royce
Filippo Berto - Institutt for Produktutvikling Og materialer
Javier Aran - Idiada
Cristobal Garcia - Idiada
Hayder Ahmad - Safran Group
Geoff Calvert - VisEng Ltd
George Painter - JCB
Jim Howard - JCB

Corporate Members

The following companies are corporate members of the Engineering Integrity Society. We thank them for their continued support which helps the Society to run its wide-ranging events throughout the year.

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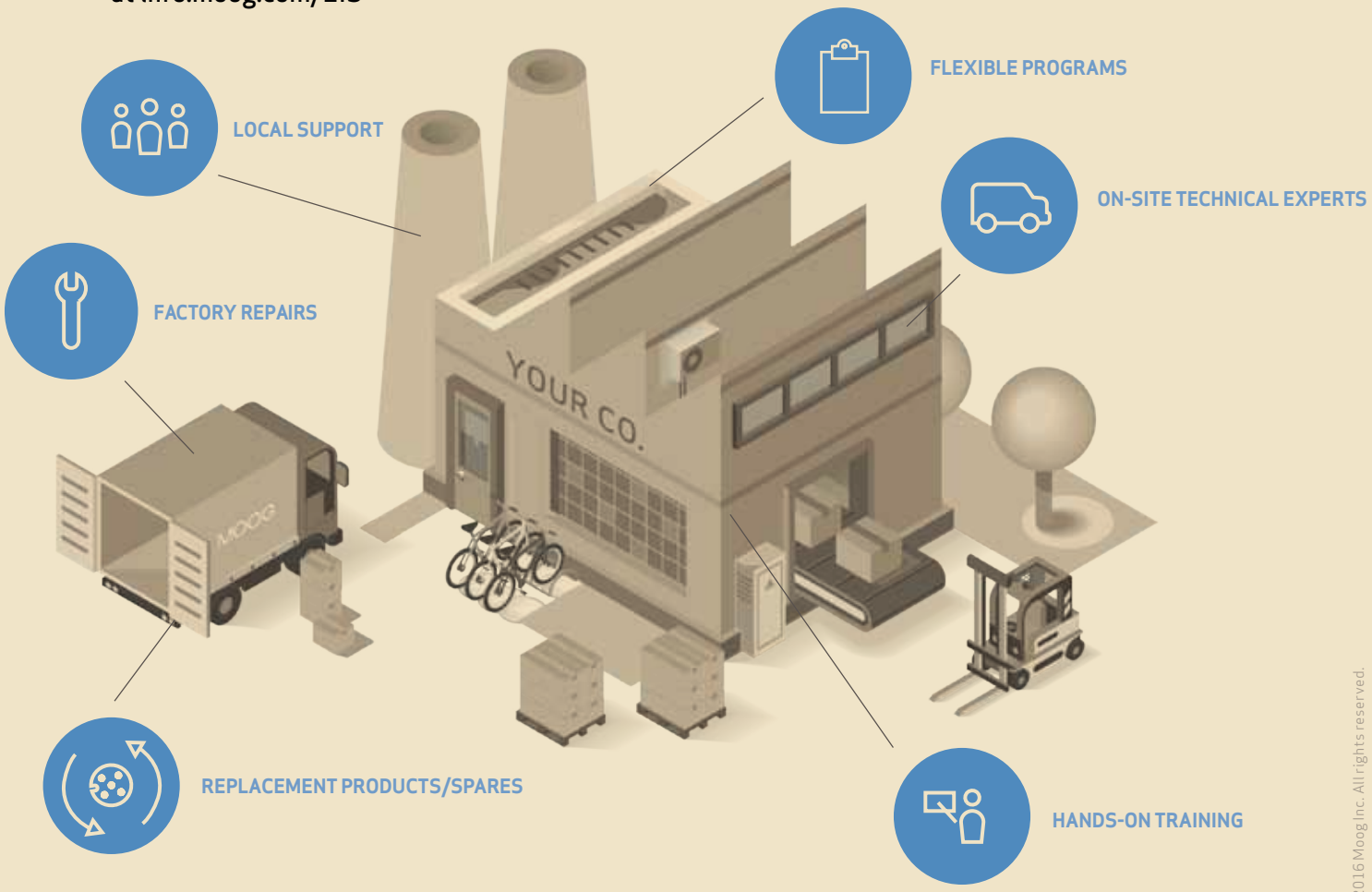

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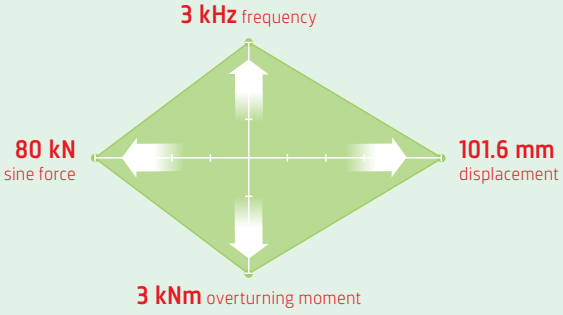

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