HBM Prenscia Technology Day

Tuesday, 6th November 2018

09:30 **Welcome and Introduction**

1Gbs from a moving car at 250kph
Mr. Peter Stoker, Chief Engineer – Connected & Autonomous Vehicle, Millbrook
Mr Paul Spence, Chief Technologist, McLaren Applied Technology

The Big Data GIGO problem: How to overcome it using automatic novelty detection techniques
Dr. Stratis Kanarachos, Centre for Connected Car Autonomous Automotive Research, Coventry University

11:00 - 11:20 **Refreshment Break**

CAN based data analytics to support Health and Usage Monitoring (HUMS) initiatives for Condition Based Maintenance (CBM)
Dr. Mark A. Pompetzki, Director-Principal Scientist, HBM nCode Federal LLC

Reliable Welded Structure Development using Weibull and FMEA Analyses
Mr Chris Wynn-Jones
HBM Prenscia

The Exploitation of an Environmental Logger as Well as Health and Usage Monitoring Systems (HUMS) Data to Extend the Life and Flight life of Munitions
Mr. David Richards, Kent Engineering Services

Durability of structures in the virtual environment
Mr Robert Cawte
HBM Prenscia

12:30 – 13:40 **Lunch** *(and optional Laboratory Tours)*

Reducing 10 years of Development Vehicle Acceleration Data into a Cross-Platform Laboratory Shaker Test
Mr Harry Yarrow, Advanced and Predictive Analysis, Jaguar Land Rover

A Unified Approach for Calculating Life of Components combining Crack Initiation and Growth
Dr. Andrew Halfpenny,
Chief Technologist, HBM Prenscia

Advances in data-driven approaches for Structural Health Monitoring
Dr. Elizabeth Cross and Dr. Ramon Fuentes,
Dynamics Research Group, University of Sheffield

Using web based Analysis to improve productivity across a team or enterprise
Mr. Manish Gautam, HBM Prenscia

14:50 – 15:10 **Refreshments Break**

Low-cost Structural Usage Validation of Military Helicopters
Prof. Steve Reed, Structural Integrity and Ageing Aircraft, Defence Science and Technology Laboratory

Analysis of Streamed Data (Including Connected Vehicles)
Dr. Andrew Halfpenny, Chief Technologist, HBM Prenscia

16:45 **Summary, Questions and Close**

Addressing Analysis Challenges in a Digitally Driven World

This one-day event introduces some challenges and solutions for storing, analysing, and interpreting the ever-increasing quantities of data. Guest speakers representing a number of industries will present their solutions for understanding operational usage, managing and maintaining highly sensitive assets, and improving product design, durability, and reliability.

In addition, HBM Prenscia technical staff will share an in-depth look at solutions for ensuring the reliability and durability of welded structures, using web analysis to improve productivity, and predicting fatigue life of structures in a virtual environment.

The ever increasing quantities of sensor data continually streaming from vehicles, machines, plant and infrastructure presents durability and reliability engineers with many challenges.

For example, in the automotive industry, connected cars are already upon us, with sensor data continually streaming within their internal CAN bus, and pushing usage data to our mobile phone apps. Vehicle and component manufacturers want access to this sensor data to understand operational usage and identify manoeuvres, to improve their product design, durability and reliability. Vehicle manufacturers are rapidly developing Advanced Driver-Assistance Systems (ADAS) and moving closer to fully autonomous vehicles. These developments will require orders of magnitude more miles of vehicle testing to demonstrate their functionality and reliability.

The ability to store, analyse and interpret these increasing quantities of sensor data will require combining traditional signal processing algorithms [*] with new data-science driven approaches.

[*] From statistical models to cycle counting, and vibration analysis to fatigue analysis.

What lessons can be learned from other industries? – from military applications, where both high value and highly sensitive assets must be managed and maintained with high reliability. Over many years these industries have developed and applied methods to demonstrate structural integrity and reliability; Operational Loads Monitoring (OLM), Structural Health Monitoring (SHM), Health and Usage Monitoring Systems (HUMS).

With ever increasing quantities of sensor data…

- **continually streaming from vehicles, machines, plant and infrastructure**
- **engineers and engineering analyses need to cope with these quantities of data**
- **where Big Data exists in the cloud, because it is too big for one machine,**
- **where Digital Twin's model the operational performance of systems**
- **using Operational Loads Monitoring (OLM), Structural Health Monitoring (SHM), Health and Usage Monitoring Systems (HUMS) approaches**
- **to plan Condition Based Maintenance (CBM)**
- **to demonstrate structural integrity and reliability**
- **all require algorithms (statistical, dynamic, vibration, fatigue) to turn data into information**

… to enable engineering reliability decisions.

Biographies and Abstracts

1Gbs from a moving car at 250kph

Mr Peter Stoker, Chief Engineer – Connected & Autonomous Vehicle, Millbrook
Mr Paul Spence, Chief Technologist, McLaren Applied Technology

Biography

Peter started in the auto industry in 1983 in what was then the Austin Rover Group, after graduating from UMIST in Polymer Physics. His first position was in Trim & Hardware development. He left Rover Group for 5 years as a Tier 1, Webasto roof systems, before moving to GM Europe in Luton in 1992.

He was assigned to Japan for 3 years, on the launch of the Frontera and then he project managed the development of the AstraVan, for GME the first virtually developed vehicle derivative without prototypes. He became head of the Vehicle Engineering group in 2012, and Chief Engineer in 2017.

Peter led the successful bid for the Government's Controlled urban CAV testbed, due to start construction in April 2018.

Abstract

One of the challenges for connected and autonomous vehicle (CAV) testing and development is capturing the very large volumes of data generated by these vehicles. From a vehicle perspective, they have increasingly complex sensors on-board (lidar, radar and cameras) all generating megabytes of data per second. From a testing perspective, many more test miles are required to validate autonomous vehicle control systems in many more scenarios.

Collecting these "big data" is a challenge to vehicle manufacturers; traditional data acquisition systems store their measurement data locally, on-board the vehicle, until it can be uploaded to a base station.

The next generation of wireless technology (5G) could provide part of the solution by enabling much higher data rates to transfer vehicle data in near-real time. Though it may be several years before 5G technology reaches our smart phones, privately operated 5G networks at vehicle proving grounds are much closer.

Millbrook and McLaren Applied Technologies are part of the AutoAir consortium developing a "5G Testbed for Connected and Autonomous Vehicles" with UK Government funding as part of the UK's Digital Strategy for future rollout of 5G technology in the UK.

This presentation describes these challenges for CAV testing and development, and the development of this 5G network at Millbrook Proving Ground to enable "1Gbs from a moving car at 250kph".

The Big Data GIGO problem: How to overcome it using automatic novelty detection techniques

Dr. Stratis Kanarachos,
Centre for Connected Car Autonomous Automotive Research, Coventry University

Biography

Stratis is a Reader in Dynamics & Structures at the Future Transport & Cities Institute. He is an expert in Dynamics, essentially at the intersection of signal processing, system dynamics, sensor fusion, and soft computing. He has significant expertise in the management of R&D projects having successfully completed more than 25 funded research projects. Stratis has authored more than 100 publications in scientific journals and conferences.

He is currently the Academic director of the Centre for Connected and Autonomous Automotive Research and is member of the editorial board of the International Journal of Vehicle Systems Modeling and Testing. He participates as associate member in CARTRE, is a member of PEARS standardization initiative and member of the bsi committee on Intelligent Transportation Systems.

He is currently participating in three research projects on ADAS and automated vehicles, funded by the EU and Innovate UK. Two of them are the TIC-IT and Digital CAV Proving Ground projects, which are part of the CAV testbed eco-system currently developed in the UK.

Abstract

Nowadays, getting simulation results using models with millions of Degrees of Freedom and measurement data from numerous sensors has become relatively straightforward and the problem does not lie any more in getting the information but in identifying which information is trustworthy and informative for model development. The quality of data can significantly influence the results and therefore "bad data" need to be removed. Furthermore, there is a growing need to move beyond statistical correlation and black-box models, towards methods that provide insight and a better understanding of the process involved. In this talk, we will present the most popular methods, as well as future research directions, for identifying "informative" or "anomalous" data.

CAN based data analytics to support HUMS initiatives for CBM,

Dr. Mark A. Pompetzki,
Director-Principal Scientist, HBM nCode Federal LLC

Biography

Dr. Pompetzki has over thirty years of experience in fatigue life evaluation, methods development, data acquisition, duty cycle development, component and material testing and multi-axial simulation testing. He has over twenty-five technical publications on durability, fatigue applications and HUMS, is a member of two SAE committees related to fatigue and reliability and is a co-chairman at the annual SAE World Congress. He is the Director and Principal Scientist for HBM nCode Federal LLC. He has been with HBM nCode for 19 years and has led multiple projects on Health and Usage Monitoring Systems (HUMS), Condition Based Maintenance (CBM) and fatigue evaluation of components and systems. Mark holds a Ph.D. in Civil Engineering from University of Waterloo, Canada.

Abstract

Vehicle CAN data is a low-cost readily available data source that has tremendous value to provide insight into vehicle usage. A pragmatic approach is used to combine selected CAN data with maintenance data and data from other sources to expand the range of the solutions that can be realised for improvements in fleet management and life cycle performance.

Using subject matter expertise in the key areas of durability and reliability, further benefits can be achieved through data analytics, which incorporates processes such as inferential sensing, predictive modelling, and machine learning. This can be done to estimate sub-system deterioration rates, remaining useful life, or system performance to understand and improve operational and maintenance scenarios in line with business goals.

This presentation will describe the different aspects of the Health and Usage Monitoring System (HUMS) process and how data analytics can be used to extend such a system for Condition Based Maintenance (CBM) applications. The various components of the CBM system will be discussed and the applicable areas for data analytics will be highlighted, including a technique for virtual vehicle data simulation for performance/scalability testing to ensure that the system meets fleet management goals.

The Exploitation of an Environmental Logger as Well as Health and Usage Monitoring Systems (HUMS) Data to Extend the Life and Flight life of Munitions

Mr. David Richards CEng, CEnv, HonFSEE, FIMechE
Kent Engineering Services

Biography

David Richards has 40 years' experience in the UK Defence Industry. For the majority of this time he has been involved with determining the environmental conditions experienced by weapons and establishing their effects on safety and suitability for service. For 15 of those years he has been involved with establishing and verifying the life of weapons in-service with the UK. For the past 5 years he as a consultant generating standards and best practice procedures for the UK Defence Ordnance Safety Group. He also chairs the Through Life Expert Advisory Group of the UK Weapon Science and Technology Centre.

Abstract

Currently, a variety of environmental data loggers are in use to monitor and record munition environmental parameters. Environmental loggers are typically intended to provide information for munition life assessment and specifically to assist in munition life extension. Such devices are a practical and cost effective means of extending storage and deployment life, even in safety critical circumstances. However, the use of environmental loggers becomes more problematic when adopted as the basis for extending the flight life of air carried munitions. This largely because storage and deployment life are mostly related to temperature exposure, but flight life is mostly set by exposure to mechanical environmental conditions.

This presentation addresses current and future approaches, for establishing an individual munitions exposure, to mechanical environmental conditions occurring during flight carriage. It considers the potential to use data loggers embedded internally within the munition, as well as the potential to utilise externally sourced information. In either case the information needs to be amalgamated with other data sources, in order to facilitate flight life extension. The presentation also addresses the use and misuse of data analysis tools to establish flight life.

Reducing 10 years of Development Vehicle Acceleration Data into a Cross-Platform Laboratory Shaker Test,

Mr. Harry Yarrow,
Advanced and Predictive Analysis, Jaguar Land Rover

Biography

The Advanced and Predictive Analysis team at Jaguar Land Rover are responsible for turning measured vehicle data into useful information. This information is key in guiding engineering decisions within the business, and the team supports this through bespoke analysis and consulting services. As part of this work we have, through the use of nCode Glyphworks and Automation, been able to support a far-reaching and complex correlation project involving measured Road Load data and laboratory vibration tests.

Abstract

When a new vehicle is being created, verification tests are carried out at certain points in the prototype development process. These tests exist at the component level, all the way through to full vehicle measurements and, when a component or system fails a test, the failure needs to be investigated thoroughly. When a new or existing test procedure needs to be validated, to ensure that any failures during the test are representative, this creates an interesting challenge.

The aim of this project was to quantify the relative damage of a vibration test procedure to another, customer-correlated, and widely accepted test procedure that took place in the “real world”. If the damage from this real world test was greater than the damage in the vibration test, then the latter test would surely not cause premature failures and would indeed be representative.

Using nCode Automation to access and manipulate our historical record of 10 years of Road Load Data, and Glyphworks processes for Shock Response and Fatigue Damage spectra, we were able to build a robust picture of how our real world testing compares to laboratory vibration tests. Combined with enveloping algorithms to reduce the visual complexity of the results, this allowed us to reduce tens of thousands of test data files into a handful of easy to understand graphs.

Advances in data-driven approaches for Structural Health Monitoring,

Dr. Elizabeth Cross and Dr. Ramon Fuentes,
Dynamics Research Group, University of Sheffield

Biography

Lizzy Cross is a Senior Lecturer in the Dynamics Research Group at the University of Sheffield. Her work is broadly concerned with how SHM can be made to work for the real world and encompasses the application of statistics and machine learning technology, as well as mathematics from other disciplines such as econometrics.

Ramon Fuentes is a Research Associate in the same group and specialises in developing algorithms for structural health and condition monitoring in an industrial setting. He has developed a number of Bayesian approaches for SHM systems in different contexts including applications for aerospace and energy systems.

Abstract

In this talk we will present the latest developments from the Dynamics Research Group at the University of Sheffield on assessing structural condition based on measured data. The talk will introduce recent advances in dealing with confounding influences in data that arise from changing operational and environmental conditions, new and robust means of detecting outlying and abnormal data and how a Bayesian approach to perform inference under uncertainty can enrich our analysis and consequent decision making.

Low-cost Structural Usage Validation of Military Helicopters

Prof. Steve Reed,
Structural Integrity and Ageing Aircraft, UK Defence Science and Technology Laboratory

Biography

Steve Reed has over 35 years' experience in military aerospace, primarily as an aircraft structures engineer in the Royal Air Force, Defence Evaluation and Research Agency, QinetiQ and the Defence Science and Technology Laboratory. Over the past 10 years he has been the MOD's Technical Authority on the Ageing Aircraft R&D Programme and, within this programme, he has developed low-cost structural usage monitoring systems for over 20 different military aircraft types. Steve has a BSc in aeronautical engineering from the City University, a MSc in aerospace vehicle design from Cranfield University and PhD in mechanical engineering from the University of Sheffield, during which he developed advanced aircraft fatigue monitoring systems using artificial neural networks. He is a Chartered Engineer, a Fellow of the Aeronautical Society and a Visiting Professor at the University of Sheffield.

Abstract

Understanding how the usage of a machine with failure consequences compares with its design assumptions is one of the cornerstones of structural integrity. History has shown, all too graphically, the consequences of failing to understand this. However, we have to live in the real world of ever-constrained budgets and hence there is a need to gain this understanding of structural usage using lower-cost programmes. This paper will explore some of the low-cost methods used to achieve an adequate understanding of the relationship between in-service usage and design usage spectra. Examples will include a range of military helicopter fleets where existing data systems have been utilised where available and low-cost commercially available equipment have been used to provide essential data where required.

Analysis of Streamed Data (Including Connected Vehicles)

Dr. Andrew Halfpenny,
Director of Technology, HBM-Prenscia

Biography

Dr. Halfpenny has a PhD in Mechanical Engineering from University College London (UCL) and a Masters in Civil and Structural Engineering. With over 25 years of experience in structural dynamics, vibration, fatigue and fracture, he has introduced many new technologies to the industry including: FE-based vibration fatigue analysis, crack growth simulation and accelerated vibration testing. He holds a European patent for the 'Damage monitoring tag' and developed the new vibration standard used for qualifying UK military helicopters.

He has worked in consultancy with customers across the UK, Europe, Americas and the Far East, and has written publications on Fatigue, Digital Signal Processing and Structural Health Monitoring. He sits on the NAFEMS committee for Dynamic Testing and is a guest lecturer on structural dynamics with The University of Sheffield.

Abstract

Many industries require fast and efficient means to analyse massive sets of streamed measurements; one of the leading ones is automotive requirements for Connected Vehicles. Connected vehicle applications include: remote diagnostics, firmware updates and evolving use of Advanced Driver Assist Systems (ADAS) and active safety systems. Much "data" (measurement, driving, environment, navigation, media) will become transferable vehicle-to-vehicle and vehicle-to-infrastructure (roadside or cloud). To develop and qualify vehicles with these ADAS will require many more miles of testing than for traditional vehicles in order to develop statistical models, simulation models for vehicle situation response, in addition to existing durability and reliability models.

Vehicle development engineers have traditionally had close control of their measurement data; high precision calibrated, anti-aliased, high sample rates, synchronous across channels. These measurement data were designed for the purpose of vehicle analysis and design.

On-board ADAS use many sensors to provide vehicle state awareness, and Connected Vehicles gives vehicle development engineers access to these sensor measurements remotely; however, they are: asynchronous, aliased, often low sample rate, and event-driven. These sensor data were designed for the purpose of real-time control and so using these data for vehicle analysis and design is a secondary consideration. In order to use these data effectively requires new methods and new algorithms to cope with this change of data source and quality. This presentation discusses the challenges of using these massive sets of streamed data from vehicle bus in order to understand and design future vehicles.