Through-life Engineering Services

The 7th International Conference on Through-life Engineering Services

Cranfield University, Cranfield, UK

6-7 November 2018

In partnership with

Cranfield University

University of Nottingham UK | CHINA | MALAYSIA

IET The Institution of Engineering and Technology

IRP

DMG MORI

Online conference details

Internet access

The internet access is provided by Sky Wi-Fi and is free to use during the conference.

Please follow the steps below to get connected;

- From the list of Wi-Fi connections please connect your device to "_The Cloud"
- Make sure your device's Wi-Fi is switched on
- Once connected, most devices will redirect you to the Sky Wi-Fi login page.
- Please create a new account if you are using the network for the first time.
  Alternately, if you are a previous user, please sign in using your email and password.
- Your device will now automatically connect you to the Wi-Fi hotspot.
- You can register up to 6 wireless-enabled devices using your account.

For creating an account you may also use the
link https://service.thecloud.net/service-platform/login/registration/

Additional information on the Wi-Fi network can be accessed through
https://www.sky.com/help/articles/connect-to-sky-wifi

Conference proceedings online

The conference proceedings will be available to access and download papers as pdfs from the publisher's website:
www.sciencedirect.com/journal/procedia-manufacturing

Welcome

Dear Colleagues,

It is a great pleasure for us to welcome you to the 7th International Conference on Through-life Engineering Services hosted by the Through-life Engineering Services Centre, Cranfield University in partnership with the University of Nottingham. This conference is sponsored by CIRP, DMG Mori and supported by The IET.

Over the last decade, we have observed a significant shift in business strategies that not only affect traditional business niches, but shape the entire supply chain networks. Where the provision of after-sales service used to be optional, it has now become the norm to sell the high value product bundled with extended after-sales support, with the manufacturer entering the market of maintenance and service. The performance and cost combined with market requirements drives these technology intensive, complex and expensive assets that need maintenance and service over the entire life of the product at optimal maintenance costs.

This year's conference is a platform to develop the applicability of Through-life Engineering Services (TES) to solve industry problems of the future. With the increased use of state-of-the-art technologies and the implementation of Industry 4.0 based architecture, it is important to understand the digital footprint in the area of product lifecycle. Today's conference identifies the applicability and impact of digital service engineering on high technology manufacturing industries.

This edition of the conference includes six academic sessions that broadly covers the latest advances in Through-life Engineering Services, degradation prognosis, management of reliability and obsolescence and digital engineering services. In addition to five keynotes from academics and industrialist and a debate on the Future of TES, attendees will benefit from two workshops focused on technology and Digital TES.

With these words, we wish you have a successful conference.

Professor Rajkumar Roy,
General Chair
TESConf2018

Dr Gustavo M Castelluccio,
Programme Chair
TESConf2018

Conference Schedule

The 7th International Conference on Through-Life Engineering Services

6-7 November 2018
Vincent Building, Cranfield University

At a glance

Monday 5 November 2018						
17:30	**19:00**	**Refreshments (CMDC bar)**				
Tuesday 6 November 2018						
		Auditorium	**Room 1**	**Room 2**	**Room 3**	**Room 4**
08:30	**09:30**	**Registration**				
09:30	**09:50**	Opening session				
09:50	**10:30**	**Keynote one:** Professor David Taylor (Trinity College, Dublin)				
10:30	**11:10**	**Keynote two:** Andy Harrison (Rolls-Royce Plc, UK)				
11:10	**11:40**	**Coffee break**				
11:40	**13:00**		**A1:** Future Through-life Engineering Services		**A2:** Degradation prognosis	
13:00	**14:00**	**Lunch**				
14:00	**15:30**	**W1:** Future of TES (debate)				
15:30	**16:00**	**Coffee break**				
16:00	**17:30**		**A3:** Design and Manufacturing for TES		**W2:** Aircraft Health Monitoring	
18:00		**Bus for dinner**				

Wednesday 7 November 2018

		Auditorium	Room 1	Room 2	Room 3	Room 4
09:00	09:40	**Keynote three:** Dr Paul Theron (Cranfield University, UK)				
09:40	10:20	**Keynote four:** Toru Takagi (Nissan, Japan)				
10:20	11:00	**Keynote five:** Dr Makoto Fujishima (DMG Mori, Japan)				
11:10	11:40	**Coffee break**				
11:40	13:00		**A4:** Reliability and Obsolescence		**A5:** Digital Service Engineering	
13:00	14:00	**Lunch**				
13:50	15:30		**A6:** Planning and Management		**W3:** TES Digital	
15:30	16:00	Closing and award presentation				
16:00	16:30	**Networking and TES Lab Tour**				

Key

Plenary session | Academic Sessions (A) | Workshop Sessions (W) | Break

Keynote speaker biographies

Professor Paul Théron, Cranfield University, UK

Professor Paul Théron, PhD, runs the Atkins-Cranfield Chair of cyber-secure engineering systems and processes and he is the Head of the Manufacturing Informatics Centre within Cranfield's School of Aerospace, Transport and Manufacturing.

His central research area is cyber resilience, seen from the perspectives of dynamic phenomena, engineering and ecosystemic governance processes. Focusing today on Autonomous Cyber Defence, he is the deputy lead of NATO's IST 152 Research & Technology Group and was formerly the co-director of the "Aerospace Cyber Resilience" research chair (French Air Force, Dassault Aviation, Thales).

Previously, he has worked for Thales Communications & Security's cybersecurity unit on the cyber resilience of the Telecommunications, Aviation, Automotive and Defence sectors. A former member of ENISA's Permanent Stakeholders Group and DG CNECT expert, he has worked for the European Commission's DG Joint Research Centre and led the research group who produced the IACS Cybersecurity Certification Framework (ICCF) that inspired the EU's 2017 strategy on cybersecurity certification presented in Join(2017)450 and COM(2017)477

Professor David Taylor, Trinity College, Dublin

David Taylor holds the position of Professor of Materials Engineering at Trinity College Dublin, Ireland. He is a member of the Royal Irish Academy and holds Fellowships of the Institution of Engineers of Ireland and of the Royal Academy of Medicine in Ireland.

His research interests lie in the strength, fracture and repair of materials. In four books and over 200 journal articles, his work covers all kinds of engineering materials and more recently he has focused on biological materials such as bone, insect cuticle and plant stems. He was the founding editor-in-chief of the Journal of the Mechanical Behaviour of Biomedical Materials and is a director of the Association of Consulting Forensic Engineers.

Dr Makoto Fujishima,
DMG MORI, Japan

Makoto Fujishima graduated at Doshisha University in 1981 and joined MORISEIKI. He worked from 1981 to 1997 as an electrical designer for machine tool design. Subsequently, he was responsible of the control-engineering department.

He received PhD degree in Mechanical Engineering under the guidance of Professor Kakino from Kyoto University in 2002. He was responsible for US R&D section of MORISEIKI from 2008 to 2009. Following the economic downturn precipitated by the Lehman Brothers bankruptcy in 2008, he became responsible of the purchasing section and afterwards of the electrical control technologies of development HQ.

Dr Fujishima is now mainly working for HMI development, IoT, sensing, energy efficiency, and remote maintenance and monitoring technologies of machine tools. He has published over 50 papers for journals and conferences and has applied for 67 patents.

Toru Takagi,
Nissan Motor Company, Japan

Mr. Takagi is manager of the Laboratory of Mobility Service at Nissan Motor Co., Ltd and manager of the division of Production Engineering at Nissan Motor Co., Ltd.

Mr. Takagi's research interests include AI technology, Big Data analytics and Connected Car Services. He has done work on Nissan Carwings, eg, Telematics service, EV support centre for Nissan LEAF, Failure Prediction for manufacturing robot.

Professor Andy Harrison, Rolls-Royce Plc, UK

Professor Andrew Harrison (BSc, MBA, FRAeS, C-Eng), has worked at Rolls-Royce plc for over 32 years, with the last 18 leading the development of the companies strategies for ‘Design for service’ and ‘engineering for services digitisation’.

He is a leading figure in the National Through life Engineering Services (TES) council, leading the development of a national vocabulary and standards for TES for both industry and academia.

Workshop one:

Future of Through-life Engineering Services (Expert Panel Discussion)

Chair: **Professor Rajkumar Roy**,
Cranfield University, UK

6 November 2018, 14:00-15:30

Background

The current manufacturing landscape, especially in the manufacturing and maintenance of both legacy and long-life high value parts, has transformed significantly with the influence and expansion of product service systems (PSS). This has not just reversed the responsibility of the after-sales maintenance and service support, but also has introduced the manufacturer into the service sector, together with its competitors who have traditionally supported the product previously. Where there is a continuous introduction of a variety of technology intensive platforms into everyday manufacturing and maintenance activities, it is now a requirement to understand and identify those technologies together with evolving business strategies to support the entire life of the high value asset.

This panel discussion and debate is organised by the Through-life Engineering Services Centre.

Workshop aim

The aim of the session is to develop a roadmap of the future in the area of TES. It must be understood that TES does not just include maintenance, but starts right at the conceptual design stage through to component disposal. This session will be organised in the form of a debate and will consist of an expert panel, and an open debate that will identify potential topics that will grow in the future. The topics will cover the TES challenges in different sectors to TES for Mobility as a Service.

Workshop two:

Towards higher TRLs in aircraft health monitoring

Organised by: **Dr Isidro Durazo-Cardenas, Dr Cristobal Ruiz-Carcel, Professor Andrew Starr,** Cranfield University, UK

6 November 2018, 16:00-17:30

Background

Aircraft systems suppliers are looking to implement health monitoring systems for cost effective maintenance and added safety. Recent research efforts at lower TRLs have proved to be effective in timely diagnosing fault development and provide sufficient warning.

The research now needs to target higher TRLs. In this special session we would like to engage with researchers and industrialist to capture best practice, recent developments and innovative trends to achieve the next TRL. The workshop is organised by the Through-life Engineering Services Institute.

Workshop aim

To provide a platform for discussion and engagement of the industrial and academic community to discuss opportunities and challenges for the development of health monitoring systems in aircraft at higher TRLs..

Workshop Structure:

1. Introductory presentation: achievements and challenges of the i-BEARING and i-GEAR projects; Speaker: Professor Andrew Starr
2. Split discussion/contributions: Participants will be split in to 2 groups. Group A facilitated by Isidro; and groupB facilitated by Cristobal will discuss on the topics as mentioned below for 20 minutes.The groups will then switch to the second topic. A final wrap-up discussion facilitated by Andrew will precede the discussion and will summarise and collate the general conclusions. Post it notes and white boards will be used to capture the participants' contributions.
3. Split discussion topics:
   a. Data management: data budgets, how much data and how often, algorithm warning releases, data storage, transmission, safety protocols;
   b. Exploitation route: approaches and experiences, partnerships, funding sources, testing protocols

Workshop three:

Towards a true digital twin of Through-life Engineering Services (TES)

Organised by: **Dr Maryam Farsi**,
Cranfield University, UK

7 November 2018, 13:50-15:30

Background

This session is organised by Through-life Engineering Services Centre to address the industrial challenges in the deployment of digitalisation in TES toward the industry 4.0 trend. The session focuses on the industry three top challenges in TES and the digital capabilities to solve these issues. Digital capabilities can be categorised in terms of digital technologies and knowledge. As part of the workshop, the challenges will be prioritised based on previous studies and expert's knowledge. The workshop will provide a platform to find the solutions for successful adoption of such digital capabilities.

Workshop aim

This session aims to develop recommendations for key TES challenges. The objectives for the workshop activity are two folded:

- To identify the critical challenges in TES
- To determine the most promising digital approaches to address the TES challenges

The outcome from this workshop will be published as a white paper. A report on the workshop outcomes will be sent to the attendees to establish the workshop objectives within four weeks.

Industry speakers:

- **Andrew Harrison,**
  Engineering Associate Fellow
  at Rolls-Royce
- **Malcolm Lee,**
  Group Head of Technology and Innovation
  at Babcock

Detailed programme

All the meeting rooms are in Vincent Building (B52A), unless otherwise specified.

Monday 5 November 2018	
17:30-19:00	**Welcome drinks** (CMDC Bar)

Tuesday, 6 November 2018	
08:30-09:30	**Registration** (Entrance Area)
09:30-09:50	**Opening Session** (Auditorium) General Chair: Rajkumar Roy, Cranfield University, UK
09:50-10:30	**Keynote one: Through-Life Engineering - Inspiration from Nature** Professor David Taylor, Trinity College, Dublin, Ireland (Auditorium)
10:30-11:10	**Keynote two: Digital TES** Professor Andy Harrison, Rolls-Royce Plc, UK (Auditorium)
11.10-11.40	**Coffee break** (Foyer)
11:40-13:00	**A1: Future of Through-life Engineering Services** (Room 1), Chair: Professor Andy Harrison (Rolls-Royce Plc, UK) TBC; Dr Maryam Farsi (Cranfield University, UK)
11:40-12:00	**Comparison of Automated feature selection and reduction methods on the condition monitoring issue,** Kerman López de Calle, Susana Ferreiro, Aitor Arnaiz and Basilio Sierra (IK4-TEKNIKER)
12:00-12:20	**Towards a unified predictive maintenance system - a use case in production logistics in aeronautics,** Karl Hribernik, Moritz von Stietencron, Alexandros Bousdekis, Bernd Bredehorst, Gregoris Mentzas and Klaus-Dieter Thoben (Bremer Institut für Produktion und Logistik GmbH)
12:20-12:40	**Digital twins: Understanding the added value of integrated models for through-life engineering services** Rok Vrabič, John Ahmet Erkoyuncu, Peter Butala and Rajkumar Roy (University of Ljubljana)
12:40-13:00	**Future-proofing the Through-life Engineering Service Systems,** Tariq Masood, Johannes Egger and Maximilian Kern (University of Cambridge)

11:40-13:00	**A2: Degradation prognosis** (Room 3), Chair: Professor David Taylor (Trinity College, Dublin); Dr Pavan Addepalli, (Cranfield University, UK)
11:40-12:00	**Modelling the influence of laser drilled recast layer thickness on the fatigue performance of CMSX-4,** Nicolau Iralal Morar, Rajkumar Roy, Simon Gray, John Nicholls and Jörn Mehnen (Cranfield University)
12:00-12:20	**Impact of Duty Cycle on Wear Progression in Variable displacement Vane Oil Pumps,** Aleksandr Doikin, Esmaeil Habib Zadeh, Felician Campean, Martin Priest, Andrew Brown and Andrew Sherratt (University of Bradford)
12:20-12:40	**Mechanical performance of composite bonded joints in the presence of localised process-induced zero-thickness defects** Hamed Yazdani Nezhad, Dimosthenis Stratakis, David Ayre, Sri Addepalli and Yifan Zhao (Cranfield University)
12:40-13:00	**A review of miniaturised NDT techniques for in-situ inspection,** Weixiang Du, Yifan Zhao, Rajkumar Roy, Pavan Addepalli and Lawrence Tinsley (Cranfield University)
13:00-14:00	**Lunch** (Foyer)
14:00-15:30	**W1: Future of TES (Debate – Expert Panel Discussion)** (Auditorium), Chair: Professor Rajkumar Roy, (Cranfield University, UK)
15:30-16:00	**Coffee break** (Foyer)
16.00-17.30	**A3: Design and Manufacturing for TES** (Room 1), Chair: Professor Stephen Newman (University of Bath, UK) TBC; Professor Benoît Iung (Université de Lorraine, France)
16:00-16:20	**Through Life Machine Tool Capability Modelling,** Parag Vichare, Aydin Nassehi, Joseph Flynn and Stephen Newman (University of Bath)
16:20-16:40	**Predictive Maintenance and part quality control from joint product-process-machine requirements: application to a machine tool,** Alexandre Voisin, Thomas Laloix, Benoit Iung and Eric Romagne (University of Lorraine)
16:40-17:00	**Conceptualising the impact of information asymmetry on through-life cost: case study of machine tools sector** Maryam Farsi, Alex Grenyer, Madhu Sachidananda, Mario Sceral, Steve Mcvey, John Erkoyuncu and Rajkumar Roy (Cranfield University)
17:00-17:20	**An approach to support reliable test processes between suppliers and OEM,** Marco Franke, Karl A. Hribernik and Klaus-Dieter Thoben (Bremen Institute for Production and Logistics)
16:00-17:30	**W2: Towards higher TRLs in aircraft health monitoring** (Room 3), Chair: Dr Isidro Durazo-Cardenas, Dr Cristobal Ruiz-Carcel, Professor Andrew Starr, Cranfield University, UK
18:30-22:00	**Dinner** (Woburn Sculpture Gallery)

Detailed programme

Wednesday, 7 November 2018	
09:00-09:40	**Keynote three: Through-life seamless cyber resilience** Professor Paul Théron, Cranfield University, UK (Auditorium)
09:40-10:20	**Keynote four: Maintenance challenges in Mobility as a Service** Toru Takagi, Nissan Motor Company, Japan (Auditorium)
10:20-11:00	**Keynote five: Latest developments in Machine Tool maintenance and aftermarket support** Dr Makoto Fujishima, DMG MORI, Japan (Auditorium)
11:00-11:30	**Coffee break (Foyer)**
11:30-12:50	**A4: Reliability and Obsolescence** (Room 1), Chair: Professor Robert Gao (Case Western Reserve University) TBC; Dr Suresh Perinpanayagam, Cranfield University, UK
11:30-11:50	**Modeling of Layer-wise Additive Manufacturing for Part Quality Prediction,** Jianjing Zhang, Peng Wang and Robert Gao (Case Western Reserve University)
11:50-12:10	**Reliability Challenges for Automotive Aftertreatment Systems: a State-of-the-art Perspective,** Morteza Soleimani, Felician Campean and Daniel Neagu (University of Bradford)
12:10-12:30	**Obsolescence paths through the value chain** Marc Zolghadri, Amel Soltan, Sid-Ali Addouche, Maher Barkallah and Mohamed Haddar (Quartz-Supmeca)
12:30-12:50	**Obsolescence Mitigation in Automotive Industry using Long Term Storage Feasibility Model,** Kevin Boissie, Sid-Ali Addouche and Marc Zolghadri (Valeo)
11:30-12:50	**A5: Digital Service Engineering** (Room 3), Chair: Professor Kirsten Tracht (Bremen Institute for Mechanical Engineering); Professor Paul Théron, Cranfield University, UK
11:30-11:50	**Development of a Context-aware framework for the Integration of Internet of Things and Cloud Computing for Remote Monitoring Services,** Ali Al-Shdifat and Christos Emmanouilidis (Cranfield University)
11:50-12:10	**Modelling of false alarms and intermittent faults and their impact on the maintenance cost of digital avionics,** Ahmed Raza and Vladimir Ulansky (National Aviation University Ulkraine)
12:10-12:30	**Layered Security for IEEE 1687 Using a Bimodal Physically Unclonable Function** Maulana Randa, Mehmet Bozdal, Mohammad Samie and Ian Jennions (Cranfield University)
12:30-12:50	**Hardware Trojan Enabled Denial of Service Attack on CAN Bus,** Mehmet Bozdal, Maulana Randa, Mohammad Samie and Ian Jennions (Cranfield University)
12:50-13:50	**Lunch (Foyer)**

Detailed programme

13:50-15:30	**A6: Planning and Management** (Room 1), Chair: Dr Ajith Kumar Parlikad (University of Cambridge, UK) TBC; Dr John Erkoyuncu (Cranfield University, UK)
13:50-14:10	**Heuristic optimisation for multi-asset intervention planning in a petrochemical plant,** Sanyapong Petchrompo and Ajith Kumar Parlikad (University of Cambridge)
14:10-14:30	**Decentralised dis- and reassembly control in maintenance of large-scale products,** Torsten Sievers, Sebastian Hogreve and Kirsten Tracht (Bremen Institute for Mechanical Engineering)
14:30-14:50	**Automated selection and assembly of sets of blades for jet engine compressors and turbines** Maik Dammann and Thorsten Schüppstuhl (Technische Universität Hamburg-Harburg)
14:50-15:10	**Design, testing and operation phase improvement taking profit of data obtained in test benches,** Iñaki Bravo, Thomas Epple, Egoitz Konde and Enrique Guruceta (IK4-Tekniker)
15:10-15:30	**Simulating mechanical stress on a micro Unmanned Aerial Vehicle (UAV) body frame for selecting maintenance actions,** Alberto Martinetti, Mihran Margaryan and Leo van Dongen (University of Twente)
13:50-15:30	**W3: Towards a True Digital Twin of Through-life Engineering Services** (Room 3), Chair: Dr Maryam Farsi, Cranfield University, UK
15:30-16:00	**Closing Ceremony and Best Paper Award**
16:00-16:30	**Networking and TES Lab tour**

Committees and chair

General Chair

Rajkumar Roy, Cranfield University, UK

Programme Committee

Gustavo M Castelluccio
(Programme Chair), Cranfield University, UK

Essam Shehab
(Award Chair), Cranfield University, UK

Dragos Axinte
(Co-Chair), Nottingham University, UK

John Ahmet Erkoyuncu
(Local Organising Chair), Cranfield University, UK

Pavan Addepalli
(Publicity Chair), Cranfield University, UK

Andrew Starr,
Cranfield University, UK

Kirsten Tracht,
University of Bremen, Germany

Ashutosh Tiwari,
University of Sheffield, UK

Tetsuo Tomiyama,
Cranfield University, UK

Jose Luis Endrino,
Cranfield University, UK

Ian Jennions,
Cranfield University, UK

Laura Lacey,
Cranfield University, UK

Suresh Perinpanayagam,
Cranfield University, UK

Zakwan Skaf,
Cranfield University, UK

Yifan Zhao,
Cranfield University, UK

David Palmer,
Nottingham University, UK

Xin Dong,
Nottingham University, UK

Mingfeng Wang,
Nottingham University, UK

David Alatorre,
Nottingham University, UK

Organisation Committee

Cranfield University, UK

Conference Venue

Conference Venue:
Vincent Building (B52A), Cranfield University

Reception Drinks:
Cranfield Management Development Centre (CMDC), Cranfield University

Gala Dinner:
Woburn Sculpture Gallery, Woburn Abbey, Woburn, Bedfordshire, MK17 9WA
Bus will depart from CMDC on Tuesday 6 November 2018 at 6pm

Additional Travel Information:
Situated close to Milton Keynes and Bedford, the Cranfield campus is located in Wharley End, very close to Cranfield village, and is about 10 minutes from the M1 motorway. There is rail and road access to most major airports as well as coach and train stations. Cranfield campus also has its own airport for private executive business travel. Post code is MK43 0AL.

For complete travel information, please look at the details on following webpage:
www.cranfield.ac.uk/about/how-to-find-cranfield

A printable version of visitor info can be downloaded using the link
www.cranfield.ac.uk/~/media/files/arrivals_registrations_maps_directions/welcome-to-cranfield-campus.ashx?la=en


Reception Drinks
Main Reception
Lab Tour
Conference Venue
To M1 (North) J14
To M1 (South) J13
Cranfield Village
To Bedford and Newport Pagnell
Receptions
Staff & visitor parking
Disabled parking
Restaurant/cafe
Shops
Cash machine
Bus stop
Petrol station and garage
Cycle path
Two-way traffic
One-way traffic
N
09 45 0 135 180
Metres

Conference dinner

Tuesday 6 November 2018

Dinner at the Woburn Sculpture Gallery,
Woburn Abbey, Woburn Bedfordshire MK17 9WA

Dress code: "smart casual"

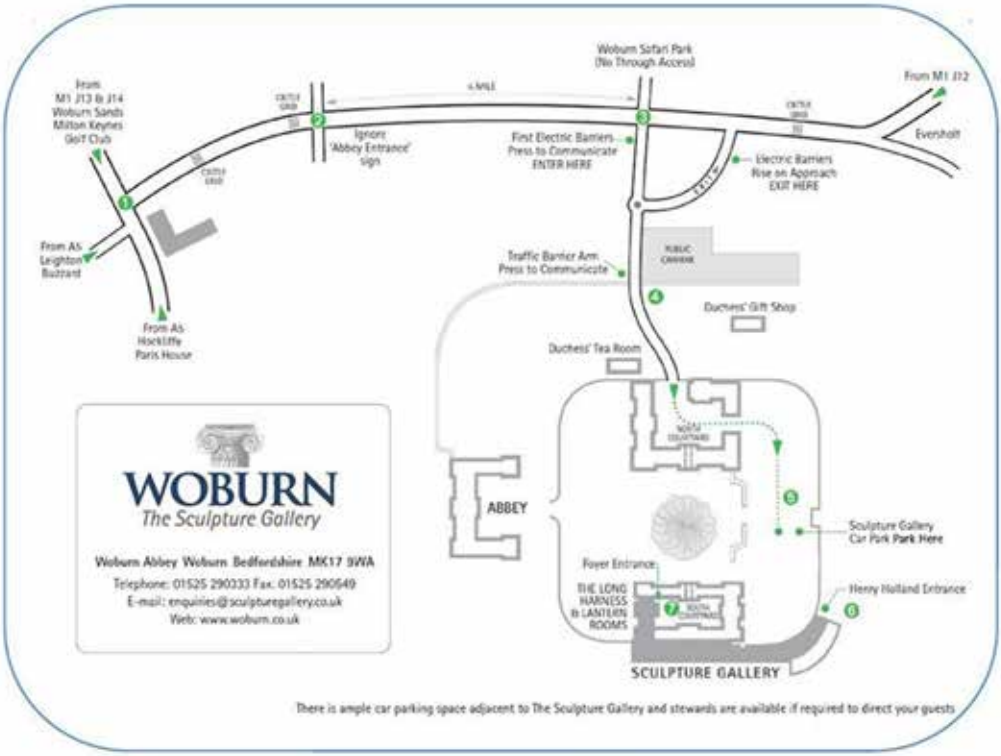
We will be organising coaches to take you to the conference dinner from the recommended hotels.

Details of this transport will be announced at the conference.

If you have any questions, please ask at the registration desk.

For accompanying guests costs, please contact Mrs Anne Fiorucci on

T: +44 1234 750111 ext 4031
E: a.fiorucci@cranfield.ac.uk



Directions from Woburn village

1. From Woburn village, at the junction by towards Woburn Abbey.
2. Cross over two cattle grids, ignore the Abbey visitor entrance on right.
3. Carry on to the top of the hill and turn right at the entrance with electric barriers. Ignore 'Delivery Vehicles Only' sign. To the right of the barriers is an intercom button, press to communicate.
4. Once through the barriers continue down the access road, past the main car park on your left and drive through the opening arch in the wall ahead, through the barrier, over small a cattlegrid.
5. Continue past the Duchess' Tea Room on your right. Drive into the North Courtyard and on through the only accessible archway to your left and park in the gravel parking area to your right.
6. The Henry Holland corridor is located at the far end of The Sculpture Gallery car park or walk onto the roundabout with the large cedar tree and into the courtyard
7. The Foyer Entrance is through the archway and immediately ahead to your right.

By Road

Woburn Abbey is ideally situated being just 4 miles west of the M1 between junctions 12 and 13, giving easy access from most areas of the country.

Milton Keynes, Leighton Buzzard, Bedford, Cranfield	20 mins
Watford, Northampton, Aylesbury	45 mins
London, Oxford, Cambridge, Rugby	1 hour
Leicester, Coventry	1 hour 15 mins
Birmingham, Nottingham, Reading	1 hour 30 mins
Sheffield, Stoke, Swindon	2 hours
Leeds, Manchester, Bristol	2 hour 15 mins

By Rail

Bletchley and Milton Keynes to Euston	50 minutes
Flitwick to Kingscross	1 hour
Flitwick station direct to and from Gatwick	1 hour 40 mins

By Air

Luton Airport	35 mins
Heathrow	1 hour 30 mins
Stansted	1 hour 30 mins
Gatwick	2 hours
Birmingham Airport	1 hour 30 mins

Notes

This conference is organised by the:

The Through-life Engineering Services Centre

Cranfield University, Cranfield,
Bedfordshire, MK43 0AL, UK

www.through-life-engineering-services.org/TESConf/