

## A One-day Workshop on Transdisciplinary Modeling and Simulation using Hybrid System Models

**Organised by The UK Operational Research Society (UKORS) Simulation Special Interest Group, The Centre for Simulation, Analytics and Modelling (CSAM) at University of Exeter, with support from The Leverhulme Trust**

*Date:* Tuesday 17<sup>th</sup> July, 2008 from 0900 to 1700

*Venue:* Constantine Leventis Teaching Room, Building: ONE, University of Exeter Business School (Streatham Campus, Rennes Drive, Exeter EX4 4ST).

*Registration information:* This event is free to attend. Please [register here](#).

About the event: The University of Exeter Business School is pleased to invite you to its one-day workshop on transdisciplinary modelling and simulation (M&S), being co-organised by the *Centre for Simulation, Analytics & Modelling* and the *UKORS SIG Simulation*. Transdisciplinary M&S brings together approaches and methodologies from distinct disciplines, with the objective of developing hybrid system models that transcend discipline-specific boundaries, thereby contributing to the development of the field of M&S. The workshop has two main goals, (1) to bring together a wide variety of theorists and practitioners interested in modeling so that all may learn a diversity of approaches, and (2) to explore cross-connections between the approaches in the hope of forging new clusters. We hope that you are able to attend the workshop. The organisers encourage engagement across disciplines.

The workshop will feature two keynote addresses by:

- **Prof Paul Fishwick**, Distinguished University Chair of Arts, Technology and Emerging Communication, Professor of Computer Science, UT Dallas, USA, and The Leverhulme Trust Visiting Professor with University of Exeter Business School.
- **Prof Andreas Tolk**, The MITRE Corporation and Adjunct Professor at Old Dominion University, Norfolk, Virginia.

*Prof Paul Fishwick's visit to the UK is funded by the Leverhulme Trust Visiting Professorship award with University of Exeter Business School.*

### Programme:

0900-0915: Registration and Tea/Coffee

0915-0930: Welcome and Setting the Scene by Nav Mustafee (Exeter)

0930-1030: **Keynote 1: The Art and Science of Modelling by Paul Fishwick (University of Texas Dallas).**

1030-1100: Big Simulation Analytics by Simon J E Taylor and Anastasia Anagnostou (Brunel University London)

1100-1115: Tea/Coffee

1115-1145: The Scope of Modelling in Digital Humanities by Paul Caton (Kings College London)

1145-1215: Undertaking a Multi-disciplinary Research Project - The Good, The Bad and The Ugly by Sally Brailsford (Southampton)

1215-1245: Symbiotic Simulation: Hybrid Systems Model Meets Big Data Analytics – Stephan Onggo (Trinity College Dublin) and Nav Mustafee (Exeter)

1245-1330: Lunch

**1330-1430: Keynote 2: Mapping Integrateability, Interoperability, and Composability to M&S Supports for Interdisciplinary, Multidisciplinary, and Transdisciplinary Research by Andreas Tolk (The MITRE Corporation/Old Dominion University)**

1430-1500: Inter-disciplinary Collaborative Modelling using Journey-based Modelling Techniques from User Experience Design by David Bell (Brunel University London)

1500-1530: A Hybrid Systems Approach using Real-Time Data and Computer Simulation: A Research Framework and its Implementation in the Context of Urgent and Emergency Care by Alison Harper and Nav Mustafee (Exeter)

1530-1545: Tea/Coffee

1545-1645: Panel Discussion (chaired by Simon Taylor)

1700: Close

Information for the attendees:

**Registration:** This event is free to attend. Please [register here](#).

**Directions:** Click [here](#) for directions to University of Exeter's Streatham Campus. The event will be held in Building: ONE, University of Exeter Business School (number 84 in [campus map](#)).

**Parking information:** Visitors may only park in car park C and 15 marked bays in car park A ([campus map](#)). Further information on car parking.

**Accommodation:** University of Exeter accommodation can be booked using the following link: <https://bookings.eventexeter.com/>.

**Local contact point:** Please email Tom Crawford ([T.Crowford@exeter.ac.uk](mailto:T.Crowford@exeter.ac.uk)) if you have any queries.

## Abstracts and Author Biographies

### # Keynote 1 (0930-1030):

*Title:* The Art and Science of Modelling

*Keynote Speaker:* Paul Fishwick, University of Texas Dallas

*Abstract:* One of the characteristics of being human is to model. In our history, we began with representations of animals made from natural materials, and painted on cave walls. We also made regular marks on animal bones. While the modern accounting of these products is art (animal representations) and mathematics (bone marks), a more comprehensive understanding points to modelling in both cases. We saw or imagined things, and then we made models of our experience. This talk will be a non-technical, cross-disciplinary, introduction to modelling. I will discuss (1) the history of modelling, (2) a way of thinking about modelling using three broad categories, (3) the notion that computer and information science is a form of modelling, and (4) approaches to modelling across disciplines – from art and humanities to business, science, and engineering.

*Bio:* **Paul Fishwick** is Distinguished University Chair of Arts and Technology (ATEC), and Professor of Computer Science. He has six years of industry experience as a systems analyst working at Newport News Shipbuilding and at NASA Langley Research Center in Virginia. He was on the faculty at the University of Florida from 1986 to 2012, and was Director of the Digital Arts and Sciences Programs. His PhD was in Computer and Information Science from the University of Pennsylvania. Fishwick is active in modelling and simulation, as well as in the bridge areas spanning art, science, and engineering. He pioneered the area of aesthetic computing, resulting in an MIT Press edited volume in 2006. He is a Fellow of the Society for Computer Simulation, served as General Chair of the Winter Simulation Conference (WSC), was a WSC Titan Speaker in 2009, and has delivered over 24 keynote addresses at international conferences. He was Chair of the Association for Computing Machinery (ACM) Special Interest Group in Simulation (SIGSIM) four years from 2012 to 2016. Fishwick has over 230 technical publications and has served on all major archival journal editorial boards related to simulation, including ACM Transactions on Modeling and Simulation (TOMACS) where he was a founding area editor of modelling methodology in 1990. He is CEO of Metaphorz, LLC which assists the State of Florida in its catastrophe modelling software engineering auditing process for risk-based simulation for hurricanes and floods.

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### # Keynote 2 (1330-1430):

*Title:* Mapping Integrateability, Interoperability, and Composability to M&S Supports for Interdisciplinary, Multidisciplinary, and Transdisciplinary Research

*Keynote Speaker:* Andreas Tolk, The MITRE Corporation/Old Dominion University

*Abstract:* Recent developments of computational methods supporting scientific research have led to the rise of a variety of computational science disciplines. Applying comparable modeling and simulation methods, several of these disciplines are using this opportunity to

intensify their collaborative efforts with other researchers. In order to better understand how simulation engineers can support such efforts, it is necessary to understand the various degrees of interoperation between disciplines, as they are captured in the work on multidisciplinary, interdisciplinarity, and transdisciplinarity on the one side, and the simulation science and engineering concepts of integrateability, interoperability, and composability. This presentation presents the concepts on multidisciplinary, interdisciplinarity, and transdisciplinarity and shows the needs for alignment of the supporting modeling and simulation concepts, methods, and tools, resulting in a mapping. It shows how these mapping can be aligned with recent research results on hybrid simulation alignment based on a common framework that addresses the various facets of hybrid approaches that in general merge two or more components of different categories to generate something new, that combines the characteristics of these components into something more useful, using examples of different application domains.

*Bio:* **Andreas Tolk** is Technology Integrator for the Modeling, Simulation, Experimentation, and Analytics Division of the MITRE Corporation and Adjunct Professor at Old Dominion University. He holds a PhD and M.Sc. in Computer Science from the University of the Federal Armed Forces in Munich, Germany. He published more than 250 journal articles, book chapters, and conference papers and edited nine textbooks and compendia on Modeling and Simulation and Systems Engineering topics. He is a senior member of ACM and IEEE and a Fellow of SCS.

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#### **# 1030 Talk:**

*Title:* Big Simulation Analytics

*Speakers:* Simon J E Taylor and Anastasia Anagnostou (Brunel University London)

*Abstract:* Driven by innovations such as mass customisation, complex supply chains, smart cities and emerging cyber-physical and Internet of Things systems, Big Data is presenting a fascinating range of challenges to Analytics. New fields are emerging such as Big Data Analytics and Data Science. Modeling & Simulation (M&S) is core to Analytics. Additionally, as system boundaries grow there is a need to capture and model different system elements in appropriate hybrid simulation world views. Arguably, contemporary M&S practices cannot deal with the demands of Big Data or new systems challenges. The implication of this is that M&S may not feature in the Big Data Analytics techniques and tools of the future. Based on recent experiences from high performance simulation projects and associated industrial experiences, this talk will outline the key challenges that Big Data has to M&S and strongly argue that M&S has to get “Big” to meet these challenges. Exciting opportunities lie ahead for interdisciplinary teams of practitioners and researchers from OR/MS, Computer Science and domain specific fields. Indeed “Big” Simulation presents its own possibilities and the talk will conclude with thoughts on the potential for “Big” Simulation Analytics to move beyond Big Data into future Symbiotic Control and Digital Twin Systems.

*Bio:*

**Professor Simon J E Taylor** is the Director of the Modelling & Simulation Group in the Department of Computer Science, Brunel University London. He has a successful track record of research in Modelling & Simulation, particularly with high performance distributed simulation in industry through digital infrastructures. He has developed these solutions with over 20 companies resulting in over £5M in cost savings and increased production. He has successfully applied these experiences in the development of digital infrastructures in Africa and has led innovation in over 10 African countries. He has also led the development of international standards in these areas. He regularly audits and chairs commercial project reviews in distributed computing and Modelling & Simulation. He is a member of the ACM SIGSIM Steering Committee and founder of the Journal of Simulation. He has chaired several major conferences and has published over 150 articles.

**Anastasia Anagnostou** is a Research Fellow in the Modelling & Simulation Group, Department of Computer Science, Brunel University London. She holds a BSc(Hons) in Electronics Engineering, an MSc in Telemedicine and e-Health Systems, and a PhD in Distributed Modelling & Simulation. Her research interests lie in the areas of Advanced Computer Infrastructures for Modelling and Simulation, Open Science for Simulation, Hybrid Distributed Simulation and Modelling and Simulation for Healthcare and Industrial Applications. She is co-Chair for the OR Society's Simulation Workshop (SW20) and member of organising committees for international conferences sponsored by IEEE and ACM/SIGSIM. Since 2011, she has been involved in several interdisciplinary research projects with stakeholders from industry and academia across manufacturing, healthcare, defence and food supply chains. She has also worked in Africa helping to develop digital infrastructures and collaborative services enabling open science.

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#### **# 1115 Talk:**

*Title:* The Scope of Modelling in Digital Humanities

*Speaker:* Paul Caton, Kings College London

*Abstract:* Modelling in DH is both a tool and a topic: a method to enable examination and interpretation but also itself a subject of examination and interpretation. I will discuss illustrative examples of both those aspects: examples which represent the 'poles' of the axis of scope. One is a project dedicated to investigating and revealing the semantic scope of the term 'modelling' and its cognates in digital humanities work. The other is a sustained effort over many years and through multiple iterations to specify a formal model that rigorously describes one particular phenomenon. I will conclude by showing how easily in digital humanities work the opportunity/temptation comes to approach an issue by thinking in terms of modelling.

*Bio:* **Paul Caton** took up his first digital humanities post in 1996 - as Electronic Publications Editor at the Women Writers Project - whilst completing his Ph.D in English Literature at Brown University. Currently a Senior Analyst in the Digital Lab at King's College London, he has worked in several places and on numerous projects over the years. Much of his work has focused on text encoding and document analysis and he is particularly interested in formal models associated with those practices.

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### # 1145 Talk:

*Title:* Undertaking a Multi-disciplinary Research Project - The Good, The Bad and The Ugly

*Speaker:* Sally Brailsford, University of Southampton

*Abstract:* The Care Life Cycle was a five-year multidisciplinary research program funded by the UK Engineering and Physical Sciences Research Council. Its aim was to apply “complexity science” methods to study the links between supply and demand for health and social care in an ageing population, and involved a team of researchers from demography, gerontology, computer science and operational research. We developed a suite of linked simulation models, including an agent-based model of family formation, a system dynamics model of social care provision, and a hybrid DES-SD-ABS model for the eye condition age-related macular degeneration. In this talk I briefly describe some of these models, and discuss the joys - and challenges - of doing multidisciplinary research.

*Bio:* **Sally Brailsford** is Professor of Management Science at the University of Southampton, UK. She received a BSc in Mathematics from the University of London, and MSc and PhD in Operational Research from the University of Southampton. Her research interests include simulation modeling methodologies and the modeling of human behavior in healthcare systems.

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### # 1215 Talk:

*Title:* Symbiotic Simulation: Hybrid Systems Model Meets Big Data Analytics

*Speakers:* Stephan Onggo (Trinity College Dublin) and Nav Mustafee (Exeter)

*Abstract:* Symbiotic simulation is one of Industry 4.0 technologies that enables interaction between a physical system and the simulation model that represents it as its digital twin. Symbiotic simulation is designed to support decision making at the operational levels by making use of real- or near real- time data that is generated by the physical system, which is used as an input to the simulation model. From the modelling perspective, a symbiotic simulation system comprises a hybrid systems model that combines simulation, optimization and machine learning models as well as a data acquisition module and an actuator. The actuator is needed when the symbiotic simulation system is designed to directly control the physical system without human intervention. This talk reviews the components of a symbiotic simulation system from the perspective of hybrid systems modelling and highlights research questions needed to advance symbiotic simulation study.

*Bio:*

**Bhakti Stephan Onggo** is an Associate Professor of Data Analytics at Trinity Business School, Trinity College Dublin, Ireland. His research interests lie in the areas of predictive analytics using simulation (symbiotic simulation, hybrid modelling, agent-based simulation, discrete-event simulation) with applications in operations and supply chain management (e.g.

hospital, manufacturing, transportation) and social dynamics (e.g. social risk). He is an Associate Editor for the Journal of Simulation and the secretary of The OR Society's Simulation SIG.

**Navonil Mustafee** is Associate Professor of Operations Management & Analytics and Deputy Director of the Centre for Simulation, Analytics and Modelling (CSAM) at University of Exeter Business School. He is the founding co-chair of the Health and Care IMPACT Network and honorary researcher with Torbay and South Devon and RD&E Foundation Trusts. His interests are in hybrid systems modelling, hybrid simulation, healthcare analytics and bibliometric analysis. He is the current Chair of the OR Society's Simulation SIG.

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#### # 1430 Talk:

*Title:* Inter-disciplinary Collaborative Modelling using Journey-based Modelling Techniques from User Experience Design

*Speaker:* David Bell, Brunel University London

*Abstract:* Modelling constructs typically emerge using the domain or modelling semantics that are in play. Unsurprisingly, semantic difference (in language and meaning) is more pronounced in communities where computational simulation is less mature – one example being the arts. Heritage or artistic communities have very specific issues around visitor flows and experiences – primarily in response to a designed artefact or collection. This presentation will introduce journey based modelling techniques from user experience (UX) design as a foundation for inter-disciplinary collaborative modelling. Personas and journey maps are used as an abstract representation from which tools and techniques are chosen. Two case studies will be covered: 1) A UK county museum where collections are linked to the physical landscape and 2) a Danish beach art installation where experiences are captured using mobile technology. Hybrid techniques are used to operationalise UX models in order to explore and better understand visitor experience.

*Bio:* **Dr David Bell** is a Senior Lecturer in the Department of Computer Science at Brunel University London where he carries out research into digital service design – including the simulation of user interaction and behavioural change. He spent 15 years working in the IT industry (primarily within Investment Banking) in roles from developer to technology director. Dr. Bell is the Education Chair for the ACM SIGSIM where he is involved in the promotion and support of doctoral simulation researchers.

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#### # 1500 Talk:

*Title:* A Hybrid Systems Approach using Real-Time Data and Computer Simulation: A Research Framework and its Implementation in the Context of Urgent and Emergency Care

*Speakers:* Alison Harper and Nav Mustafee

*Abstract:* Conventional simulations rely on historic data and are generally used for medium to long-term decision making. With the advent of technologies associated with business intelligence and data sciences, it is now possible to process and store an increasing volume and variety of data, including high-velocity and real-time data. With open architectures and standards for data sharing, this data is increasingly available for data-driven applications which may run, for example, prediction algorithms or visualisations. This study aims to investigate how real-time simulation can support short-term decision-making in urgent and emergency care. A hybrid systems modelling approach is proposed, which is the combined application of real time-data feeds, forecasting and simulation. The hybrid approach is encapsulated in a research framework, which proposes a step-by-step approach to inform the development of a real-time simulation. The framework is implemented through a case study that focuses on the urgent care network in Torbay and South Devon; it relies on the NHSquicker platform for real-time data feed. The potential impact of the real-time model will be evaluated in terms of their contribution to distributed situation awareness using staff interviews. Distributed SA is system knowledge held in both the human and technical components of a system which supports short-term decision-making.

*Bio:*

**Alison Harper** is in the second year of her PhD at University of Exeter Business School. She has a background in clinical healthcare and healthcare human factors. Her research interests include hybrid approaches to simulation and real-time simulation, and she is particularly interested in healthcare applications.

**Navonil Mustafee** is Associate Professor of Operations Management & Analytics and Deputy Director of the Centre for Simulation, Analytics and Modelling (CSAM) at University of Exeter Business School. He is the founding co-chair of the Health and Care IMPACT Network and honorary researcher with Torbay and South Devon and RD&E Foundation Trusts. His interests are in hybrid systems modelling, hybrid simulation, healthcare analytics and bibliometric analysis. He is the current Chair of the OR Society's Simulation SIG.