

## Mission Statement

*“The Turing Gateway to Mathematics (TGM) acts as a vehicle for knowledge exchange between the mathematical sciences and potential users of mathematics, including industry, government, business and other academic disciplines, both in the UK and internationally. It does this by facilitating interactions and activities such as programmes of work, research and training events, as well as bespoke projects. The TGM aims at widening access to mathematics generally, to shorten pathways to impacts for academic research, and to support education and training in areas where mathematical skills are needed”*

## What makes TGM different

*The Turing Gateway to Mathematics is a knowledge intermediary for the mathematical sciences. Based at the Isaac Newton Institute for Mathematical Sciences and supported by the University of Cambridge, the TGM reaches out to and engages with the users of mathematics – in industry, business, public sector and other scientific disciplines. With extensive access to multiple communities across the UK and globally, the TGM can respond in an agile and flexible manner. The TGM works as a delivery partner to facilitate the transfer, translation and dissemination of knowledge. Using effective communications and proven methodologies, the TGM develops and runs a wide range of activities, bringing people and organisations together in order to share knowledge and stimulate further research and collaboration.*

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The Turing Gateway to Mathematics (TGM) is an impact initiative of the Isaac Newton Institute (INI) based at the University of Cambridge.

It acts as a vehicle for knowledge exchange between the mathematical sciences and potential users of mathematics, such as industry and other academic disciplines in the UK as well as internationally. It helps to bridge the gap between those engaged in frontier mathematical research and those working in more applied areas, by stimulating the interchange of knowledge and ideas between academics from different disciplines and users of modern mathematics, such as industry and policy makers.

The TGM was established in 2013 and since then has consolidated its presence, delivering a range of activities across a number of different themes and sectors including biology and healthcare systems, environment and energy, financial risk, security sectors, Big Data and public policy.

A number of programmes of work were delivered during the report period, including working with the Maths Foresees Network, the Warwick Centre for Predictive Modelling & the Knowledge Transfer Network, and the Alan Turing Institute.

Working with Maths Foresees, an EPSRC network funded under the Living with Environmental Change (LWEC) umbrella, and the PURE network (Probability, Uncertainty and Risk in the Environment), the TGM delivered a four day Maths Study group, where challenges were presented by industry and potential solutions were discussed and developed. Following the event, collaborations between the end users who set the challenges and the academics have continued, with short peer reviewed reports being developed that highlight the most promising potential solutions. The TGM has also been successful in being awarded the tender to deliver the second *Environmental Modelling in Industry Study Group* in April 2017.

In collaboration with the Warwick Centre for Predictive Modelling and the Knowledge Transfer Network, the TGM developed and delivered a four day *Predictive Multiscale Materials Modelling* workshop, to help identify advances in fundamental mathematical, statistical and machine learning approaches to impact data-driven predictive multiscale materials modelling. Methods discussed at the workshop have significant potential to reduce the cost, time and risk of advanced material system validation for assessing risk and capability at the system level.

Funded by the Alan Turing Institute, the TGM hosted a three day *Data-Rich Phenomena - Modelling, Analysing and Simulations using Partial Differential Equations* event. This was one of a number of scientific scoping workshops, to help define their research programme and identify the most promising research directions to be taken forward. The TGM has since explored delivery opportunities with the Alan Turing Institute and further activity will be developed going forward.

User engagement activities to help enhance partner and end-user interaction were developed, working with two new entities, the EPSRC Centre for Mathematical Imaging in Healthcare and the Cantab Capital Institute for the Mathematics of Information. The TGM helped develop some specific programmes of work that ensured effective dissemination and identified new collaborative opportunities to help enrich the existing communities.

The TGM and the Institute of Mathematics and its Applications (IMA) agreed to form a *Strategic Understanding*, which included the development of proposals for joint activity. The IMA is the UK's professional and learned society for Mathematics, with a mission "to support the advancement of mathematical knowledge and its applications and to promote and enhance mathematical culture in the United Kingdom and elsewhere". The IMA supports professional development, education, research and outreach in mathematics and its applications through publications, meetings and engagement with policy.

The TGM and IMA share common interests and support largely overlapping communities. The *Understanding* will help combine resources, yield access to larger communities, share best practice, maximise effective communications and help avoid duplication of effort and consequently dilution of impacts.

The TGM has continued to expand engagement opportunities and strategic relationships with the public sector, academia and industry are ongoing. This has been achieved by facilitating interactions and activities such as programmes of work, consultations, workshops, research and training programmes, as well as less formal, small working groups in which academics and business personnel work together. This approach enables engagement between individuals and organisations who were not previously working together and helps to achieve greater synergy across activity and more creative and imaginative approaches.

### The TGM Advisory Board

The TGM Advisory Board has members from industry and public bodies to help advise on strategic matters and on overall development of the TGM. The Board meets twice a year in Cambridge.

Membership:

Name	Organisation
Dougal Goodman	The Foundation for Science & Technology
Graham Keniston-Cooper	Investor and Entrepreneur
Peter Landrock	Cryptomathic ( Advisory Board Chair)
Natasa Milic-Frayling	University of Nottingham & Intact Digital Ltd.
Richard Pinch	Institute of Mathematics and its Applications

### The TGM Programmes Committee

The TGM Programmes Committee provides input and guidance on specific scientific or research matters related to TGM activities. The Committee Members are all academics and operate largely in a virtual way via email and telephone and are responsive to ad-hoc questions and requests for guidance from the TGM.

Membership:

Name	Organisation
Jacek Gondzio	University of Edinburgh
Des Higham	University of Strathclyde
Jane Hutton	University of Warwick
Arieh Iserles	University of Cambridge
Robert Leese	Smith Institute
Nigel Smart	University of Bristol

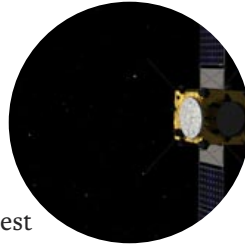
**The Manager of the TGM** has responsibility for overall management and delivery of TGM activities. The Manager is also pivotal in the strategic direction and developments of the TGM and identifies potential research opportunities of mutual benefit to mathematicians and industry.

**The Knowledge Exchange Coordinator** supports diversification of the TGM, coordinates events and marketing activity with industry and businesses, and leads some specific programmes of work.

**The Events and Marketing Coordinator** provides administrative support to TGM events and marketing activities, as well as inputting to financial administration.

**3rd European  
Optimisation in  
Space  
Engineering  
(OSE)  
Workshop**  
17 - 18 Sept 2015

There is a recognised need for technology improvements and further research in the area of optimisation in space engineering. This 2 day workshop consisted of a number of presentations related to optimisation challenges, where participants were invited to share their latest engineering problems and proposed solutions, to promote the creation and exchange of ideas and the identification of new trends and required developments. The workshop brought together experts from the UK and across Europe from a range of backgrounds in mathematics and industry, to discuss these technical challenges and possible solutions.

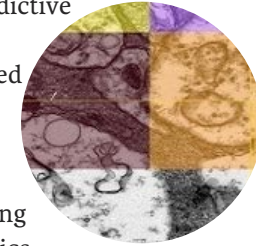


**Environmental  
Modelling in  
Industry**  
21 - 24 Sept 2015

The TGM hosted this Maths Study Group, in partnership with the Maths Foresees Network (who sponsored the event) and the PURE (Probability, Uncertainty and Risk in the Environment) Network. The mitigation of severe environmental events and natural hazards is of huge importance. Mathematical modelling and analysis have the potential to help address challenges identified in this area, so one aim was to forge collaborations between the mathematical sciences and environmental change communities. A number of challenges were presented by industry which involved both broad and specific issues relating to the application of models to predict and analyse environmental events. Potential solutions were discussed and developed over the week and peer reviewed reports were subsequently developed.



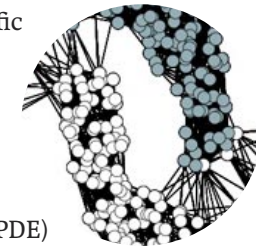
Working with the Warwick Centre for Predictive Modelling and the Knowledge Transfer Network, the TGM developed and delivered this four day workshop, to identify and integrate synergistic methodologies from various research fields, towards finding solutions for predictive materials modelling challenges. The multiscale and multiphysics nature of materials gives rise to extremely challenging and unique mathematical and algorithmic problems currently prohibiting uncertainty quantification and predictive materials modelling.



**Predictive  
Multiscale  
Materials  
Modelling**  
1 - 4 Dec 2015

Through a series of talks, the workshop helped identify state-of-the-art in predictive multiscale materials modelling that could be applied to industry led challenges, such as those related to chemical mechanical materials modelling, complex fluid and solid material interaction, error estimation, high dimensional optimisation, machine learning and multi-fidelity simulations.

This event was one of a number of scientific scoping workshops funded by the Alan Turing Institute, to help define their research programme. It brought together expert mathematicians and statisticians, working on nonlinear, nonlocal, and stochastic Partial Differential Equations (PDE) models and on large, complex network problems, with industrial and academic data science users. By encouraging discussion among the participants in informal presentations and breakout sessions, it helped identify the most promising research directions combining PDE and data science, to be taken forward, details of which were fed back to the Alan Turing Institute.



**Data-Rich  
Phenomena -  
Modelling,  
Analysing and  
Simulations  
using Partial  
Differential  
Equations**  
14-16 Dec 2015

### Big Data Analytics for the Financial Services

7 January 2016

This half-day event embedded within the UCL Theory of Big Data Conference, focused on Big Data Analytics - looking at systemic risk and financial regulation. A major component of Big Data analytics is mathematics - the models and algorithms that are needed to extract knowledge from the data in order to maximise these insights. A key objective of this event was to investigate the challenges and possible solutions for this area from a mathematical perspective. Talks provided context from researchers and end users and included presentations from the Bank of England and the FCA.



### Computational and Data Challenges in Environmental Modelling

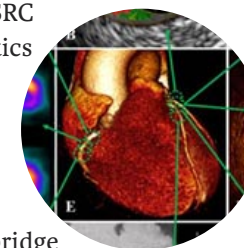
10 February 2016

The TGM delivered this event in partnership with the Probability, Uncertainty and Risk in the Environment (PURE) Knowledge Exchange Network, with contributions from SECURE (Statistics of Environmental Change, Resources and Ecosystems) and ReCoVER (Research on Changes of Variability and Environmental Risk). It was supported by the Institute of Physics - Computational Physics Group & Environmental Physics Group. The aim was to discuss how the most recent developments in computer sciences and the availability of new environmental data may be harnessed to advance large environmental models, including models of climate change and natural disasters.



The day focused on aspects of both models and data - with speakers from industry and academia looking at the availability and quality of open data for environmental modelling, using environmental data to build new models and the use of new technologies to collect novel environmental data.

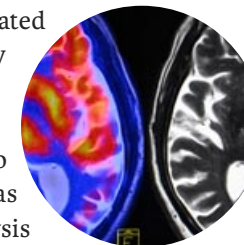
This celebrated the launch of the new EPSRC Centre, which will explore how mathematics and statistics can help clinicians to tackle serious health challenges such as cancer, heart disease and antibiotic resistant bacteria.



The new Centre at the University of Cambridge aims to achieve synergies between applied mathematics and statistics by focusing on the analysis of clinical imaging, particularly arising in neurological, cardiovascular and oncology imaging. The event provided an introduction to the Centre and outlined the projects where cutting-edge mathematics and statistics will be applied to investigate specific healthcare imaging problems.

EPSRC Centre for Mathematical Imaging in Healthcare - Launch Event  
8 March 2016

This event explored the challenges associated with developments in imaging technology across biology and medicine. It brought together those working on advances in imaging technology, with researchers who investigate new image analysis methods, as well as image technology and image analysis users.



Big Data, Multimodality & Dynamic Models in Biomedical Imaging  
9 March 2016

The event focused on Big Data Problems and Solutions, Multimodality and Dynamic Imaging. A 'Lightning Talks' session provided the opportunity for early stage researchers and students to deliver short elevator pitches on relevant research projects in biomedical image analysis.

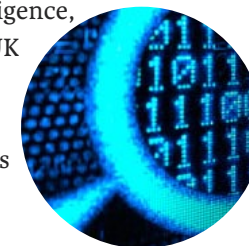
The event was delivered with support from the POEMS (Predictive mOdelling for hEalthcare technology through MathS) network and was in partnership with colleagues from across the University of Cambridge.

**Cambridge  
Mathematics &  
Big Data  
Showcase**  
20 April 2016

The TGM delivered this event in partnership with the University of Cambridge's Centre for Mathematical Sciences and the Big Data Initiative, to highlight areas of research and expertise in mathematics and Big Data, from within the University. It was delivered with support from The National Physical Laboratory (NPL) and The Engineering and Physical Sciences Research Council (EPSRC) and provided the opportunity for 200 delegates to see what Cambridge has to offer and to better understand the diversity and impact that research in mathematics and Big Data at Cambridge can make on business and policy across a wide range of areas. The event included a series of presentations, as well as an exhibition of 60 posters, where researchers discussed specific areas of mathematics and Big Data.



Sponsored by BAE Systems Applied Intelligence, this workshop aimed to engage with the UK research community to discuss broad research directions in cryptographic technologies, the underlying mathematics that underpins them and the potential applications to cyber-security.

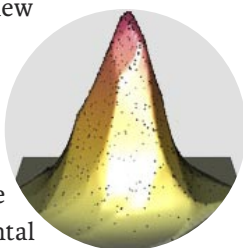


**New Directions  
in Cryptography  
and  
Applications to  
Cyber-Security**  
15 June 2016

Talks covered areas such as encryption, secure computation and their applications across a number of areas including cloud computing, smart grid, mobile and embedded computing, hardware, software, and network security. One key aim of the event was to increase awareness of R&D activities across the research community to help inform future research directions and address challenges such as with legacy schemes and time frames for keeping data secure.

**The Cantab  
Capital Institute  
for the  
Mathematics  
of Information  
Launch**  
9 May 2016

This celebrated the launch of an exciting new research Institute which is a collaboration between Cantab Capital Partners LLP and the University of Cambridge. The event provided an opportunity to learn more about the work of the Institute, such as the specific questions that feed into fundamental methodology development. Presentations at the event introduced areas of mathematical expertise represented in the Institute and outlined how fundamental techniques can be drawn on to meet the challenge of deciphering meaning in the ever growing volumes of data.



## Open for Business Events

The Isaac Newton Institute sponsors Open for Business (OfB) events as a part of its continuing objective to bring academic researchers involved with its research programmes into contact with end users such as industrial, commercial and government organisations and individuals.

These activities, which are delivered by the TGM, provide opportunities, at senior level, for cross-fertilisation between the business-facing activities of users from industry and the public sector, and the research focus of the Institute. OfB events are structured to enable the formation of new public-private partnerships, collaborative research and to assist in identifying the common challenges that have greatest potential for research, knowledge exchange, public policy and commercial impact.

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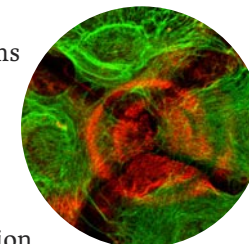
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Two OfB events were hosted over the past year:

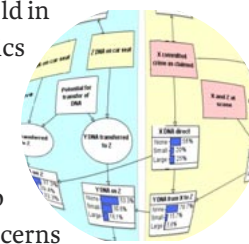
This workshop aimed to highlight new mathematical and computational problems and potential solutions involved in cell motility, morphogenesis and pattern formation. It was linked to the Coupling Geometric PDEs with Physics for Cell Morphology, Motility and Pattern Formation Programme. It brought together scientists working on these timely and challenging topics of mathematical biology, soft matter physics, image process and analysis, cellular biology, analysis and numerics, with other key stakeholders in industry and the public sector. Further development in the modelling of such biological phenomena is needed and an effective way to achieve this is by strengthening synergies between mathematics and the life sciences.



Understanding the Mathematics and Physics of Cell Motility and Pattern Formation

9 December 2015

This consultation event in London was held in advance of the INI Probability and Statistics in Forensic Science Research programme running from July to December 2016. It involved discussion with members of the legal community and senior academics, to better understand the difficulties and concerns that the profession faces. Discussions highlighted the need for a clear consensus as to the uses and limitations of statistics and probability in criminal evidence and how these should be expressed. It was agreed that mathematics experts in Court should communicate in ways that people can understand and that more independent validation of assumptions and models, including software used for DNA analysis, is required. It will be followed by a dissemination event in Cambridge in December 2016.



Probability and Statistics - Perspectives from the Legal Profession

9 February 2016

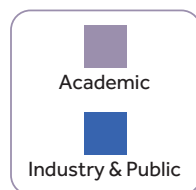
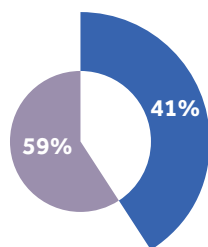


## Participation

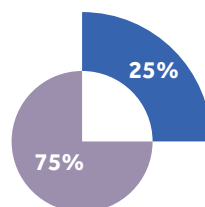
The TGM has established itself as an effective vehicle for the delivery of knowledge exchange between the mathematical sciences and users of mathematics.

From August 2015 to July 2016, 917 participants attended the 14 events that the TGM coordinated. The focus has been to facilitate links between academics and industry and this has been achieved by ensuring a good spread of attendance from both communities. The pie charts below show attendance at TGM delivered events, divided by affiliation.

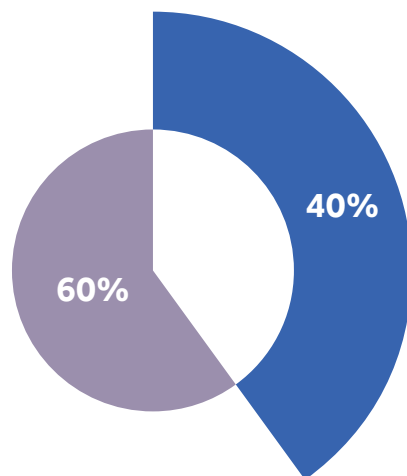
### TGM Events



### Open for Business Events



### Open for Business & TGM Events Combined



## Accounts for August 2015 to July 2016

	2013 - 2014 £,000	2014 - 2015 £,000	2015 - 2016 £,000
<b>Income</b>			
University of Cambridge Funding <sup>1</sup>	70	70	70
University of Cambridge Funding for OFB <sup>2</sup>	6	0	6
Sponsorship <sup>3</sup>	10	104	93.5
Partnership <sup>4</sup>			23
Registration Fees <sup>5</sup>			17.5
<b>Total Income</b>	<b>86</b>	<b>174</b>	<b>210</b>
<b>Expenditure</b>			
Staff Costs	58	102	116
Travel & Subsistence	2	1.5	2
Event Expenditure	17	49	43
OFB Event Expenditure <sup>6</sup>	8	6	6
Marketing & Documentation	3	0.5	0
Overheads & Administration <sup>7</sup>	1	1	1
<b>Total Expenditure</b>	<b>89</b>	<b>160</b>	<b>168</b>
<b>Surplus</b>	<b>3</b>	<b>14</b>	<b>42</b>
<b>Brought Forward</b>	<b>57</b>	<b>54</b>	<b>68</b>
<b>In Year</b>	<b>3</b>	<b>14</b>	<b>42</b>
<b>TOTAL SURPLUS</b>	<b>54</b>	<b>68</b>	<b>110</b>

<sup>1</sup> This funding is provided by the University of Cambridge's Higher Education Innovation Funding stream.

<sup>2</sup> The TGM delivers Open for Business events on behalf of the Isaac Newton Institute, so these are itemised as separate income and expenditure. This funding is provided by the University of Cambridge's Higher Education Innovation Funding stream.

<sup>3</sup> Ten sponsorship amounts were received, as contributions towards specific delivery projects/events.

<sup>4</sup> Funds received/projected for Retained and Corporate Partnerships.

<sup>5</sup> These are fees charged to delegates to cover registration and accommodation costs at some events.

<sup>6</sup> The TGM delivers Open for Business events on behalf of the Isaac Newton Institute, so these are itemised as separate income and expenditure.

<sup>7</sup> To date, the TGM has been supported by the INI in its early development stage, with free use of seminar/AV facilities for events, administration and human resources.

## Grants & Funding

Initially the TGM was funded by the University of Cambridge through the Higher Education Innovation Funding scheme, which covered human resource costs, but not TGM activities. Therefore all TGM events and projects require independent funding, for example from other public or government sources, industrial sponsorship, philanthropy and participant registration fees.

The TGM continues to pursue longer term financial support for operational costs and to fund activities.

### Corporate Partnership

In April 2015, the TGM launched its Corporate Partnership Scheme, to build relationships with organisations who seek deeper engagement with the mathematical sciences. Through Corporate Partnership, an organisation can gain privileged access to experts from mathematics and across the multiple disciplines it underpins, and will benefit from enhanced opportunities to develop and gain access to ground-breaking research and meet other relevant stakeholders. It is also an effective way to increase an organisation's visibility to other communities, such as Government, business, industry and technology, and presents opportunities for networking, knowledge transfer and collaboration.

There are three partnership levels to suit different needs, and organisations can also be specifically associated with a TGM Thematic Programme of Work.

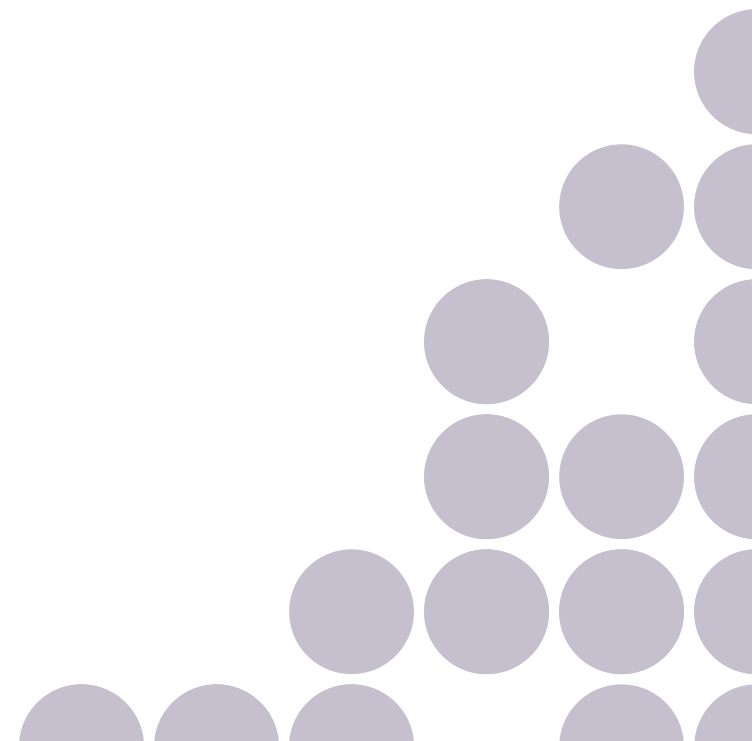
GCHQ and CRYPTOMATHIC are Corporate Partners and negotiations with several other organisations progressing towards Partnership are ongoing. Further information on Corporate Partnership can be seen at [www.turing-gateway.cam.ac.uk/tgm-cps.shtml](http://www.turing-gateway.cam.ac.uk/tgm-cps.shtml)

## User Engagement

The TGM is working as a delivery partner with two new entities to help enhance partner and end-user engagement and interaction. These are the Cantab Capital Institute for the Mathematics of Information and the EPSRC Centre for Mathematical Imaging in Healthcare.

As part of this collaboration, the TGM will develop programmes of work, communicate activity and develop strategic relationships, to ensure effective translation from science to user. This will help partners to understand and gain consensus on the challenges that need to be overcome and facilitate other interdisciplinary collaborations to enrich the existing communities.

For more information on working with the TGM as a delivery partner, please contact the TGM Manager at [info@turing-gateway.cam.ac.uk](mailto:info@turing-gateway.cam.ac.uk)



# Future Development

The TGM aims to respond in a speedy and focused way to new ideas and approaches, but recognises the need for a targeted and continuous approach to the delivery of longer term knowledge exchange activities in the mathematical sciences. In appreciation of this its series of thematic knowledge exchange programmes are designed to stimulate and support research activities and include workshops, consultations and project meetings. These include Mathematics for Financial Services, Mathematics for Biology and Healthcare Systems, Mathematics for the Space and Security Sectors, Mathematics for the Environment and Energy, and Mathematics of Big Data.

Over the coming year, the TGM will continue to develop this thematic work in partnership with stakeholders, Corporate Partners and Delivery Partners and progress with its aspiration to play a key national role in mathematical knowledge exchange.

## Activity in 2016-2017

The TGM continues to expand and build its programme of work. Recent and forthcoming events include:

Soft Matter - Theoretical and Industrial Challenges. Celebrating the Pioneering Work of Sir Sam Edwards  
(7 - 9 September 2016)

Perspectives on Data Linkage - Techniques, Challenges and Applications  
(16 September 2016)

Developments in Healthcare Imaging - Connecting with Industry  
(19 October 2016)

Statistical Network Analysis - Challenges in Industry and Society  
(1 November 2016)

Cantab Capital Institute for the Mathematics of Information - Research Directions Launch  
(10 November 2016)

Statistical Scalability for Streaming Data Launch Event  
(15 November 2016, London)

Probability & Statistics in Forensic Science  
(1 December 2016)

New Approaches to Anonymisation  
(5 December 2016)

Engaging People in Data Privacy  
(6 December 2016)

Emerging Phenomenon & Impacts of High Frequency Trading  
(1 March 2017)

Maths Foresees Study Group  
(3-6 April 2017)

2nd Edwards Symposium. Challenges and Opportunities in Soft Matter  
(6-8 September 2017)