

Annual Report
2014–15



UNIVERSITY OF
CAMBRIDGE



Isaac Newton Institute
for Mathematical Sciences

Mission Statement

The Turing Gateway to Mathematics acts as a channel for the flow of knowledge and ideas between the mathematical sciences and the users of mathematics. It does this by facilitating interactions and activities such as programmes of work, events, projects, education and training in areas where maths skills are needed. Acting as a gateway between academic mathematicians and industry, government, and other disciplines, it helps to widen access to mathematics generally and shorten pathways to impacts.

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Foreword

The *Turing Gateway to Mathematics* (TGM) is an impact acceleration initiative of the Isaac Newton Institute (INI) based at the University of Cambridge. It acts as a vehicle for knowledge transfer between the mathematical sciences and potential users of mathematics, such as industry and other academic disciplines, internationally as well as in the UK. 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 financial risk, space and security sectors, Big Data and public policy.

Two large programmes of work were delivered during this report period, for EPSRC and BAE Systems. EPSRC's *Maths and Public Policy* programme included a launch event and two day-long workshops which further engaged stakeholders and helped disseminate information related to *Cities & Infrastructure* and *Health & Society*. These three workshops helped to raise the profile of the mathematical sciences and its importance to the public policy areas by engaging with nearly 200 academics and policy makers.



Supported by BAE Systems, the *Dynamic Imaging Data* three-day workshop was developed in conjunction with Microsoft and the University of Cambridge to investigate the technology challenges around the analysis of very large and complex data streams. Three industry challenges were presented (one on each day), covering the areas of security, medical imaging, media and creative industries. Connections facilitated at the event continue to be explored, including joint working and potential new programmes of work.

Relationships with Research Councils have deepened, particularly EPSRC, ESRC, NERC and BBSRC, due to joint programmes of work and projects delivered over the report period.

The TGM has continued to nurture and expand engagement, 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. This flexibility helps address targeted activity, without being proscriptive. A *Corporate Partnership Scheme* has been introduced, to build relationships with organisations who seek deeper engagement with the mathematical sciences, and facilitates specific networking and collaborative opportunities.



Governance

TGM Advisory Board

The TGM Advisory Board is made up of members from industry and public bodies who advise on strategic matters and on overall development of the TGM. The Board meets twice a year in Cambridge.

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

TGM Programmes Committee

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

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

Staff and Management

The Knowledge Transfer Manager has overall responsibility for managing the TGM and for developing contacts with non mathematical academics, with industry and business. This role is pivotal in identifying potential research opportunities of mutual benefit to mathematicians and industry.

The Knowledge Transfer 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.



From left to right: Lissie Hope, Events and Marketing Coordinator, Clare Merritt, Knowledge Transfer Coordinator and Jane Leeks, Knowledge Transfer Manager

Activities 2014/15

Below is a summary of what the TGM has been doing in the past year.

NC3Rs/POEMS Network Maths Study Group: Mathematical Approaches to 3Rs Problems in Medicine and Healthcare (8–12 September 2014)

The aim of this study group was to connect mathematicians and biomedical scientists, to encourage collaborative work towards applying mathematics to gain new insights and to develop partnerships. The structure of the week involved problems being presented by delegates from industry and academia to participants on the first day, with the rest of the Study Group week spent brainstorming ideas and beginning to develop novel mathematical, statistical, or computational models for each of the problems.

Post-Quantum Research - Addressing Future Challenges and Directions (18–19 September 2014)

This workshop took forward ideas generated at an earlier TGM event in May 2014. It continued with the key aim of gaining consensus in identifying the mathematical challenges in post-quantum cryptography and sought to set the agenda for future research directions. It facilitated the process of community building and helped to further inform GCHQ of the challenges and links to possible research areas.

Techniques for Data Linkage and Anonymisation (23 October 2014)

This workshop examined how to link effectively or merge multiple databases describing individuals, including how to cope with inaccuracies, partial overlap and ambiguous records in a trustworthy way. Supported by ESRC, it included reviews of current methods and of the state-of-the-art in the two areas, but also aimed to identify the critical challenges faced in the areas of data linkage and anonymisation. The event was run in response to the huge interest in this area preceding a 2016 INI Research Programme on *Data Linkage and Anonymisation*, which it will help to inform.

Maths & Public Policy (Launch event 10 December 2014)

Public policy forms the framework by which government and non-governmental organisations work to resolve social, economic and political issues in society. This in turn determines the allocation and distribution of the resources needed to achieve these goals. On behalf of EPSRC this launch event was held in London at the start of a series of targeted activities looking at mathematical techniques, methodologies and expertise that help to improve modelling and

problem-solving in policy making, ensuring that policies are fit-for-purpose. Feedback after the event demonstrated that the public policy case studies offered a good insight into how Government departments have implemented mathematical techniques to assist with policy decisions.

Following the launch, two further workshops engaged stakeholders, helped disseminate information about state-of-the-art mathematical techniques and facilitated development of relationships between academics and those leading on developing policy.

Maths & Public Policy for Cities & Infrastructure covered mathematics for a future cities framework, mathematical modelling of traffic systems, modelling variability and uncertainty in energy systems and probability modelling to attribute weather events to climate change.

Maths & Public Policy for Health & Society discussed health - optimising immunisation programmes; changing demographics - planning for an ageing population; societal risk - modelling variability and uncertainty, and modelling for health and disability.

Big Data - Analytics & Computational Perspective (7 January 2015)

This workshop was on day one of the 1st UCL Workshop on the *Theory of Big Data*. It brought together leading expertise in the areas of Big Data methodology, analytics and computation and provided an insight into the latest approaches and techniques needed to cope with this rapidly developing and important area. The event was positively received, which led to the TGM working with UCL to deliver a further workshop at their 2nd *Theory of Big Data* event in January 2016.



Reasoning by Formal Models in the Social Sciences (April/May 2015)

This course of 6 lectures on 29 April, 6 May & 13 May 2015, supported by the ESRC Impact Acceleration Account, explored the role of mathematical modelling in the social sciences. Professor Sir Partha Dasgupta, FRS, FBA and Nobel Prize winning Professor Eric Maskin, gave three talks each. Overall attendance at the lecture series was 120 participants and attendees highlighted the opportunities to engage with new contacts and the freedom to explore separate but

related topics over the three afternoons, as well as receiving links to the recorded presentations.

Scoping Meeting on Incorporating Uncertainty Quantification into Biophysical Multi-Scale Models of the Heart (7 May 2015)

This meeting took place at Kings College, London, following programmes on models of the heart held at the INI in 2001 and 2009. It aimed to investigate whether to make a proposal for an INI programme, centred on uncertainty quantification techniques in models of cardiac physiology that would enable parameter estimation, quantify sensitivity and provide guidance on model confidence.

Challenges in Dynamic Imaging Data (9–11 June 2015)

This workshop was part of a programme of work jointly developed with the University of Cambridge, BAE Systems, Microsoft and the INI. It sought to investigate the analysis of very large and complex data streams, such as for videos, where there is a need to improve the current state-of-the art techniques. In this context there is a need to understand what is currently possible and what the main technical challenges are. Three industry challenges were presented (one on each day), covering the areas of security, medical imaging, media and creative industries. The application of deep-learning techniques and machine learning, and their associated mathematical models and algorithms, were cited many times in both the feedback forms and discussion sessions as being of great importance to this research area. Positive feedback was provided including *"The industrial people seemed to be very well-chosen. They had enough technical knowledge to be able to engage effectively and enough seniority to understand the strategic importance of different applications"*.

The Role of Inverse Problems and Optimisation in Uncertainty Quantification (17–18 June 2015)

This activity was a partnership of the Smith Institute, International Centre for Mathematical Science (ICMS), the INI, the TGM and the Knowledge Transfer Network. A number of recognised problems in the areas of inverse problems and optimisation in uncertainty quantification, particularly related to advanced manufacturing (including space and defence), energy and environment and precision farming sectors were investigated. One aim was that the meeting would stimulate mathematicians working on estimation, to turn their attention to the less well-developed area of control under uncertainty. The event provided the opportunity to hear from a variety of sectors. Possible collaborations, such as inverse methods for materials characterisation (glass, waste, chemical treatments); interactive visualisation / communication of uncertainty; and random field theory applied to inverse problems, were suggested.

Open for Business Events

The INI 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 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 transfer, public policy and commercial impact. Three OfB events were hosted over the report period:



Systemic Risk and Macro-Prudential Regulation: Perspectives from Network Analysis (13 October 2014)

This event was part of the INI programme *Systemic Risk* and was co-organised with the Bank of England. It took place at the Bank of England in London and highlighted recent research contributions and regulatory initiatives, with an emphasis on the role played by network models in understanding systemic risk.

Understanding Microbial Communities - Developing the Potential (4 December 2014)

This workshop was part of a research programme which brought together industrial stakeholders with leading experts from a number of academic disciplines, including biology, mathematics, statistics, physics and engineering. In doing so it sought to identify the key areas where future application and development of mathematical and experimental approaches to microbial communities would be most beneficial from industrial and medical standpoints.

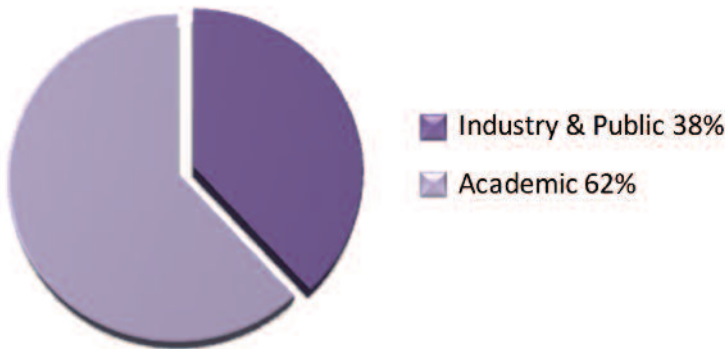
Design of Experiments in Drug Development (9 July 2015)

This day-long workshop was part of a week-long event, which followed on from a research programme held at the INI in 2011. It brought together expertise in the multiple disciplines involved in the design and analysis of experiments in healthcare, with a focus on exploring innovative methodologies to evaluate treatment effect and the adoption of innovative clinical trial designs. Attendees were impressed by the range of high level speakers and representatives, with opportunities for effective networking.

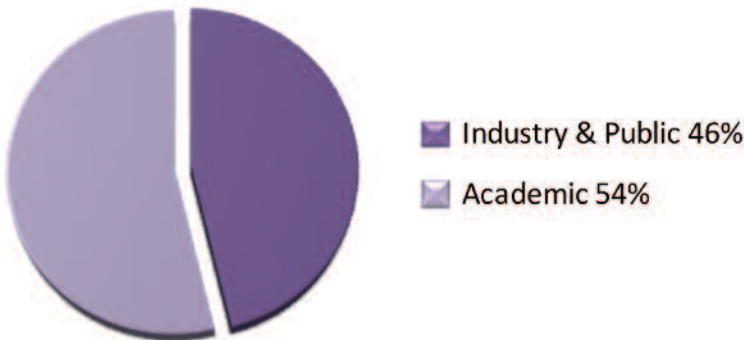
Participation

The TGM has established itself as an effective vehicle for the delivery of knowledge transfer from the mathematical sciences. From August 2014 to July 2015, 930 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.

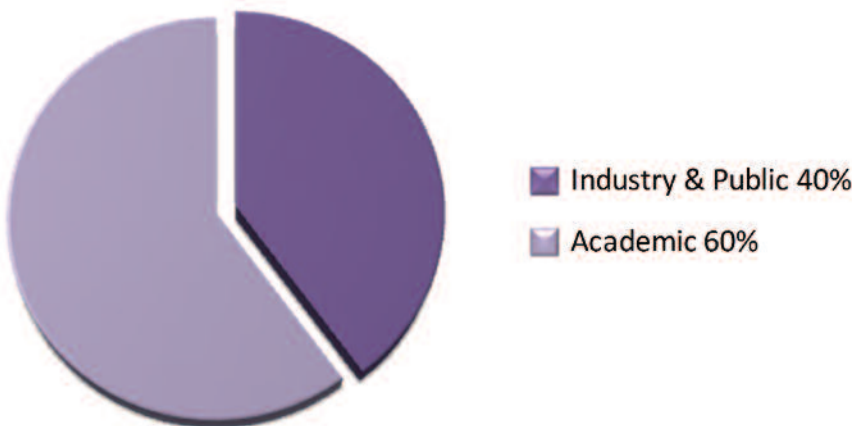
TGM Events



Open for Business Events



Open for Business and TGM Events Combined



Accounts for August 2014 to July 2015

	2013/14 £'000	2014/15 £'000
Income		
University of Cambridge Funding ¹	70	70
University of Cambridge Funding for OfB ²	6	0
Sponsorship ³	10	104
Total Income	86	174
Expenditure		
Staff Costs	58	102
Travel and Subsistence	2	1.5
Event Expenditure	17	49
OfB Event Expenditure ⁴	8	6
Marketing and Documentation	3	0.5
Overheads and Administration ⁵	1	1
Total Expenditure	89	160
Surplus / (Deficit)	(3)	14

Notes to the Accounts

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

2. University of Cambridge Funding for OfB. 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, though none was provided in 2014/15.

3. Sponsorship. Contributions were received from six organisations towards specific events.

4. OfB Event Expenditure. The TGM delivers *Open for Business* events on behalf of the Isaac Newton Institute, so these are itemised as separate income and expenditure.

5. Overheads and Administration. 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 and 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 is the first confirmed Corporate Partner and negotiations with several other organisations, to progress towards Partnership, are ongoing.



Further information on Corporate Partnership can be found on the TGM website at www.turing-gateway.cam.ac.uk/tgm-cps.shtml

Future Development

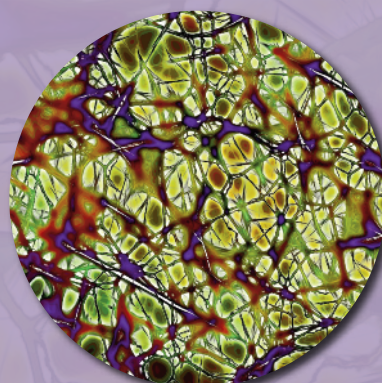
The TGM aims to respond in a speedy and focused way to new ideas and approaches, but recognises the need for a targeted and continuous approach to the delivery of longer term knowledge exchange activities in the mathematical sciences. In recognition of this, a series of thematic knowledge exchange programmes have been developed, which 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 develop this thematic work in partnership with stakeholders and Corporate Partners and progress with its aspiration to play a key national role in mathematical knowledge exchange.

Activities 2015/16

The TGM continues to build its programme of work and these are the most recent activities and some of the upcoming events.

- **3rd European Optimisation in Space Engineering (OSE) Workshop**
(17–18 September 2015)
- **Environmental Modelling in Industry Study Group**
(21–24 September 2015)
- **Predictive Multiscale Materials Modelling**
(1–4 December 2015)
- **Understanding the Mathematics and Physics of Cell Motility and Pattern Formation**
(9 December 2015)
- **Data-Rich Phenomena - Modelling, Analysing and Simulations using Partial Differential Equations**
(14–16 December 2015)
- **Big Data Analytics for Financial Services**
(7 January 2016)
- **Computational and Data Challenges in Environmental Modelling**
(10 February 2016)
- **EPSRC Centre for Mathematical and Statistical Analysis of Multimodal Clinical Imaging - Launch Event**
(8 March 2016)
- **Big Data, Multimodality & Dynamic Models in Biomedical Imaging**
(9 March 2016)
- **University of Cambridge Mathematics and Big Data Showcase**
(20 April 2016)
- **Soft Matter - Theoretical and Industrial Challenges: Celebrating the Pioneering Work of Sir Sam Edwards**
(7–9 September 2016)



The images on the front cover represent some of the areas of work that the TGM has been involved in throughout the year.

Top left and right: Railway tracks stacked and ready for use and the Briksdal Glacier located in the Jostedalsglaci National Park, Norway (the little black spots near the bottom on the glacier are people!). The TGM initiative *Maths & Public Policy* included an event on *Cities & Infrastructure* which looked at mathematics for a future cities framework, mathematical modelling of traffic systems, modelling variability and uncertainty in energy systems and, crucially in the case of glaciers, probability modelling to attribute weather events to climate change.

Bottom left: A presenter during a session at the *N3CRs/POEMS Network Maths Study Group* that took place in September 2014. (Photo credit RA Wilkinson)

Bottom right: Illustration of the human heart. During May 2015 the TGM facilitated a scoping meeting on *Incorporating Uncertainty Quantification into Biophysical Multi-Scale Models of the Heart*.

Centre: Test tubes. The TGM held an *Open for Business* event in July 2015 on the *Design of Experiments in Drug Development*.

Turing Gateway to Mathematics

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