



Mission Statement

The Newton Gateway to Mathematics 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 Newton Gateway to Mathematics aims to widen 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 the Newton Gateway to Mathematics Different?

The Newton Gateway to Mathematics is a knowledge intermediary for the mathematical sciences. Although based at the *Isaac Newton Institute for Mathematical Sciences (INI)* and supported by the *University of Cambridge*, the Newton Gateway is an independent body serving the whole of the UK mathematical sciences community and reaches out to and engages with all users of mathematics – in industry, business, public sector and other scientific disciplines. With extensive access to multiple communities across the UK and globally, the Gateway can respond in an agile and flexible manner. It works as a delivery partner to facilitate the exchange, translation and dissemination of knowledge. Using effective communications and proven methodologies, the Gateway develops and runs activities such as workshops and meetings, bringing people and organisations together in order to share knowledge and stimulate further research and collaboration.

Engaging with Users of Mathematics

The Newton Gateway to Mathematics is the impact initiative of the *Isaac Newton Institute for Mathematical Sciences (INI)* based at the *University of Cambridge*. It works with the whole of the UK mathematical sciences community to extend the reach and highlight the importance of mathematics to all potential users such as other academic disciplines and researchers in business/industry and the public sector. User engagement is therefore a key focus, helping to understand the community and end-users in order to collaborate effectively.

The Newton Gateway to Mathematics delivers a range of activities, such as research scoping workshops and knowledge dissemination events 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.

Gateway activities have expanded, seeing continued emphasis on partnership and collaboration with other organisations, which is an effective way of engaging with a wider group of stakeholders, helping to reduce duplication. Since March 2020 in response to the COVID-19 pandemic, the majority of activity has been delivered virtually and the Gateway has explored a number of different technologies to realise this.

The Gateway continues in the delivery of the *Edwards Symposium Series* working with the *Edwards Centre for Soft Matter* at Cambridge and supported by *Unilever*. Since 2016, the Gateway has been the user engagement partner for the *Cantab Capital Institute for the Mathematics of Information (CCIMI)* and also works with the *EPSRC Cambridge Mathematics of Information in Healthcare (CMIH)* Hub which was launched in 2020. These partnerships

result in the organisation and running of a number of series of events as well as promotion of collaborative opportunities across an expanding community.

In 2019, the Gateway began a programme of work with *Dstl (the Defence Science and Technology Laboratory)* and *PA Consulting*, with an aim to apply new or alternative mathematical approaches to challenges in the electromagnetic environment (EME). Research workshops have taken place in 2020 and 2021 that explored potential solutions to a number of identified challenges and work continues as part of the ongoing delivery of workshops and project activity.

From January 2021, the Gateway has been leading on a specific programme of work to support efforts to model the COVID-19 pandemic and help guide the UK's response – the *RAMP (Rapid Assistance in Modelling the Pandemic)* Continuity Network. The aim has been to ensure scientific networking to develop links with the wider modelling community around COVID-19. This is helping to create a truly multiscale approach for engagement with those from industry and the public sector. It has helped demonstrate the ability of the Newton Gateway to Mathematics to work in partnership, to effectively respond to specific needs, deliver mathematical sciences knowledge exchange and create impact.

As part of all of these collaborations, the Newton Gateway to Mathematics develops programmes of work, disseminates information and develops strategic relationships, to ensure effective translation of science to the user. This has helped partners to understand and gain consensus on the challenges that need to be overcome and facilitate other interdisciplinary collaborations to enrich the existing communities.

Foreword

As for many other organisations, the past year continued to bring challenges for the Gateway, but we have embraced the opportunities and flexibility to develop and deliver virtual and semi virtual activity. For much of the reporting year, Gateway staff worked virtually, but ensured regular contact with colleagues, partners and stakeholders. As restrictions were eased, the *Isaac Newton Institute (INI)* reopened to staff and then a limited number of visitors. The majority of Gateway events have remained as virtual ones, making use of a wide variety of virtual technologies and networking activities that aim to replicate, as much as possible, the experience of attending a physical event. More recently, we have been able to hold hybrid events, with some attending physically and others joining online and this approach has been welcomed.

Much of the focus of the Gateway has been on collaborative virtual activity in response to the COVID-19 pandemic. The Gateway's role in *V-KEMS* (the *Virtual Forum for Knowledge Exchange in the Mathematical Sciences*) has remained a priority, with the aim to identify a range of virtual approaches to help address challenges from business and industry, the third sector, and other groups outside academia. Most of the challenges that have been explored resulted directly as a consequence of the disruption to UK society caused by COVID-19. *V-KEMS* delivery has been a truly collaborative programme and one

that the Gateway and partners have built upon over the past year and also going forward.

More information about *V-KEMS* can be read later in this Annual Report, but one notable event was *Modelling Solutions to the Impact of COVID-19 on Cardiovascular Waiting Lists – Virtual Study Group* which took place in February 2021. This explored the challenges related to the delays in seeking and gaining access to cardiovascular treatments caused by the COVID-19 pandemic and the impact this had upon waiting lists. The event brought together clinicians and mathematicians to explore if and how mathematical models could be used to provide insights and solutions into three issues. These were the overarching state of the delivery of elective cardiovascular procedures and outpatient consultations at the national level; an exemplar cardiovascular procedure – aortic stenosis; and an exemplar cardiovascular condition – chronic heart failure.

Clinicians have been able to report what has been happening with respect to the reduction in emergency cardiac admissions and procedures, as well as quantify the excess deaths from emergency cardiac conditions. However, they have not quantified the impact on outpatient consultations. Potential solutions to the three issues were developed and presented on the final day, with a number of possible models being developed to input to a tool for use by those who plan care services.

The Gateway's role has carried on since the event – facilitating ongoing engagement between the clinicians and academics and helping to seek funding for PhD students and a Research Assistant to progress the outcomes to help develop a tool to improve outcomes for those seeking treatment.

Since January 2021, the Gateway has been leading on a specific programme of work to support efforts to model the COVID-19 pandemic and help guide the UK's response. The *RAMP (Rapid Assistance in Modelling the Pandemic)* Continuity Network is funded by *UKRI (UK Research and Innovation)* and the Gateway has been delivering a series of meetings, workshops and virtual study groups to ensure continuance of relevant research and scientific networking. This has helped maintain strong communication links and further develop engagement with the wider modelling community, as well as other mathematicians and those from industry and the public sector – particularly policy makers.

Within this activity, the Gateway has developed a number of scientific meetings that have focused on *Environmental and Aerosol Transmission, Urban Analytics and Human Dynamics in Small Spaces*. A number of Virtual Study Groups linked to *RAMP* are now taking place, which are being developed and delivered in partnership with *V-KEMS*. The focus of these is around economic recovery from the pandemic – working with those, for

example, in hospitality and leisure.

The Gateway has continued to deliver user engagement for *CCIMI (Cantab Capital Institute for the Mathematics of Information)* – with two events – one with an academic focus and the other aimed at highlighting the industrial collaboration of the Institute. The *EPSRC Cambridge Mathematics of Information in Healthcare (CMIH)* Hub was launched in 2020 and the Gateway delivered its first annual engagement event bringing together those working in mathematical healthcare data analytics across the UK, with mathematicians working in similar areas.

The programme of work with *Dstl (the Defence Science and Technology Laboratory)* and *PA Consulting* has developed, with the aim to apply new or alternative mathematics to challenges in the electromagnetic environment (EME). A virtual study group took place in September 2020, where a number of specific challenges were worked on – leading to innovative potential solutions being presented. In July 2021, a hybrid workshop took place at *INI*, which reported back on progress on research endeavours and presented a number of new research challenges, which continue to be progressed.

In November 2020, the Gateway was pleased to be appointed as the UK representative within *EU-MATHS-IN* – a European network that aims to establish connections between stakeholders working in industrial mathematics.

EU-MATHS-IN was created in 2013 in response to the *Forward Look on Mathematics in Industry* report which recommended that the countries of Europe needed to work together to facilitate interaction on mathematics and innovation. The Gateway *Scientific Advisory Panel* acts as the network for the UK and has presented case studies and exemplars at a number of virtual events over the year.

Despite the COVID-19 pandemic, the Newton Gateway has continued to extend its reach across different sectors. The ability to engage virtually has enabled an increased number of participants to attend Gateway events offering greater opportunities for interaction between those in industry, the public sector and academia, often for individuals who have not worked together previously. As in previous years, activities have been delivered in partnership with other organisations, as detailed within this Annual Report, which has ensured further collaborative opportunities with new connections made across a breadth of sectors and subjects.

Last year, the Gateway and its partners started to explore the feasibility of a *National Connected Centres Knowledge Exchange Network*. The proposal was that a scalable and flexible *Connected Centres Network* for fostering knowledge exchange could be established, with the

Gateway and the *International Centre for Mathematical Sciences (ICMS)* serving as its hub and made available to and for every mathematical sciences department in the UK. Because of COVID-19, discussion was paused, but work has been taken forward to develop an independent consultation document and has since been shared with the community.

As last year, there have been challenges faced by us all and the Newton Gateway to Mathematics is very grateful for the support given by *INI*, the *University of Cambridge* and our colleagues, partners and stakeholders. We have been in the fortunate position to continue to work effectively in novel virtual ways and have ensured continued delivery of partnership activity. We look forward to continuing to develop these ways of working, including the delivery of hybrid events, but are hopeful to being able to welcome further participants at our physical events at *INI* and elsewhere.

Responsibility for the budget and financial planning is overseen by *INI's Management Committee* and undertaken on a day-by-day basis by Newton Gateway staff. The Gateway reports to the *INI Director* who in turn is responsible to the *Management Committee*.

The Newton Gateway is supported in delivering activity by the *Gateway Advisory Board* and *Scientific Advisory Panel*, who advise on programmes and activities and help with quality assurance in aspects of delivery and operations. The key aim is to help ensure that the highest levels of delivery and operations are achieved throughout Gateway activity and its effectiveness is fully maximised.

Newton Gateway to Mathematics Staff

The **Gateway Manager**, Jane Leeks, has overall responsibility for managing the Gateway and for developing contacts with mathematical and non-mathematical academics, with industry, business and public sector. This role is pivotal in identifying potential research and collaborative opportunities of mutual benefit to mathematicians and end-users, such as industry, business and Government.

The **Senior Knowledge Exchange Coordinator**, Clare Merritt, supports diversification of Newton Gateway to Mathematics activities, coordinates and develops events and marketing activity with industry and businesses, and leads some specific programmes of work, including user engagement on behalf of Newton Gateway to Mathematics Partners. Clare leads on Gateway Governance.

The recently appointed **Scientific Knowledge Exchange Coordinator**, Dr Maha Kaouri, provides technical research and knowledge exchange support to Gateway activities. This involves scientific and technical exploration and analysis of the Gateway delivery, in particular the translation and dissemination of scientific details and information to a broader audience.

The new **Events and Marketing Coordinator**, Claire Bonner leads on the day-to-day coordination of events and related activities. Claire supports the development and delivery of Gateway events and marketing activity as well as providing financial management and administration.

Governance

The **Newton Gateway to Mathematics Advisory Board** has Members from industry and public bodies to help advise on strategic matters and on the overall development of the Newton Gateway to Mathematics.

Members have helped to facilitate the delivery of a number of activities and programmes of work and act as “Ambassadors” for the Gateway in discussion and interaction with other partners.

Advisory Board Membership (at July 2021):

Name	Organisation
David Abrahams	Isaac Newton Institute – Director
Matt Butchers	Knowledge Transfer Network
Alan Champneys	Representative of Gateway Scientific Advisory Panel
Nick Easton	BAE Systems Applied Intelligence
Joanna Jordan	Freelance Mathematics Knowledge Exchange
Peter Landrock (<i>Chair</i>)	Cryptomathic
Jane Leeks	Newton Gateway to Mathematics – Manager
Robert Leese	Smith Institute
Clare Merritt	Newton Gateway to Mathematics – Secretary
Dan Shepherd	National Cyber Security Centre
Sian Thomas	Department for International Trade
Stacie Tibos	PepsiCo International

The Board meets twice a year in Cambridge. The Chair is invited to attend *INI Management Committee* meetings to provide supplementary reporting on Gateway activity and delivery.

The **Newton Gateway to Mathematics Scientific Advisory Panel** provides input and guidance on specific scientific or research matters related to Newton Gateway to Mathematics activities. Members are all academics and operate largely in a virtual capacity via email and telephone and are responsive to ad-hoc questions and requests for guidance from the Newton Gateway to Mathematics.

The Chair is invited to attend Newton Gateway to Mathematics Advisory Board meetings.

Scientific Advisory Panel Membership (at July 2021):

Name	Organisation
Philip Aston	University of Surrey
Martine Barons	University of Warwick
Chris Breward	University of Oxford
Peter Challenor	University of Exeter
Alan Champneys (Chair)	University of Bristol
Chris Dent	University of Edinburgh
Rosemary Dyson	University of Birmingham
Jacek Gondzio	University of Edinburgh
Des Higham	University of Edinburgh
Rebecca Hoyle	University of Southampton
Jane Hutton	University of Warwick
Arieh Iserles	University of Cambridge
Gabriel Lord	Radboud University (and Heriot-Watt University)
Anotida Madzvamuse	University of Sussex
Adele Marshall	Queen's University Belfast
Jeremy Oakley	University of Sheffield
Surajit Ray	University of Glasgow
Nigel Smart	KU Leuven
Manuchehr Soleimani	University of Bath
Emily Walsh	University of the West of England
Adrian Weller	University of Cambridge

All Members of the *Scientific Advisory Panel* are invited to meet with the *Advisory Board* every 12 months to ensure they have opportunity to input more strategically to the range and nature of Newton Gateway to Mathematics activities.

Membership is regularly reviewed to ensure it reflects the breadth of disciplines that the Gateway can work on and a fuller geographical spread of representation by Members.

Activities from August 2020 – July 2021

7 – 11 September 2020

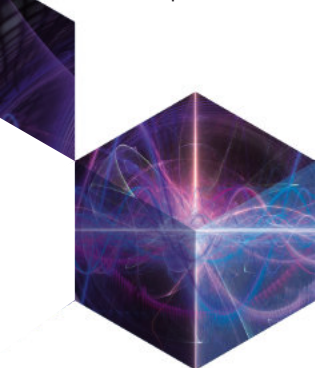


Integrating Quantitative Social, Ecological and Mathematical Sciences into Landscape Decision-Making

This workshop was a follow-on event to the July 2019 *INI Programme on Mathematical and Statistical Challenges in Landscape Decision-Making* which brought multiple disciplines together to discuss the issues facing landscape decision-makers and how mathematical and statistical approaches could help. It was delivered by *INI*, with scientific development input by the Gateway.

This workshop built on previous work by exploring how to integrate social modelling approaches with environmental and mathematical approaches in landscape decision-making. There were talks from leading academics as well as key stakeholders including *Defra* (*Department for Environment, Food and Rural Affairs*) and the *Food, Farming and Countryside Commission*. A number of facilitated discussion sessions took place, which focused on the challenges facing decision-makers including accounting for human and social processes as well as dealing with complexities and non-linearities.

15 – 18 September 2020



Mathematical Challenges in the Electromagnetic Environment

The Newton Gateway began a programme of work in 2019 with *Dstl* (*the Defence Science and Technology Laboratory*) and *PA Consulting*, with the aim to apply new or alternative mathematics to challenges in the electromagnetic environment (EME). Operating in the EME has become increasingly complex due to continuing growth in civilian and military demand for spectrum (for example 5G), which has made it a highly congested and contested area. Current approaches to solving the challenges of operating in this environment have been successful over many years, but this increased complexity means it is now necessary to explore innovative approaches.

Applying new or alternative mathematics to these challenges presents big opportunities to develop new approaches and create exciting possibilities for this field. This event was run virtually over four days. Seven challenges were presented and five of these went on to be worked on in the main workshop sessions. On the final day, potential solutions using innovative led approaches were provided to the challenges and some possible new activities were identified to be taken forward as funded projects.

Mathematics and Statistics for Effective Regulation

The reliability and accuracy of reporting is key to ensuring confidence in the financial sector, yet there is limited regulation on data quality and the software used, a lack of consistency and no agreed documentation of modelling. This is in contrast to medicines and medical devices, where there are auditable processes in place with the requirement to demonstrate the source of data used and the need to show documentation of the workings of the software.

This workshop provided an overview of the different expectations of regulatory bodies, and an opportunity to discuss best practice and useful resources. Following the event, a short report was written which summarised the presentations that were given and identified some possible next steps. The event was developed and delivered with Professor Jane Hutton (*University of Warwick*) and in collaboration with the *Royal Statistical Society*.

Privacy Enhancing Technologies in Practice

Companies have been repeatedly told that data is one of their most valuable commodities, but realising the full value of that data may require re-mixing, comparison, or computation against data held by others. Unfortunately, sharing data is one of the hardest things for companies to do, because of the perceived commercial and legal risks. The last few years however, has seen the emergence of technologies which allow for the secure collection, sharing, processing, and storage of data without the downsides of reducing privacy of users, or compromising corporate security.

A key aim of this series, was to highlight how business, industry and the public sector can find effective ways to utilise these new privacy enhancing technologies. Developed with Professor Nigel Smart (*KE Leuven*) and in collaboration with the *Digital Catapult*, the first three events featured conversations with experts deploying technologies such as multi-party computation, fully homomorphic encryption schemes and zero knowledge proofs. The fourth event featured end-users interested in applying them. The final webinar focused on investor focused perspectives.

17 November 2020



19 & 30 November,
8 & 15 December 2020
& 19 January 2021



24 November 2020

Mathematical Foundations of Optimisation in Data Science

This fourth annual academic conference of the *Cantab Capital Institute for the Mathematics of Information (CCIMI)* focused on the academic interactions taking place related to *Mathematical Foundations of Optimisation in Data Science*. It provided an update on the research and collaborations taking place at CCIMI, associated challenges and other potential collaborative opportunities, as well as highlighting projects being developed elsewhere related to data analysis.

There was a session for shorter “elevator pitches” from next generation researchers, who also had the opportunity to present more detail about their work.

25 November 2020

Cantab Capital Institute for the Mathematics of Information - Connecting with Industry

The main focus of this afternoon industrial engagement event was to provide an update on research and collaborations taking place at the *Cantab Capital Institute for the Mathematics of Information (CCIMI)*, as well as presenting interesting research being developed elsewhere. The advance of data science and the solution of big data questions heavily relies on fundamental mathematical techniques and in particular, their intra-disciplinary engagement. This is at the heart of the Institute, involving mathematical expertise ranging from statistics, applied and computational analysis, to topology and discrete geometry – all with the common goal of advancing data science questions.

Speakers looked to explore the big questions in data science, especially where mathematics is most suited to help provide answers. Industry talks were given by *GAM*, *Aviva* and *PostEra*. It included a virtual poster session where CCIMI students presented their research.

Mathematical Study Group for Electromagnetic Challenges

This three-day virtual study group formed part of a programme of work with *Dstl (the Defence Science and Technology Laboratory)* and *PA Consulting* which began in 2019 and which seeks to apply a mathematical framework to address challenges in the electromagnetic environment (EME). It followed two research scoping workshops held in January and September 2020.

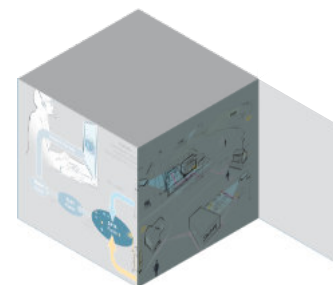
This event took forward some of the challenges from the earlier events as well as introducing others. On the first day, the challenges were presented, workgroups were then formed with the aim of producing viable solutions that were presented back to the problem presenters on the final day. Each challenge was facilitated by an academic lead with input from *Dstl*. Following the event, a report on the possible solutions was written and the partners discussed the potential next steps.

Modelling Solutions to the Impact of COVID-19 on Cardiovascular Waiting Lists Virtual Study Group

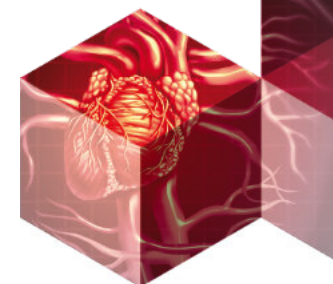
This study group was developed by the Gateway on behalf of *V-KEMS (Virtual Forum for Knowledge Exchange in the Mathematical Sciences)*. It explored the challenges related to the delays in seeking and gaining access to cardiovascular treatments caused by the COVID-19 pandemic and the impact this may have upon waiting lists. Clinicians have been able to report what has been happening with respect to the reduction in emergency cardiac admissions and procedures, as well as quantify the excess deaths from emergency cardiac conditions. However, they have not quantified the impact on outpatient consultations.

Three specific issues were explored and potential solutions were developed and presented on the final day. Each of the three problems have since been worked through to help provide a useful tool for use by those who plan care services. The Gateway has continued to project manage this post event activity working with clinicians and academic partners. It is hoped that this activity can help augment a model developed by the *NHS Strategy Unit, Midlands and Lancashire Commissioning Support Unit* and help to deliver a decision support tool for understanding how to optimise treatment.

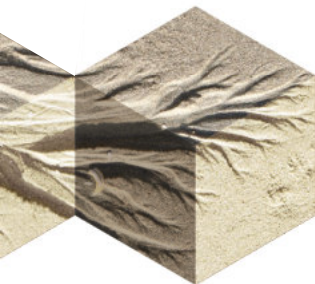
6 – 8 January 2021



2 – 4 February 2021



16 March 2021



Unlocking Data Streams

This workshop highlighted a number of exciting research activities and outlined some of the successful collaborations within the *UKRI* funded *DataSig* Programme. This Programme looks to address a key challenge of data science, to better understand multimodal data streams. Researchers are developing mathematical descriptions of these streams, using ‘*rough path*’ (RP) theory. This allows for the direct capture of the order in which events happen and, in many cases, can better model the effects of these data streams via a top-down signature description of the stream. This event aimed to increase awareness of the research and applications being undertaken by the *DataSig* team. It also sought to further develop signature-based mathematical tools for dealing with complex streamed data and connect partners with the capability and the challenges to benefit from and achieve significant outcomes with the methodology.

It attracted end-users from multiple settings including industry, business, public sector and clinicians who were interested in collaborating and who could benefit from the development of useful open-source software tools that could be utilised in various machine learning environments and had needs around the interaction with complex, real world evolving data, to be able to easily tackle questions where there is a variety of different data to consume.

29-31 March 2021



UK Graduate Modelling Camp

The annual UK Graduate Modelling camp took place virtually in partnership with the *Industrially Focused Mathematical Modelling (Centre for Doctoral Training)* at the *University of Oxford*. The camp was open to all PhD students and designed to promote a broad range of problem-solving skills, such as mathematical modelling & analysis, scientific computation and critical assessment of solutions. It provided participants with hands-on experience of mathematical modelling under the guidance of experienced instructors and mentors.

Over the three-days, the challenges that students worked on were inspired by real-world challenges that had arisen in industry or science. Scientific communication was an important part of the camp and all participants were expected to make presentations. Prizes were awarded by the *IMA* and the Gateway for the two teams who were able to best demonstrate good understandings of the problems and application of the most appropriate mathematical and statistical techniques.

4-Dimensionalism in Large Scale Data Sharing and Integration

This workshop presented an opportunity to get up-to-date on the state of the art with 4-dimensionalism and its application. In foundational ontology, 4-dimensionalism is shorthand for a mathematical-philosophical basis for a rigorous global identity criterion based upon composition. It acquired this name as a vital part of the approach is treating individuals as extended in time as well as space, with two objects composed of the same spatio-temporal parts being considered identical. The opportunity this brings to data sharing and integration on a large scale (both within and across organisations) is that it introduces an increased level of rigour into the way we model the world.

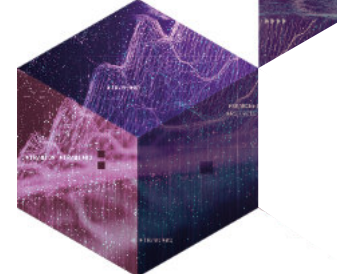
Current and potential applications of 4D/Digital Twin data modelling are wide ranging, for instance in the oil and gas sectors and in defence and security environments. Potential other uses include the built environment and various engineering applications including aircraft engines, wind turbines, buildings and large structures, control systems. The event was a joint collaboration between the Gateway, *GCHQ*, *UCL STEaPP*, *University of Southampton*, *University of Warwick* and *Brunel University*.

Launch Event of the Cambridge Mathematics of Information in Healthcare (CMIH) Hub

This was the first external event of the *EPSRC Cambridge Mathematics of Information in Healthcare (CMIH)* Hub which was launched in 2020. The hub focuses on some of the most challenging public health problems of our time, including cancer, cardiovascular disease and dementia.

The event brought together those working in mathematical healthcare data analytics across the UK, including academic, clinical, and industrial users with mathematicians working in similar areas. Talks focused on the key theme of the *CMIH Hub*, which is the development of robust and clinical applicable algorithms for analysing healthcare data in an integrated fashion. In addition, there were introductory talks from partner *EPSRC Hubs for Mathematical Sciences in Healthcare*.

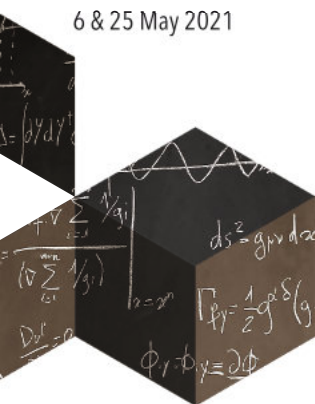
22 April 2021



4 - 5 May 2021



6 & 25 May 2021



IMA Mathematics 2021 Online Series

For a number of years, the IMA (*Institute of Mathematics and its Applications*) has been running a series of conferences to promote mathematics with the aim of demonstrating to both mathematicians and non-mathematicians the many uses of modern mathematics. Following the very successful *IMA Mathematics 2020* series collaboration with the Gateway, two further events took place in May 2021.

6th May 2021

- Nick Higham, Gold Medallist Talk – Communicating Applied Mathematics in 2021
- David Abrahams and Jane Leeks – Mathematical Sciences in the UK – Future Developments and Directions in Mathematical Sciences Knowledge Exchange.

25th May 2021

These talks highlighted the work of *V-KEMS (Virtual Forum for Knowledge Exchange in Mathematical Sciences)*. The presentations highlighted recent *V-KEMS* activity which were delivered in partnership with *INI*, the Gateway, the *Knowledge Transfer Network (KTN)* and *ICMS (International Centre for Mathematical Sciences)* and featured the work of two very successful virtual study groups, which ran earlier in the year.

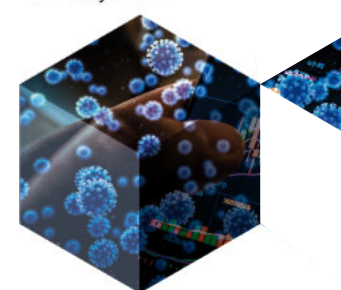
- Matt Butchers (*KTN*) – Introduction to *V-KEMS*
- Chris Budd (*University of Bath*) – Reducing the Risk of COVID-19 Transmission on Trains
- Alan Champneys (*University of Bristol*) – Modelling Solutions to the impact of COVID-19 on Cardiovascular Waiting Lists.

The Flip Side of the Pandemic: Recent Advances in the Mathematics of Information

This half day virtual event was the fifth annual academic conference of the *Cantab Capital Institute for the Mathematics of Information (CCIMI)* and provided an update on the research and collaborations taking place at *CCIMI* specifically related to understanding and modelling the COVID-19 pandemic and associated challenges.

The event featured a number of longer plenary talks from senior academics, which looked at the role of artificial intelligence, machine learning and how modelling helped inform policy. There was a session of short “elevator pitches” from next generation researchers and a poster session by some registered delegates. This took place in Gather Town which provided the opportunity for informal virtual networking between the speakers and delegates. A prize for the most enlightening poster by an Early Career Researcher was awarded to Paolo Campodonico from the *University of Cambridge*.

20 May 2021



The Future of Mathematical Challenges in the Electromagnetic Environment

This workshop followed on from three events which took place over the previous 18 months. It was held in a hybrid format, with some delegates joining in person and others remotely. This initiative is a response to the need for the UK to be able to operate in the electromagnetic environment (EME) across all domains. It seeks to apply new or alternative mathematics to these challenges and presents an opportunity to develop new approaches and create exciting possibilities for this field.

Dstl (the Defence Science and Technology Laboratory) have been working with *PA Consulting* and the Gateway to develop a framework to engage the mathematical community in this area. This event aimed to report back on what progress had been made and specifically on research endeavours and projects which have emanated from the previous research scoping workshops and study groups. It presented a number of new research challenges, which went on to be converted into funded projects following further briefing events.

27-28 July 2021



RAMP Continuity Network:

Scientific Meetings, Rapid Review Group, and Policy Support for COVID-19

From March 2020, *The Royal Society* used its convening power to support efforts to model the COVID-19 pandemic and help guide the UK's response. In particular, it set up the *Rapid Assistance in Modelling the Pandemic (RAMP)* initiative and the *Data Evaluation and Learning for Viral Epidemics (DELVE)* group. *RAMP* brought modelling expertise from a diverse range of disciplines to support the pandemic modelling community already working on COVID-19.

From January 2021, for up to eighteen months, the Newton Gateway has been playing a key role in the follow-on *UKRI* funded project. The *RAMP* Continuity Network is helping to support efforts to model the COVID-19 pandemic and help guide the UK's response. The Gateway has been delivering a series of meetings, workshops and virtual study groups to ensure scientific networking to help maintain strong communication links and further develop links with the wider modelling community around COVID-19. This will help to create a truly multiscale approach and will ensure engagement between the mathematical community as well as with those from industry and the public sector.

Three strands of work have been taking place:

The Gateway is developing a number of short meetings that react to key priority areas in the UK's response to the current pandemic. These reflect and share details of the key emerging issues, discussions, and expertise that is being developed, exploiting new data as available. These meetings set agendas to help provide rapid- response support, engaging with the wider modelling community. These events are guided by links with groups such as the *JUNIPER (Joint UNiversities Pandemic and Epidemiological Research)* consortium to ensure their relevance to current UK policy and engage with the wider mathematical modelling and epidemiology communities.

The Gateway is also developing a number of scientific meetings that further develop those taken forward by different Task Teams as part of the *RAMP* initiative. Specific topics continue to emerge over the period of the project, but the initial activity has discussed Environmental and Aerosol Transmission, Urban Analytics and Human Dynamics in Small Spaces.

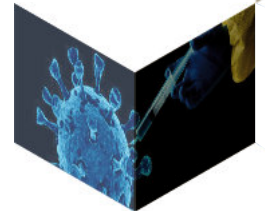
A number of Virtual Study Groups linked to *RAMP* have taken place. These were developed and delivered in partnership with *V-KEMS*.

Evolutionary Implications of the COVID-19 Vaccination Programme

19 & 20 April 2021

The COVID-19 vaccine is being rolled out in the UK and globally, but there is a limited supply available. Therefore, countries have had to prioritise which subgroups of the population receive the vaccine first. In the UK vaccination has been targeted at the older age groups, health-care workers and those that are at greater risk of needing hospitalisation as a result of contracting COVID-19.

This workshop focused on the use of quantitative modelling approaches to understand the evolutionary implications of vaccination programmes. Such approaches are key to developing optimal vaccination strategies and understanding which subgroups in society should be prioritised for vaccination against COVID-19. A key goal of this event was to build links between epidemic modellers and the wider modelling community with interests in COVID-19, such as within-host modelling teams – including, but not limited to members of *RAMP*-initiated projects.



Environmental and Aerosol Transmission of COVID-19

26 – 28 April 2021

Better understanding of the transmission of COVID-19 is a key factor in managing risk and designing practical interventions. With the reduction of lockdown restrictions, insights into areas such as the role of ventilation and the impact of people moving around within buildings were particularly timely.

Building on the work begun by *RAMP*, this three-day science meeting reviewed existing work and identified where further research was most urgently needed. The meeting included a standalone public-facing component providing an accessible overview of the latest science, alongside scientific talks and discussion sessions targeting active researchers. The aims were to bring together a wide range of participants to maximise the engagement from different communities, better inform the public on the science underlying viral transmission, progress the most promising areas of research and reach consensus on future research directions and research activity.



Activities from August 2020 – July 2021

26 – 27 May 2021



New Models of Spatial and Social Behaviour in a Pandemic

This two-day science meeting brought together two longer term research activities – Urban Analytics and Human Dynamics in Small Spaces. These RAMP-initiated projects are inter-related and differ mainly in terms of geographical scale. The event helped fulfil a key aim to maintain strong communication links between them, as well as extending to other relevant communities around COVID-19.

The event sought to continue to gain further insights as lockdown restrictions were loosened in order to provide supporting evidence and assistance to the scientists advising the government on national and local policy responses using urban analytics and spatial modelling. There are important implications for extending these models to embrace key social and economic issues that result from the pandemic and will be explored through future workshops.

13 – 15 July 2021



Virtual Study Group – COVID-19 Safety in Large Events

This three-day virtual study group hosted by ICMS and delivered by V-KEMS explored the challenges related to the delivery of Large Events during the COVID-19 pandemic. It brought mathematical scientists and other disciplines together to solve end user-defined challenges.

The study group covered the spectrum of large events and heard from organisers including *ASM Global*, *Edinburgh Fringe Festival*, *Church of England* and *Bath Rugby Club* who were running a variety of events – large indoor gatherings; large outdoor festival type gatherings and large outdoor events where attendees were seated. Researchers modelled the impact of queuing geometries, staggering arrival times, signage, and some process of pre-checking to provide insight for the event organisers. Since the event, participants have collaborated to develop a working paper which can be seen on the Gateway RAMP webpages.

Understanding the Generation Time for COVID-19

The generation time of COVID-19 is the duration between the moment a person gets infected to the moment they infect another person. This is very important in the context of new variants which may have different generation times, which in turn would have implications for the estimates of the R number. The generation time is also important for the evolution of new variants.

This workshop focused on understanding the different factors which affect the generation time, as well as the interaction between these, which is important to be able to better assess what aspects of new variants may be of concern. The aim of this event was to hear talks related to each of the factors affecting the generation time, to try to understand current work and thinking in each area and in turn to try to identify how these may be more joined up.

28 – 30 July 2021



More information on RAMP activity can be found on the webpage
<https://gateway.newton.ac.uk/ramp>

Virtual Forum for Knowledge Exchange in the Mathematical Sciences (V-KEMS)

Over the past year, the Gateway has continued to develop, deliver and support activity by *V-KEMS (Virtual Forum for Knowledge Exchange in the Mathematical Sciences)* which was established in March 2020, in response to the COVID-19 pandemic. The Newton Gateway to Mathematics, *Isaac Newton Institute (INI)*, *International Centre for Mathematical Sciences (ICMS)* and *Knowledge Transfer Network (KTN)* have worked with various representatives from the mathematical sciences community to develop this virtual forum. The main aim has been to identify a range of virtual approaches to help address challenges from business and industry, the third sector, and other groups outside academia. These challenges may have been long-standing or may have arisen directly as a consequence of the present disruption to UK society.

Many initiatives were already taking place to help provide infrastructure and resources to clinicians and others who were urgently helping to model the current pandemic. Where appropriate, *V-KEMS* has provided direct support to this activity. However, *V-KEMS'* main focus has been to identify broader areas for input from the mathematical sciences community – for example tackling issues related to food supply and logistics etc. A subsequent focus, linked to the *RAMP* continuity already highlighted, has been around recovery from the pandemic, for a variety of different sectors and venues such as large events, hospitality and leisure.

Activities

A number of activities have been taking place:

- Virtual Study Groups
- Webinars/Scoping Meetings
- Mathematical Support to Business, Industry, the Public and Third Sectors

Virtual Study Groups

Much of *V-KEMS* activity has focused on the development and delivery of Virtual Study Groups – a number of which have input directly to advice being developed by officials who have been working with Government in response to COVID-19. For example, *Unlocking Higher Education Spaces* helped input to dialogue between the *Department for Education*, the *Department of Health and Social Care*, *Universities UK*, the *Scottish*

Government and the *Welsh Government*. Other activity has input to advice going to *SAGE (Scientific Advisory Group for Emergencies)* and *SPI-M (Scientific Pandemic Influenza Group on Modelling)*.

The Newton Gateway has been directly involved in the development and delivery of these Virtual Study Groups, including *Modelling Solutions to the Impact of COVID-19 on Cardiovascular Waiting Lists Virtual Study Group* that took place in February 2021.

Webinars/Scoping Meetings

V-KEMS has also been able to provide the infrastructure to host appropriate webinars and scoping meetings online. These have included talks, with options to participate in parallel sessions via virtual breakout rooms.

Mathematical Support to Business, Industry, the Public and Third Sectors

Where industry, business, the public sector or the third sector have an identified problem that would benefit from mathematical input (such as physical modelling, statistics, data analysis etc.), *V-KEMS* has been able to help facilitate this, by putting the organisation in contact with relevant individuals or teams from the mathematical sciences community who then go on to undertake a scoping and triaging process.

More information on *V-KEMS* activity can be found on the website www.vkemsuk.org and through its Twitter account [www.twitter.com/V_KEMS](https://twitter.com/V_KEMS)

Knowledge Exchange Activities for INI Research Programmes

The *Isaac Newton Institute* sponsors Knowledge Exchange activity, referred to as 'Open for Business' (*OfB*) knowledge exchange events, as a part of its continuing objective of bringing academic researchers involved with its research programmes into contact with industrial, commercial and government organisations and individuals. These activities, which are delivered by the Newton Gateway to Mathematics, provide opportunities for cross-fertilisation between the 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.

In this reporting year no *OfB* events took place because of the COVID-19 pandemic. However, the Gateway did engage with the *Infectious Dynamics of Pandemics Programme* held at INI from May to December 2020. Numerous links were made between this Research Programme and the activities developed and delivered by *V-KEMS*, including ongoing work that related to the *Unlocking Higher Education Spaces Virtual Study Group* held earlier in 2020.

Participation

The Newton Gateway to Mathematics remains successful in facilitating links between industry, academia and the public sector, ensuring participation from a significant number of researchers in disciplines other than the mathematical sciences.

Due to COVID-19, events that were in development were rescheduled for delivery later in 2020 and in 2021. The majority delivered in this reporting year took place online, though one hybrid event was able to take place at INI in July 2021.

The Gateway continued to engage across a wide range of sectors, with 2,127 delegates attending the twenty one events that it developed and delivered between August 2020 and July 2021. The virtual nature of these events has enabled increased numbers and diversity of people to attend, including more Early Career Researchers who have engaged in the virtual study groups, as well as an increased number of attendees from overseas who were more easily able to engage via the virtual nature of the events.

The diversity of sectors has expanded and includes analytics, biotechnology, communication, data science, defence, energy, engineering, environment, finance, healthcare,

information technology, medical imaging, security, space, technology and transport.

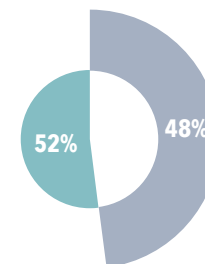
From March 2020, the Gateway has been key to development of *V-KEMS* activity in the form of web meetings, webinars and virtual study groups. These events were developed and delivered in partnership with the *International Centre for Mathematical Sciences (ICMS)*, *Knowledge Transfer Network (KTN)* and *Isaac Newton Institute (INI)*. Engagement with *V-KEMS* partners has helped to expand some specific academic sector contacts as well as those involved in health, social care and education.

More than 150 different organisations and over 1,300 delegates have been involved to July 2021, but these numbers are not captured in the participation rates below as they were fully collaborative activities with the four partners.

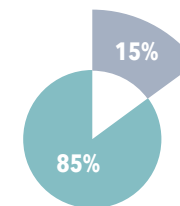
The events related to the *RAMP* continuity activity attracted a much higher proportion of academic attendees, but this is to be expected as one aim was to ensure engagement with the wider mathematical community and multiple disciplines and sub-fields. These events were attended by delegates from a wide range of academic disciplines, so enabling discussion linked to other relevant fields of research.

These charts show attendance at Gateway delivered events, divided by affiliation.

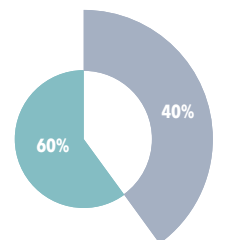
Gateway Events



RAMP Events



Gateway & RAMP Events Combined



Academic Industry & Public Sector

Gateway Summary 31 July 2021¹

	2020-2021²	2019-2020
Income	£72,120	£302,000
Registrations, fees and event support costs		
 Expenditure	 £22,275	 £295,000
Event catering, accommodation and delivery; professional services and software		

1 Any surplus at the end of the year is used by INI to make a contribution to covering Gateway salaries and overheads

2 2020-2021 income and expenditure are low because of the COVID-19 pandemic.
The majority of Gateway events took place virtually in this period.

Grants and Funding

The Newton Gateway to Mathematics is an integral component of the *Isaac Newton Institute* and therefore support is provided by *INI* to enable the Gateway to continue to develop and expand its current service to the community.

The *University of Cambridge* has contributed to the funding of the Newton Gateway to Mathematics through the *Higher Education Innovation Funding* scheme, which has partially covered administrative costs. Direct costs for specific Gateway activities are funded through partnerships with stakeholders including from industry and the public sector, philanthropy and participant registration fees.

Future Development

The Newton Gateway to Mathematics 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. The series of Thematic Knowledge Exchange Programmes are designed to stimulate and

support research activities and include workshops, consultations and project meetings. These include Mathematics of Big Data, Mathematics for Biology and Healthcare Systems, Mathematics for the Environment and Energy, Mathematics for Financial Services, and Mathematics for the Space and Security Sectors.

Activity from September – December 2021

With its ongoing aspiration of playing a key national role in mathematical sciences knowledge exchange, the Newton Gateway to Mathematics has developed the following activities in collaboration with stakeholders, funders and other academic partners.

5th Edwards Symposium – Future Directions in Soft Matter

(8 – 10 September 2021)

Recovery from the Pandemic: Hospitality & Leisure – Virtual Study Group

(12 – 14 October 2021)

Modelling Behaviour to Inform Policy for Pandemics

(2, 4 & 5 November 2021)

Machine Learning Training for Industry

(3, 10 & 17 November 2021)

Cantab Capital Institute for the Mathematics of Information – Industry Engagement

(24 November 2021)

Optimal Vaccination Strategies

(14 December 2021)

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