Climate

ACCURATE WEATHER FORECASTS

EPSRC-supported research teams have partnered with the Met Office on projects invaluable to UK services and industries, such as agriculture, aviation and construction. By providing advanced warning of severe weather, these forecasts have an annual UK economic value of £600 million.

EPSRC-supported maths researchers at the University of Bath, working with the Met Office, developed an algorithm to enable improved prediction of severe storms. By creating reliable ways to increase accuracy of data assimilation the research has reduced the impact of cold weather on road networks, enabling local authorities to plan road clearing and gritting when snow or ice are predicted.

In another partnership with the Met Office, which employs around 2,000 mathematicians, EPSRC-funded researchers at the University of Exeter made a key contribution to ENDGame, the new dynamical core of the Met Office's global weather and climate prediction model. By solving the equations of atmospheric dynamics and thermodynamics, the research has improved the robustness, stability, accuracy and efficiency of the system.

Environment

EFFECTIVE FLOOD DEFENCES

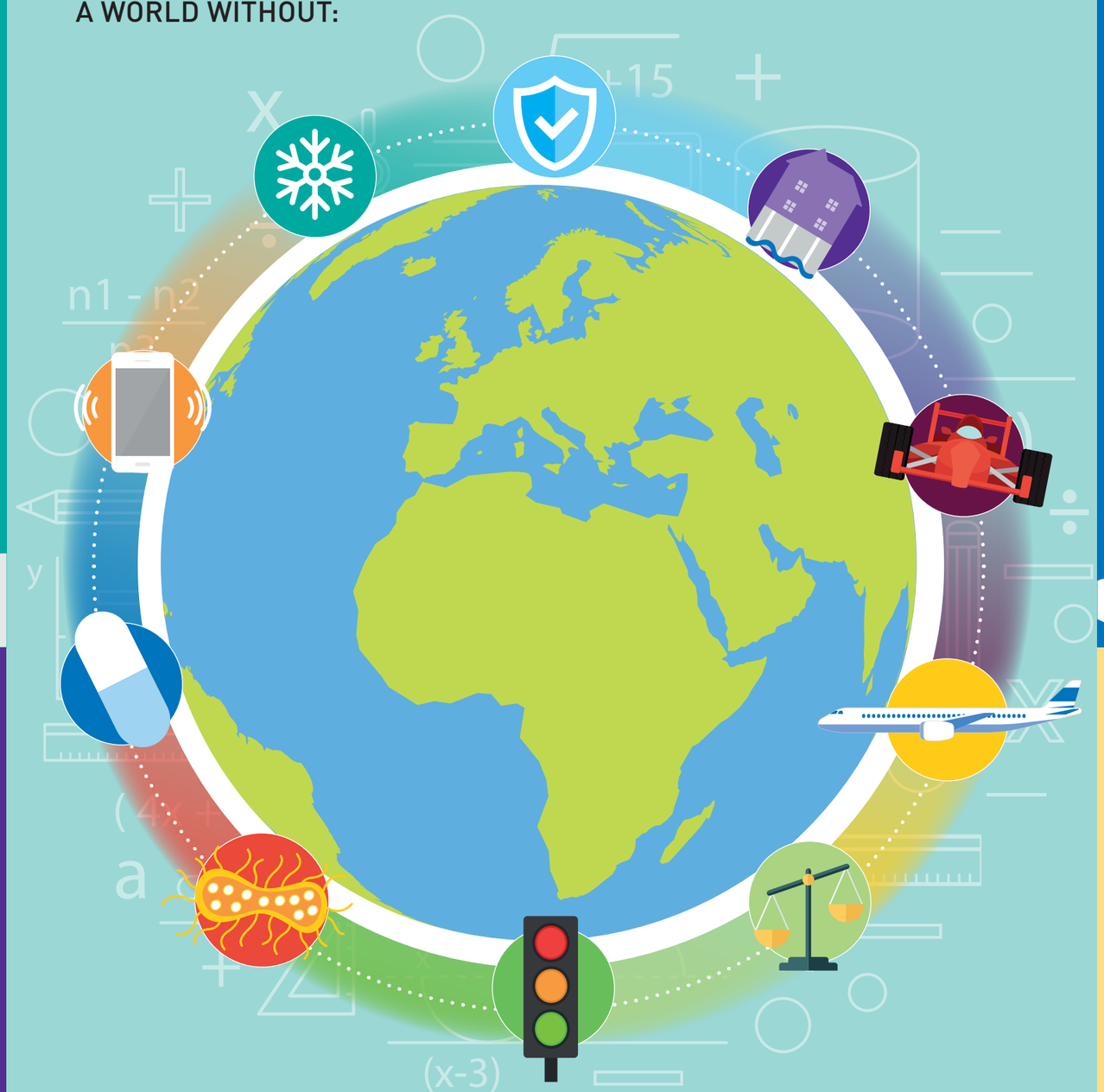
Mathematics research on modelling extreme events has been fundamental to optimising the design of the UK's flood defences.

Estimating the frequency of events that are more extreme than any previous observation is a key element in environmental risk prevention and assessment. The EPSRC-supported team from Lancaster University used extreme value theory (EVA), a branch of statistics that assesses the probability of such events, to create mathematically justified models.

This enabled the optimisation of the design of coastal and river infrastructure and has led to strong financial and societal benefits. For example, the UK has around 600 miles of walls, and one metre of extra height costs on average £150,000 per 100-metre length. Calculating the optimal height of sea walls has led to a reduction in unnecessary building costs – saving £22.5 million on 450 schemes.

The research also resulted in the development of software to help the insurance industry accurately estimate annual flood loss for insured properties, leading to less reliance on outsourced consultancies – with estimated savings of £6 million since 2010.

A WORLD WITHOUT MATHEMATICS MEANS A WORLD WITHOUT:



- ACCURATE WEATHER FORECASTS
- MODERN MOBILE TELEPHONY
- POWERFUL NEW ANTIBIOTICS
- PROTECTION AGAINST EPIDEMICS
- INTEGRATED TRAFFIC SYSTEMS
- REDUCTION IN CRIME
- SAFER AIR TRAVEL
- ADVANCES IN ENGINEERING
- EFFECTIVE FLOOD DEFENCES
- COMPETITIVE INSURANCE PRODUCTS

Healthcare

POWERFUL NEW ANTIBIOTICS

Antibiotic resistance means that diseases that are relatively minor today could soon become untreatable and fatal. To tackle this, researchers at Imperial College London have been using mathematical modelling to determine what timing and dosage of antibiotics work best to prevent the drug-resistant strains of bacteria emerging.

Dr Caroline Colijn's research team, funded by EPSRC, modelled the behaviour of drug-resistant and drug-susceptible bacteria under both aggressive and moderate treatment regimes in several scenarios. They found that both treatment strategies could be effective, but the mathematical models showed that the best course of treatment depended on the ways in which the drug-resistant and susceptible bacteria were interacting with each other. This allows treatment to be more targeted to individuals' needs.

The team noted that even when aggressive treatment is best for individuals, it can still drive up the levels of resistance in whole populations over time. The focus for the future therefore is to use observational techniques and better mathematical modelling of the population to help tackle the problem on a greater scale.

Transport

SAFER AIR TRAVEL

Ice can have a detrimental impact on aircraft safety. If it builds up on an aeroplane's wings, for example, it can affect lift and control and lead to accidents.

Until recently, models used to predict ice formation on aircraft have not managed to take into account the behaviour of the water droplets and how the splashing of the droplet hitting the aircraft affects how the ice is formed.

A team led by Professor Richard Purvis, from the University of East Anglia, worked with aircraft icing specialists AeroTex UK to better understand the physics of large droplet impacts and splashing dynamics and how that might affect ice formation, particularly on the wings of aeroplanes.

The research, which included work by EPSRC-supported Research Associate, Peter Hicks, who spent a year with the company, helped AeroTex to produce improved numerical models, resulting in protection design software the company claims is better than its competitors', and ultimately leading to improved aircraft safety.

Communications

MODERN MOBILE TELEPHONY

In a complex urban environment, mobile phone signals scatter when they bounce off buildings, causing echoes that take longer to reach their destination. These delayed echoes can interfere and cancel out when they meet again at the receiver, leading to dead zones and dropped phone calls.

Rather than viewing this as a problem, EPSRC-supported engineers and mathematicians such as John McWhirter at Cardiff University have figured out ways to make these multiple-path effects actually improve signal transmission by exploiting important new developments in broadcasting technology.

The process is similar to tuning an FM radio into your favourite station, but rather than twiddling the radio dial, a mathematical algorithm rapidly tries different array configurations until it finds the best signal. As a result, we get better, cheaper and faster mobile phone calls.

Finance

COMPETITIVE INSURANCE PRODUCTS

Research into data mining and statistical analysis by researchers at the University of East Anglia (UEA), in collaboration with leading UK insurance group, Aviva (formerly Norwich Union), helped pioneer data mining techniques for use in industry.

The research also led to better value for money for Aviva's general insurance and pensions customers, savings of many millions as a result of changes in pricing for general insurance products, and advances in computer science and statistics.

These results are based on underpinning research in the 1990s by Professor Vic Rayward-Smith, a pioneer in the emerging discipline of data mining. Using advanced computer algorithms, data mining makes it possible to identify potentially useful and ultimately understandable patterns from vast and complex data sets.

Professor Rayward-Smith and Beatriz de la Iglesia, then a postdoctoral research associate, were among the first to describe how the mathematical techniques underpinning data mining could be used in industrial applications, now used across a wide range of sectors, from the insurance industry to healthcare; telecommunications to retail.

Security

REDUCTION IN CRIME

An EPSRC-supported consortium including mathematicians, policing partners and social scientists have joined forces in a five-year programme to test and improve 'predictive policing' and tackle other challenges for future cities.

Predictive policing uses maths and statistics, based on historical crime data in a given area, to predict times and places where serious crimes will occur, allowing police to efficiently allocate resources.

The team are drawing on the results of a highly successful trial in Los Angeles, and are confident they can improve on these, providing greater levels of statistical validity that will lead to more powerful models.

The project is led by Professor Mark Girolami, from the Department of Mathematics Imperial College London, and includes scientists from UK universities, UK and US police forces, software companies and the Home Office. It also includes the Alan Turing Institute's data ethics group, which is working with West Midlands Police to examine ethical issues.

Engineering

ADVANCES IN ENGINEERING

Long-term collaboration between Professor Malcolm Smith at the University of Cambridge and legendary British supercar maker and Formula 1 giant, McLaren, led to revolutionary suspension technology now used in all Formula 1 cars.

The partnership dates back to the late 1990s, and grew out of Professor Smith's research into mechanical networks and suspension systems forged from an earlier collaboration with the Williams Formula 1 team.

The cornerstone of the research is a fusion of cutting-edge mathematical theory, physics and modelling, applied to solve real-world engineering problems. The result was a new suspension component, the inerter, which helps to control a car's oscillations, improving mechanical grip and cutting lap times.

Smith and his team continue to refine the technology, and have developed devices that show great potential for use in railway suspension systems, reducing wear on the tracks and wheels, lowering costs for the carriers and providing a more comfortable ride for passengers.

WHY INVEST IN MATHEMATICAL SCIENCES?

Mathematical sciences' contribution to the UK economy:*

- 10% of jobs (2.8 million)
- 16% of Gross Value Added (GVA) (£208 billion)

Mathematics is the bedrock of civilisation and the language of science. Without it we couldn't measure anything, make anything or build anything. There would be no money, houses or roads. No hospitals or schools. No internet. No antibiotics.

For every advance in science, mathematics has been at its core – from systems that ensure smooth traffic flow and safer air travel to the algorithms behind cyber security and the technology in all our smartphones.

Not only does mathematics form the fundamental basis for many other disciplines, it delivers real-world impact in its own right. In the modern world, we use mathematical sciences for:

Data analysis: a process for obtaining raw data and converting it into information useful to make decisions. For example, supermarkets use electronically-gathered customer purchasing data to improve their stock management and for marketing purposes.

Modelling: used to 'model' or forecast future behaviour. For example, an ice cream company might use the weather forecast to decide how many ice creams it needs to make.

Optimisation: essentially a process to make the most appropriate decisions based on a range of alternatives. For example, an aircraft manufacturer that wants to make a fuel-efficient plane will consider factors such as: speed, fuel consumption, range, noise, weight, type of propulsion, cost, ease of use, amount of drag, and payload.

EPSRC is the UK's main funding agency for research and training in the mathematical sciences. Through continued investment we will sustain core research capability in the UK while promoting transformative and cross-disciplinary research that has the potential for real-world impact.

*Independent report commissioned by EPSRC and the Council for the Mathematical Science: https://bit.ly/2Lqae9N

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EPSRC
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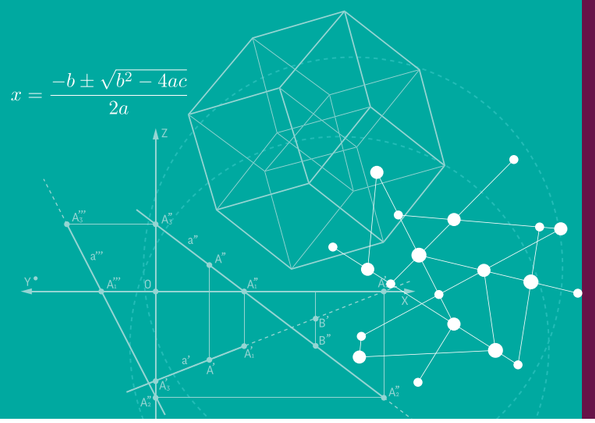
Mathematical sciences research

Leading the way to UK economic growth, prosperity and wellbeing



ABOUT EPSRC

EPSRC is the main funding agency for engineering and physical sciences research in the UK. By investing in research and postgraduate training, we are building the knowledge and skills base needed to address the scientific and technological challenges facing the nation.

Working across a vast range of fields including mathematics, ICT, engineering, physics, chemistry and materials, the research we invest in has an impact on all sectors. It provides a platform for future UK prosperity by contributing to a healthy, connected, resilient and productive nation.

EPSRC is part of UK Research and Innovation.

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