AUTUMN 2023
ISSUE 32

DEPARTMENT OF ENGINEERING

NEWS

UNIVERSITY OF CAMBRIDGE

In this issue

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Cover image: Alumna Tombo Banda, who is leading the Mini-Grid Innovation Lab at CrossBoundary in Nairobi.

Note from the editors

Welcome to the Department of Engineering News. We have another edition for you packed with news, including a collection of stories and interviews with some of our phenomenal female alumni who are making an impact in: energy, sailing, motorsport, geotechnical engineering, emergency disaster search and rescue and more.

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Charlotte Hester and Jacqueline Saggers
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Head's welcome

Welcome to this latest edition of the Department of Engineering News for Autumn 2023. I am honoured to have been appointed Head of Department and assumed the role at the beginning of October. Since I last wrote, the EIETL (Electrical and Information Engineering Teaching Laboratory) refurbishment has been completed and the first batch of undergraduate projects in the reimagined space took place starting on October 5.

Another topic which I know will be of interest to you is the reform of Part I. This has been some time coming, and work on it started a few years ago, only to be hampered by COVID. We have re-launched this project and are aiming for the new Part I to come into effect from Michaelmas term 2026. This time will come around quickly and there is much to do, but it is in the very capable hands of Professor Seb Savory. At the core of the reform is tighter integration between topics, and between lectures, labs and examples papers. We are weaving the UN Sustainability goals throughout, and there will be an increased emphasis on transferrable skills, with no compromises on the academic rigour of the core course.

As a Department we continue to evolve, and have just appointed Professor Harald Haas as the new Van Eck chair in Engineering. Harald is well-known in the field of high-speed comms, as the inventor of Li-Fi, as well as many developments in wireless communications. He will be joining the Electrical Engineering division in spring 2024. There have also been recent appointments in areas related to climate change and air transport, all due to start in the coming months.

Looking through this edition of the newsletter, you will see the groundbreaking ceremony for the New Whittle Laboratory, which will house the aviation impact accelerator and the National Centre for Propulsion and Power, and you can find the story on **page 4**. This was King Charles' first public engagement since the Coronation, highlighting the importance of this endeavour at the National level and beyond.

Next you will see our cover story on **page 7** about alumna Tombo Banda and her work on mini-grids, with the aspiration of bringing energy to hundreds of millions of people in sub-Saharan Africa.

On **pages 8-9** you will see the story of the work carried out by Sakthy Selvakumaran who is both an alumna of the Department and an Isaac Newton Trust Research Fellow at the Department and Newnham College. As a civil engineer, she helped out with the emergency operation in Turkey earlier this year after the series of devastating earthquakes.

On **page 11** is an alumni story about Sam Davies and her courageous efforts at round-the-world sailing, and the challenges she faced. An inspiring tale of resilience and of course with a helpful dose of engineering thrown in.

Then on **page 15** is an article on Hannah Schmitz who is Oracle Red Bull Racing's Principal Strategy Engineer. Hannah will also be coming back later this term as a panellist for an F1 careers session with our undergraduates.

Throughout the rest of the newsletter, you will see a range of stories about faculty, alumni and undergraduates, and I hope you will agree there is something for everyone.

A final word – in 2024 it will be 150 years since students first started studying Engineering in Cambridge. This is an important moment in our evolution as a Department, and there will be more to come on this as well as much more, in the next edition.

Professor Colm Durkan FIET, FInstP

→ The King at the groundbreaking for the New Whittle Laboratory

Credit: Lloyd Mann

The King breaks ground on Cambridge's New Whittle Laboratory

His Majesty The King visited the University of Cambridge on 9 May 2023 in his first public engagement following the Coronation.

His Majesty was in Cambridge to break ground on the New Whittle Laboratory, where he also met with staff and researchers, leaders from the aviation industry and senior government representatives.

The New Whittle Laboratory, a £58 million facility, will be the leading global centre for net zero aviation and energy. Its mission is to halve the time to develop key technologies to support a sustainable aviation industry.

Alongside the groundbreaking, senior figures from government and industry gathered for an international roundtable as part of an initiative led by Cambridge and MIT. This will present insights based on global aviation systems modelling capabilities developed through the Aviation Impact Accelerator, a project led by the Whittle Laboratory and the Cambridge Institute for Sustainability Leadership.

Today, it typically takes six to eight years to develop a new technology to a point where it can be considered for commercial deployment in the aerospace and energy sectors. Recent trials in the Whittle Laboratory have shown this timeframe can be accelerated by breaking down barriers that exist between academia and industry.

The New Whittle Laboratory will incorporate the Bennett Innovation Laboratory – made possible through a philanthropic gift from the Peter Bennett Foundation – to bring together a critical mass of talent, giving them the right skills, tools, culture and working environment to solve complex multidisciplinary challenges. It will also be home to the UK's National Centre for Propulsion and Power, built around a fast feedback model pioneered in Formula One to cut the time to develop technologies from years to months.

Organisations participating in the roundtable included the UK Government, UK Aerospace Technology Institute, the US Federal Aviation Administration, NASA, EU Clean Aviation Joint Undertaking, Airbus, Boeing, Rolls-Royce, and the Sustainable Markets Initiative.

The Prince of Wales, His Majesty previously visited the Whittle Laboratory in January 2020 and March 2022 to encourage the acceleration of sustainable aviation, as well as hosting an industry roundtable in February 2020 in London with the Sustainable Markets Initiative and World Economic Forum to explore solutions for decarbonising air travel.

Professor Rob Miller, Director of the Whittle Laboratory, said: "We need to completely transform the innovation landscape in the aviation and energy sectors if we are to reach net zero by 2050. The New Whittle Lab has been designed as a disruptive innovation laboratory targeting the critical early stages in the lifecycles of technologies, where there are windows of opportunity to translate scientific strengths into global technological and industrial leadership.

"The Lab is designed to work at the intersection of cutting-edge science and emerging engineering applications, providing fast feedback between the two and dramatically cutting the time to deliver zero-emission technologies."

Speaking at the time, Grant Shapps, the UK Government's former Energy Security Secretary, said: "The UK is leading a revolution in aviation, looking to new technologies to cut emissions.

"Having established the Jet Zero Council three years ago by bringing together government, industry and academia, I strongly welcome the Whittle Laboratory being at the forefront of that endeavour today.

"This will further help the best minds from the fields of energy and aviation push ever-further and faster with the latest innovations in order to solve the problem of environmentally friendly and affordable flying."

Mark Harper, the UK Government's Transport Secretary, said: "Having already invested £165 million in the production of sustainable aviation fuels, this Government is determined to harness the economic benefits of flying while supporting industry and academia to create cleaner skies for the future.

"The breaking ground of the New Whittle Laboratory is great news for the UK's world-leading aviation sector, representing another step towards the UK hitting our Jet Zero goals."

whittle.eng.cam.ac.uk

Credit: Franz W. from Pixabay

Carbon emissions from fertilisers could be reduced by as much as 80% by 2050

Researchers have calculated the carbon footprint for the full life cycle of fertilisers, which are responsible for approximately 5% of global greenhouse gas emissions – the first time this has been accurately quantified – and found that carbon emissions could be reduced to one-fifth of current levels by 2050.

The researchers found that two-thirds of emissions from fertilisers take place after they are spread on fields, with one-third of emissions coming from production processes.

Although nitrogen-based fertilisers are already known to be a major source of greenhouse gas emissions, this is the first time that their overall contribution, from production to deployment, has been fully quantified. The analysis found that manure and synthetic fertilisers emit the equivalent of 2.6 gigatonnes of carbon per year – equivalent to the global steel industry.

The researchers say that a combination of scalable technological and policy solutions are needed to reduce fertiliser emissions while maintaining food security. However, they estimate that if such solutions could be implemented at scale, the emissions from manure and synthetic fertilisers could be reduced by as much as 80%, to one-fifth of current levels, without a loss of productivity. Their results are reported in the journal *Nature Food*.

"Incredibly, we don't actually know how many chemicals we produce globally, where they end up, where and how they accumulate, how many emissions they produce, and how much waste they generate," said co-author Dr André Cabrera Serrenho from Cambridge's Department of Engineering.

"In order to reduce emissions, it's important for us to identify and prioritise any interventions we can make to make fertilisers less harmful to the environment," said Dr Serrenho. "But if we're going to do that, we first need to have a clear picture of the whole lifecycle of these products. It sounds obvious, but we actually know very little about this."

The researchers mapped the global flows of manure and synthetic fertilisers and their emissions for 2019, along all stages of the lifecycle, by reconciling the production and consumption of nitrogen fertilisers and regional emission factors across nine world regions. The researchers found that unlike many other products, the majority of emissions for fertilisers occur not during production, but during their use.

Emissions from the production of synthetic fertilisers are mostly from ammonia synthesis, partly due to chemical reactions used in the production process. The most effective mitigation at the production stage would be for the industry to decarbonise heating and hydrogen production. Additionally, fertilisers could be mixed with chemicals called nitrification inhibitors, which prevent bacteria from forming nitrous oxide. However, these chemicals are likely to make fertilisers more expensive.

"If we're going to make fertilisers more expensive, then there needs to be some sort of financial incentive to farmers and to fertiliser companies," said Dr Serrenho. "Farming is an incredibly tough business as it is, and farmers aren't currently rewarded for producing lower emissions."

"We're incredibly inefficient in our use of fertilisers," said Dr Serrenho. "We're using far more than we need, which is economically inefficient and that's down to farming practices. If we used fertiliser more efficiently, we would need substantially less fertiliser, which would reduce emissions without affecting crop productivity."

The researchers also looked at the mix of fertilisers used around the world, which varies by region. The researchers say that replacing some of the fertilisers with the highest emissions, such as urea, with ammonium nitrate worldwide could further reduce emissions by between 20% and 30%. However, this would only be beneficial after decarbonising the fertiliser industry.

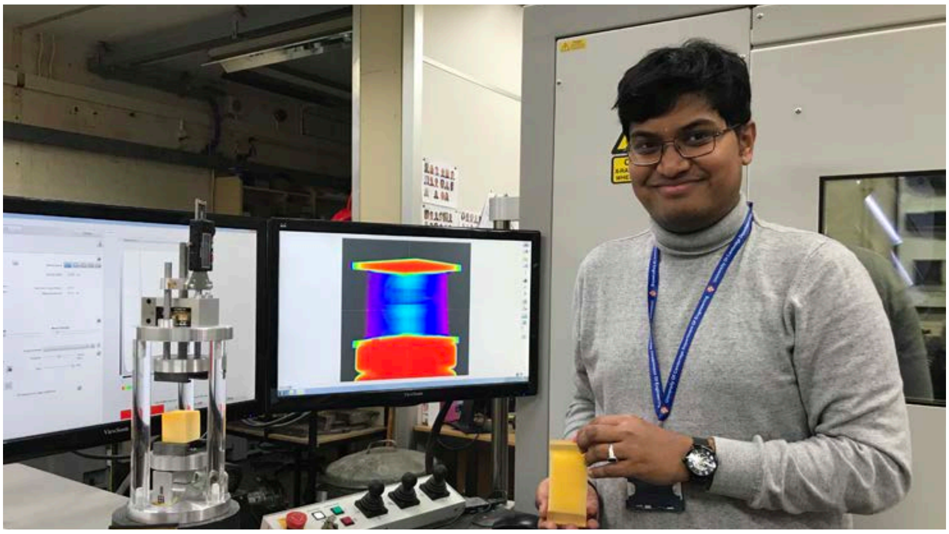
"There are no perfect solutions," said Dr Serrenho. "We need to rethink how we produce food, and what sorts of economic incentives work best. Perhaps that means paying farmers to produce fewer emissions; perhaps that means paying more for food. We need to find the right mix of financial, technological and policy solutions to reduce emissions while keeping the world fed."

Dr Serrenho and his co-author Dr Yunhu Gao estimate that by implementing all the mitigations they analysed, emissions from the fertiliser sector could be reduced by as much as 80% by 2050.

The research was part of the C-THRU project, led by Professor Jonathan Cullen, where researchers from four UK and US universities are working to bring clarity to the emissions from the global petrochemical supply chain.

www.c-thru.org

Dr Angkur Shaikeea joins the Department as the inaugural Ashby Research Fellow



Dr Angkur Shaikeea earned his PhD in Engineering at Cambridge between 2017 and 2021, supported by the Cambridge India Ramanujan Scholarship. He later became an Ashby Postdoctoral Fellow in Mechanics and Materials and in 2023 was appointed Assistant Professor at the Institute for Manufacturing (IfM), part of the Department of Engineering.

Congratulations on your recent appointment as an Assistant Professor – how does it feel?

Thank you. Transitioning from an Ashby Postdoctoral Research Fellow to an Assistant Professor is a significant milestone in my career. The fellowship allowed me to hone my skills as an independent researcher, collaborate across disciplines, and develop a passion for teaching. I am grateful for mentorship from esteemed researchers in the Department and external collaborations. In my new role, I am eager to contribute more to the Department's research and teaching.

Could you reflect on your experiences that have shaped your trajectory?

Since arriving at Cambridge for my PhD, I have enjoyed courses, lectures, seminars and social activities at the University and my College. During my PhD, I received the Cape Acorn Postgraduate Research Award and participated in the Biomaker Challenge. I also improved my teaching by supervising small student groups, and received recognition as a Highly Commended Supervisor from the Cambridge University Students' Union.

You have been proactive in both research and extracurricular activities. How did you balance them?

I followed my curiosity during my doctoral research, exploring projects like the Architected Cellular Surgical Mesh, supported by the Cape Award, which later led to the Lindemann Fellowship at Harvard. Inspired by D'Arcy Wentworth Thompson's work, I delved into bees' hexagonal combs in collaboration with the St. John's Beekeeping Society. This research expanded with support from the Ashby Fellowship and guidance from Professor Vikram Deshpande. Exploring the wonders of the natural world brings immense joy.

What was your strategy for approaching faculty positions?

After my PhD, I considered moving to the US for research, but a visa issue coincided with receiving the Ashby Fellowship, making my decision to stay at Cambridge easy. This fellowship offered exceptional collaboration opportunities and crucial financial support for independent experiments. Looking back, I do not feel I missed out on the "US experience".

As an Associate Professor, what are your primary goals for research and teaching?

My primary goal is to bridge the gap between cutting-edge research and practical industry applications. I aim to lead research aligning with industrial scale-up needs, drawing on my expertise in X-ray tomography and materials mechanics. Simultaneously, I am excited about enhancing students' academic growth. By incorporating real-world challenges into the curriculum, I want to equip students with practical skills and a deep understanding of industrial processes.

Philanthropic support of the Department of Engineering

The Cambridge India Ramanujan Scholarship is a full-tuition and maintenance award supported by the Science and Engineering Research Board of India and the Cambridge Trust.

The Ashby Postdoctoral Fellowship in Mechanics and Materials was established 2021 in honour of the pioneering research by Professor M F Ashby CBE, FRS, FREng. This was thanks to the generous donations from Professor Ashby, David and Susan Hibbitt, and friends, colleagues and past students of Professor Ashby.

Postgraduate support and early career fellowships help the Department attract and retain the best young academics, and give recipients the opportunity to jumpstart their academic careers through access to exceptional mentorship, research and teaching opportunities.

To discuss philanthropic support of the Department of Engineering, please contact Ann Cernek (Associate Director – Engineering) at ann.cernek@admin.cam.ac.uk

www.philanthropy.cam.ac.uk

ALUMNI UPDATE

Meet the engineer striving to close the energy access gap in Africa

When alumna Tombo Banda embarked on the MPhil in Engineering for Sustainable Development programme at Cambridge, she had one goal in mind: to pursue engineering work that culminated in meaningful, sustainable and long-standing change for her home country of Malawi, and across the African continent.

Fast-forward seven years and Tombo's aspiration to achieve greater impact has been realised. She now leads the Mini-Grid Innovation Lab at CrossBoundary in Nairobi. The Innovation Lab is a dedicated research and development fund established to test business model prototypes on mini-grids, working with both mini-grid developers and utilities to develop the 'grid of the future' – one that is more interconnected, reliable, flexible, efficient and economical.

A mini-grid typically involves stand-alone small-scale electricity generation isolated from the main grid. They tend to be used for electrifying rural communities and, with more than 600 million people in Sub-Saharan Africa still without access to electricity, it is conservatively estimated that at least 265 million of these people are most cost-effectively served by mini-grids.

Here she reveals more about her Cambridge experience and career jouney to date.

My engineering journey began back in 2004, when my dad convinced me that my natural strengths in design and technology, mathematics and physics were suited to a career in mechanical engineering. I decided to study mechanical engineering at Imperial College London. Unbeknownst to me, this was also part of my dad's succession planning; he ran an engineering consultancy. After completing my studies, I went back to Malawi to work with him.

I spent seven years in our company, Prime Engineering, working on key infrastructure projects locally and in West Africa. One highlight was working on an 8-tonne-per-hour mango processing factory in Salima, a town in central Malawi, providing more than 100 local jobs and generating much-needed foreign exchange for the country. A pioneering value-addition project, this work culminated in me achieving my chartership with the Institution of Mechanical Engineers (IMechE).

My work had highlighted the potential of engineering projects to bring about development and improve people's lives. However, I was aware that this development could come at an environmental price, with long-standing economic implications in the long term. This was what led me to pursue the MPhil in Engineering for Sustainable Development (ESD) – the desire to ensure that my engineering work did, in fact, bring about meaningful, sustainable and long-standing change for my country and the region.

After graduating from the MPhil in ESD course, I joined McKinsey & Company's Africa Delivery Hub, where I served African governments and the public sector in the delivery of development projects. The work centred broadly around public investment management – ranging from multi-billion-dollar infrastructure projects, to energy access projects, to supporting public holding companies.

My learning curve was steep and the stakes were a lot higher than some of the projects I had previously worked on in Malawi. However, my hands-on engineering experience, coupled with my learnings from the MPhil in ESD, seemed to stand me in very good stead. Foremost in my mind was Cambridge Emeritus Professor Peter Guthrie's Sustainability Assessment of Large Infrastructure Projects module, which centred around balancing economic, environmental and social dimensions in large-scale infrastructure project design, evaluation and decision-making. Though I certainly applied the theory, the roleplay we did at the end of term (which was of disgruntled community members suing an infrastructure company) was most relevant – dealing with emotional stakeholders can be more challenging than any complex project analysis!

I came to realise that energy was the real catalyst for development and that everything depended on it – health, sanitation, education and industry. The transformative impact of energy was what led me to my current position leading the Innovation Lab at CrossBoundary.

Cambridge was 11 months of pure fun for me. I am excited for everyone pursuing the MPhil in ESD course at this time – it could not be more important to be in this space. When I started the course, we were fresh out of COP21, and despite the Paris Agreement's goal to limit global warming to well below 2°C, now we are tragically off course. It is up to current and future cohorts of this course to redirect public opinion and policy, and implement the radical changes we need to avert irreversible climate change.

Read the full interview at:
www.eng.cam.ac.uk/tombo-banda

↑ The SARAID team in Turkey, with Sakthy Selvakumaran, pictured centre, holding the flag

ALUMNI UPDATE

Engineering for emergency response: Turkey and Syria earthquakes

Alumna Sakthy Selvakumaran is a civil engineer who volunteers for the charity Search and Rescue Assistance in Disasters (SARAID). She was on the ground as part of the emergency coordination search and rescue efforts in Turkey after the earthquakes earlier this year.

On 6 February 2023 an earthquake measuring magnitude 7.8 (Mw) struck southeast Turkey and northwest Syria, and was followed barely nine hours later by a second earthquake of magnitude 7.5 (Mw). Both events occurred on the East Anatolian Fault Zone and over the subsequent days and weeks thousands of aftershocks continued to impact the region. By 19 February more than 41,020 fatalities had been reported, with 108,068 people injured and more than 1.2 million people displaced.

We spoke to Sakthy about the emergency coordination search and rescue efforts.

Can you tell us about the SARAID training?

It took me two years to train and qualify as an Urban Search and Rescue (USAR) Technician. After passing the selection weekend you train for one weekend once a month and the engineers have training online in between. So it's a minimum once a month commitment over a two-year period.

At the end of last year, our SARAID team was classified as an official 'Light' team. Classified 'Light' USAR teams are now recognised as part of the International Search and Rescue Advisory Group (INSARAG) network that includes Light, Medium and Heavy international Urban Search and Rescue teams.

Can you tell us about the preparation that was needed before you left for Turkey?

SARAID monitors for big events 24 hours a day, seven days a week. The UN has a system where they coordinate and start putting out information to all international teams. So at that point, SARAID asks who's available to deploy. That usually depends on whether people can get time off work and that kind of thing. SARAID volunteers always have a bag packed and are ready to go.

Even then we only deploy if we have permission from the country; the country invites us to come as a request for assistance.

What are the procedures that you follow when you reach a rescue mission such as this?

Because it was such a big disaster there was a base of operations for international rescue teams. SARAID were in the Turkish city Kahramanmaraş in one of the sub-coordination cells, coordinating with the local teams, the UN and other international teams. The affected areas are mapped into different sectors (depending on the amount of damage in an area) and then different international teams are allocated to different sectors. Through that you identify where people are likely to be stuck. Then you can set up work sites and start extricating people, or getting teams with additional resources to support. You also have to bear in mind that local people will be providing information from the ground as well. We responded to a site because somebody heard a phone ringing in a pile of rubble. And the long story short, is we pulled a 15-year-old girl out of a rubble pile from several stories down in a collapsed building.

A lot of our work was focused on the city centre, the severe damage; large apartment buildings had completely toppled and some had completely pancaked, upside down, all sorts.

How many rescue teams were there on the ground? And how do these different international rescue agencies work together?

The local emergency management authority (which varies from country to country), is in charge of their country. The sovereignty of the affected country is guaranteed and the international responders, including UN, are not in charge. Most qualified teams work under the United Nations Office for Disaster Risk Reduction. The international community decided there needs to be some way of coordinating disaster relief and so they set up a system where we all get trained to a certain level. We have this central coordination team online and in-person. And you decide your sectors. We have forms that have now gone online and access to Geographic Information System (GIS) mapping to start tagging areas where people are.

How long were you in Turkey?

About a week. We were told before we left that we would be gone for approximately seven days. If something happens, we might extend this. Because we are a Light Team, it's great in some respects, because we can mobilise and be in country very quickly. We fly using local commercial airlines. For this trip the flights were donated by Airlink and the excess baggage was donated by Pegasus airlines. We could move and get our equipment and be on-site very quickly, which is good at the beginning when you're trying to go through lots and lots of buildings and identify people; then later you have much larger teams from the American, Chinese, UK, and Israeli governments. These are huge teams: for big disasters you need sheer people power. And so they tend to do the bigger jobs. SARAID are well-suited to the early phase of response, identify where things are, and help rescue. By the time we were leaving, there were fewer and fewer people being pulled out. A lot of the bigger teams have moved in to do body recovery.

Credit: SARAID

Do other countries have the equivalent of SARAID with Light Teams that can get to disasters early?

It's actually a relatively new concept. Up until very recently, there was no Light Team qualification; you were either qualified as a Heavy Team or as a Medium Team, but Light didn't exist. SARAID qualified recently. The Light classification is for small teams that can cover a range of things and move quickly. The SARAID teams don't have rescue dogs so we tend to partner with other Light Teams for example the German Light Team called @fire. In Turkey, the @fire engineer got very, very tired at one point, so we swapped the engineering role. And then at one point, we needed a dog. And so they brought in their dog. Teams collaborate and work together.

What are the most urgent needs now?

There's a lot of questions about why this happened. It was a big disaster. In Turkey, USAR teams were able to rescue hundreds of people from collapsed buildings as a combination of the efforts of the local population, local emergency teams and national and international USAR teams.

However, the earthquake is a stark reminder of the important role owners, designers, contractors and operators play in providing resilient buildings and infrastructure, and the potential consequences when a disaster strikes.

Disasters such as these earthquakes result from a combination of natural hazards and societal, human vulnerability. The challenge for engineers is how we can adapt for future design and construction.

The actual seismic event was much larger than could have been predicted. Mother Nature is setting the bar just a little bit higher for us. This has a lot of implications for how we think about resilience. The world is changing.

Read the full interview at:
www.eng.cam.ac.uk/earthquakes

Nuclear engineer secures postdoctoral fellowship from the EPSRC

Research Associate Dr Paul Cosgrove has been awarded a three-year EPSRC postdoctoral fellowship to investigate an alternative approach to nuclear reactor multi-physics simulations – a challenging area in nuclear engineering.

Dr Cosgrove, from the Nuclear Energy group, plans to implement and test his new method using unique software developed by the Department of Engineering, called Stochastic Calculator Of the Neutron transport Equation (SCONE). Designed with a focus on modifiability and ease of learning, the software uses the Monte Carlo method and was co-authored by Dr Cosgrove. He has continued to work on it since completing his PhD in 2020.

Monte Carlo methods are used to simulate the lives of many individual neutrons in order to resolve neutron transport – the movement of neutrons through a reactor and where and how they interact with it.

The physical phenomena of heat transfer, fluid mechanics, the mechanical behaviour of fuel, and the evolution of the nuclear reactor over time, are all linked through the physics of neutron transport. As such, nuclear reactors are multi-physical; i.e. the different physical phenomena influence each other significantly and these effects must also be resolved when designing and evaluating reactors. Doing this numerically inevitably means that computational expense is multiplied.

Dr Cosgrove said: "The nature of the research that I'm being funded for is to improve methods for modelling nuclear reactors in high-fidelity – making them faster, more reliable, and better able to handle extra physics all at the same time.

"As nuclear reactors become more optimised, we must treat neutron transport physics with increasing accuracy and couple it with other physics. Unfortunately, this accuracy comes at the cost of significant computational expense, while coupling between physics can often lead to numerical instability. However, I have previously performed some numerical analysis on a method that appears to be both numerically stable and significantly more efficient than the traditional multi-physics approach. During the course of my fellowship, I plan to implement and test this method in SCONE, software that is suited to the exploration of new ideas."

Dr Cosgrove will be joined in the project by industrial partners from EDF Energy, Jacobs, the UK Atomic Energy Authority (UKAEA) and the Atomic Weapons Establishment (AWE).

"I look forward to strengthening my connections with the industrial partners as well as building new connections in industry," he said. "The fellowship will give me more time and freedom to not only expand my research ideas, but also to co-supervise some of the recently-funded PhD students in our research group who also work on numerical methods for the design and simulation of nuclear reactors."

> "
> This fellowship will allow me to improve methods for modelling nuclear reactors in high-fidelity – making them faster, more reliable, and better able to handle extra physics all at the same time.
>
> Dr Paul Cosgrove

github.com/CambridgeNuclear/SCONE
www.cnec.uk

Credit: Initiatives Coeur

ALUMNI UPDATE

Meet yachtswoman Sam Davies

Alumna Sam Davies is a talented and highly experienced skipper. She began her career in competitive sailing at the age of 24 with her first crewed round-the-world trip – the Jules Verne Trophy – in 1998.

Sam came into the limelight with her 2008-09 world circumnavigation in the Vendée Globe race, a non-stop, single-handed-around-the-world-race, where she placed fourth. She is very proud of her contribution to the Initiatives-Cœur team, which allows her to sail the oceans to support Mécénat Chirurgie Cardiaque. This charity enables children with severe heart defects to be operated on in France when it is not possible to get their vital life-saving surgery in their own country.

We sat down with Sam to hear about her sailing career.

I was lucky to grow up on the south coast of England with sailing parents and our weekends and holidays were often spent cruising around the Solent.

When I went to Cambridge I was already doing some racing on the south coast at weekends so I continued with this.

During my final year at Cambridge, Tracy Edwards selected me as part of the crew for the round-the-world record attempt in 1998.

Sadly, we didn't break the world record but I learned so much and it definitely launched me into a career that I never even knew was possible. That was my first round-the-world trip, followed by three Vendée Globe races and then skippering an all-female crew in the 2014-15 Volvo Ocean Race. So that's five attempts at sailing around the world of which I've finished three, which I am very proud of.

I think one of the hardest situations that I have faced at sea was during the last Vendée Globe, in 2020, on the Initiatives-Coeur sailboat, a 60-foot monohull. In the Southern Ocean, just past the Cape of Good Hope, I had a collision with an unknown underwater object. My boat was going at about 20 knots, which is about 54 miles an hour and stopped dead in the collision. I broke my ribs but that's a small part of the the damage. The structure around the keel of my boat was broken.

The Vendée Globe is a non-stop race; if you have to stop, you have to abandon the race because you're not allowed any outside assistance. The damage was significant and I couldn't repair it on my own, even though I had the materials and the skills; my concern was that there might have been further issues with the structure.

So I had to stop in Cape Town, and my team came to help me. We had to lift the boat out of the water and fix all the damage and test the whole boat to check there was no other collateral damage from the collision. Then I went back out and I continued the race, but outside of the official rankings, to be able to finish my second round-the-globe navigation.

When you have an accident like that, you have flashbacks. It was difficult going back out there in the same boat in the same conditions so soon after the crash, imagining it might happen again. I think about 50% of the sailors who start the race don't make it to the finish. I finished fourth in 2008-9, and I dismasted in 2012 and didn't finish. But I knew that the sooner I did it, the easier it would be to get over.

I am thrilled we've got an amazing team aiming for the next Vendée Globe in 2024, with a fantastic new boat. It is a big engineering challenge to finish the build of a new boat. I'm just happy to be able to understand most of what they're talking about!

Read the full interview at:
www.eng.cam.ac.uk/yachtswoman

Disassembly of failed appliances to understand how they are made

A new teaching extension activity for third-year students called Product Disassembly has been launched.

Dr Matteo Seita and Dr Hugh Shercliff have devised a new teaching activity, in which the students are asked to bring in old, failed appliances, which they disassemble to understand how they were made, what the working principles were, what materials were used, and how the item failed.

Speaking about the activity Dr Hugh Shercliff said: “This activity was straightforward to set up, thanks to the technical support in the Dyson Centre for Engineering Design, and the students enjoy the freedom to pursue their own investigations. It was an eye-opener to everyone to see how manual disassembly was impractical for many repairs – and it was often completely infeasible to fully separate metals from polymers for recycling.”

Product disassembly provides a good hands-on opportunity to learn about the choice of materials and processes in product design and manufacture. The students work in pairs to take apart household products, seeking to answer a selection of the following questions:

- What material is each component made of? [from its appearance and measuring density]
- What are the mechanical and other design requirements for each component?
- For strength-limited parts, what is the hardness and microstructure? [using hardness testing, microscopy]
- How were the components shaped? [using appearance, microscopy, and knowledge of manufacturing processes]
- What joining/assembly methods have been used?
- What surface treatments have been applied, and why?
- How feasible is it to separate different materials for recycling at the end of life?

- What is the embedded energy in the materials of the product, and how important is this in the life-cycle energy of the product?

The first cohort to complete the activity have disassembled products such as a paper shredder, video tape recorder and flat screen TV. Ideally, products should contain more than one material class and a sensible number of components, and be energy-using.

Commenting on the activity Dr Matteo Seita said: “One thing that appears very obvious from this activity is that products are not designed for repair/refurbish. It takes the students hours to dissect a household product and identify the broken component, especially if they want to avoid breaking joints so that they could put everything back together. That alone is already a pretty strong deterrent unless you are not a professional technician! On top of that, sometimes the damaged part is a mechanical component that cannot be bought online. Other times, the problem is with the integrated circuit board that is out of production, even though the product is only a few years old. That is how we end up trashing otherwise perfectly fine pieces of engineering, wasting a lot of resources that went into making them. I wonder if the ‘products of the future’ will be more amenable to repair as we navigate a world where the lack of resources is a growing concern.”

Third-year student Lakee Sivaraya said: “The Product Disassembly ExA has been really fun. What engineer does not love taking apart devices, having a look at how it works and seeing the materials behind it? I really liked how open ended the activity was, which allowed us to explore the parts of the product that we were interested in. We were given the ability to use an electron microscope with a mass spectrometer (SEM+EDAX) to analyse some of our materials, which was super cool. The results from the electron microscope showed us that our device (VHS Player) used Polymer Matrix Composites in the stoppers, which is a material you do not see that often. I would suggest this module to people from all divisions (not just materials/mechanics). It was really fun and it does not even feel like I am doing work; I would do this kind of stuff in my own time when I was younger."

To undertake this extension activity, students attended an initial briefing; they then went on to work independently in pairs in the Dyson Centre for Engineering Design, with technician support and staff supervision to guide the choice of investigation and help with technical queries. At the end of the practical sessions, the students gave 10-minute presentations in pairs to the rest of the group and submitted a one-page visual summary poster. The new Product Disassembly teaching extension activity is open to students in all engineering areas.

View the full image slideshow at
flic.kr/s/aHBqjAyzUz

Equipping undergraduates with hands-on experience via interactive lab sessions

New practical experiments in mechanics have been introduced to first and second-year Engineering undergraduates – bringing to life theories of angular momentum, satellite motion, centre of mass, moment of inertia and motion of a double pendulum.

The new experiments – designed to support the content of the Part IA (first year) and Part IB (second year) Mechanics courses – have been refreshed and aim to demonstrate the mechanics theories mentioned in the students' problem sheets.

These include:

Part IA

Observing orbital motion of **a puck on an air table** – conservation of angular momentum and calculating impact between discs of different sizes and rods of different masses.*

Measuring moment of inertia of a selection of objects (steel, brass, aluminium, nylon) by timing oscillations of **a trifilar pendulum** (trifilar means "three strings").

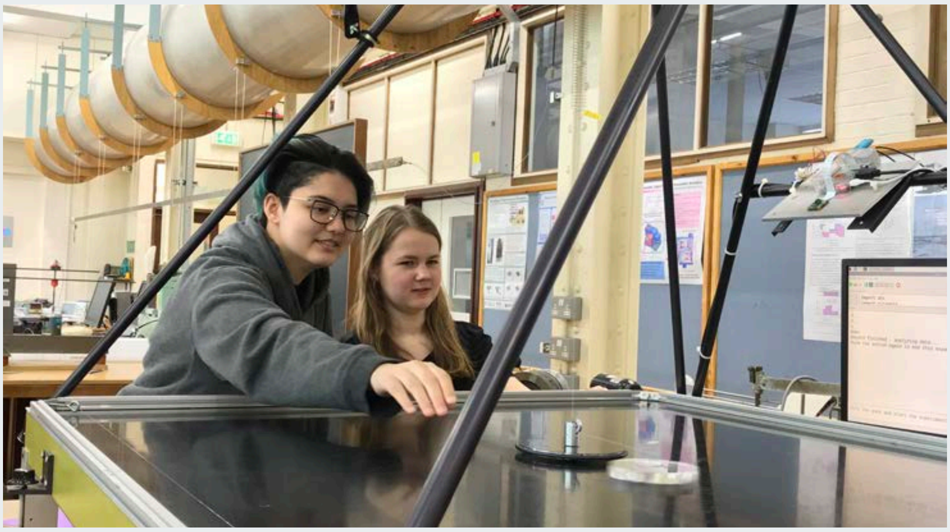
Determining the time of travel for objects (steel sphere, hollow brass cylinder) rolling down **two different inclines** equipped with motion sensors.

Part IB

Understanding the motion of **a double pendulum** – a non-linear system exhibiting chaos for large amplitudes and predictable periodic behaviour for small amplitudes.*

By the end of Lent term 2023, approximately 340 undergraduates in each year had completed the practical experiments.

Student Lonny McKiernan said: "The practical experiments help me understand the coursework I'm doing and help me connect with the teaching material. It's something I can look at and interact with and I can gain a wider understanding of what I'm here for and the potential of Engineering undergraduate study at Cambridge."



Credit: Charlotte Hester

↑ Students during one of the new practical experiments in mechanics. Here they are observing the orbital motion of a puck on an air table

"Working with different experimental apparatuses and witnessing how scenarios in our problem sheets come to life in this lab session is really enjoyable and helpful for our learning," said fellow student Jiecong Tan. "It's also fascinating to see how digital technologies, such as Raspberry Pi, can help with taking accurate real-life measurements of position and velocity."

"I have enjoyed the practical demonstrations," said student Samuel Hinks. "It's hugely satisfactory seeing real data confirm your hypotheses, and interesting to try to diagnose the problems when it doesn't."

He added: "I think that, generally speaking, engineering students are quite practically minded, which is why a focus on practical applications and projects is one of the things that defines and attracts people to an engineering course. I also feel that working collaboratively in this way builds good co-operation between students, and that co-operation will in many cases then carry over into exam preparation and revision."

Hugh Hunt, Professor of Engineering Dynamics and Vibration, said: "I'm really happy to see students enjoying themselves and they all say that the material that they've learned in lectures makes a lot more sense now that they have hands-on experience."

* Both of these experiments make use of a Raspberry Pi (credit card-sized computer) fitted with an infrared camera to monitor motion.

View the full image slideshow at
flic.kr/s/aHBqjAqJGo

Spin-out company Epsimon delivering innovative monitoring solutions for civil infrastructure

Epsimon Ltd. was launched in 2016 by researchers from the Centre for Smart Infrastructure and Construction (CSIC) to provide specialist instrumentation and monitoring (I&M) services for civil infrastructure.

Epsimon's directors are Dr Cedric Kechavarzi, a soil physicist and instrumentation specialist, Dr Nicky de Battista, a civil engineer and expert in structural health monitoring, and Professor Lord Robert Mair, founding head of CSIC, Emeritus Professor of Civil Engineering.

Fibre optic sensing (FOS) techniques

Since it was established in 2011, one of CSIC's key areas of work has been the development of FOS techniques for civil engineering applications. In collaboration with its industry partners, CSIC has deployed FOS systems on a range of assets, from tunnels and piles to bridges and historic buildings, to assess performance and enable better decision-making. Professor Mair said "The UK infrastructure and construction industry had traditionally been conservative and fragmented, operating within very tight profit margins, with no one organisation having responsibility for the whole life of the asset, which makes developing and adopting innovation challenging. It needed to change. Digital change and emerging technologies bring opportunities to acquire better information on the real performance of assets."

Epsimon's challenge is to penetrate this conservative I&M market and bring new capabilities to the way infrastructure assets are managed based on measured performance data. Dr de Battista states that their expertise with FOS technologies and deep understanding of the FOS supply chain allows them to develop reliable monitoring solutions that offer valuable insights into asset performance for engineers, contractors, asset owners, and managers.

Monitoring of concrete piles using distributed fibre optic sensors (DFOS)

One application where Epsimon has translated CSIC's early research into a commercial service is the monitoring of concrete piles using DFOS, which is now a well-established technique included in the guidance document ICE Specification for Piling and Embedded Retaining Walls (SPERWall). By using DFOS, Epsimon can measure a pile's behaviour throughout its entire depth with unprecedented spatial density. With this information, the foundations of an infrastructure can be designed more efficiently, leading to cost savings and a reduction in the carbon footprint of the project. The same DFOS monitoring technique has also been applied to existing piles, to assess their performance and verify design assumptions for pile re-use during and following tunnel clashing.

Monitoring sub-surface ground movements

Monitoring sub-surface ground movements under or adjacent to assets is another area of innovation. One of the latest developments in this field is a fibre optic-instrumented geogrid, known as Sensorgrid, developed with geosynthetics specialists Huesker. Sensorgrid allows good strain transfer required to detect small vertical or axial ground movements due to subsidence or slope failure.

A collaboration between Epsimon, CSIC, HS2, ALIGN JV, Jacobs and Huesker recently deployed 1000 m^2 of Sensorgrid on a section of the HS2 mainline near the Chiltern Tunnels. This aims to provide a real-time system for early detection of potential ground movements in an area with chalk dissolution features. Detecting ground movement early is crucial, especially given the increasing occurrence of landslides and subsidence events, which can cause disruption to services or even result in loss of life. This was highlighted by the Network Rail task force, appointed to review earthworks management after the fatal train derailment in Stonehaven, Scotland, in 2021.

Providing robust monitoring solutions

The construction industry has recently taken on increasingly complex and large projects, such as HS2 in the UK and NEOM in Saudi Arabia. Dr de Battista believes that using novel yet commercially proven monitoring technologies like fibre optic sensing is necessary to provide data and information during construction and operation to asset owners and stakeholders to manage these challenging projects more efficiently.

Read the full article at:
www.eng.cam.ac.uk/epsimon
www.epsimon.com
www-smartinfrastructure.eng.cam.ac.uk

ALUMNI UPDATE

Meet Hannah Schmitz – the F1 race strategist with nerves of steel

Credit: Getty Images / Red Bull Content Pool

In Formula One, every millisecond counts. Just ask alumna Hannah Schmitz, Oracle Red Bull Racing's Principal Strategy Engineer, who alongside a skilled team of analysts makes split-second in-race decisions based on complex and ambiguous data.

Since joining the Formula One racing team as an intern in 2009, Hannah has risen through the ranks to become the race strategist of drivers Max Verstappen and Sergio Pérez. It is a job that requires adaptability and the ability to make quick, race-defining decisions under pressure – skills, some of which, Hannah says she first learned during her Cambridge Master's Degree in Mechanical Engineering.

As one of the architects of Oracle Red Bull Racing's winning strategies, alongside Head of Race Strategy Will Courtenay and a large team of analysts, it is imperative that Hannah keeps a clear head – whether she is on the pit wall, at the circuit or back in the state-of-the-art operations room facility in Milton Keynes.

On race days, Hannah is required to instantly react to live scenarios, and when stationed on the pit wall for example, Hannah must look at the bigger picture of how to win the race. Supporting her in these decisions are the analysts, who are collectively responsible for processing billions of simulations before each race and live at each Grand Prix to enhance team strategy and work out pit stops. The timing of these pit stops (for new tyres etc.) are crucial, and races can be won or lost in these moments.

At the Monaco Grand Prix in May 2022, the team orchestrated a pit stop plan that ultimately led to Pérez taking the chequered flag and Verstappen clinching a podium place. And it was the winning strategy used at Monaco, considered bold and proactive at the time, that prompted the team's advisor and former professional racing driver Dr Helmut Marko to say afterwards: "We were all exceptional, but if we won, it was mainly due to Hannah".

We caught up with Hannah to find out more.

Reacting to live scenarios on a race day is incredibly exciting – you sit on the edge of your seat when you have made that split-second decision. You then have maybe 20 seconds, but in a race environment, sitting there waiting to see if your decision has paid off can feel like a lifetime.

As a race strategist, you have to tell a lot of people what to do and they have got to listen to you. It's all about building up that trust, and I think as a woman unfortunately that was harder to achieve in the beginning, but now I have that respect, and I hope other young women who want to get into the sport will see that they can do it too.

At the Brazilian Grand Prix in 2019, I was asked to step onto the winner's podium alongside Verstappen to collect the Constructors' trophy – this was a special moment and the pinnacle of my career. I had made the call to pit Verstappen for a third time, despite knowing he would initially lose the race lead, but the move resulted in him winning! I had also just come back to work after having my first child, so this was quite a big thing for me, to prove I was still here and could do the job well.

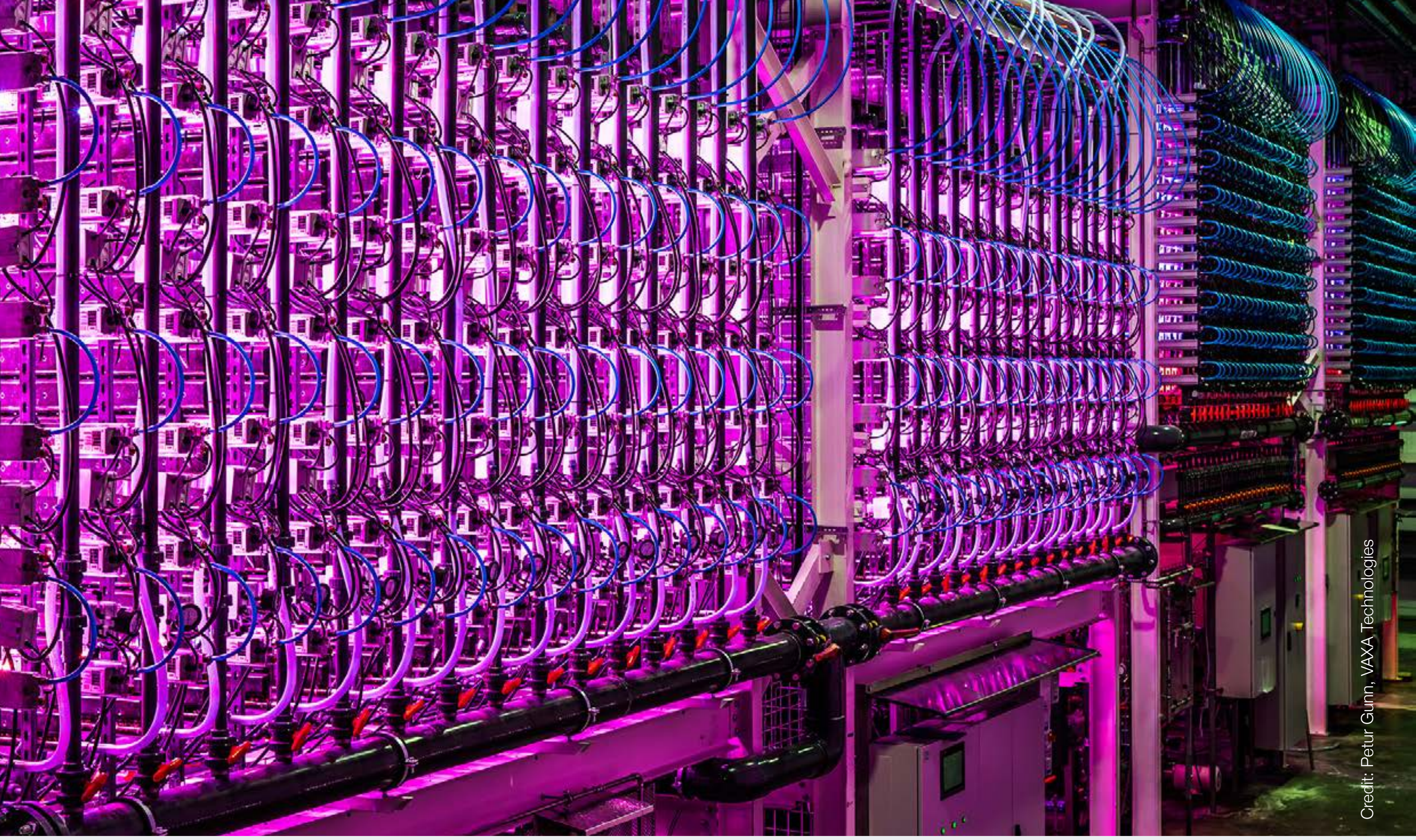
Working in race strategy has given me the opportunity to look at the bigger picture and play a key role in race by race decisions. I have always loved board games and been a good communicator, so strategy has played to those strengths and allowed me to maintain an engineering backbone.

My time at Cambridge prepared me well for life in general, including how to work with others and problem solve in a high pressure environment. I definitely use all the skills I learned during my master's, as well as the maths! Having the more general structure to the engineering degree initially was a great foundation, as in my experience most engineering problems draw on a combination of things.

Being a part of Cambridge University Eco Racing (CUER) was one of the highlights. It taught me so much about working as a team, conflicting priorities and how to resolve them, and working to a timescale, all with real-world obstacles.

My experience at CUER really set me apart when I was applying for my role at Red Bull Racing. There's something about working in a team and supporting and encouraging each other that you don't get sitting at a desk. I also learned some resilience during my time at CUER, which I have found to be an important attribute in the real world!

Read the full interview at:
www.eng.cam.ac.uk/hannah-schmitz


Credit: Petur Gunn, VAXA Technologies

How Iceland could have a starring role as a sustainable alternative protein exporter to Northern Europe

Iceland could help address Northern Europe's food security issues with the scaling-up of its industrial production of Spirulina – an alternative protein source that is nutritious, sustainable and risk resilient. Under the most ambitious of estimations, Iceland could be protein self-sufficient and capable of feeding more than six million Europeans every year, a new feasibility study suggests.

The environmental implications of humans continuing to hinge their diets on animal source foods for protein (including eggs, milk, beef, pork, poultry and fish), together with Europe's dependency on protein-rich crop imports to meet food demand, has pushed the topic of sustainable protein self-sufficiency higher up the political agenda.

Now 'future foods' such as Spirulina – a blue-green algae with multiple health benefits – have been proposed as substitutions for conventional meat, with the potential to reduce environmental impacts, e.g. greenhouse gas (GHG) emissions and freshwater withdrawals, by more than 90%.

It has been reported that Spirulina contains a higher content of protein (up to 70% per 100g) than meat from beef cattle (up to 30% per 100g lean meat), with the average European consuming nearly 80kg of beef meat per year. While Spirulina is currently less affordable than beef, it is anticipated that once it similarly becomes produced at mass-scale the price would become more affordable.

In Iceland, Spirulina is already produced successfully in a novel, industrial-scale, biomass cultivation system powered by renewable energy. Currently in operation is the Hellisheidi Production Unit, operated by Vaxa Iceland and situated in the Hellisheiði geothermal power plant. The production process is carbon neutral.

For the purpose of the feasibility study, Dr Asaf Tzachor and Dr Catherine Richards, from the Centre for the Study of Existential Risk (CSER) at the University of Cambridge, in collaboration with researchers from Denmark and Iceland, explored Iceland's role in supporting Northern European countries to achieve protein self-sufficiency. Data from the Hellisheidi Production Unit is used as a benchmark for the researchers' protein self-sufficiency feasibility model. The model is used to assess scenarios of further scale-up of Iceland's Spirulina production capacity and export of the edible biomass. Their findings are reported in the journal *Foods*.

Using six Spirulina production scale-up scenarios, the researchers assess possible production expansion based on the use of currently installed and potentially installed renewable energy capacity[1]. The model consists of two main components: protein supply (including real-world Spirulina production data) and protein demand (accounting for adult daily protein intake requirements as well as the suitability of Spirulina biomass to satisfy these requirements). According to the researchers, to ensure sufficient intake of all essential amino acids, men would need to consume 39.34kg of Spirulina biomass (in dry weight), and women would need to consume 33.72kg of Spirulina biomass, each year.

Under the first production scale-up scenario, assuming a conservative scale-up, Iceland could be protein self-sufficient with 20,925 tonnes of Spirulina produced

← An enclosed and modular photobioreactor used to produce Spirulina

Credit: Mara Zemgaliete – stock.adobe.com

per year using 15% of currently installed electricity generation capacity. This is enough to meet the protein and dietary requirements of 572,867 individuals.

In the sixth scenario, billed the "ultimate scale-up", Iceland could be self-sufficient and – in a greater allocation of energy capacity used by heavy industry – the country could additionally meet the needs of Lithuania and Latvia, or Lithuania and Estonia, plus Jersey, Isle of Man, Guernsey, and the Faroe Islands. Under this most ambitious scenario using planned energy projects, Iceland could support itself plus Denmark (population of 6,104,474 in 2030), or Finland, or Norway, or Ireland with up to 242,366 tonnes of Spirulina biomass per year, satisfying 6,635,052 people.

"Europe's reliance on third parties for the importation of protein-rich crop imports to meet domestic food demand, exposes such countries to protein supply change disruptions," said Dr Asaf Tzachor. "This renders European food security vulnerable, a situation that is only further exacerbated by the impacts of climate change on our global agricultural systems. This is why sustainable protein self-reliance is such a hot topic at the moment, with Spirulina identified as one such 'future food' recognised as a superb provider of complete protein with nutritional benefits including antioxidant and anti-inflammatory effects."

Although not the main focus of their feasibility study, the researchers also note the ancillary environmental benefits of Spirulina production, namely GHG emissions reduction. It is anticipated that if global GHG emissions reduction took precedence over Northern Europe's protein self-sufficiency, and instead Spirulina biomass was adopted in Western diets as a beef meat protein alternative (in the form of pills or pressed powder), the average consumer may maintain a balanced diet while decreasing GHG emissions associated with beef cattle agriculture and meat processing.

"On a protein-per-protein basis, for each kilogram of Spirulina (dry weight) consumed instead of meat from beef cattle, 315kg CO_2 equivalent (CO_2-eq) could be reduced," said Dr Catherine Richards, who completed her PhD at the Department of Engineering. "As a climate change mitigation option, and under the most ambitious scenario, this intervention alone may yield annual savings of 75.1 million tonnes CO_2-eq or 7.3% of quarterly European greenhouse gas emissions."

While the scaling-up scenarios considered in the feasibility study assume idealised production conditions, the researchers do acknowledge that the success of these are dependent on the allocation of adequate electricity. Additionally, there are financial considerations to factor in with regards to the ramping-up of Iceland's Spirulina production, as well as wider awareness-raising work needed to communicate to the public the benefits of Spirulina consumption.

"Ultimately, there is a real opportunity here for Iceland to advance its biotechnology industry," said Dr Richards. "By relocating electricity currently consumed by heavy industry, Iceland could transition to a position as a major and sustainable alternative protein exporter."

↑ Spirulina in pressed powder form

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[1] More than 99% of total electricity in Iceland is generated from low-carbon, renewable and non-intermittent hydropower and geothermal resources.

Ehsan Shafiei et al. *Potential impact of transition to a low-carbon transport system in Iceland*. Energy Policy (2014).

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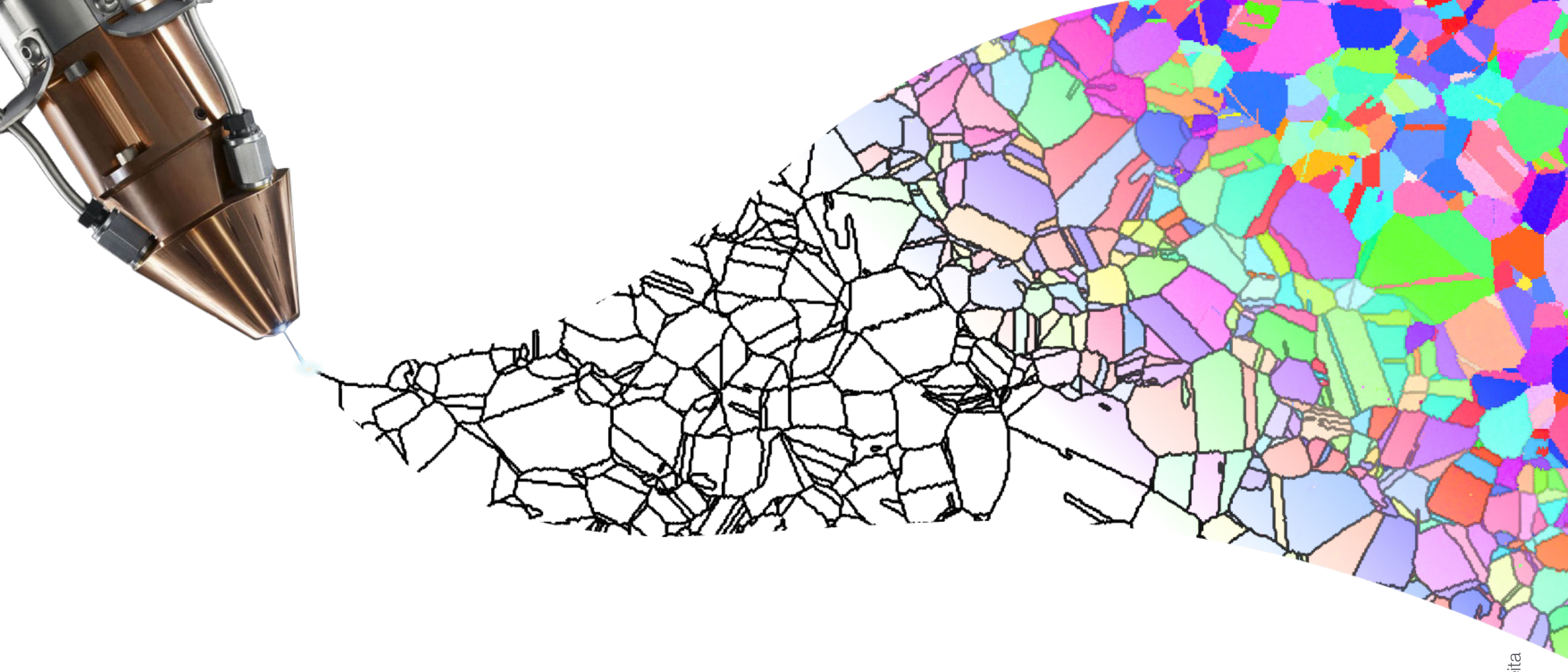


↑ Artistic view of "microstructure control during metal 3D printing"

Credit: Dr Matteo Seita

Sustainable manufacturing of metals using 3D printing technology

Dr Matteo Seita, Granta Design Assistant Professor, has won the The Minerals, Metals & Materials Society (TMS) 2023 Young Innovator in the Materials Science of Additive Manufacturing Award.

He explains how 3D printing technology can be used to enable a more sustainable manufacturing of metals.

My research focuses on metal 3D printing. The reason why 3D printing technology has gained so much attention in recent years is that it enables the production of parts with improved performance by optimising their geometry. For instance, metal components can be designed with an open lattice architecture (something that resembles the Eiffel Tower) to be both strong and lightweight. This is possible because 3D printed builds are made from the bottom up, by stacking slices of material on top of one another. Conceptually speaking, it is like assembling LEGO bricks into a 3D architecture. No other manufacturing process provides the same freedom to design and produce bulk metal parts with arbitrary shape.

What excites me the most about 3D printing, however, is not the possibility of optimising the geometry of metallic components. My interest lies within the opportunity to control their internal microscopic structure. I use 3D printing technology to design and produce new metallic materials with enhanced performance by "architecting" their microstructure. If we imagine the material's microstructure as the colour of LEGO bricks, my goal is to figure out how to create bricks with different colours and how to assemble them together in configurations that yield improved mechanical and physical properties.

The idea of mixing different microstructures to make materials with superior properties is not new. Blacksmiths have been doing that for thousands of years using complex thermal and mechanical processes to forge microstructure mixtures that impart metal alloys with high strength and toughness. The extraordinary performance of katana swords is an example of this materials design strategy, which yields a steel blade that is both hard and durable.

Applying the same principles to 3D printing technology is very challenging (if not impossible) using traditional blacksmithing strategies, since they are not compatible with this "brick-by-brick" manufacturing process. Thus, my research is concerned with devising novel 3D printing processes to gain control over the microstructure of metals directly during 3D printing.

My vision is that this approach will be the foundation of a more sustainable metal manufacturing paradigm. Parts made with improved materials and optimised geometry would easily last longer and have even higher strength over weight ratio compared to the current 3D printed designs. Longer lifetime equals less replacement of parts and thus less waste of materials and energy. Moreover, improving the specific strength of materials implies being able to achieve the same load-bearing capabilities using less materials and thus less mass. Light yet strong metals are very important for transportation, where lightweight translates directly into less fuel consumption and thus a lower carbon footprint.

Speaking about the award, Matteo says; "It is a great honour for me to receive this award from TMS. I consider TMS as the place where my aspirations to work on Additive Manufacturing (AM) 'crystallised' back in 2015. That meeting, I believe, was the first one that included an entire symposium dedicated to AM, which I attended wholly. I remember listening to inspiring talks and running my ideas by the people who were at the top of the field. One year later, I found myself starting my own research group to work on those very same ideas. As it has been for me, I am sure that TMS will be the place where future generations of materials scientists gather to get inspired, discuss ideas, and bring innovation to this exciting and ever-growing field."

addme.eng.cam.ac.uk

OPINION

Changing how we talk – and think – about manufacturing

The ability to make things is the bedrock of strong economies and societies. However, in the UK, manufacturing is too often seen as 'something we don't really do much of anymore' or 'a problem to be fixed'.

Do such misperceptions matter?

Yes, because if we cannot explain the true importance of manufacturing, it will drift down policymakers' agendas, it will fail to attract the most skilled people, and we won't get the balanced and robust economies and communities we all want.

It's time for a change in how we think and talk about manufacturing.

In the UK, we are rightly proud of our central role in the first Industrial Revolution. And manufacturing today plays a major role in our economy. It provides over 2.5 million jobs, almost half of our exports, and around two-thirds of all UK R&D business expenditure. The UK is a top 10 global manufacturing nation.

But manufacturing is often simply discussed in terms of its share of GDP — which is about 10% in the UK — and how it is declining in relation to other parts of our economy. This substantially misses manufacturing's real contribution to our lives. As a result, the role of manufacturing is often undervalued. Is this a problem? Yes, because a poor understanding of manufacturing's real importance to our economy weakens the case for the investment needed for manufacturing firms to flourish.

But there is a way we can ensure this doesn't happen.

In 2019, a report published by the Department of Engineering's Institute for Manufacturing offered a new perspective. The report showed that the contribution of manufacturing was much more significant than conventional and simplistic measurements such as GDP seem to show. Why? Because economic value of manufactured goods increasingly depends on activities — such as R&D, design and testing services — that are officially categorised as belonging to other sectors of the economy.

Not only are we measuring it incorrectly, but manufacturing is also changing. Digital technologies, new production processes, complex business models that combine products and services and international supply chains in a constant state of flux, are combining to transform the manufacturing world.

But to allow manufacturing firms to cope with these changes, three things need to happen.

Firstly, even greater strides are needed to incrementally reduce the harmful impact of how we make and move things. And it is great to see the scale of efforts that is going into the designing, making and scaling-up of products that, by their very nature, reduce environmental impact — from zero emission vehicles to renewable energy systems.

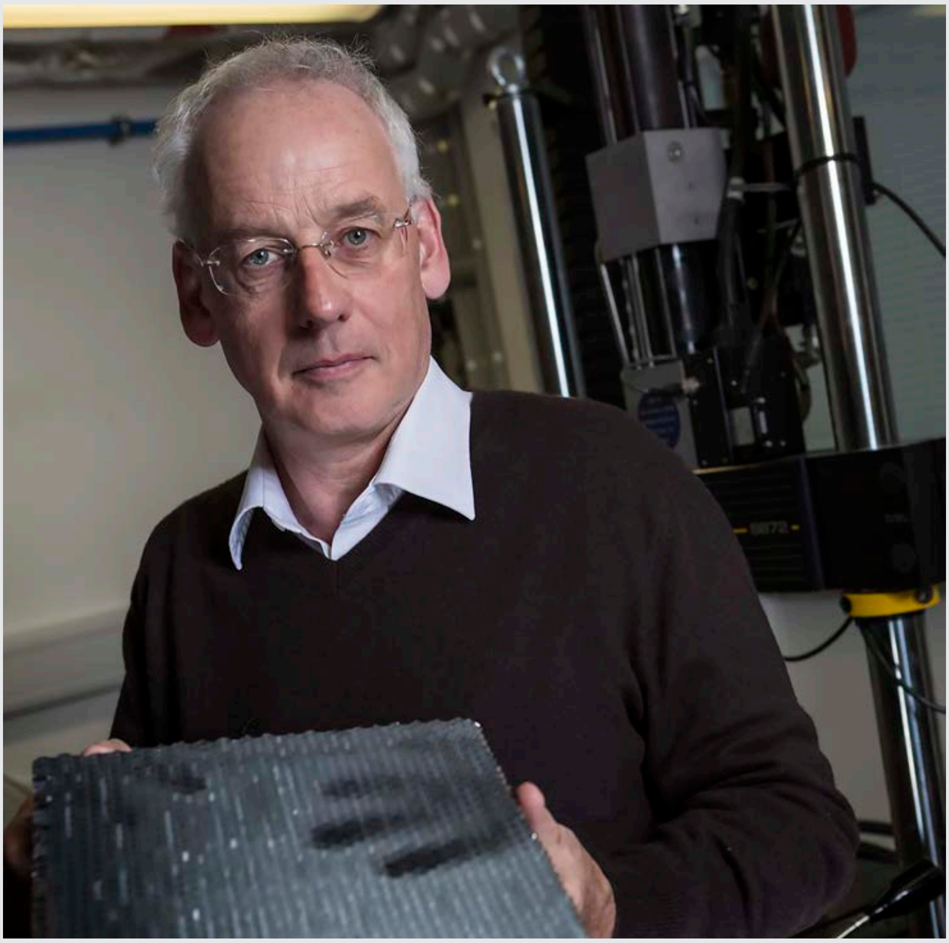
Pandemics, natural disasters, wars, even a single error on one ship navigating the Suez Canal have shown how easily disrupted our industrial systems are. Our current approaches are just too fragile, and must be re-designed. There are also longer-term, 'slow burn' changes to which we need to respond — think of the impact of automation and digitalisation on so many aspects of manufacturing, and the shift to low emission technologies for all land, air and sea transport.

Finally, we cannot forget that people are at the heart of manufacturing. Digitalisation and automation will change the types of jobs required to make the things we need, but manufacturing will continue to offer well-paid, high-skilled jobs. New technologies are of zero value if we do not have people with the right skills in the right place at the right time needed to generate and scale-up new concepts. This will only work if we take an integrated view of skills development, combining the academic with the vocational, spanning full-time education and through-life learning.

Manufacturing plays a vital role in achieving the high-level goals we all want: economies that are less damaging to the planet but that still give us the quality of life we want, more capable of responding to shocks and change, and better able to provide fulfilling and rewarding opportunities for all.

We need to spread the word that #manufacturingmatters.

Read the full article at:
www.eng.cam.ac.uk/manufacturing


Credit: Stills Photography

Professor Norman Fleck receives The William Prager Medal

Professor Norman Fleck has been awarded The William Prager Medal 2023 by the Society of Engineering Science (SES).

The Medal is in recognition of his outstanding contributions – combining theoretical and experimental research in micro-architected materials, composites, ferroelectrics, and strain gradient plasticity – which have significant engineering implications in aeroengines, defence and shipbuilding.

The William Prager Medal is awarded annually to an individual who has made exceptional research contributions to theoretical or experimental solid mechanics, or both.

Norman is renowned as the world's leading authority in micro-architected materials, having pioneered the field long before it became popular. His work involves fabricating, testing, and computing material properties, which pushes the boundaries of the field and defines its frontier. In addition to this, he has also made pioneering and sustained contributions to other areas of research, including strain gradient plasticity, metallic foams, and composites.

After obtaining his PhD from Cambridge in 1984 on the topic of metal fatigue, Norman spent a postdoctoral year at Harvard University working with Professor John W. Hutchinson on creep fracture. He returned to Cambridge in 1986 as a lecturer and was later promoted to a Readership and then to a Professorship. He is the Founder-Director of the Cambridge Centre for Micromechanics and served as Head of the Mechanics, Materials, and Design Division for 11 years until 2009.

Norman's research focuses on the mechanical behaviour of solids under different microscopic conditions. His work on novel materials and their applications in various industries, including aerospace, automotive, and construction, has yielded ground-breaking results. For instance, his research on the failure of fiber-reinforced composites, which combine waste cellulose fibres and polymer resin, has yielded important insights.

Norman is also recognised for his studies on metal foams, which have potential applications as impact absorbers in cars, and on stiff but lightweight lattice materials that can be used in aircraft. His research combines theoretical understanding with a passion for experimentation and application, and he has received numerous accolades for his contributions, including the Warner T. Koiter Medal and an honorary doctorate from Eindhoven University of Technology.

Norman is a highly cited author with over 280 journal publications. He is a Fellow of The Royal Society and the Royal Academy of Engineering. He is also an International Member of the National Academy of Engineering (NAE) in the USA; the Academia Europaea and the European Academy of Science. He serves on the editorial boards of several engineering journals and has collaborated closely with many US and European groups, having held visiting positions at Harvard University and NASA Langley. Norman's work combines experiments and theory to develop mesoscale and macroscale constitutive models of engineering materials.

www.ccm.eng.cam.ac.uk

Award-winning business calculating the carbon footprint of food

What started as a lockdown project by two Cambridge alumni has grown into an award-winning business called 'My Emissions', which has since expanded far more than either of them could have expected.

My Emissions now works with 70 food companies to calculate, reduce and carbon label their food, has completed two investment rounds, been featured in the FoodTech 500 and Sifted's Start-Ups to Watch, and in 2022 won a Young Innovator's Award from Innovate UK, the Government's national innovation agency. *Nathan Bottomley and Matthew Isaacs take us on their journey of discovery.*

"In October 2015, we both started our studies at Girton; Matt studied Law and Nathan, Engineering. We graduated with excitement about what was to come next. At the start of the 2020 lockdown, we decided to research how we could reduce our own carbon footprint. Very quickly we realised that food is one of the largest sources of global greenhouse gas emissions (at least 25%) and offers one of the best and easiest ways to reduce our impact on the planet. Our initial research showed us that data on individual foods existed, but that it wasn't being made accessible to consumers.

"We set to work researching the carbon footprint of different foods and building a comprehensive food emissions calculator.

"Our first project was chosen based on what we wanted to see: a simple food emissions calculator that broke down the emissions by food item, as opposed to the 'overall diet' emissions calculators that were already available. Matt focused on finding existing 'life cycle assessments' for our database, whilst Nathan focused on developing our website and calculator.

"We finished this project in three months and published our calculator for the world to see. The calculator remains live on our website and has now received almost half a million uses. Crucially, it showed us there was an interest in food emissions, and provided the foundation for the model we use today to offer carbon assessments in a more scalable way.

"My Emissions helps companies understand, reduce and carbon-label their food. We believe clear climate data is the best way to inspire sustainable choices and reduce our impact from food. 67% of consumers are more likely to purchase from brands reducing their carbon footprint. My Emissions follows a data-driven life cycle assessment approach to efficiently calculate the carbon footprint of a product or meal. We collect information about each food product and meal and rely on a mix of primary data from clients and secondary data from research to complete our calculations. All of our secondary data comes from 'life cycle assessments' published in peer-reviewed journals, and we are constantly adding new values as more research is completed. Every carbon label from My Emissions uses the same system boundary, which covers emissions from farming up to when the food reaches a store, restaurant, or home. This system boundary covers the majority of a food's emissions, allowing you to make an informed choice, and is standardised so different labels can be compared. My Emissions also offers full cradle-to-grave analysis, which covers the entire lifecycle of each product/meal. My Emissions recommends this analysis if you want a full picture of a product's impact and/or want to go carbon neutral.

"The My Emissions carbon label rates a product or meal from A (Very Low) to E (Very High) based on the 'per kg' carbon footprint of the food. The thresholds are based on a statistical analysis of all the 3000+ foods in the My Emissions database and were audited by external consultants W2R Solutions. We believe the thresholds for a carbon label should be set by the Government (just like nutritional thresholds) and are actively engaging with regulators about this.

"As we gained more traction, we quickly realised the scale of the challenge in front of us and knew that we couldn't tackle it on our own. With the help of some friends, The Prince's Trust and an Accelerator run by NatWest Bank we developed a business plan and started to think about external investment. The turning point for us was a hectic 'sprint week' in early 2021. We'd been introduced to an 'angel investor' with lots of experience investing in early-stage companies, with whom we had weekly calls.

"He became our first investor and the following months were occupied with emailing, pitching, and finding our remaining investors. A larger funding round was subsequently completed in May 2022. The funding rounds gave us the opportunity to work full-time on developing My Emissions, but importantly we also gained a group of people who buy into our mission and have supported and advised along the way."

Read the full interview at:
www.eng.cam.ac.uk/myemissions
myemissions.green

ALUMNI UPDATE

Meet Professor Dame Sarah Springman

Alumna Professor Dame Sarah Springman is an accomplished academic geotechnical engineer and a pioneer in the study of soft soil mechanics, ground improvement and mass movement of slopes, renowned for her research, teaching and academic leadership. She is also an acclaimed international triathlete and sports administrator and has won the British and European Triathlon Championships several times. As Vice-President of the International Triathlon Union, Professor Springman played a central role in making the sport an Olympic and Paralympic discipline.

How did your career develop?

After three degrees at Cambridge (Girton, Catz, Magdalene) and engineering overseas in Australia (designing diaphragm walls for water cooling culverts), Fiji (building 85m high Monasavu Dam to provide over 90% of the island's electricity demand at that time, and still nearly 50% today) and in Reading (Head Office), I left the world of consulting engineering to study for an MPhil and PhD in Soil Mechanics. Obtaining a Junior Research Fellowship at Magdalene was the key to an academic career, followed in short order by a university assistant lectureship, gaining tenure 6 years later as I was moving to a chair at ETH Zurich, as I turned 40.

What contribution to your field are you most proud of and why?

It's difficult to choose so here are a few: Working with some amazing students, both in Cambridge and at ETH Zurich, as undergraduates and doctoral researchers, and learning from them and helping to start them off in their careers.

Having been able to advance the application of centrifuge modelling to understand mechanisms in soil structure interactions and for some geotechnical aspects of natural hazards, initially at the (Andrew) Schofield Centrifuge Centre and later founding the ETH Zurich Geotechnical Centrifuge Centre, and contributing to expert international technical committees.

Unpicking the different contributions to what causes lateral deformation of a bridge abutment when building an embankment on soft clay. Thereafter, recommending a design method and applying a similar approach to other types of soil-structure-interaction. And then, it was applied to the design of the approach embankments to the Prince of Wales (second Severn) bridge.

Exploring constitutive response of postglacial lacustrine clays in Switzerland through site investigation, in situ testing and state of the art laboratory testing, in order to improve prediction of deformations and the potential for failure.

Carrying out multidisciplinary field tests in Switzerland to investigate mechanisms of mass movement and erosion associated with rainfall-induced landslides, river dyke stability and overflow, rock avalanches and the degradation of permafrost. After analysis, advanced lab testing and sometimes modelling numerically, or physically at enhanced gravity in a centrifuge, producing practical engineering advice to local communities affected.

The Department of Engineering Centre for Languages and Inter-Communication impact

Founding the Language Programme for Engineers at Cambridge (1990-1993) with Anny King and Edith Esch of the Cambridge University Language Centre was a career-defining moment for me.

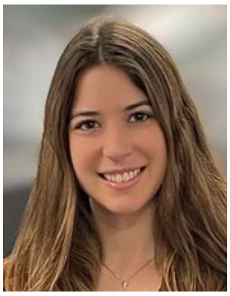
The Department's Centre for Languages and Inter-Communication (CLIC) has just celebrated its 30th anniversary. It may be relevant to record how it started: I had the idea to include languages in the new BA/MEng degrees while cycling in the summer of 1990 in Switzerland and Germany. Dame Ann Dowling was a supporter of the idea and obtained almost instant support from Lord Alec Broers who was then the Head of Department and who told me to 'get it done' in the equivalent parlance of the day.

The University Language Centre, in the form of Edith Esch and Anny King, designed the CLIC according to good practice at the time and helped the Department obtain money from the French government and the German Academic Exchange Service (DAAD) for the first two lectors. Alec Broers approved the new Language Lab to be created on a new mezzanine floor and members of the Department worked with the University development office to raise the money to pay for it. It is so exciting to witness the growth and success over 30 years since then. Well done to the Department!

The Department's language lab had a huge impact on my career – I went to ETH after 2 x 8 week courses in beginner's German and eventually was elected as Rector – the second woman and the first-ever Rector since foundation in 1855 who did not have German as either a mother tongue nor been educated in German. Thank you!

Read the full interview at:
www.eng.cam.ac.uk/sarah-springman

Honours, awards and prizes



Rising Talent Fellow

Postdoctoral researcher Dr Amparo Güemes González has been announced as a recipient of the 2023 Rising Talent Awards by the L'Oréal-UNESCO For Women In Science programme.

Dr Güemes González is an 1851 Research Fellow at the Department's Bioelectronics Laboratory. Her current interdisciplinary research aims to develop advanced algorithms and neurotechnology to be integrated into a closed-loop platform to help improve glucose control for people with type 1 diabetes.

Dr Güemes González plans to use her £15,000 grant award to pursue research collaborations with other labs in Europe, where she will learn novel techniques and expertise to develop her closed-loop system that mimics the natural physiology of the body.

Helios Prize winner

The winner of the Department's Helios Prize – awarded for graduate research in sustainable energy or energy efficiency – is PhD student Antoine Koen.

Antoine, from the Energy, Fluids and Turbomachinery division, accepted a cash prize and a brass medal depicting the Greek sun god Helios for his paper titled *A low-temperature glide cycle for pumped thermal energy storage*.

The Helios Prize is made possible thanks to a generous donation from Cambridge alumnus John Firth.

Mid-Career Researcher Award

Professor George Malliaras' pioneering work in the development of organic electronic materials as novel tools for interfacing with the brain has been recognised with the 2023 Mid-Career Researcher Award.

The Award, presented by the Materials Research Society, is in honour of Professor Malliaras' exceptional achievements and leadership in the field, including the successful application of organic electronic materials in biology and medicine. Professor Malliaras is Director of the EPSRC Interdisciplinary Research Collaboration (IRC) in Targeted Delivery for Hard-to-Treat Cancers and Prince Philip Professor of Technology.

Fellowship in Fluid Dynamics

PhD student Alexandros Kontogiannis has been awarded a National Fellowship in Fluid Dynamics to extend the capabilities of magnetic resonance imaging (MRI) scanners. He will do this by generating high-resolution imaging of blood flow using Digital Twin methods developed during his PhD.

Alexandros is one of 11 new postdoctoral research fellows funded by the Engineering and Physical Sciences Research Council (EPSRC) with an investment of £3.7 million. The fellows will work together to solve common research problems in fluid dynamics and drive industrial and academic collaboration across the UK.

Pilkington Prize winner

Nathan Crilly, Professor of Design, has been awarded one of the University's Pilkington Prizes for excellence in teaching.

The citation reads: "Nathan is an outstanding teacher of engineering design, creativity and problem-solving. He uses his research expertise to develop courses both for undergraduate students and for those undertaking professional training. These courses teach the key skills required for identifying and solving problems, and also for communicating those solutions to others".

Double award winner

Dr Brian Sheil, Laing O'Rourke Associate Professor in Construction Engineering, has won two awards: The Crampton Prize and the Europe Bright Spark Lecture Award.

The Institution of Civil Engineers' prestigious Crampton Prize is in honour of Dr Sheil's paper titled *Monitoring the construction of a large-diameter caisson in sand*, which was co-authored with industry partner Ward & Burke. The International Society for Soil Mechanics and Geotechnical Engineering's Europe Bright Spark Lecture Award was presented to Dr Sheil recently at a symposium, where he delivered a lecture about machine learning for underground construction.

Meet the Guinness World Record-holding juggling engineer

Credit: James Cozens

When first-year Cambridge PhD student James Cozens took up juggling seven years ago, little did he know he would go on to become a Guinness World Record (GWR) holder. He currently holds the GWR for 'the most objects juggled while riding a unicycle' – a total of seven balls for a period of 16.77 seconds (achieved on 7 May 2023).

While competitive juggling is a rapidly emerging sport with thousands of athletes worldwide, for James there has been one thing missing: a lack of tracking software for performance analysis. So, he set out to find a solution.

Similar to rhythmic gymnastics, juggling competitions, such as those within the World Juggling Federation (WJF), involve the performance of a routine (often with seven or more balls) that is then ranked by difficulty and execution. The routines are typically formulated from a notation system called 'Siteswap'. Siteswaps are sequences of numbers that represent the relative durations of throws in a juggling pattern.

James, who is studying for a PhD in Statistical Signal Processing and Machine Learning, has been developing software that provides insight into jugglers' technique through tracking, visualisation and simulation of Siteswap routines – similar to the performance analysis tools employed in sports such as golf and tennis.

James said: "I first noticed the lack of training software available for athletes during my attendance at the juggling conventions. Despite almost all ball sports having some form of tracking software for analysis, none existed for this sport. So, I set out to develop a prototype for this software. Its development began as a personal research project, before becoming a dissertation module as part of my fourth-year while studying for my Master of Engineering (MEng) in Information and Computer Engineering under the supervision of Professor Hugh Hunt."

The module, which focused on the inference of the relative difficulty of Siteswap routines, was also supervised by one of the founders of the Siteswap system, Colin Wright. The tracking and visualisation software meanwhile, originally developed as part of James's personal ongoing research project, has now been integrated into James's PhD work, which also includes research into Generative Music (AI) under the supervision of Professor Simon Godsill.

The prototype tracking software was first tested at the 2022 European Juggling Convention, with numerous world-renowned jugglers contributing to the testing of James's software. James has since followed up with the first official prototype application of the software, based on feedback from the Convention. He is also planning on competing in the WJF's 2023 Champions for Team GB, as well as trialling the tracking software live in competition.

The software aims to provide athletes with a method for analysing their technique and suggests potential solutions and training routines to improve technical efficiency. This is in addition to providing a system for recognising Siteswap routines in real time for adjudicators as an aid for evaluating performances during competitions.

"This is increasingly important, given that those in the juggling industry are hopeful that the sport can make its Olympic debut in the next couple of decades," said James.

"The reason why limited software currently exists for generalised juggling tracking is due to the complexity and variability of conditions. Object segmentation and assignment are especially difficult, given the unpredictable nature of juggling trajectories in a competitive environment (with accelerations approaching 120 m/s^2) and the variety of props and background conditions.

"Ultimately, my hope is that the software will be used as a valuable training and visualisation tool for beginner and advanced jugglers alike, and a source of inspiration for the next generation of aspiring jugglers."

James, who organises welfare juggling workshops at the University, is also a composer and pianist, and recently had the unique opportunity to compose a juggling concerto, featuring a solo juggler as the central performer, and accompanied by a symphonic orchestra.

Watch juggling James in action:
youtu.be/gdkJqSh99YE

UNIVERSITY OF CAMBRIDGE

Department of Engineering
University of Cambridge
Trumpington Street
Cambridge CB2 1PZ

Telephone: +44 (0)1223 748228
Email: marketing@eng.cam.ac.uk
www.eng.cam.ac.uk