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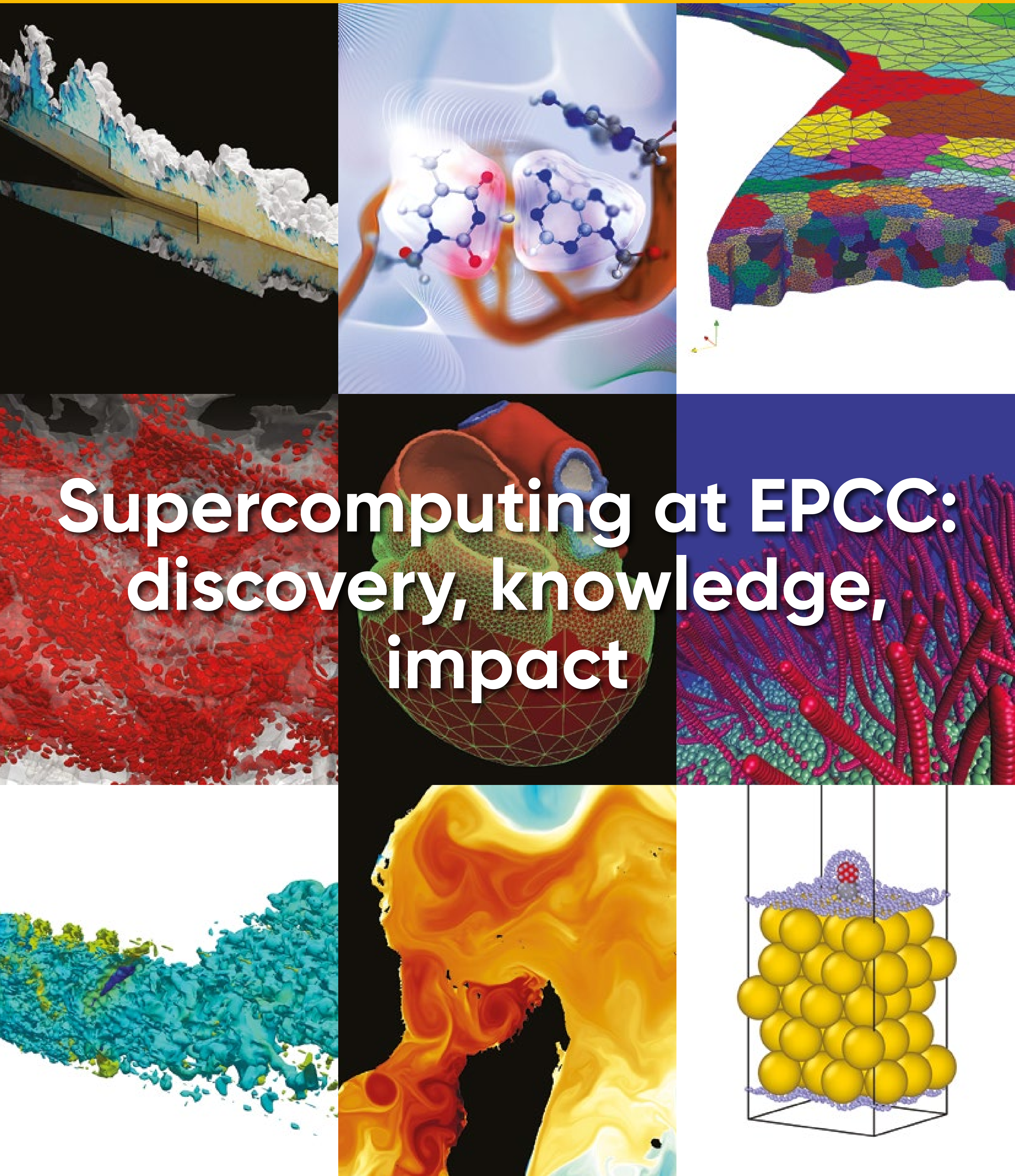
epcc news

The newsletter of EPCC, the supercomputing centre at the University of Edinburgh

Supercomputing at EPCC: discovery, knowledge, impact



From our Director

Welcome to the Autumn 2024 issue of EPCC News.

We had hoped to focus this edition of EPCC News on the start of the preparations at EPCC and the ACF for the UK Exascale service. As I write this introduction in early September 2024, the project has been “shelved” by the UK Government while a review and development of an “AI Opportunities Action Plan” led by Matt Clifford CBE is developed. One of the challenges of paper documents is that they can’t be updated as events move forward. But they also provide a snapshot in time which accurately records what was happening at that time. Events may have moved on considerably by the time you read this.

The case for investment in an Exascale capability for the UK remains compelling – as does the case for much greater AI capability in all its forms. While AI has captured everyone’s imagination over the past 18 months, it doesn’t replace the need for national supercomputers that can do the largest calculations – calculations that are much larger than the training of current AI models require. AI is already supporting many areas of numerical computing – helping to get answers more quickly and more accurately. But rarely is it replacing the need for simulations based on our scientific knowledge entirely – in its current form it cannot do that.

This summer’s announcements have not damped EPCC’s appetite for preparations for the Exascale service. In this edition of EPCC News you will find many examples of how we’re preparing for large-scale GPU-accelerated computing. Hopefully by the Spring edition I will have better news to report. Despite the current setback, I hope you enjoy this edition. I remain optimistic that the UK’s next national supercomputer will provide an Exascale capability for researchers from across academia and industry.

Professor Mark Parsons
EPCC Director
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EPCC at SC24

We will be busy across the entire conference programme. Find us at Booth 1101 in Hall B, where you can enter our scavenger hunt by trying the demo on Wee Archie, our mini supercomputer!

See our website for details of all our activities:
https://www.epcc.ed.ac.uk/whats-happening/events/sc24

Contents

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EPCC is a supercomputing centre based at The University of Edinburgh, which is a charitable body registered in Scotland with registration number SC005336.

Our cover shows images produced by users of the ARCHER2 national supercomputing service, which is operated by EPCC. Left to right from top:
E. Breard, University of Edinburgh; M. Winokan, University of Surrey; Wheel (University of St Andrews) et al.; Q. Zhou (University of Edinburgh) et al.; Strocchi and Rodero, CEMRG group, Imperial College London; X. Jiang, University College London; G. Vivarelli & M. Lahooti, Imperial College London & Newcastle University; N. Vogt-Vincent, University of Oxford; Logsdail (Cardiff University) et al.

WHPC: setting a new benchmark for early-career support in HPC

We are proud to be hosting our 20th International Women in HPC workshop at SC24 in Atlanta, Georgia, USA!

WHPC
WOMEN IN HIGH PERFORMANCE COMPUTING

Eleanor Broadway, EPCC
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At Women in High Performance Computing (WHPC), our mission is to raise awareness and address issues around diversity and inclusion within the HPC community and workforce. Lack of diversity in the workforce is a challenge faced by the entire supercomputing industry. Research shows that diverse teams have greater productivity, idea generation, problem-solving and scientific output, so addressing this challenge should be as important to the community as all others.

We use the annual WHPC workshop at SC to discuss these issues with the international high performance computing (HPC) community and to highlight the importance of diversity, equity, and inclusion (DEI) efforts. Our workshop series has become the leading DEI-focused event at SC and an important platform for driving positive change in the HPC landscape.

Opportunities to speak at prestigious international conferences can be difficult to obtain, especially for researchers at the start of their careers. Such opportunities can often be inaccessible or feel intimidating or unwelcoming due to assumptions about required experience or reputation. As a community, we lack inclusive and welcoming experiences.

Our SC24 workshop focuses on contributions from early-career or under-represented individuals, providing the chance to present at an international conference in a welcoming and inclusive environment, forge valuable networks, and attend SC with confidence.

Leading up to the event, each of our speakers is paired with an expert mentor who offers guidance on finalising their abstracts, designing a lightning talk and making the most of the conference. The final selected submissions are published in a small proceeding to formally recognise our speakers' contributions. We also sponsor two WHPC Travel Fellows to ensure our opportunities are accessible to everyone.

As the Submissions and Fellowship Chair for WHPC@SC24, my role is to organise the submission process and the selection of the Fellowship Awards, and to support all our speakers before the event. Having also served in this role for SC23 and ISC24, I have seen first-hand the impact of this level of support. All WHPC events consistently receive high-quality submissions, resulting in outstanding and confident presentations that are shining representations of the new talent in our community.

Come and join WHPC at our global events to be the change you want to see!

SC24
Atlanta, GA | hpc creates.

Find us at SC24!

- **WHPC Workshop: Diversity and Inclusion for All (18 Nov)**
- **Diversity Day (19 Nov)**
- **Networking Reception (19 Nov)**

Check out the event page on the WHPC website to stay up to date!

https://womeninhpc.org/events/sc-2024

Get involved!

Become a member, follow us on social media, join us at events and join your local chapter or affiliate. We also offer a variety of partnerships, support and sponsorship opportunities for organisations. Find out more on our website:

https://womeninhpc.org

New Imaging, Vision, and High Performance Computing MSc

Jointly launched by EPCC and Heriot-Watt University this year, our pioneering **Imaging, Vision, and High Performance Computing** Master's degree recognises the importance of high performance computing in a wide range of disciplines.

This new MSc programme will give practitioners in imaging and vision a thorough grounding in high performance computing (HPC) knowledge and skills to support their work and enable them to exploit the largest computers. Graduates will be placed at the cutting-edge of science and technology, with skills in computational imaging algorithms and computer vision, as well as HPC hardware and software technologies. The programme of study brings together Heriot-Watt University's world-leading expertise in signal and image processing and the University of Edinburgh's globally respected capabilities in HPC for the first time.

Imaging and vision, particularly through machine learning (ML) approaches, are key parts of the modern economy, used in application areas such as robotics, remote sensing, and self-driving vehicles. Significant amounts of computing power are required to understand the world from image data, even when using ML to reduce computational costs, and it is one of the areas driving HPC uptake in industry and research.

For example, if a self-driving car uses ten cameras, it will require ten deep neural networks to process images. If that vehicle drives for one hour a day, the estimates are that it will make 20+ million inference decisions daily. It is likely such vehicles will also need to integrate data from other sensors, such as radar devices and data from other vehicles. However, there will be restrictions on the amount of computing power a vehicle like this can sustain, with an estimated 1.2kW being the limit of the amount of power available for on-board computing. This power envelope can support the equivalent of two powerful GPUs for the ML inference running the systems on board the vehicle.

From this we can see that professionals working in these areas will need imaging and vision skills to solve the complex problems associated with autonomous systems operating in a chaotic world, as well as the HPC skills to efficiently use computing hardware in such constrained and safety-critical environments.

One of our aims at EPCC, across all our teaching, is to give students the skills and knowledge to ensure software is as efficient as possible. Getting the most out of our computing resources can help reduce the environmental impact of computing. This is especially important if we are contributing towards the wide-scale and day-to-day systems that are coming to dominate modern society.

We expect this new MSc to grow over the coming years. If you're interested in becoming an expert in imaging and vision algorithms and approaches, and how these can be used on modern computing technologies, do consider applying and joining us in Edinburgh.

Adrian Jackson, EPCC
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The School of Engineering and Physical Sciences at Heriot-Watt University is renowned for world-class research in imaging and vision. The School's Signal and Image Processing Lab is a leading centre for computational imaging and computer vision, both nationally and internationally.

Full details of the new MSc programme are available at:
https://www.hw.ac.uk/study/postgraduate/imaging-vision-and-high-performance.htm

Education and training opportunities at EPCC:
https://www.epcc.ed.ac.uk/education-and-training

Preparing for Exascale: GPU training on ARCHER2

As HPC adopts new approaches to compute, the need for advanced training in GPU programming is becoming ever more critical.

At the forefront of this initiative is ARCHER2, the UK's national supercomputing service, which is offering a series of comprehensive courses designed to equip researchers and developers with the skills necessary to harness the power of graphics processing units (GPUs) for Exaflop computing.

The importance of GPU training

GPUs have become indispensable in high performance computing (HPC) due to their ability to handle massive parallelism and accelerate computational tasks. Having entered the Exaflop era, where systems can perform a quintillion (10^{18}) calculations per second, the efficient use of GPUs will be pivotal. Training on ARCHER2 aims to bridge the knowledge gap and prepare the HPC community for this leap.

Available courses

GPU Programming with HIP
HIP (Heterogeneous-computing Interface for Portability) is a crucial tool for developers looking to write portable code that can run on different GPU architectures. This course covers the fundamentals of HIP including memory management, kernel programming, and performance optimisation. Participants gain hands-on experience in writing and porting applications using HIP, ensuring their code is future proof and adaptable to various hardware platforms.

GPU Programming with Directives
Directives-based programming offers a high-level approach to GPU programming, making it accessible to a broader range of developers. This course will introduce participants to OpenMP and OpenACC, two of the most widely used directive-based programming models. Attendees will learn how to annotate their existing code to offload computations to GPUs, significantly enhancing performance with minimal code changes.

We are also collaborating with the HPE Cray Centre of Excellence and vendors such as AMD to offer training for those looking to delve deeper and explore advanced topics such as performance tuning and debugging.

Why ARCHER2?

The ARCHER2 GPU development platform provides an ideal environment for GPU training. Equipped with four nodes each featuring four AMD Instinct MI210s, it offers a realistic and challenging platform for hands-on learning. Additionally, the support from EPCC ensures that participants have access to expert guidance and resources throughout their training journey.

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ARCHER2's comprehensive courses on GPU programming with HIP, GPU programming with directives, and other courses under development are designed to equip the HPC community with the skills needed to thrive in this new landscape. By participating in this training, researchers and developers can ensure they are ready to tackle the challenges and opportunities that Exaflop computing will bring.

For more information and to register for these courses, visit the ARCHER2 website:
https://www.archer2.ac.uk

Edinburgh International Data Facility: open for public data

The Edinburgh International Data Facility team has launched a suite of services to support collaborative data science.

Operated by EPCC, the Edinburgh International Data Facility (EIDF) provides a comprehensive set of data services through a large private cloud service.

Simple Storage Service

EIDF now supports Simple Storage Service (S3) [1], which enables users to easily bring data in to and take data out of EIDF. Moreover, S3 gives users of EIDF a simple protocol to move data around its heterogeneous compute services.

For example, you can fill an S3 bucket from another cloud provider then process data from the bucket in a Jupyter Notebook before running an intensive GPU-accelerated machine learning task over the data in that bucket.

Sharing data

EIDF now enables the sharing of data with other researchers and innovators as part of the process of applying for a project on the EIDF Portal [2]. The EIDF S3 service is a critical component as donated data sets will be made available as S3 buckets. Researchers can discover your data sets on the newly-launched EIDF Data Catalogue [3].

Data donation

The first donation of data was by Prof. Henry Thompson of the University of Edinburgh School of Informatics. Prof. Thompson has augmented the Common Crawl dataset by adding timestamps to its index files.

Common Crawl is a multi-petabyte longitudinal dataset containing over 100 billion web pages which is widely used as a source of language data for sequence model training and in web science research.

Easy access to donated data

Making use of donated data is as easy as referencing its S3 bucket in a compute service either on the EIDF or on another system. For example, let's say we want to see a description and distribution of certain variables in Henry Thompson's data. We can use the newly-launched Jupyter Notebook service [4] in a web browser. If we execute a few lines of Python we get descriptive statistics and a distribution of one of the variables in a plot.

EIDF Notebook does not require you to log in to a terminal or virtual desktop. For a demo of this Jupyter Notebook on EIDF see the screencast [5]. If you want to access these data yourself all you need is its unique EIDF S3 URL [6]. This URL is on its respective EIDF Catalogue page [7].

Supporting collaboration

Next in store for EIDF will be the supporting of greater collaboration. We will launch an EIDF Gitlab, which will enable teams to develop code and documentation together. These can then be accessed in EIDF compute services such as Jupyter Notebooks to collaborate on code and documentation.

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[1] https://s3.eidf.ac.uk

[2] https://portal.eidf.ac.uk

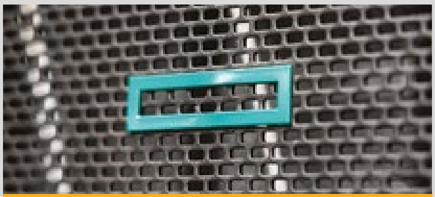
[3] https://catalogue.eidf.ac.uk

[4] https://notebook.eidf.ac.uk

[5] https://media.ed.ac.uk/media/t/1_o5psqjph

[6] https://s3.eidf.ac.uk/eidf125-cc-main-2019-35-augmented-index

[7] https://catalogue.eidf.ac.uk/dataset/eidf125-common-crawl-url-index-for-august-2019-with-last-modified-timestamps/resource/7e485f0c-d480-43e9-8cb7-9540a3d3dbc9



EIDF is governed by the Data-Driven Innovation (DDI) initiative with capital investment from the UK Government. DDI, part of the Edinburgh & South East Scotland City Region Deal, comprises a cluster of innovation hubs that bring academic disciplines together to delve into some of the world's most pressing challenges, using data to innovate.

Anyone can apply for any EIDF service. Please see:
https://portal.eidf.ac.uk

Edinburgh International Data Facility website:
https://edinburgh-international-data-facility.ed.ac.uk

FrankRamspott via Getty Images

International collaboration towards Net Zero computational modelling and simulation

EPCC, together with the National Centre for Atmospheric Science (NCAS), recently secured funding from EPSRC to set up an international collaboration with the US National Center for Atmospheric Research (NCAR).

The project, called CONTINENTS, will run for four years and aims to transform the state-of-the-art in sustainability and power/energy efficiency of computational modelling and simulation, with a particular focus on weather and climate application.

The UK's Net Zero strategy aims for all sectors of the economy to meet its Net Zero target by 2050. The US has similar long-term aims to move towards Net Zero emissions on the same timescales.

High performance scientific computing is not exempt from needing to adapt to these strategic challenges; driving computational modelling and simulation, and large-scale data analysis, towards sustainability and Net Zero is crucial if the scientific community is to justify the use and cost of large-scale high performance computing (HPC) resources in the face of climate change.

Through an ambitious collaborative programme of research, CONTINENTS will drive innovations in data centre and system operation, optimal exploitation of hardware, machine learning applied to data analysis and numerical modelling, and software design and implementation strategies, with the aim of minimising energy consumption and reducing waste.

EPCC, NCAS and NCAR will create an interdisciplinary collaboration between world leading centres of HPC research and service provision, atmospheric science experts, and numerical and machine learning application developers. The collaboration will be supported through an extensive set of knowledge exchange activities, including student internships and research visits.

Our partners

NCAR provides the atmospheric and related Earth system science community with state-of-the-art resources, including supercomputers, research aircraft, sophisticated computer models, and extensive data sets.

NCAS is a world-leading research centre, funded by the UK Natural Environment Research Council. Its research falls into three key areas: air pollution, climate, and high-impact weather and long-term global changes in our atmosphere.

CONTINENTS is funded by the Engineering and Physical Sciences Research Council.

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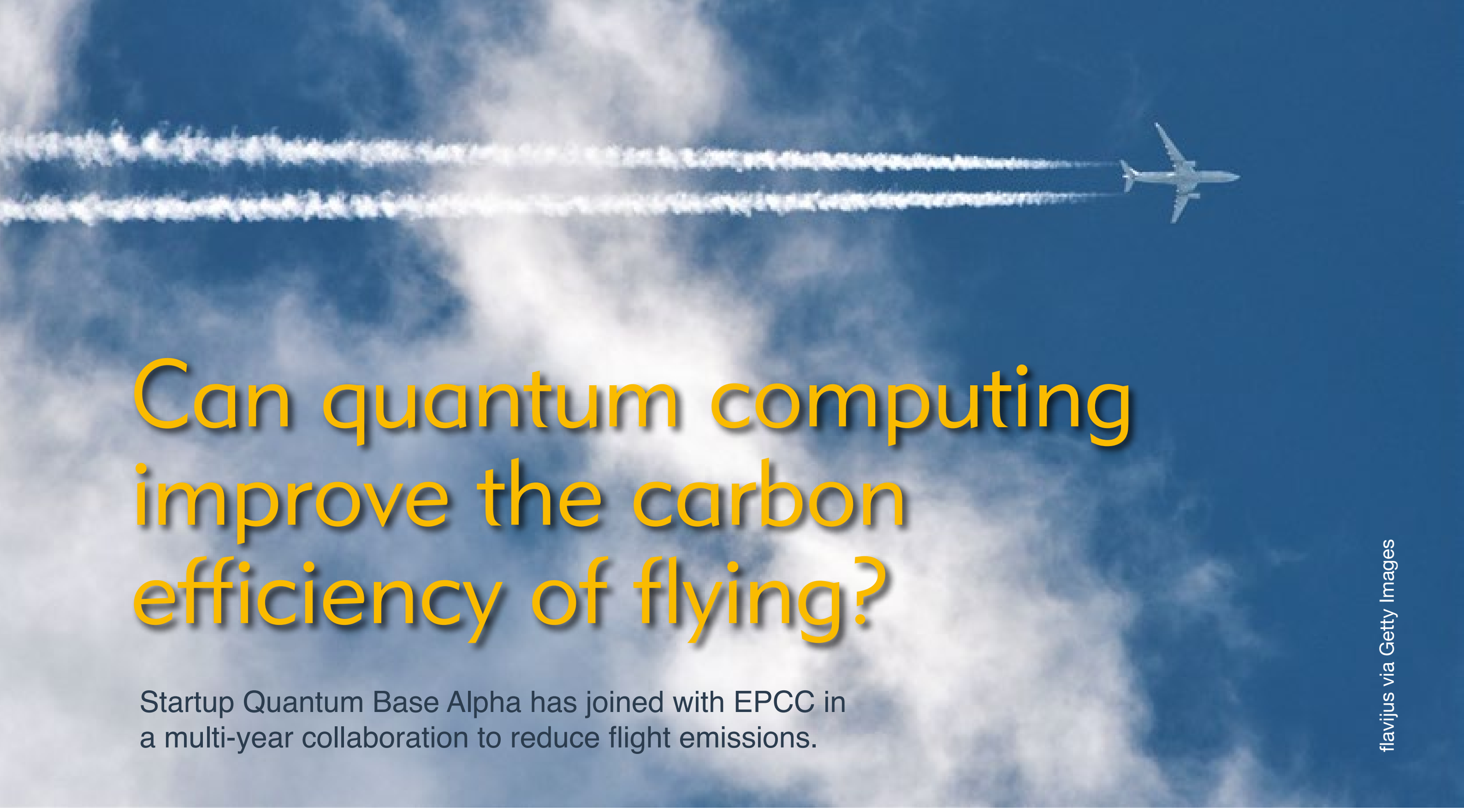
NCAR:
https://ncar.ucar.edu

NCAS:
https://ncas.ac.uk

Research at EPCC:
https://www.epcc.ed.ac.uk/research



flavijus via Getty Images

Can quantum computing improve the carbon efficiency of flying?

Startup Quantum Base Alpha has joined with EPCC in a multi-year collaboration to reduce flight emissions.

Quantum Base Alpha (QBA) is a Brighton-based startup exploring applications of quantum computing for the benefit of society. Since its inception it has focused principally on using quantum computing techniques to model air traffic systems with a view to minimising air traffic emissions. More recently, QBA has expanded to explore the utility of quantum machine learning in the biomedical and image recognition fields.

Aviation and Net Zero

QBA's primary concern is best exemplified by the so-called "Gatwick issue". The revised UK 2008 Climate Act commits the UK to reducing its greenhouse gas emissions to Net Zero by 2050. In 2019, aviation in the UK accounted for nearly 40 megatonnes of carbon dioxide equivalent per year (MtCO2e/year). Rising demand for UK flights indicates that yearly emissions will continue to grow to 2050. Gatwick Airport alone counts for 0.43 MtCO2e/year and offsetting these emissions would require 7.1 million trees being grown for ten years!

QBA believes that quantum computing could significantly reduce the greenhouse gases generated by the UK aviation industry.

QBA approached EPCC to explore the readiness of quantum computers for delivering on its ambitions. The company wanted to gain an understanding of what could be done today to prepare for solving the problems of tomorrow. As a proof-of-concept exercise, QBA and EPCC investigated optimising flight paths for fuel efficiency. Optimising these for a single plane is quite easy and, at a very high level, is dictated by three factors:

- The shorter the flight path, the less fuel is consumed.
- Planes consume most fuel at takeoff and during ascent.
- Fuel consumption decreases with a plane's cruising height.

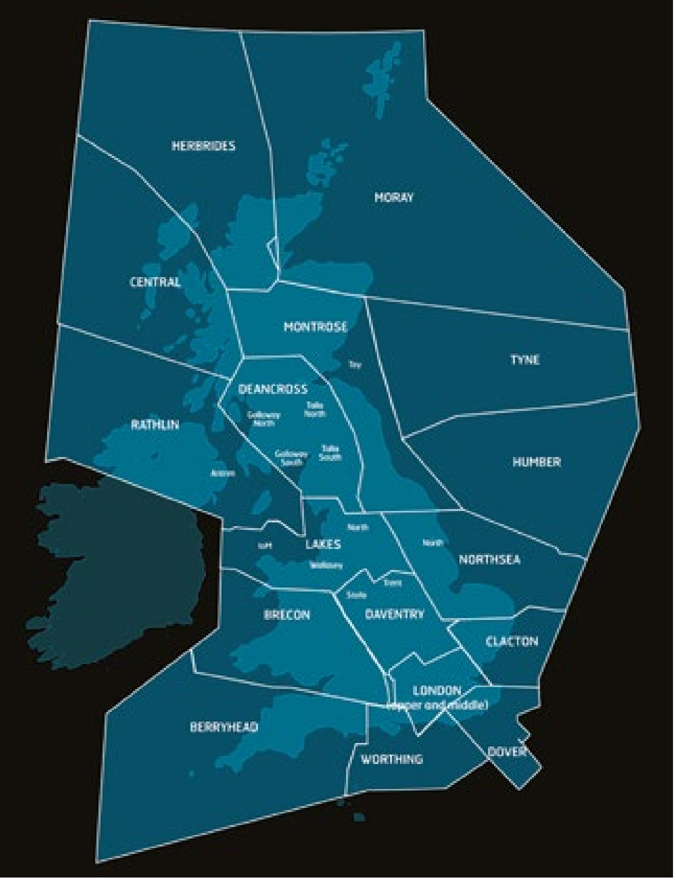
This single-plane problem is easy to solve, and many existing open source codes could solve it. The complexity arises when considering multiple planes flying over the same airspace or including external factors such as headwinds and dangerous weather. While an optimal solution can be found, it requires significant computational resources. Given the frequent change in weather, these must be re-calculated on a regular basis to ensure good results.

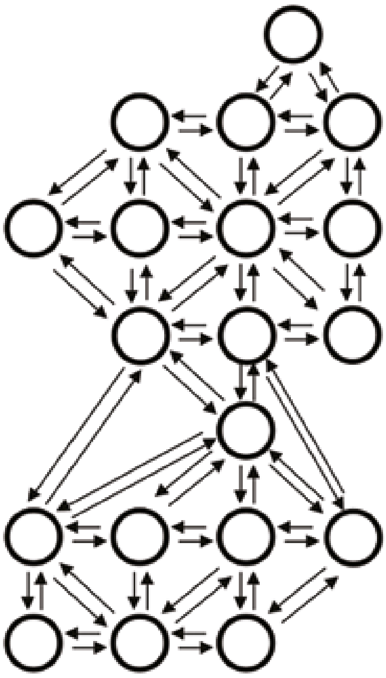
Graph-based representation

As quantum computers are highly efficient at solving graph-based problems, our first step was to transfer the classical representation used in aviation control into a graph-based representation. We converted a latitude-longitude representation of our airspace into an abstract representation that only considers the individual sub-regions within an airspace and defined the connection from region to region as the minimum centre-to-centre distance.

Emulating a quantum computer

Current circuit-based quantum computers are not capable of running code of this complexity. While modern quantum computers have somewhere in the region of 100s to 1,000s of qubits, they can only remain switched on for a very short time, and each qubit is prone to randomly becoming erroneous due to minor fluctuations in temperature. We used the ARCHER2 supercomputing service to emulate a 44-qubit quantum computer that is error free and can run jobs that would take longer





|ψ⟩ Quantum Base Alpha

Left: a highly simplified representation of the UK airspace broken down into regions (image from NCAP). Right: a graph representation of this simplified airspace, where each region is replaced by a circular node, and each border is replaced by arrows going from each region to its adjacent regions.

than a circuit-based quantum computer could cope with.

For this work, we decided to compare the performance of classical algorithms against a full circuit-based quantum computer emulated on ARCHER2, and against a "quantum annealer"[1], a non-circuit-based quantum computer that is particularly good for optimisation problems like finding shortest paths.

This proof-of-concept project demonstrated that quantum algorithms for determining the shortest traversal paths can be made to work on both a quantum annealer and on an emulated circuit-based quantum computer. However, we also found that the size of the aviation problem is too large to run on an ARCHER2-based emulated circuit-based system, and that current quantum annealers take significantly longer to reach a solution than we obtain using classical algorithms.

These complications should not take away from the accomplishments of this project. EPCC has demonstrated that a real (though non-circuit-based) quantum computer can find the optimal path that an airplane should take through a simulated airspace. While we have also found that quantum computers do not yet outperform classical computers, we fully expect there to come a time where quantum computers will be able to solve these problems more quickly than a classical computer, and this work means that QBA will be ready to exploit that advantage.

Complications of quantum annealing

To achieve these results, we needed to substantially simplify the problem we were solving. While quantum annealers could deal with larger and more complex graphs, any resulting solution is probabilistic. Often, as problems become more complex, software will need to be rerun multiple times before the quantum annealer converges towards a single definite (and correct) solution. This, when combined with the significant time that a single run takes, makes it costly to simulate large-scale, realistic problems on a quantum annealer.

[1] We accessed a quantum annealer through the D-Wave LEAP programme:

https://cloud.dwavesys.com

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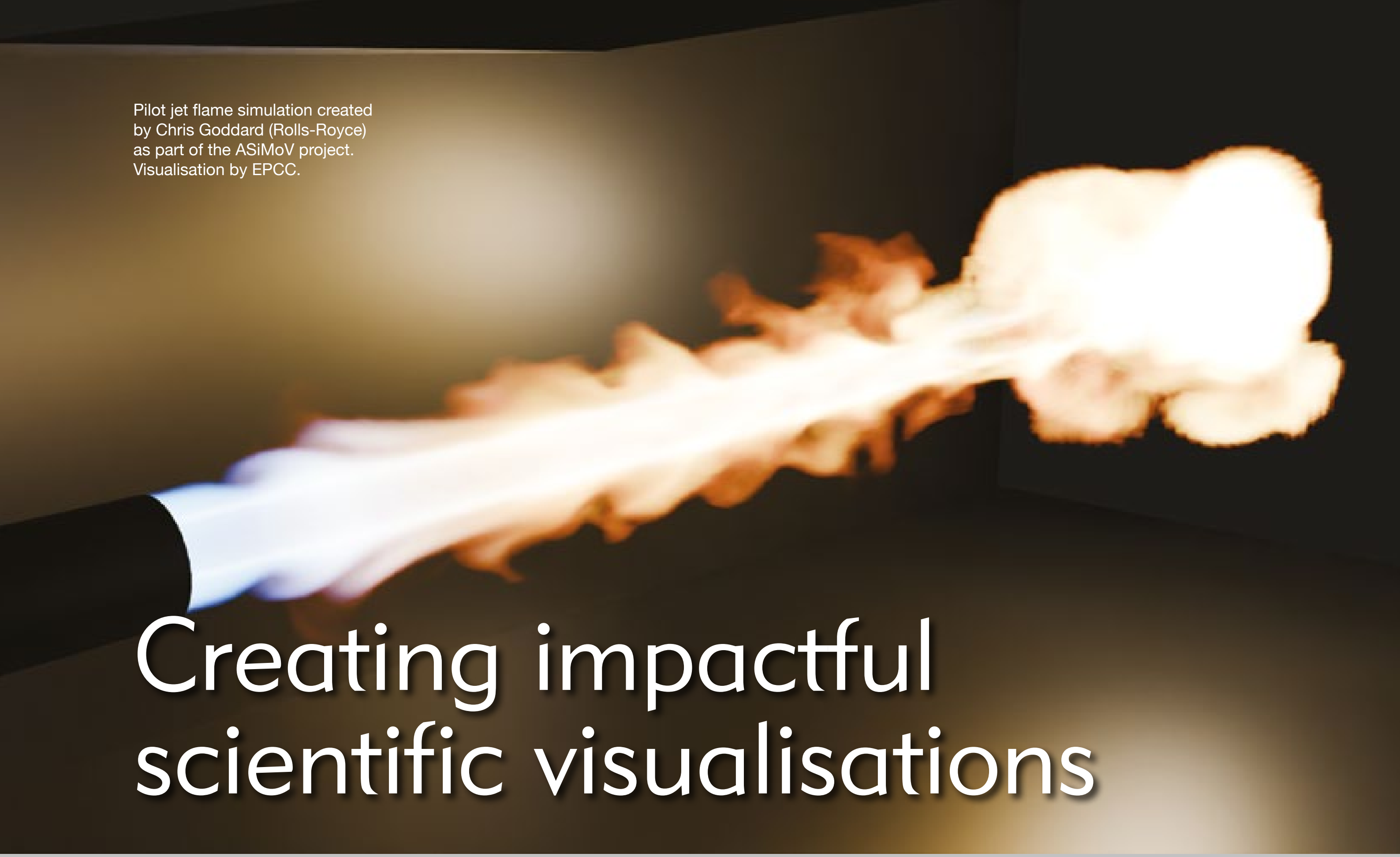
CONTACT
If you are interested in exploring whether quantum computing could be applied to your workflow, or to learn about other recent approaches to solving software development problems, please get in touch:
Commercial@epcc.ed.ac.uk

Quantum Base Alpha:
https://qba.one



Pilot jet flame simulation created by Chris Goddard (Rolls-Royce) as part of the ASiMoV project. Visualisation by EPCC.

Creating impactful scientific visualisations

Visualisation is a core component of most high performance computing (HPC) workflows and assists researchers in communicating their findings and results to others.

Any field working with 3D data, from computational fluid dynamics (CFD) to molecular dynamics or structural mechanics, requires researchers to analyse the large amounts of data produced and communicate their findings and results to others. Producing engaging, visually appealing, and impactful imagery is the main aim of the 3D animation and CGI/VFX industries. Their use of tools like Blender, Houdini, Maya, or Cinema4D is something the scientific community can learn from.

Taking the example of Blender, an open-source libre 3D package, it is capable of 3D modelling, animating objects, accurate colour grading, rendering ray-traced images, texturing, video editing, and much more.

All of these features allow for very fine control over every element of the visualisation, producing either photorealistic or stylised images. This is particularly interesting when the target audience is not technical; a photorealistic render gives context, a sense of scale, and can make the overall image more appealing.

When considering fluid dynamics, two different categories of flow can be distinguished. The first includes flows for which the relevant characteristics are visible to the eye. This encompasses free surfaces, such as air-water interfaces, cavitation bubbles behind a propeller, or flames, for example. See the image above, which resulted from a pilot jet flame simulation created by Chris Goddard (Rolls-Royce) as part of the ASiMoV project.

The second type of flow is more complex to represent because its features are not usually visible. In this context, scientists must use methods like the Q-Criterion or streamlines to visualise them, both of which break the photorealism of the visualisation.

Rendering the QCriterion quantity as a volume created a smoke-like effect in the render of wind turbine wakes in the simulation by Andrew Mole (Imperial College) shown on the opposite page.

The colours are based on the flow velocity and were chosen to ensure the wake couldn't be mistaken for actual smoke.

HPC perspective

3D engines like Blender can render images and animations on a wide variety of hardware backends, from x86 CPUs to NVIDIA, AMD, or Intel GPUs (using CUDA, OptiX, HIP, and oneAPI, respectively). This makes them very versatile tools that can run on current CPU-based HPC systems but also on the next generation of Exascale GPU-based systems.

Performance-wise, as a point of comparison, this kind of workload is a lot more efficient on GPUs; a single NVIDIA 4090 renders frames

Simulation by Andrew Mole (Imperial College), visualisation by EPCC

about six times faster than a full ARCHER2 node (dual AMD EPYC 7742 64-core CPU).

Additional resources

The following resources are highly recommended for anyone who wishes to start using Blender for scientific visualisations.

Surf provides an extensive freely available online webinar about the usage of Blender for scientific visualisations:

https://surf-visualization.github.io/blender-course

The NCSA Advanced Visualization Lab has a video series about data visualisation for science communication. It is less technical and does not look at individual tools, but it details what makes a visualisation engaging:

https://www.youtube.com/@ncsaavl

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Strategic Partnership in Computational Science for Advanced Simulation and Modelling of Engineering Systems (ASiMoV)

The ASiMoV Strategic Prosperity Partnership is a ground-breaking five year project that seeks to develop the next generation of engineering simulation and modelling techniques, with the aim of developing the world's first high-fidelity simulation of a complete gas-turbine engine during operation.

ASiMoV is jointly led by EPCC and Rolls-Royce, and includes the universities of Bristol, Cambridge, Oxford and Warwick. (EP/S005072/1)

CONTACT

EPCC webinar "Blender for scientific visualisations":

https://www.archer2.ac.uk/training/courses/240214-visualisation-vt

To learn more about research at EPCC see:

https://www.epcc.ed.ac.uk/research

Research Fellows at EPCC

The University of Edinburgh is building its research base through a major investment in outstanding early career researchers. Chancellor's Fellows benefit from prestigious five-year fellowships aimed at fostering cutting-edge interdisciplinary research and innovation in a supportive environment.

EPCC is actively involved in the Fellowship programme and has so far recruited three Chancellor's Fellows working in priority research areas. Here they give an insight into their research ambitions.

Oliver Brown: quantum computing

I came to EPCC in 2018 from Heriot-Watt University, where I completed my PhD on stationary states of driven dissipative many-body quantum systems. My early work at EPCC focused on programming models for Exascale, which sparked an interest in programming model research, especially for novel accelerators. As quantum computing grew in popularity, I was asked to define EPCC's strategic direction and lead our efforts in this space.

In 2023 I became a Chancellor's Fellow at EPCC. My research is focused on a long-term vision of quantum computers as accelerators to high performance computing (HPC), and the software and tools required to make that useful. The three lines of research I follow to achieve that vision are: implementing and benchmarking quantum algorithms; designing programming models for quantum computing that will help integrate them into the HPC environment, and developing scalable classical emulators to ensure that we can do this work without necessarily having access to capable quantum hardware.

My work is embedded in a much wider ecosystem of quantum research in the UK. I am a member of the Quantum Software Lab (affiliated to the National Quantum Computing Centre), a co-lead of the Quantum Computing Applications Cluster which brings together quantum computing experts from across Scottish universities, and a member and Theme co-lead in the new QCI3 Quantum Technology Research Hub funded by EPSRC.

Rosa Filgueira: accessible data science

My research aims to bridge the computational gap for non-expert users by developing intelligent adaptive systems that enable effortless creation, discovery, and sharing of data-intensive applications. By combining new programming abstractions, auto-parallelisation techniques, and machine learning, I create 'smart' data- and compute-intensive applications.

This holistic approach enhances productivity and accelerates scientific discoveries across various fields, resulting in solutions tailored to different scientific disciplines and contributing to general domain-independent frameworks.

Empowering scientific discovery through AI and data-intensive computing, I am advancing several research projects. One notable project, "Multi-Level AI-Driven Analysis of Software Repository Similarities", enhances ML tools with a novel LLM model for multi-level embedding and repository similarity searches, improving code reusability and fostering collaborative science. Another key project is "Advancing Frances: New Heritage Textual Ontology, Enhanced Knowledge Graphs, and Refined Search Capabilities". This work improves the Frances AI-based platform for historical text analysis with advanced knowledge graphs, deep-learning-based OCR error correction, sophisticated semantic search functionalities, and parallel text-mining techniques. Additionally I am developing novel solutions for serverless frameworks in stream-based applications. These solutions feature innovative dependency management, automatic function parallelisation, and deep learning models for semantic text and code search, managing data streams more efficiently, as well improving the search capabilities within serverless environments.

Joe O'Connor: high performance fluid dynamics

My research is focused on computational modelling, simulation, and design, with an emphasis on accelerating high-fidelity simulations of fluid dynamics problems. My background is primarily in the field of computational fluid dynamics (CFD), but also includes high-performance computing, optimisation, uncertainty quantification, and data-driven engineering.

After graduating from the University of Glasgow with an MEng in Aeronautical Engineering, I undertook a PhD in Aerospace Engineering at the University of Manchester. This was followed by an EPSRC Doctoral Prize Fellowship and position as a Postdoctoral Research Associate. I then joined the Turbulence Simulation Group at Imperial College.

Since joining EPCC as a Chancellor's Fellow, my research activities have mainly focused on accelerating high-fidelity simulations of marine energy systems through a combination of data-driven techniques and novel parallel computing strategies. More specifically, over the past year I have been investigating the potential of graph neural networks to generate low-fidelity data-driven surrogate models of SPH operators. The end goal of this is to facilitate the creation of hybrid (physics+data) models that combine the accuracy and robustness of high-fidelity SPH with the efficiency of low-fidelity data-driven modes.

In parallel to this, I have also been exploring the potential of developing a differentiable SPH solver that provides automatic differentiation capability to facilitate adjoint-based workflows, such as gradient-based optimisation, uncertainty quantification, and inverse modelling. Furthermore, I have begun experimenting with dimensionality reduction of SPH simulations to develop reduced-order models for acceleration. This incorporates elements of image processing to learn dominant features of a high-dimensional distribution of particles in a reduced space.

Alongside all of this, I also have an ongoing collaboration with colleagues in the School of Engineering who are applying regional-scale CFD to improve the design and deployment of tidal energy systems.

Finally, in collaboration with partners at the University of Manchester, we were successful in the first round of the UKRI GPU eCSE call to prepare the open-source SPH code DualSPHysics for emerging Exascale machines.

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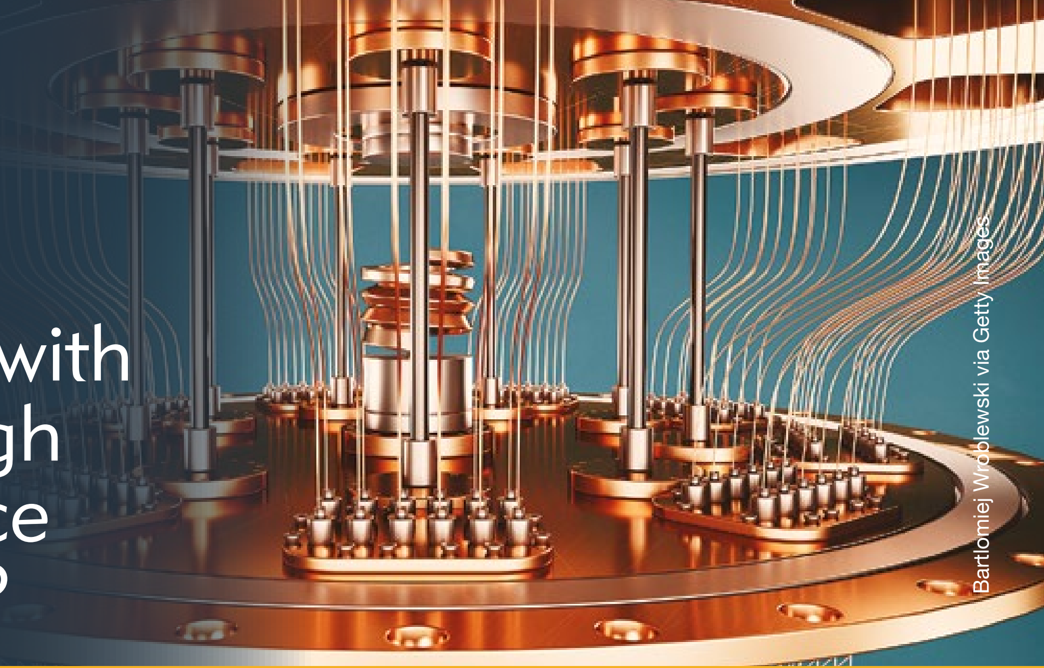
See our website to learn more about our research activities:
https://www.epcc.ed.ac.uk/research

What does quantum computing have to do with classical high performance computing?


Bartlomiej Wroblewski via Getty Images

EPCC is a partner in two projects that are working to accelerate the statevector emulation of quantum computing.

Oliver Thomson Brown, EPCC
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First let's talk about emulating a quantum computer. A computer capable of an Exaflop carries out two orders of magnitude more floating-point operations per second (flops) than the 28-petaflop UK national supercomputer, ARCHER2. If we can make use of all those extra flops we may be able to run emulators like QuEST faster, but with around the same total memory available on an Exascale machine as on ARCHER2, we won't be able to go any bigger. Faster (and using less total energy) is of course better, so we are currently involved in two projects working on accelerating statevector emulation of quantum computing: one funded by the Robust and Reliable Quantum computing (RoaRQ) project which is extending QuEST, and one ARCHER2 eCSE project extending our own emulator code.

Tensor networks

Statevector emulators are extremely powerful, giving the user complete access to the quantum information and doing so with no error. There is, on the other hand, an approximate method of simulating quantum systems using tensor networks (TN). They struggle to represent highly entangled quantum states (a set of states that are unique to quantum systems) but can be used to emulate much larger quantum computers. This can be particularly important for quantum hardware developers who need to run quantum simulations which include models of the noise in their hardware, as these scale even worse with the number of qubits than the statevector simulations.

What makes tensor network simulations especially interesting for the Exascale era is that they run extremely well on graphics processing units (GPUs). In fact, many of the underlying operations are the same as those used for machine learning (ML), so they could even leverage existing ML frameworks. I look forward to seeing just how far we can push TN codes on a quantum computing system!

Programming models

Finally, let's talk about programming models. Although GPUs and quantum computers are undeniably very different, some of the core challenges of getting many devices to co-operate on the same problem will carry through. I expect there will be many interesting lessons to take forward to a future hybrid quantum-HPC system and we are already learning from the work we are undertaking to make current codes Exascale-ready.

So there you go. The answer to the question of what quantum computing has to do with high performance computing is not a lot, but certainly a little.

Previously we've demonstrated that we can emulate 44 quantum bits (qubits) using 4,096 nodes of ARCHER2 and software called QuEST. Surely then using Exascale we can go to even more qubits? Sadly, probably not. We don't yet know what the architecture of a future UK Exascale facility will be, but we can guess that it will be GPU accelerated and, given the available power, that it will have around the same number of nodes as ARCHER2.

To learn more about research at EPCC see:
https://www.epcc.ed.ac.uk/research

If you are interested in exploring quantum computing in a commercial context, please email:
Commercial@epcc.ed.ac.uk

Modelling wind turbines using energy-efficient novel architectures

EPCC has been extensively involved in ExCALIBUR, a £45.7m UK research programme that aims to deliver the next generation of high performance simulation software for the highest priority fields in UK research. The programme will end in early 2025 but new collaborations and research projects will build on its successes.

EPCC has hosted several novel architecture testbeds throughout the ExCALIBUR programme incuding Field Programmable Gate Arrays (FPGAs), AMD AI Engines (AIEs), the Cerebras CS-2, and the RISC-V testbed which contains many RISC-V based technologies.

All these technologies have the potential to deliver not only good performance but also significant energy efficiency gains over and above current choices. Energy efficiency is becoming ever more critical as we look to decarbonise our workloads, and these testbeds have enabled scientists to explore these new options.

With ExCALIBUR drawing to a close we are looking for opportunities to derive further benefits and activities from the programme's testbeds, for example with a project on the theme of sustainable digital technologies. Led by Imperial College London, it will explore the role of simulation in modelling wind turbines.

Reducing energy costs

Wind farms have a key role in delivering green energy, and modelling the interaction of wind and turbine can not only lead to important design improvements, but furthermore help inform the placement of individual turbines within a farm.

However, an important consideration is the energy used in running these simulations on high performance computing (HPC) machines, and this is where the energy-efficient novel architectures come in.

EPCC's role in this project is to explore the appropriate architectures and associated techniques to support such workloads running at very reduced energy cost. By working with vendors and exploring different hardware designs as part of the RISC-V testbed, we will undertake co-design of the entire ecosystem, all the way from the hardware to the application.

This is a great example of how work in the ExCALIBUR programme now has the potential for wider impact, with this project promising to deliver new capabilities in wind turbine modelling without costing the earth!

Nick Brown, EPCC
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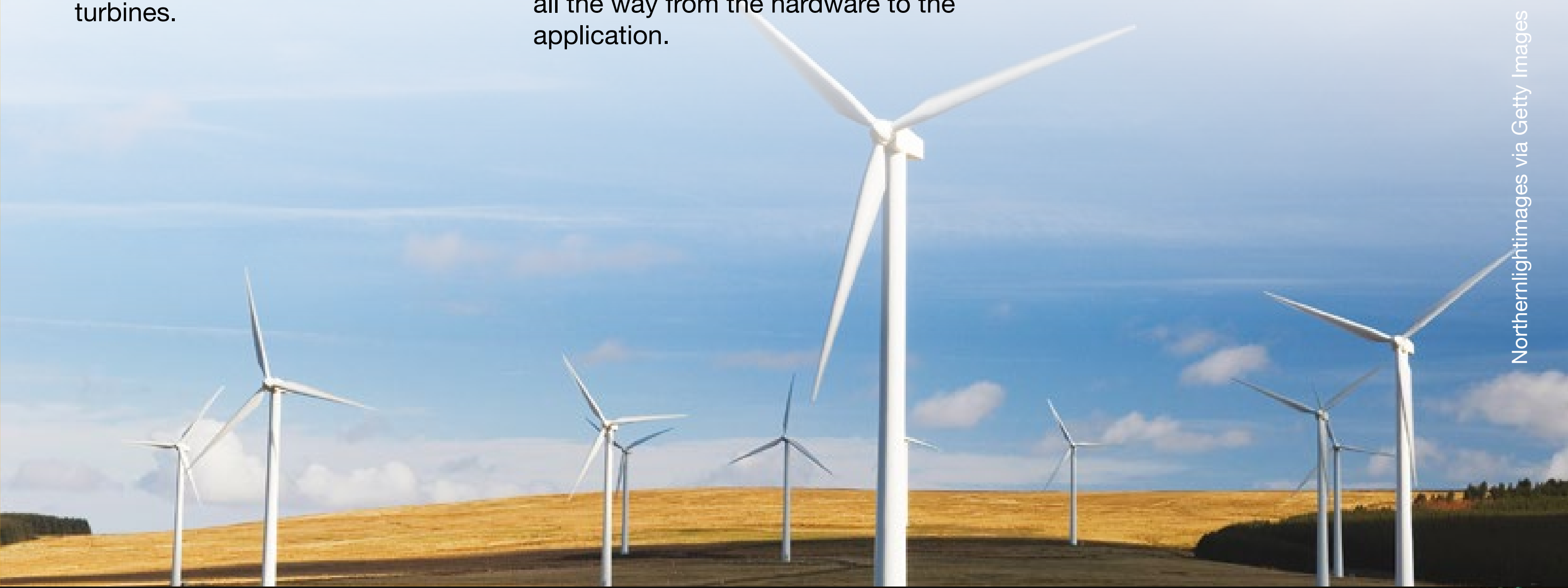
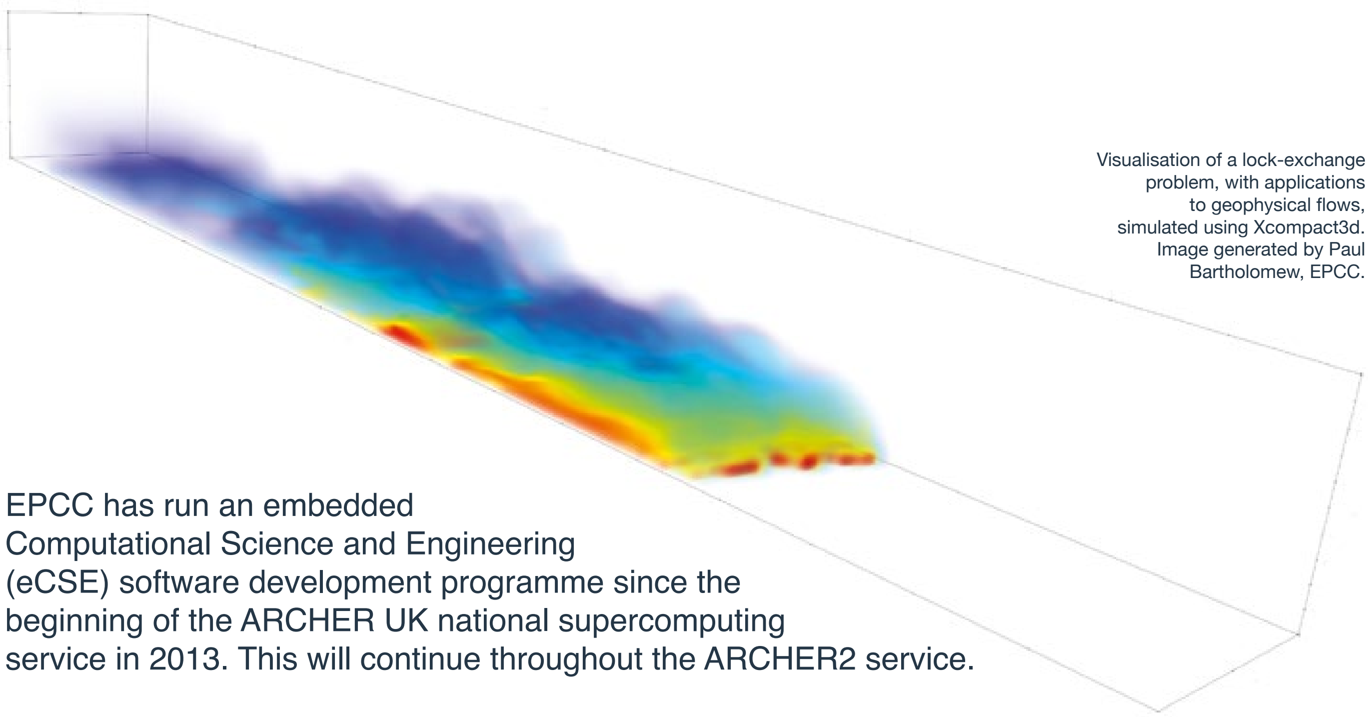
ExCALIBUR started in October 2019 and will run through until March 2025, redesigning high priority computer codes and algorithms to meet the demands of both advancing technology and UK research.

https://excalibur.ac.uk



Northernlightimages via Getty Images

GPU software development programme



Visualisation of a lock-exchange problem, with applications to geophysical flows, simulated using Xcompact3d. Image generated by Paul Bartholomew, EPCC.

EPCC has run an embedded Computational Science and Engineering (eCSE) software development programme since the beginning of the ARCHER UK national supercomputing service in 2013. This will continue throughout the ARCHER2 service.

So far we have awarded almost 1800 person months of effort to around 180 projects: a total of almost 150 staff years!

These projects were focused mainly on the hardware of ARCHER and ARCHER2, meaning that most of the development was CPU based. Following on from the success of the ARCHER and ARCHER2 programmes, earlier this year we opened a call for the development of GPU-based software within all of UKRI's research areas. It was extremely popular, and eight projects were awarded funding. Here we describe two such projects which have drawn on EPCC expertise.

Porting x3d2 to AMD GPUs

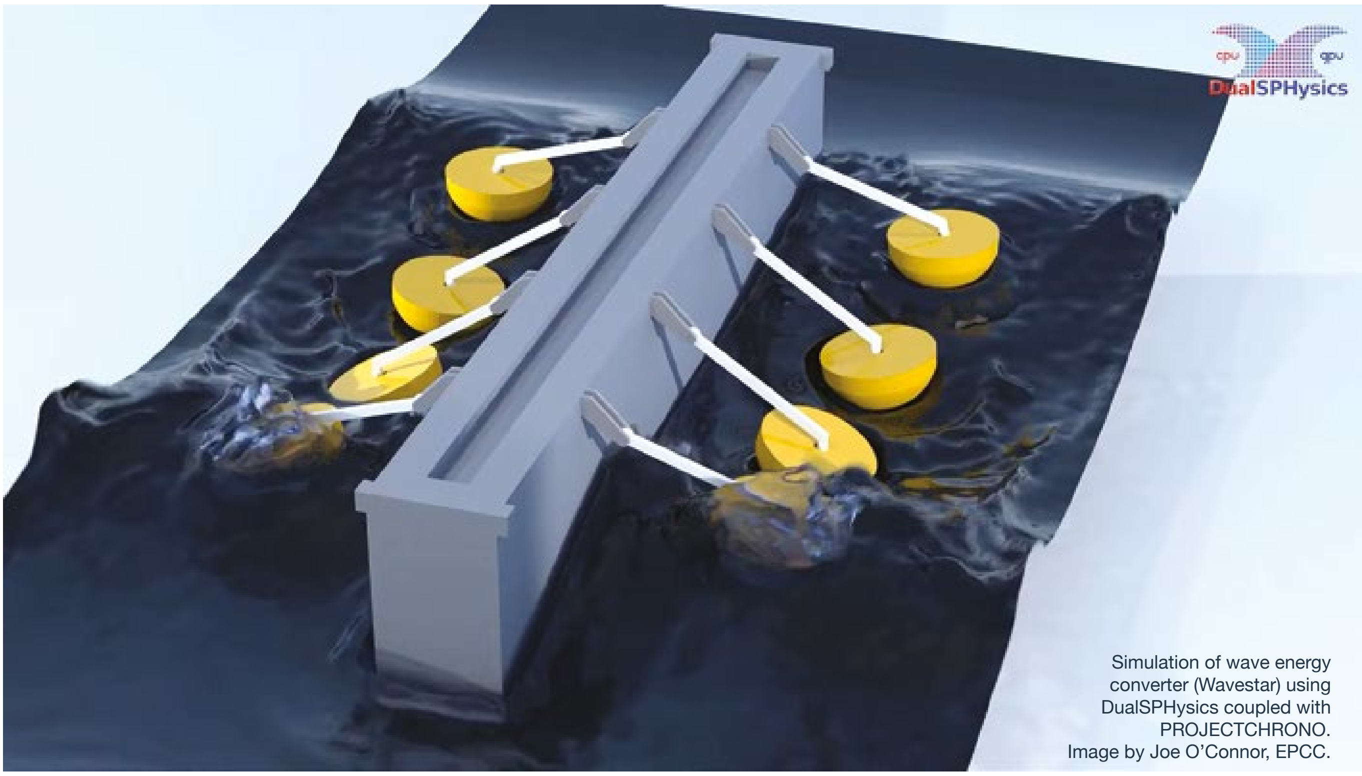
x3d2 is the new version of the Xcompact3d CFD code and is designed to exploit modern multicore and GPU-accelerated architectures with an "MPI+X" strategy to scale across multiple nodes. Using an OOP-based design enabled by modern Fortran standards, x3d2 features a single science code base built upon abstractions that implement the required numerical operations for the targeted backend. Currently multicore CPUs are supported via OpenMP directives and NVIDIA GPUs through CUDA Fortran. To ensure x3d2 remains portable across the next generation of supercomputers with accelerators from multiple vendors, this project will implement an accelerator-agnostic backend using OpenMP target offload directives. Following implementation of the accelerator-agnostic backend, specific kernels identified by profiling the code will be optimised for the AMD GPU architecture using HIP to achieve performance portability.

This project is a collaboration between Prof. Sylvain Laizet (PI, Imperial College London), Dr Charles Moulinec (Co-I, STFC Daresbury Laboratory), Prof. Michèle Weiland and Dr Paul Bartholomew (Co-I and Technical Staff, EPCC).

Developing a heterogeneous SPH solver based on the DualSPHysics GPU code

Smoothed particle hydrodynamics (SPH) is a meshless alternative to traditional computational fluid dynamics (CFD) methods. Thanks to its Lagrangian particle-based formulation, it is ideally suited to fragmented flows with highly deforming interfaces, such as violent free-surface flows, fluid-structure interactions, and multiphase flows. As a result, it has found widespread adoption in a variety of applications ranging from coastal and offshore engineering to fuel sloshing.

DualSPHysics is one of the leading open source SPH codes, with over 120,000 downloads and a user base consisting of both researchers and industry. Stemming from a joint collaboration between the universities of Manchester, Vigo, Parma, Barcelona, and New Jersey, DualSPHysics has been designed for multi-core CPU (OpenMP) and single GPU (CUDA). However, in preparation for emerging Exascale



Simulation of wave energy converter (Wavestar) using DualSPHysics coupled with PROJECTCHRONO. Image by Joe O'Connor, EPCC.

machines, there is a need to provide a hardware-agnostic implementation that can run on heterogeneous large-scale distributed systems (eg multi-GPU). This project will address this need through two main work packages (WPs).

WP1 will provide a hardware-agnostic implementation by first investigating and then integrating one of the available performance-portable programming models (eg OpenMP, SYCL, Kokkos).

WP2 will provide a multi-GPU implementation by redesigning the code for large-scale distributed systems (via MPI).

The main technical challenge for WP2 is that SPH is meshless. Therefore, instead of a mesh, the fluid is described as a distribution of particles that move and advect with the flow. In comparison to mesh-based methods, this is conceptually similar to an unstructured mesh that changes every time step (both in terms of nodal positions and edge connectivity). This poses a major challenge in terms of partitioning, communication and load balancing. Before the end of the project, the developments from both WPs will be merged into the upstream release cycle, allowing the users of DualSPHysics to make full use of these developments. Ultimately, this will unlock previously intractable problems (eg full floating offshore wind farms, and tsunami prediction at real-world coastal sites) and enable ambitious new science and engineering research in the drive for Net Zero, future sustainability, and infrastructure resilience.

This project is led by a multi-institutional team consisting of Prof. Benedict Rogers and Dr Georgios Fourtakas (University of Manchester), Dr Stephen Longshaw (STFC Daresbury Laboratory), and Dr Joe O'Connor (EPCC).

Paul Bartholomew, Chris Johnson, and Joe O'Connor, EPCC

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The ARCHER2 service, hosted and operated by EPCC, is the UK's most powerful supercomputer. Based around a 750,080-core HPE Cray Ex system and with around 3,500 active users, it puts world-leading capabilities in the hands of UK-based scientists. EPCC provides the Service Provision, and Computational Science & Engineering services. We also provide training to both academia and industry users.

CONTACT

eCSE reports:
https://www.archer2.ac.uk/ecse/reports

eCSE case studies:
https://www.archer2.ac.uk/research/case-studies

x3d2:
https://github.com/xcompact3d/x3d2

Xcompact3D:
https://github.com/xcompact3d/Incompact3d

Video showing a simulation of a wave energy converter:
https://www.youtube.com/watch?v=JeD89PMiLLQ

Software Sustainability Institute update

Since 2010, the Software Sustainability Institute (SSI) has played a vital role in improving research culture, revolutionising access to software training and working with collaborators to develop policies that better recognise and support software in research.

Members of the 'Task Management for Humans as Self-Care' team receiving first place at the Collaborations Workshop 2024 Hack Day.

Research Software Camp (RSC) 18–29 November 2024

The theme of this Camp will be Research Software Skills for Technicians.

The Software Sustainability Institute runs free online Research Software Camps once a year over the course of two weeks. Each Camp focuses on introducing basic research software skills and good practices, thus starting discussions among various research communities. Researchers from all career stages are welcome to join in the live and offline discussions that will take place throughout the Camp.

The event is filled with diverse online events held at different times each week, accompanied by a carefully curated collection of online resources, from engaging discussion forums to informative blog posts and helpful guides.

This iteration of the RSC is aimed at technicians working in academia or research who code or help others with coding as part of their roles.

Research Software Camps:
https://www.software.ac.uk/training/research-software-camps

Fellowship Programme

The SSI Fellowship Programme improves and promotes good computational practice across all research disciplines and supports those who are doing this important work. SSI Fellows have been recognised as ambassadors of good practices in their areas of work due to their dedication in promoting better software practices.

Fellows receive a £4000 budget for organising or attending activities. They are matched with mentors and participate in regular monthly Community Calls and the annual Collaborations Workshop. Additional opportunities within the SSI include involvement in steering committees, as well as participating in study or focus groups. Once Fellows' inaugural periods end, they remain an active part of the community as continuing Fellows: once a Fellow, always a Fellow.

Applications for the new cohort of SSI Fellows are now closed and the successful applicants will be announced in December 2024.

Check our Fellowship Programme page for updates:
https://www.software.ac.uk/programmes/fellowship-programme

Green DiSC: a Digital Sustainability Certification

Green DiSC is a new certification scheme which provides a roadmap for research groups and institutions who want to tackle the environmental impacts of their computing activities.

Until now computing groups didn't have such a roadmap (unlike wet labs for example, or clinical trials). This has prompted a partnership between the team behind the Green Algorithms project at the University of Cambridge led by SSI Fellow Loïc Lannelongue and the Software Sustainability Institute to come up with such a framework.Three levels of certifications will be available: Bronze, Silver, and Gold. The criteria were selected following some key principles:

- Evidence-based
- Open access
- Iterative
- Community-based.

Green DiSC:
https://www.software.ac.uk/GreenDiSC

RSE Conference 2024
3–5 September, Newcastle University

The UK's Annual Conference for Research Software Engineering (RSECon) is the first and largest conference in this field in the world. It provides an unparalleled opportunity to network with Research Software Engineers (RSEs), the technical decision makers in research, from the UK and around the world.

The conference theme was based on the Nine Research Software Development Principles proposed by SSI Director Neil Chue Hong:

Helping your team

1 FAIR: Reusable by as many users as possible

2 Secure: Respect data privacy and assume attacks

3 Maintainable: Easy to adapt and to correct faults

Helping your peers

4 Reproducible: Enable trust in research

5 Recognition: Reward all roles and develop the next generation

6 Inclusive: Accessible and supportive of a broad community

Helping the world

7 Responsible: Build to reduce impact on our environment

8 Open & global: Transcend national and discipline boundaries

9 Humanist: Unbiased, ethical and in support of humanity.

This year's keynote addresses featured inspirational and visionary thought leaders from academia and industry, including Anne-Marie Imafidon (one of Forbes Magazine's top 50 women in tech globally); Muzlifah Haniffa (Interim Head of Cellular Genetics at the Wellcome Sanger Institute), and Martin Sharkey (founder and CEO of CloudKubed).

RSECon24:
https://rsecon24.society-rse.org

Denis Barclay, EPCC
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The Software Sustainability Institute (SSI) is the first organisation in the world dedicated to improving software in research. It was founded on the premise that helping individuals and institutions understand the vital role that software plays in research would accelerate progress in every field of scientific and academic endeavour.

Software Sustainability Institute
https://www.software.ac.uk

Internships at the Advanced Computing Facility

This summer we took part in the University of Edinburgh's Employ.ed On Campus programme for the first time, welcoming three undergraduate students to the Advanced Computing Facility (ACF).

This has been a positive experience for all and a fantastic collaboration between EPCC and the School of Engineering. It is a huge credit to the School that our first three students were of such a high calibre and fitted in so well at our global leading supercomputing site. I wish them all success in their future careers.

Left to right: Vaidehi, Alistair, James, and EPCC Director of HPC Systems Paul Clark demonstrate a raised floor in the ACF. ARCHER2, seen in the background, is hosted in this computer room.

Paul Clark, EPCC
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Vaidehi Laata

What I enjoyed most about my placement was drawing circuit diagrams for the power distribution system, which tested my electrical engineering skills in a real-world context and was a great learning experience. Networking with various stakeholders boosted my confidence in my technical abilities and broadened my understanding of different aspects of the industry. A particularly memorable experience was a conversation with an industry contact, which has inspired me to explore computational data storage. By actively seeking out conversations with external visitors, I gained fresh insights into the ACF and the broader industry.

Overall, the internship exceeded my expectations, providing me with both technical knowledge and personal growth that will be invaluable in my future career.

Alistair Murison

I enjoyed my time on site, learning about all the pieces that make up the cooling systems of the computing systems, from mechanical components to the piping networks, and building management systems. I also created detailed electrical metering hierarchies which allowed me to explore the power distribution systems in great detail, and it was satisfying to build a complete understanding of how it all fits together.

The biggest takeaway from the internship has been seeing what I have learned in lectures applied in the real world. I will be returning to university with a much better understanding of cooling plant infrastructure and the work environment.

James Walter

We worked on updating and reviewing the on-site documentation, mechanical schematics, and spreadsheets for energy usage data and calculations. We also collaborated with internal and external teams, who all gave us an insight into their field of work. It was eye-opening to learn about the control systems and mechanical cooling strategy that optimise and reduce site energy usage while maintaining such powerful computing systems.

I will benefit greatly from the knowledge I have gained of heating, ventilation and air conditioning, and also electrical systems and power engineering, which I can take forward into university and my future career. I also really benefited from talking to a wide variety of people at the ACF.

Summer student placements at EPCC

Nuffield Research Placements

Left to right: Thomas, Maya and Kevin.

Chris Wood, EPCC
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Nuffield Research Placements: https://www.nuffieldfoundation.org/students-teachers/nuffield-research-placements

For the third year we hosted four Nuffield Research Placements, with students undertaking hands-on projects contributing to the work of EPCC. As student supervisor Lorna Smith noted: "It was refreshing to have the work experience students on-site. They brought a different perspective to their projects and identified issues and improvements early on."

Student Seamus worked on creating interactive visualisations from air quality data for a public audience. His work contributed to a longstanding collaboration between the universities of Edinburgh and Leeds. Kevin mapped UK HPC resources to help researchers find the most appropriate system for their needs. This involved researching UK HPC systems, writing a custom Python script to clean the data, and creating a Flask web app to produce an interactive web-based map.

Thomas compared the performance of a computational fluid dynamics (CFD) code on Wee Archie, our mini supercomputer, and ARCHER2, the UK national supercomputing service. The results will be used in EPCC outreach activities. Finally, Maya used Blender to visualise output from CFD simulations. She adapted the raw output for different uses and used EPCC's six-GPU workstation designed for visualisation.

EPCC summer students Lucas and Caroline.

Laura Moran and James Richings, EPCC
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Work experience placements

Our work experience placements give students the opportunity to learn about topics beyond what their school might offer. They are also exposed to an academic environment, learn some skills related to programming and software development, and complete a small project.

The benefits to EPCC in offering these placements include the opportunity to test new ideas in a short project and to give staff supervisory experience. In the past we have designed work experience projects to help develop outreach activities, ensuring the work and messaging are at the right level for school students.

This year our students explored themes including machine learning (ML) frameworks and benchmarking high performance computing (HPC) scripts which use OpenMP and MPI.

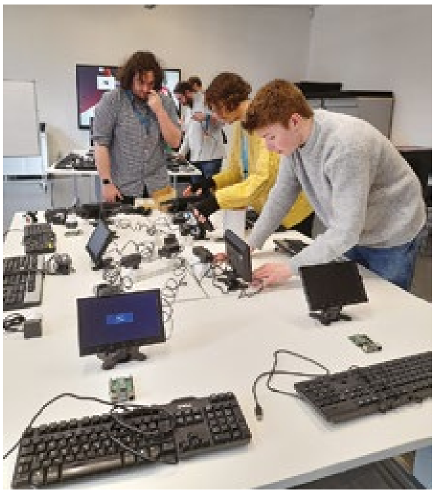
What our students say...

"My project used Cirrus to run code under different settings and then record and analyse the results. I found it extremely exciting to use such a powerful computer and my skills improved over the week with lots of patience and advice from EPCC staff. I found my placement so rewarding, interesting and fun!" Caroline

"My project involved me learning how to use the PyTorch machine learning library, the steps for creating a reinforcement agent, and how to train a model and create a neural network. I had a great experience and definitely recommend an EPCC work placement." Lucas

Outreach activities by EPCC

EPCC outreach has had an eventful year so far, with more to come!



Edinburgh Science Festival

In April, we took our new "Power of Programming" workshop to the Edinburgh Science Festival. Using BBC micro:bit boards, attendees learned how computers can work together to solve problems such as modelling the spread of infectious diseases. The micro:bit board can communicate to other boards via radio, and with a bit of clever programming you can have a group of "uninfected" micro:bits slowly become infected while moving around a space. It was a big hit, and we look forward to bringing this workshop to other events in the future!

Big Bang Fair

We made our yearly appearance at the Big Bang Fair in Birmingham in June. We had a blast and enjoyed our interactions with many of the 24,000 attendees over the three days! The refreshed Wee Archie had its first public outing at this event. The underlying framework has been redeveloped from the ground up and Wee Archie now has a Slurm scheduling system, just like we use on ARCHER2, and an improved, web-based user interface. This will help improve the development of future activities and allow several attendees to set up and run their own simulations at once. We also took along our sorting activity to demonstrate the benefits of working in parallel. This was given a new look by swapping the solid-colour balls with patterned socks to improve accessibility.

A new addition to our logic puzzle activity demonstrated just how fast computers can be by exploring what happens if we use a dice to act as a random number generator to pick choices. Rolling by hand is slow, but we also have new random-number based solvers for each of our logic puzzles that can find the correct answer in a fraction of a second, even on a relatively low-power laptop.

We are continually improving our activities, and the forthcoming refresh of Wee Archie's hardware will include GPUs to reflect the modern trend for HPC systems. A current MSc student has also begun the process of developing a new simulation for Wee Archie.

Finally, we are working on publishing more content online, such as VR tours of the main systems we host and web-based versions of the logic puzzles and their random solvers. We have also extended the micro:bit workshop with the help of summer placement students and are looking to develop new activities using these devices.

Darren White, EPCC
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EPCC Outreach at SC24

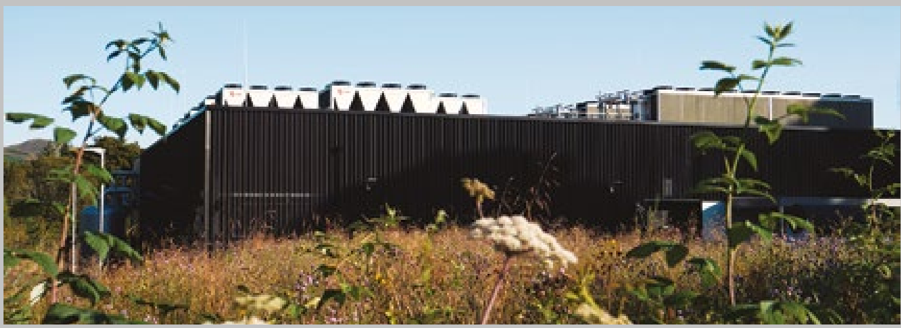
EPCC Outreach will be taking part in a scavenger hunt at SC24 in Atlanta, USA in November, where you could win a Raspberry Pi starter kit!

Discover and Learn is the outreach and public engagement website developed by the EPCC and ARCHER2 Outreach team.

https://discover.epcc.ed.ac.uk

Biodiversity at the Advanced Computing Facility

We have been working with the University of Edinburgh landscaping team to ensure we promote biodiversity within the ACF site and provide staff with opportunities to enjoy it.



The environmental footprint of the Advanced Computing Facility (ACF) is a key consideration for EPCC, and we have achieved significant energy efficiencies such as through natural cooling. What is less well known is the work we have been doing to enhance our outdoor space, improving biodiversity and recreation areas.

The ACF is located within the grounds of a former mansion house and its rural location makes it a haven for wildlife and a wonderful site for staff to enjoy. The University's landscaping team has further enhanced the campus by ensuring the biodiversity of the estate is maximised, for example with pollinator-friendly wildlife meadows and naturalised planting schemes.

The ACF is built around a ring of mature Scots pines and this roundel is a key part of the site and a beautiful place to relax. Seats have been added to the glass corridor that connects different parts of the ACF building, allowing this special area to be enjoyed in any weather.

Some pines have been felled recently for safety reasons. Rather than removing the wood, we are making efforts to reuse it, for example to create a large-scale bug hotel to support our invertebrate community.

The area beneath the roundel is largely left natural and is covered in a carpet of daffodils and bluebells in springtime. A natural bark path now links this area with other paths to create a circuit around the site, with the route including a straw path that loops through a nearby natural wild area which is a haven for pollinators. A focus of future work will be to further improve the accessibility of the pathways around the whole site.

The ACF is a secure site, and our fences are designed to maximise security. However, this doesn't mean they can't support local wildlife. We have been planting native hedging such as blackthorn, field maple, wild cherry, hawthorn and hazel along the fences to create a corridor for insects, birds and mammals. We are also creating small gaps at regular intervals along the fences to allow hedgehogs to roam freely across the site.

To maximise the site's value to wildlife, we aim to keep things as natural as possible. Large areas have been left to grow naturally, offering pollinator-rich sites. Possibly my favourite part of the site is an old, now unused fence close to the offices. This has gradually been colonised by brambles and over the summer provides what seems like an endless supply of berries for both wildlife and staff to enjoy.

Lorna Smith, EPCC
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We offer Masters' degrees in High Performance Computing (HPC); HPC with Data Science; and Imaging, Vision, and HPC.

EPCC is the UK's leading supercomputing centre. We are a major provider of HPC training in Europe, and have an international reputation for excellence in HPC education and research.

Our MSc programmes in High Performance Computing (HPC) and HPC with Data Science have a strong practical focus and provide access to leading edge systems such as ARCHER2 (the UK's National HPC Service), and Cirrus (an EPSRC Tier-2 National HPC facility including over 150 GPUs).

MSc students have the opportunity to undertake their dissertations as an industrial project, building on EPCC's strong business links. Recent project partners range from start-ups to multinationals.

Programmes can be undertaken on-campus (full-time and part-time) and online (part-time intermittent).

Optional course choices include modules from the School of Informatics and the wider College of Science and Engineering.

This year we also launched a new on-campus MSc programme in Imaging, Vision, and High Performance Computing in collaboration with Heriot-Watt University, UK.

Our graduates are in high demand in both academia and industry in the UK and abroad.

The University of Edinburgh is ranked in the top 30 universities in the world by Times Higher Education World University Rankings 2024, and 27th by QS World University Rankings 2025.

"Overall, my experience with EPCC has been excellent, especially thanks to my supervisor who has been incredibly dedicated. I am grateful to have had the opportunity to know such a great mentor and friend." **Yongkang Qiu** *On-campus MSc in HPC with Data Science, 2023-24*

"The programme was incredibly rewarding. I now feel well-prepared for a future career in HPC." **Petter Sandås** *On-campus MSc in HPC, 2023-24*

www.epcc.ed.ac.uk/msc