PostGraduate Institute
for measurement science

7th ANNUAL
PGI CONFERENCE
7-8 JUNE 2023, GLASGOW

Connecting Challenges and Solutions through Measurement Science

Learning and Teaching Building, University of Strathclyde,
49 Richmond Street, Glasgow, G1 1XU

NPL

Department for Business, Energy & Industrial Strategy

UNIVERSITY OF SURREY

University of Strathclyde Glasgow

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FOREWORD

We are delighted to welcome you to the 7th annual PGI Conference, which will be held at the University of Strathclyde this coming June. After three years of virtual meetings, we eagerly anticipate transitioning back to an in-person conference for PGI students, supervisors, and a wide array of delegates from academia and industry alike.

This year's programme is packed with presentations on science, engineering, and measurement, alongside sessions dedicated to career development. The PGI has grown significantly over the past eight years, and to match this spirit of progression, we offer this fantastic opportunity for all our students to immerse themselves in the conference experience: attending, presenting, and networking.

The opportunity for the PGI to forge and strengthen connections with both academia and industry has proven invaluable year after year, and we are confident this year will be no exception.

We are excited to officially welcome you to this year's conference and wish everyone an enjoyable and rewarding two days at the University of Strathclyde.

Agnieszka Sierhej & Tarek Haloubi
PGI 2023 Conference Co-Chairs

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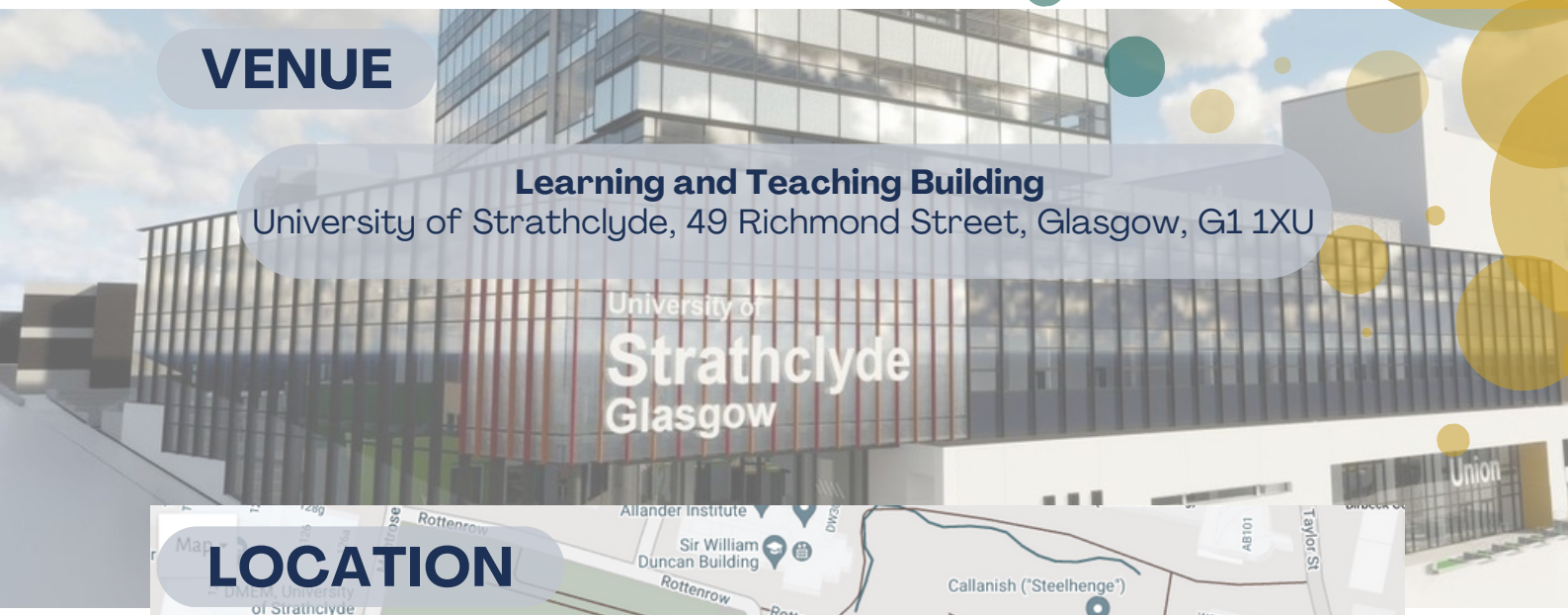
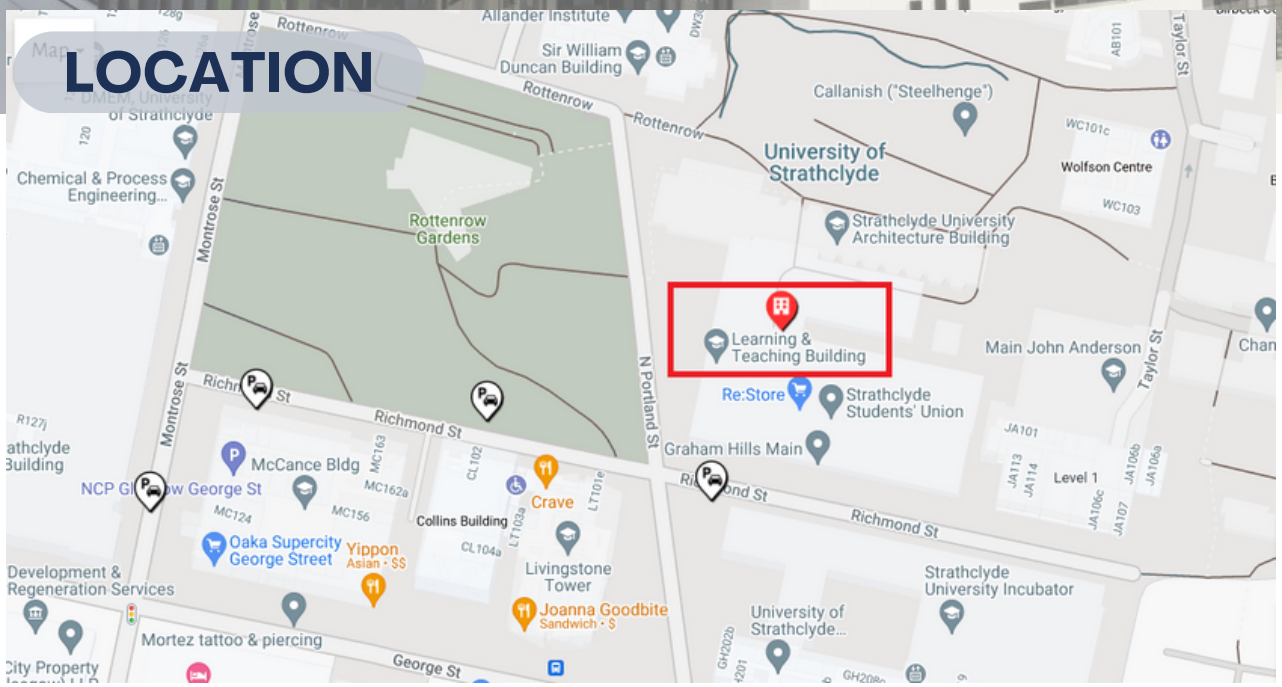
VENUE

Learning and Teaching Building
University of Strathclyde, 49 Richmond Street, Glasgow, G1 1XU



LOCATION



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PROGRAMME

DAY 1		7th JUNE 2023
Time	**Activity**	**Location**
09:30	Arrival and registration	TL 328
09:55	Opening remarks: Richard Burguete; PGI Director, *National Physical Laboratory*	TL 325b
10:00	Welcome: Gillian Docherty OBE; Chief Commercial Officer, *University of Strathclyde*	TL 325b
10:15	**Keynote: Responding to immediate crisis** *Allister Ferguson; Senior Advisor to the Pricipal, University of Strathclyde*	TL 325b
10:45	3D printed Phantoms for Quality Assurance in Paediatric Radiotherapy *Mariana Carreira Bento; University College London*	TL 325b
	Shedding light on the onco-immunogenic CCR5 receptor one protein at a time *Patrick Hunter; University of York*	
	Determining the feasibility of calculating a pancreatic cancer risk score for people with new diabetes in primary care: protocol for a data quality audit and descriptive observational study *Hugh Claridge; University of Surrey*	
11:15	Poster pitch and breakout	TL 325b
12:15	Poster session	TL 328
13:15	**LUNCH**	**TL 328**
14:00	**Keynote: Building Security and Resilience** *Adrian Burden; CEO, BlockMark Technologies Ltd*	TL 325b
14:30	Progress towards a compact cold-atom microwave clock *Martin Knapp; University of Oxford*	TL 325b
	Expanding seismic monitoring capability in a marine setting: environmental and event observations on a telecommunications cable *David Fairweather; University of Edinburgh*	
	SWaP: A Water Process Testbed for ICS Security Research *Matthew Calder; University of Strathclyde*	
15:00	**BREAK**	**TL 328**

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PROGRAMME

DAY 1 (continued)		7th JUNE 2023
Time	**Activity**	**Location**
15:30	**Keynote: Engineering the Future** *Rowena Innocent; SVP Engineering, UltraLeap*	TL 325b
16:00	Development of a high-pressure vessel for measurement and validation of tunable diode laser spectroscopy for gas turbine engines *Stuart Clark; University of Strathclyde*	TL 325b
	Large volume 3D imaging of defects in energy production materials *Jacopo del Gaudio; University of Manchester*	
	Development and Testing of OPTIMUM *Jonathan Heaps; University College London*	
	Labelling of Glycolytic Volumes in PET Using Deep Texture Analysis *Robert John; University of Surrey*	
16:30	**Awards & closing remarks**	TL 325b
17:00	**DRINKS RECEPTION**	**TL 401**
19:00	**DINNER AND CEILIDH; National Piping Centre**	

DAY 2		8th JUNE 2023
Time	**Activity**	**Location**
09:30	Arrival & coffee	TL 328
10:00	Welcome: Richard Burguete; PGI Director, *National Physical Laboratory*	TL 330
10:15	**Keynote: My life in metrology** *Peter Loftus; Deputy Director, UK Research Centre in Nondestructive Evaluation*	TL 330
10:55	Career panel: The power of the PGI and other Career networks	TL 330
11:55	Breakout with panel	TL 330
12:40	**LUNCH**	**TL 328**
13:30	**Workshop: Imposter Syndrome Masterclass** *Marc Reid; UKRI Future Leaders Fellow, University of Strathclyde*	TL 330
15:30	**Keynote: My life in research** *Muffy Calder DBE; Vice-Principal, University of Glasgow*	TL 330
16:00	Closing remarks	TL 330
16:15	**END**	

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KEYNOTE SPEAKERS

Allister Ferguson; *University of Strathclyde*

Allister Ferguson FRSE, is the Professor of Photonics in the Department of Physics at the University of Strathclyde. He founded the Institute of Photonics and has led discussions on the formation of the Technology and Innovation Centre and the establishment of the relationship between Fraunhofer and the university. He is a former Deputy Principal giving him responsibility for the university research and knowledge exchange portfolio. He was the principal investigator on a RCUK Science Bridges project that brought together four Scottish universities (Heriot Watt, Glasgow, St.Andrews and Strathclyde) with two Californian universities (Stanford and Caltech) under the banner of SU2P. He has worked with NPL since the early 1980s.

He was the recipient of the first NPL Metrology Award in 1983. He is a Fellow of the Institute of Physics, the Optical Society of America, the Institute of Electrical and Electronics Engineers and the Royal Society of Edinburgh. His present role is as Senior Adviser to the Principal.

Adrian Burden; *BlockMark Technologies*

Dr Adrian Burden is a serial technology entrepreneur with a background in material science. He undertook research on electron microscopy, display technology and nanotechnology before embracing the world of startups and scale-ups. In Singapore he was the founding CEO of an anti-counterfeiting spin-out called Singular ID, raising venture capital finance and exiting the business through a trade sale. He currently runs an innovation centre on the Malvern Hills, curates the annual Malvern Festival of Innovation, and is a co-founding director of a company that has launched a certificate management platform with blockchain and NFT functionality.

Adrian was previously a director of the UK Cyber Security Forum CIC social enterprise, a Royal Society Entrepreneur in Residence at the School of Metallurgy & Materials at the University of Birmingham, and chair of the Industrial Advisory Board at the School of Physics at the University of Bristol. He was listed as a Maserati 100 Entrepreneur by the Centre for Entrepreneurs in The Sunday Times in February 2015. Adrian is author of the book Start to Exit: How to maximize the value in your start-up, published in October 2017, and Inspiring outside the box: The ten-year backstory to the Malvern Festival of Innovation, published in October 2022.

Rowena Innocent; UltraLeap

Rowena Innocent is SVP Engineering at Ultraleap, a Bristol based tech company. Having recently jumped from instrumentation design and manufacturing to the tech industry, she leads a mixed disciplined team of scientists and engineers creating solutions focussed at the interface between human and machine, with world leading hand-tracking and mid-air haptics.

Rowena studied Physics with Astrophysics at the University of Leicester before beginning her career in metrology. She has worked with research and product development teams specialising in pressure measurement and material characterisation for a wide range of industries including pharmaceuticals and biopharmaceutials, motorsport, oil and gas, aerospace, chemicals, building materials and many other industries. A strong belief that STEM subjects should be accessible for all students, led Rowena to become a STEM ambassador early in her career and later a Trustee, Non-Executive Director, and Chair of the Partnership Advisory Group for NMITE (www.nmite.ac.uk). In 2021 she led the creation of the Spectris Foundation, funding improved access to STEM education.

Rowena is also an Aegis Professor for the science faculty and chair for the industrial advisory board for the School of Physics at the University of Bristol, and co-chair for the strategic advisory board for the Post Graduate Institute for Measurement Science.

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KEYNOTE SPEAKERS

Pete Loftus; *Centre in Nondestructive Evaluation*

Pete had a 38-year career in Instrumentation and Measurement at Rolls-Royce followed by a developing portfolio career where he has continued to indulge his passion for measurement and love of helping others to grow. His first challenges were concerned with the measurements associated with Jet engine testing. He progressed into managing this activity, ultimately running a department of 50 people working in this area before broadening his accountabilities. His role for his last 8 years with the company was Head of Measurement Engineering with accountability for ensuring the creation, maintenance, and improvement of all forms of measurement capability for the company worldwide. He holds a bachelor's Degree in Applied Physics and a Masters in Gas Turbine Engineering.

He is Chair of the UK Sensing Innovation Leadership Council; Deputy Director of the Research Centre for NDE, Past President of the European Virtual Institute for Gas Turbine Engineering; former member of the National Measurement Board and is active in the ASME International Gas Turbine Institute, The Institution of Engineering and Technology, BINDT and NCSLI as well as a CIM Conference organiser and Guest Editor of the International Journal of Turbomachinery Propulsion and Power. He reviews for Innovate UK, EPSRC, Euramet and ASME. He also has his own consultancy business: Evalu8ion Ltd.

Marc Reid; *University of Strathclyde*

Marc completed his Masters in Chemistry at the University of Strathclyde in 2011. In 2015, he completed his Carnegie Trust-sponsored PhD in Chemistry at Strathclyde. From 2015-16, Marc was a postdoctoral research associate at the University of Edinburgh. During that time, he was inducted into the SciFinder Future Leaders in Chemistry programme.

In 2016, Marc won the prestigious Leverhulme Trust Early Career Fellowship and re-joined the Department of Pure & Applied Chemistry at Strathclyde from 2017-20. This position was supported by GlaxoSmithKline, and he was thus the first Strathclyde-GSK Early Career Academic. In 2018, Marc was selected to participate in the Scottish Crucible leadership program, the Merck Innovation Cup, and was part of the Converge Challenge Entrepreneurship Competition Top 30. In 2020, Marc became a CPACT-supported Research Fellow and then Lecturer for Innovation in Education at the University of Bristol.

Most recently, Marc was awarded a UKRI Future Leaders Fellowship, joining the Department of Pure & Applied Chemistry at Strathclyde in 2021. He holds a visiting lectureship at the University of Bristol, and a visiting Enterprise Fellowship in the Hunter Centre for Entrepreneurship at the University of Strathclyde. In 2021, Marc completed Seth Godin's altMBA. Outside academia, Marc is the founder of the safety culture and accident readiness company Pre-Site Safety. He is the author of the book 'You Are (Not) a Fraud: A Scientist's Guide to the Imposter Phenomenon'.

Dame Muffy Calder; *University of Glasgow*

Muffy Calder has been Vice-Principal and Head of College of Science and Engineering, University of Glasgow, since 2015, previously she was the Chief Scientific Adviser for Scotland. She has a PhD in Computational Science from the University of St. Andrews, a BSc in Computing Science from the University of Stirling, and Honorary DSc's from University of Edinburgh and Strathclyde.

She is a computer scientist with research interests in modelling and automated reasoning for complex, interactive, and sensor-driven systems. She is a member of the Prime Minister's Council for Science and Technology and was deputy chair of REF Main Panel B. Previously, she was a member of UKRI-EPSRC council and chair of the EU Future and Emerging Technologies Science Advisory. She has been a Royal Society Leverhulme Research Senior Fellow and a Suffrage Science award winner in Computing Science and Mathematics. She was awarded the DBE in 2020 and OBE in 2011.

She has collaborated with scientists and engineers from a wide range of disciplines, from Electrical and Aerospace Engineering, to Cancer and Cardiovascular medicine. She has worked with companies including NATS and in the distant past she was a research fellow at BT Research Laboratories and at DEC (Digital Equipment Corp) Research Labs in California.

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ABSTRACTS - PGI
ORAL PRESENTATIONS

Mariana Carreira Bento; *University College London*

Around 30 years ago, ionizing radiation was discovered and its benefits for medical applications were quickly understood. Ionizing particles are nowadays widely used for cancer treatment, also known as radiotherapy. In radiotherapy, cancer cells are irradiated and killed with high doses of radiation.

However, the interaction of radiation with the body tissues is not only beneficial and the healthy tissues in the patients' body are at risk to suffer from toxicity. Treatments are therefore performed so that high doses are delivered to the tumour cells, within the target volume, while avoiding the surrounding healthy tissues. Quality assurance techniques are required to ensure that the treatments are delivery as intended, in order to achieve the best treatment outcomes and avoid consequent secondary ill conditions caused by the damage of healthy tissues.

Paediatric patients, in specific, have a higher risk to develop late secondary effects due to radiation toxicity, as their tissues are still developing, and these patients will also live longer periods of time with such conditions. Anthropomorphic physical phantoms, that represent the human body, both at the anatomic and tissue composition levels, have been proposed in the past for quality assurance applications in radiotherapy.

In this study, 3D-printing technology is explored for the development of children anthropomorphic phantoms. This alternative technology is associated with reduced manufacturing costs and allows for higher customisation of the models to be better suited for paediatric applications.

Patrick Hunter; *University of York*

With around 375,000 new cases of cancer reported across the UK annually, the advent of effective therapeutics would help to relieve crises within health services and amongst thousands of families across the UK. The ability of tumors to establish a pro-tumorigenic microenvironment is an important point of investigation in the search for new therapeutics.

Tumors form microenvironments in part by the "education" of immune cells attracted via chemotactic axes such as that of CCR5-CCL5. Further, CCR5 upregulation by cancer cells, coupled with its association with pro-tumorigenic features such as drug resistance and metastasis, has suggested CCR5 as a therapeutic target. However, with several conformational "pools" being reported, phenotypic investigations must be capable of unveiling conformational heterogeneity. Addressing this challenge, we performed super-resolution structured illumination microscopy (SIM) alongside single-molecule partially TIRF-coupled HILO (PaTCH) microscopy of CCR5 in fixed cells.

A newly developed technique, PaTCH microscopy utilises a novel intermediary angle of excitation beam delivery which benefits from the high signal-to-noise ratio of total internal reflection fluorescence (TIRF) microscopy and the increased penetration depth of highly inclined and laminated optical sheet (HILO) microscopy. SIM data revealed a non-random spatial distribution of CCR5 assemblies, while intensity-tracking of CCR5 assemblies using PaTCH indicated dimeric sub-units independent of CCL5 perturbation. Extended studies investigate the effect of CCR5 antagonists such as Maraviroc, a HIV therapeutic considered for clinical trials in cancer patients, on the behaviour of CCR5 on the cell surface.

These biophysical methods can provide important insights into the structure and function of onco-immunogenic receptors and many other biomolecules, with the capability of these techniques being showcased in a recently published research article 'https://www.sciencedirect.com/science/article/pii/S2589004222019472'.

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ABSTRACTS - PGI
ORAL PRESENTATIONS

Hugh Claridge; *University of Surrey*

Globally, pancreatic cancer is the seventh leading cause of cancer deaths, responsible for 4.7 % (466,003 decedents). However, we are facing an immediate crisis, as in Europe it is projected to overtake breast cancer as the third leading cause of cancer deaths by 2025.

Early diagnosis and surgical resection offer the best chances for long-term survival, but as the majority are diagnosed at advanced stages, 5-year survival in the United Kingdom is below 7 %. Pancreatic cancer in its early stages is difficult to recognise and diagnose, and therefore technological advancements using healthcare data are urgently needed to help clinicians respond to this crisis. With the emergence of big data and its availability for research, numerous prediction algorithms have been developed for the earlier diagnosis of pancreatic cancer based on primary care data. However, only a few of these models have been externally validated, and one of these models is the Enriching New-Onset Diabetes for Pancreatic Cancer (ENDPAC) risk prediction model.

ENDPAC uses three simple measures: age of a patient, blood glucose and body weight to produce a risk score for a patient. This makes it ideally suited for primary care, as these data are routinely collected in this setting. In this study, we will contribute to the scientific community's response to the pancreatic cancer crisis by investigating the feasibility of calculating ENDPAC scores in a UK primary care setting.

ENDPAC is effective in predicting pancreatic cancer, however, because it has been developed and validated in the United States, it is unknown how possible it is to apply it in a real-world primary care setting in the UK. As the performance of ENDPAC is affected by the availability, standardisation, and quality of the data we will develop and test a method of extracting and standardising the clinical information required and undertake a data quality audit to investigate the feasibility of using ENDPAC in a UK primary care setting.

Martin Knapp; *University of Oxford*

Over the years, significant progress has been made to develop new types of compact microwave atomic clocks. Their small size and portability make them suitable for a variety of applications including telecommunication synchronisation, tests of fundamental physics, autonomous deep space navigation and Global Navigation Satellite System (GNSS) holdover to name a few. This last application is particularly important, whereby a great deal of critical national infrastructure relies on timing signals from GNSS. Compact microwave clocks can serve as holdover references during periods of GNSS outages. These outages can be accidental or malicious.

Existing compact atomic clocks typically operate using thermal atoms confined to a vapour cell with a buffer gas. Thermal atoms at room temperature have velocities of ~100 m s-1 and hence a large second-order Doppler shift of the observed resonant frequency ($\Delta\nu/\nu 0$ = 10-13). Additionally, long-term drifts associated with the buffer gas composition ultimately limit the stability and accuracy of these clocks.

Laser-cooled atoms have velocities of ~10 cm s-1, thereby mitigating the Doppler shift and the need for buffer gas. This leads to improved accuracy and stability. However, the experimental complexity that accompanies laser cooling can increase the overall clock size. The primary focus of our research is to develop a compact cold-atom microwave clock. Thus far we have constructed a demonstrator system which is capable of cooling caesium atoms to measured temperatures of ~20 μK. Preliminary microwave spectroscopy of the clock transition has been conducted. The next steps involve operating the system as a clock and characterising the performance.

The next generation of compact clocks will use laser cooling. Their ability to provide enhanced accuracy and stability will lead to improved capabilities for the previously mentioned applications. In particular, this will strengthen the resilience of national infrastructure in relation to GNSS holdover capabilities.

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ABSTRACTS - PGI
ORAL PRESENTATIONS

David Fairweather; *University of Edinburgh*

Optical interferometry can be used to measure the travel time of the light along fibre optic cables, enabling the detection of environmental perturbations such as earthquake waves as they interact with the cable.

However, at any point in time, the measured signal is the sum of the optical path length changes along the entire fibre. This can result in a low signal-to-noise ratio, since the ambient noise along the entire length of the seafloor cable is integrated. Over the lengths of 1000s kilometres of transoceanic seafloor cables, this can prevent the detection of smaller magnitude events.

We present a novel technique that allows many separate spans along a single fibre optic cable to be used as individual ocean bottom seismometers. These spans are tens of kilometres long and means a reduction in sensor length from a whole-cable distance to just a fraction of it. This allows us to monitor specific locations along the cable path simultaneously.

Over a period of four months, we show that earthquakes, tides, wave heights and ocean microseisms can all be recorded on these individual spans on a 5,860 km-long transatlantic cable, in addition to monitoring along the whole cable length. On the continental shelf we observe strong correlations between periodic signals at different frequencies with tides, wave heights and microseisms. In the comparatively quieter deep ocean we have detected two teleseismic earthquakes greater than Mw7. Other enigmatic signals related to ocean tides and the solid Earth's microseisms are also evident.

By demonstrating the sensitivity to these signals we show that using pre-existing infrastructure in novel ways can aid and enhance the global seismic monitoring capability. By expanding this coverage, there is a potential benefit to the resilience of collocated communities in previously under-monitored areas.

Matthew Calder; *University of Strathclyde*

We present the Security Water Processing (SWaP) testbed, an Industrial Control System (ICS) for security research and training.

SWaP will be used to (a) assess the security of industrial protocols, (b) design and test defensive technologies, (c) assess the effectiveness of side-channel based defenses, and (d) share datasets with the security community. SWaP consists of a 3-stage water process, each stage is autonomously controlled by Programmable Logic Controllers (PLCs).

The local communications between sensors, actuators, and PLCs is realized through wired and wireless channels. The testbed is designed to be a resource to a wider research community and encourage collaborative research in the field of ICS security. We envision to make this resource available for practical work among the ICS security community. Towards that end, as a first step, we have collected and curated a dataset to be shared with the research community.

Moreover, given the scarcity of attack/anomalous data; several attacks are designed and executed on the testbed, providing examples of attack data, which can further be used for model based and machine learning based security research.

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ABSTRACTS - PGI
ORAL PRESENTATIONS

Stuart Clark; *University of Strathclyde*

Air travel has become an integral part of modern life but is a significant contributor to climate change. As the world moves towards a low carbon future, airlines face significant challenges to achieve the UK governments "Jet-Zero" target by 2050.

A better understanding of the combustion process is required to ensure continued efficiency improvements in current gas turbine engines and to measure the performance of alternative fuels, such as synthetic or hydrogen fuels; this can be achieved by accurately measuring the gas parameters and distribution of combustion gases, particularly understanding stoichiometry.

Tunable diode laser spectroscopy is an a non-intrusive, in-situ technique which can be used for the measurement of the concentration, pressure, and temperature of gas species using high repetition rates and in hostile environments. The gas parameters can be obtained from the experimental data by fitting to modelled gas absorption spectra calculated from a database of line parameters, such as HITRAN. At the temperature and pressures found in gas turbine engines HITRAN does not accurately model the absorption spectra, resulting in large confidence intervals.

It is therefore essential for an improved model that a detailed investigation of the absorption spectra of key combustion gas species is carried out in a controlled high temperature and pressure environment. A high pressure and temperature spectrometer was built for the interrogation of the absorption features at 1964 and 1999 nm in a controlled environment to improve the confidence interval of the modelling of combustion gases at these wavelengths. The improved modelling approach will inform and verify a multi-species tomographic imaging system for use in both exhaust and in-combustor applications.

Jacopo del Gaudio; *University of Manchester*

Femto-second laser ablation is a technique of ablation that can be used in a scanning electron microscope to build up a 3D model through an analysis of numbers of 2D layers analysed by slicing a sample. It has some advantages over the FIB and BIB milling, but the most noticeable is much higher materials removal rates in fs-laser ablation.

In this project we are interested in the analysis of materials used in nuclear industry, such as Stainless Steel, Nickel superalloys, oxide layers on Zirconium alloys, which are tested under severe stress and environmental conditions. The scanning electron microscope can be used to image, measure orientation and chemistry of the surface using secondary electrons, electron back scatter diffraction (EBSD) and energy dispersive spectroscopy (EDS) analysis techniques.

Microstructural features, such like grain size and crack path can be measured with accuracy. Moreover, in order to transition from the 2D surface to the 3D bulk, the ablation process has to be well understood in terms of material removal rate and final surface topography. In order to perform a correct evaluation, it is necessary to fully understand the physics behind the measurement and build a physical model.

Femto-second lasers have ultra-short pulses which minimise heating of the sample, but can produce some microstructure changes in the first nanometres depth, where a final passage with a FIB can remove this top layer with a less compromised one. Finally, one task of this project is to will specify design a guidance line on thef parameters used to perform correct and precise characterization of materials.

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ABSTRACTS - PGI
ORAL PRESENTATIONS

Jonathan Heaps; *University College London*

The National Physical Laboratory (NPL) is currently developing a novel Large Volume Metrology (LVM) instrument, Optical Tracking for Measurement Using Multilateration (OPTIMUM), which is a Coordinate Measurement System (CMS) capable of; operating in a volume of 10 x 10 x 5 m.

OPTIMUM benefits from simultaneously measuring multiple targets at accuracies that match or exceed current state of the art (SOA) instruments; inherent self-calibration and compensation of systematic errors; built in traceability and on-line uncertainty estimation.

OPTIMUM has been designed to engineer the future, currently research and development is being carried out at NPL and the Advanced Manufacturing Research Centre Wales (AMRC Cymru) specifically looking into how the manufacturing and testing of aerospace components can be improved and streamlined, with further testing being carried out at Airbus on their wing testing facility.

This presentation will provide an overview of the OPTIMUM system, how it differs from current SOA metrology instruments and present results on the development and testing of the instrument and provide an insight into how OPTIMUM can push the boundaries of current manufacturing processes.

Robert John; *University of Surrey*

Positron Emission Tomography and Computed Tomography (PET-CT) imaging is essential for diagnosing, staging, and planning cancer treatments. This study employs a cutting-edge artificial intelligence (AI) technique, known as a 5-layer 3D convolutional deep learning model, to identify specific regions in PET-CT data related to cancer metabolism.

Using data from 486 oesophageal cancer patients, the model achieves high accuracy in differentiating primary tumour patches from other tissues. By examining the network's activations, we identify unique patterns for four classes of metabolic uptake: primary tumour, bladder, liver, and myocardium. Principal Component Analysis (PCA) is performed on these activations to reveal uncorrelated features learned during training, further demonstrating unique clusters of features in PCA space.

This information is used to optimise the network by removing low activation probability nodes, resulting in a more efficient and accurate deployable network. In line with the theme "Engineering the future," this research advances the field of medical imaging by harnessing the power of AI to revolutionise cancer diagnosis and treatment planning. The findings contribute to improved cancer detection and treatment, ultimately promoting better patient outcomes.

Moreover, the optimisation of the network and the exploration of uncorrelated features through PCA ensure a more interpretable AI system, facilitating its adoption by medical professionals. As a key component of "Engineering the future," this study demonstrates the potential for AI to bring us closer to a world with more personalised and effective cancer treatments.

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