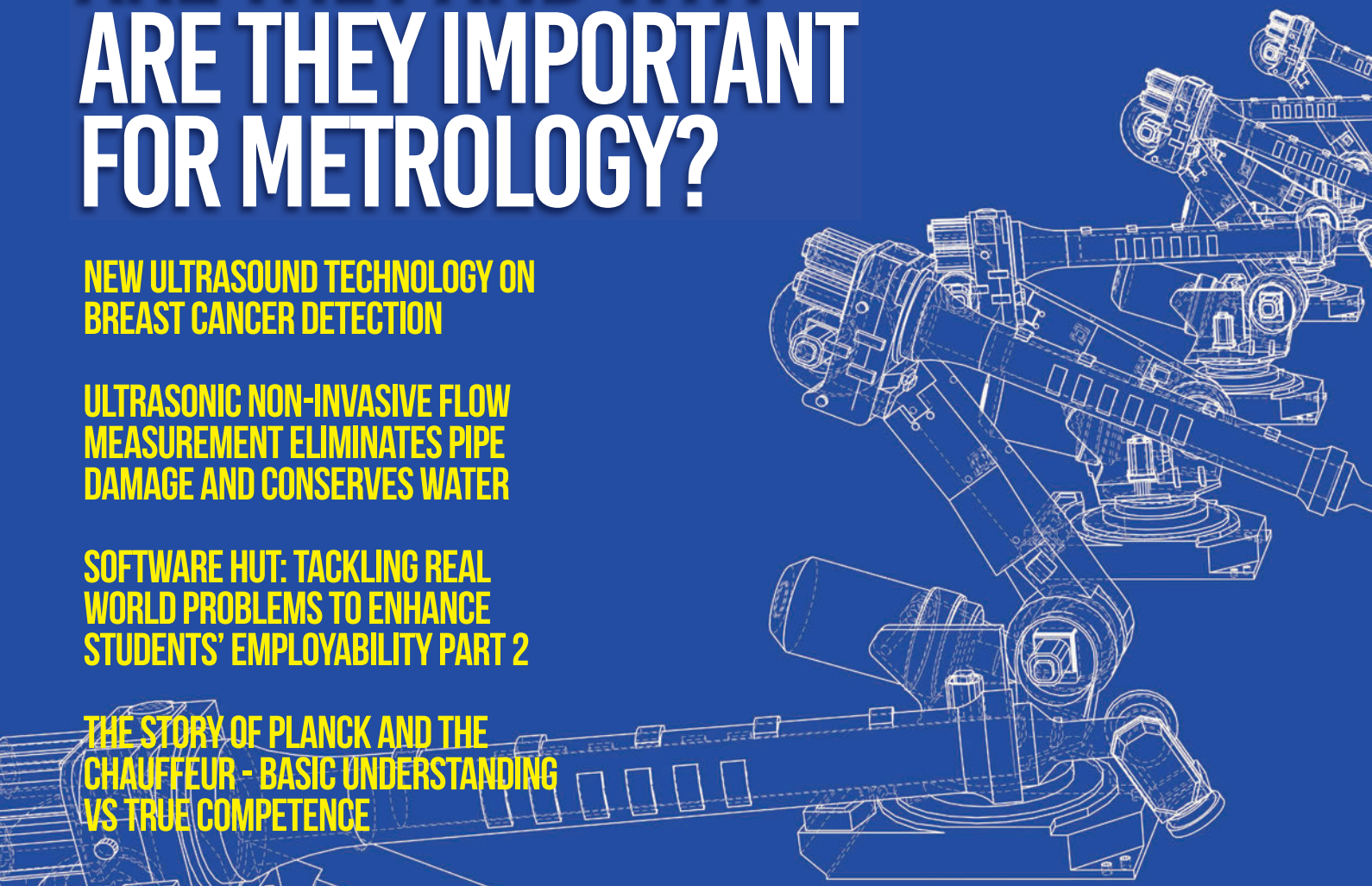
DIGITAL TWINS: WHAT ARE THEY AND WHY ARE THEY IMPORTANT FOR METROLOGY?



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DECEMBER 2022 ISSUE 26

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INSTMC END OF YEAR REVIEW

2022 has been an interesting and productive year for the Institute. As we started to feel we were moving out of the shadow of the Covid pandemic, we were able to organise and attend so many more face-to-face meetings and events than we had in the previous two years.

A particular highlight for me was our Prizes and Awards evening in October. Along with celebrating the 2020, 2021 and 2022 winners, it was an excellent opportunity to catch up with volunteers and members, many of whom I had not seen in person since early 2020 or even 2019.

In the spring of this year, we launched our brand-new website and membership database. We are really pleased with the final product and, based on feedback we have received, so are the members. The new site gives you the members more control of your profile and should make managing your membership and subscription payments much easier. It also provides a better platform for the Local Sections and Special Interest Groups to keep us all up to date on their activities and events.

We welcomed a new Special Interest Group this year, the National Metrology Skills Alliance, who are in the process of drafting a comprehensive competency standard for professional metrologists. Keep an eye on Precision in early 2023 to see how you and your organisation can get involved with the beta testing of the new standard.

At the end of this year, we come to the end of term for a couple of Institute Officers. Martin Belshaw and Ian Craig finish their terms as President and Honorary Treasurer and I would like to thank them for their work and support over the last few years. In their place, in 2023, we welcome Sheila Smith as the new President and Stewart MacFarlane as Honorary Treasurer.

With the current looming cost of living crisis, I want to use some of this space to remind members that we have fee remission available to support members who find themselves in temporary financial difficulties, so you do not have to give up you membership or professional registration. We have also taken the decision not to increase our fees for 2023.

I wish you all a Merry Christmas and a Happy 2023.

Steff Smith Chief Executive
Institute of Measurement and Control

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ARTICLES

PRECISION

The magazine of the Institute of Measurement and Control
Published by: Institute of Measurement and Control
297 Euston Road, London NW1 3AD T: +44 (0) 20 7387 4949
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Chief Executive Steff Smith
E: steff.smith@instmc.org

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BY DR MARCOS KAUFFMAN, DIRECTOR, INSTITUTE FOR ADVANCED MANUFACTURING AND ENGINEERING, COVENTRY UNIVERSITY & PROF. TREVOR TOMAN, HEAD OF METROLOGY, COVENTRY UNIVERSITY

DIGITAL TWINS: WHAT ARE THEY AND WHY ARE THEY IMPORTANT FOR METROLOGY?

The rise of Industry 4.0 and the manufacturing and engineering efforts in digital transformation over the last decade have given rise to a number of exciting new technologies and solutions applied across all corners of industry.

Despite the numerous advances, many businesses and solutions providers from across the spectrum are still struggling to achieve a return on investment on digital transformation initiatives.

Over the last 12 months the two authors attended more than 10 events and conferences across Europe and have heard from manufacturers and solutions providers of all sizes. However, there are still significant gaps in understanding some of the fundamental concepts of Industry 4.0 and more importantly how to implement such concepts to generate business value.

One important emerging Industry 4.0 technology, which is highly dependent on metrology and measurement systems, is the concept of Digital Twins (DTs). DTs has gained exponential levels of interest and according to Google Trends even tops general search interest in widely searched topics such as "Industrial IoT" or "IoT".

In this article we seek to explore three key points.

i) What DTs are and why they are important for your digital transformation in the long term;

ii) Why metrology and measurement systems are paramount to the effectiveness of high-fidelity DTs;

iii) A proposed approach to the implementation of DTs developed by our team as part of a collaborative project implementing multiple DT use cases.

What Digital Twins are and why they are important for your digital transformation in the long term

The concept of DTs can be traced back to a model introduced by Grieves (2002). However, it has only gained mainstream manufacturing and engineering attention over the last five years. As is usual with new and complex concepts, there still exists much confusion in academia and industry as to what exactly a DT is.

For example, ISO 23247-1:2021 provides a simplified definition of a DT as "… a fit for purpose digital representation of an observable manufacturing element with synchronization between the element and its digital representation."

Based on our team's experience in implementing DTs we have developed our own definition which provides a slight variation of that available in the ISO standard. For us a DT is "a digital representation of a physical asset synchronised at the appropriate fidelity level to deliver value."

Let's clarify this definition. By "digital representation" we mean that a DT will provide a representation of a real-world asset in a virtual

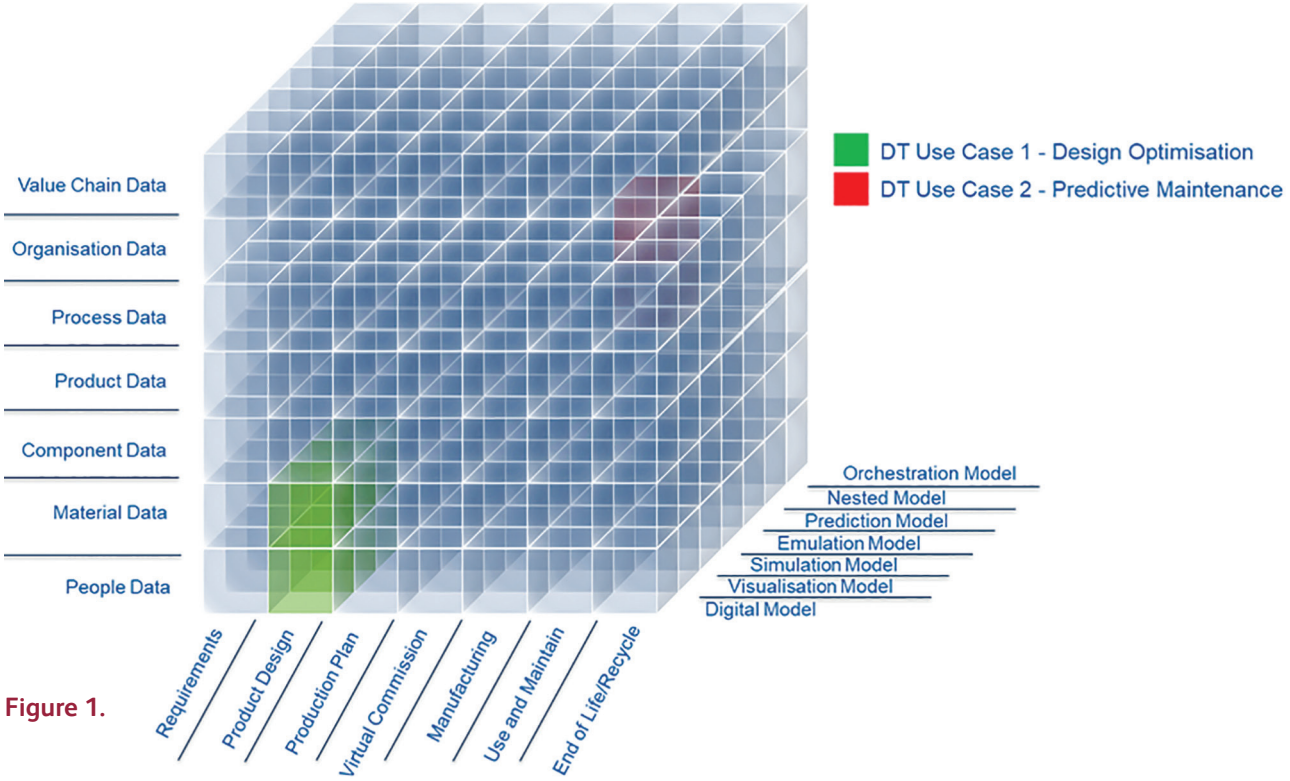

Figure 1.

environment through data, models and sub-models.

"Appropriate fidelity" means that a DT is capable of providing varying degrees of realism in the digital representation as required to achieve a particular outcome.

By "synchronised" we mean that the DT will eventually be connected to the physical asset and will transmit and receive data at an adequate frequency to represent a given asset instance in the digital world. Finally, "deliver value" means that the DT provides benefit to an individual, organisation, society or environment and such value is derived from the DT's intended purpose.

Despite efforts to convey a simple and concise text definition, we believe that models and frameworks are a much better way to describe and understand concepts. This short article will provide one such model to shed light in the concept of DTs.

To create a model to explain the various ways in which a DT can be characterised across different use cases and applications we have designed a seven-layer three-dimensional DT reference framework inspired by the Reference Architecture Model for Industry 4.0 (RAMI). The three axes are designed to demonstrate the i) datasets, ii) the life cycle phase and iii) the level complexity of the digital and computational representation.

The coloured cubes within the bigger cube represent individual use cases. A simplified example of a DT use case for product optimisation can explain how the above model can help understand the composition of distinct and yet, complementary DT use cases. In the diagram (Fig. 1) the colour green is used to demonstrate use case number one. In this scenario, people data in the form of know-how and experience is combined with material data (y axis), compiled at the product design phase of the life-cycle (x axis), and used to create a simulation model (z axis) that can be connected with the real product in order to identify opportunities for optimisation.

Why metrology and measurement systems are paramount to the effectiveness of high-fidelity Digital Twins

Trust in data is a key element of a successful and sustainable digital transformation. The sharing of data with quantified levels of quality will ensure developer, customer and supplier are guaranteed the data they send or receive has a clear statement of quantity and dispersion that has been agreed as suitable for the task at hand.

There are many reasons for ensuring captured data is trustworthy; these include calibrations, research and development and comparing of results and standards, including reference data and materials. This evidenced trustworthiness of data underpins trade, scientific research, business and development. Measurements taken in one place must be repeatable in another, within the stated uncertainties. These uncertainties of the data can be applied, as they are today in calibration and complex measurement systems to give a probability statement in terms of levels of confidence based on the complete system.

Measuring devices and systems are inseparably linked with processes and systems, capturing increasingly more data which is opening new opportunities in business. However, this will not just happen by accident; a quality infrastructure, consisting of metrology, accreditation, conformity assessment, norms & standards and

market surveillance must be in-place to ensure smooth running between stakeholders. These must include reliable systems and processes for digital calibration certificates, virtual measuring instruments, research data management and digitally supported testing and approval processes, all in compliance to metrology standards such as ISO/TS 17025. This standard clearly states the requirements of the properties of data, two of which are critical to trust in data, being traceability of measurement and measurement uncertainty.

DTs can be used for timely, autonomous decision-making from data arriving from multiple locations and in multiple units. Clearly defined datasets are critical to making the right decision, but these decisions will be made at a far greater frequency in ever more complex systems.

Implementing Digital Twins in multiple use cases

Let's consider a DT with a temperature sensitive output that depends directly or indirectly on measuring the temperatures of multiple units at multiple sites. Just stating, for example, it is 20 or 25 degrees Celsius is insufficient. Temperature as an influencing factor changes other quantities such as length. If the same length is measured at 20 and at 25 degrees Celsius the length measured will be different due to the temperature difference, therefore all direct, indirect and influencing factors should be measured to the appropriate level of accuracy, frequency and confidence levels required for the task at hand, otherwise comparisons of results could be misleading and costly.

20 degrees Celsius tells us nothing about the quality of the measurement; it could be +/- 10 degrees – we have no way of knowing.

The correct format for reporting in metrology would be, for example, 20 degrees Celsius +/- 0.4 degrees Celsius @95 % (K=2) confidence levels. This tells us there is a 95 % confidence that the result lies within 20 +/- 0.4 degrees Celsius with a coverage factor of K=2 (for further reading see T-distribution and coverage factors). This measurement result tells us about the quality of the measurement data and therefore, trustworthiness of the measured result.

International standards such as ISO/TS 17025 state the requirements for accurate and traceable measurement, calculating and reporting (not the subject of this article), this also applies to measured data that is shared.

Why is this important?

Trusted data, captured for a specific purpose, by trusted measurement systems is critical for confidence in decision-making, be that by humans or machines, to evidence quantified levels of customer and supplier trust giving confidence when sharing data. This trust in data will drive improvements in the operational systems through real-time comparisons and analysis.

Conclusions

Processes, machines, systems, and businesses are increasingly sharing timely data in to ensure smoother transactions internally and externally. This sharing of data has the potential to propagate errors as it travels through and changes in reaction to measurement stimulus, both directly and indirectly (e.g., temperature). Incorrect data updating the DT will result in false decisions and feedback to the real-world instance. Once these data start to travel through the systems, errors will propagate and expand further with time.

What can be done to address this? Compliance with international standards in metrology must be evidenced throughout the development and operational stages for each DT use case. This needs Stakeholder agreement on clearly defined business/system requirements and specifications for:

- Definition of value drivers
- Definition of digital twin use cases and scenarios
- Definition of digital twin scope and architectural design
- Definition of required accuracy and traceability
- Compliance with international metrology and digital twin standards
- Protocols for sharing data
- Protocols for testing of data
- Definition of measurement methods and systems
- Definition uncertainty rules and uncertainty management
- Methods of validation and/or qualification to higher standards
- Definition of frequency and fidelity of measurement
- Clear ownership and responsibilities
- Risk model for reactivity to unplanned occurrences.

A DT use case designed with a measurement system for data capture that is traceable to national standards and linked to the virtual twin will give confidence in performance and decision-making. This will also drive improvements for the system architecture, data capture systems and in-field monitoring and management confidence.

References:

BS ISO 23247-1:2021 Automation systems and integration. Digital twin framework for manufacturing. Overview and general principles.

RAMI 4.0 Reference Architectural Model for Industrie 4.0. Available at: https://www.isa.org/intech-home/2019/march-april/features/rami-4-0-reference-architectural-model-for-industr

Grieves M: Completing the Cycle: Using PLM Information in the Sales and Service Functions [Slides]. SME Management Forum, Troy, MI. 2002.

Grieves M: Virtually Intelligent Product Systems: Digital and Physical Twins. In Complex Systems Engineering: Theory and Practice, edited by Shannon Flumerfelt, Katherine Schwarttz, Dimitri Mavris and Simon Briceno, In Progress in Astronautics and Aeronautics, American Institute of Aeronautics and Astronautics. 2019; 175–200.

VIM (BIPM): JCGM 200:2012 International vocabulary of metrology - Basic and general concepts and associated terms (VIPM) (bipm.org)

ISTS 17025: https://knowledge.bsigroup.com/

Evaluation of measurement data — Guide to the expression of uncertainty in measurement: Guide to the expression of uncertainty in measurement - JCGM 100:2008 (GUM 1995 with minor corrections - Evaluation of measurement data (bipm.org)

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NEW ULTRASOUND TECHNOLOGY ON BREAST CANCER DETECTION

BY DANIEL SARNO, NATIONAL PHYSICAL LABORATORY (NPL)

Scientists at the National Physical Laboratory (NPL) have demonstrated the first in-person use of new ultrasound technology which aims to improve breast cancer outcomes through earlier diagnosis and monitoring effectiveness of treatment.

The innovative ultrasound technology provides quantitative measurements of breast tissue which, when developed into a medical device, will offer clinicians a non-invasive, simple tool to determine breast composition. Providing the capability for doctors to carry out reliable measurements is key to meeting the demand for more effective and efficient breast cancer care.

Breast cancer is the most common cancer in the UK and the second most common cause of cancer death in women. The NHS Breast Screening Programme invites women aged between 50 and 71 every three years for mammogram screening. Early detection and diagnosis of the disease improves survival rates and personalised breast screening models are being explored that incorporate individual cancer risk factors. Breast density – a measure of breast composition reflecting the balance of fibroglandular and fatty tissue in the breast – is a significant risk factor for breast cancer. Women who have extremely dense breasts are as much as 6 times more likely to develop breast cancer than women with low breast density. Leading charity Breast Cancer Now has warned that more than 700,000 women in the UK are living with this hidden risk. In addition, denser breasts appear cloudier on mammographic images (see Figure 1) which makes it significantly harder for clinicians to detect early signs of breast cancer.

Breast density is currently estimated from mammogram and MRI images with software analysis tools and discrete classification by clinicians. However, these existing modalities are not practical for routine measurement and there is no consensus on the best method of breast density assessment.

Development and testing of a unique ultrasound sensor and technology platform at NPL offers a path to quantitative measurement of breast tissue using ultrasound, with the potential for significant impact in breast density assessment, breast cancer diagnosis and therapy response monitoring. The study involved the participation of 12 NPL staff members and was facilitated by University Hospitals Bristol and Weston NHS Foundation Trust clinical scientist Dr Sian Curtis. Participants were invited to use the Quantitative Ultrasound Computed Tomography (Q-UCT) scanner and measurements were taken of a tissue property known as acoustic attenuation. The measurements made by the Q-UCT scanner were found to be in good agreement with previously reported data of the acoustic attenuation of the breast

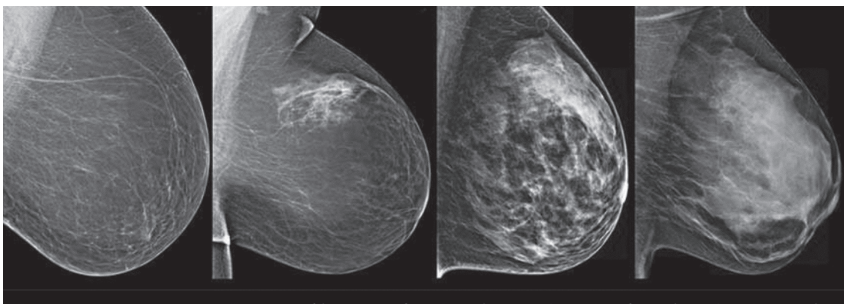

Figure 1. Mammogram scan images of breasts of various breast densities from low density on the left to high density on the right.

from both in vivo and ex vivo tissue samples. The results also showed early indication of the capability to measure expected changes in breast composition with age. This study provides vital reference data on the acoustic attenuation of breast tissue for research and the medical communities to use in applications such as ultrasound scanner design and image reconstruction algorithms. Crucially, the outcome of the study increased confidence in the technology and measurement approach that has been developed by the NPL ultrasound team.

This latest study followed a systematic development and testing programme for the patented ultrasound technology. In the early 2000s, NPL developed a new type of ultrasound receiver in response to the challenges observed in acoustic power and attenuation measurement. Acoustic attenuation is a measure of the loss of ultrasound from the interaction with the structures of a medium and is a useful biomarker for soft tissue characterisation.

How it works

Conventional ultrasound detectors rely on a phenomenon known as the piezo electric effect to transduce sound pressure waves into sensor output through mechanical compression of the sensor material. This means these receivers respond to individual compression and refraction wavefronts, also known as phase sensitivity. Phase sensitivity, however, can be an undesirable property when it comes to determining the acoustic power, especially when measuring ultrasound with highly structured wavefronts such as those that have travelled through the breast. The new ultrasound sensor developed at the National Physical Laboratory (NPL) relies on a related phenomenon known as the pyroelectric effect to transduce sound pressure waves into sensor output through the heating of acoustic absorber in the sensor structure. This mechanism is fundamentally phase insensitive and allows for the construction of large area ultrasound sensors that have a broadband and omni-directional response. The result is a unique sensor that is less prone to refraction artefacts and phase cancellation errors.

Through successive projects funded collaboratively by NPL itself, National Institute for Health and Care Research and Innovate UK, the ultrasound team were able to develop and demonstrate the unique performance of the sensor technology to quantitatively map and measure the acoustic properties of various test objects, see Figures 2 and 3. This work led to the commissioning of the Q-UCT scanner, which incorporated NPL's novel sensor technology, as a test platform for scientific research and eventual in-person technology demonstration.

The innovation in ultrasound sensor design is the work of Professor Bajram Zeqiri FREng, NPL Fellow and Head of Science for the Medical, Marine and Nuclear Physics Department. Together with Daniel Sarno, NPL Senior Research Scientist and Technical Lead of the Q-UCT scanner, the pair have progressed the technology to its first in-person demonstration and hope to see it deployed in a medical device in the future. Daniel Sarno, who also holds a position on the NHS Clinical Entrepreneur Programme, said: "while the technology is currently in the research phase, we are encouraged by our in-person results and excited for the technology journey from bench top to bedside".

The next step for the team is to conduct a larger in-person study in which their quantitative acoustic attenuation measurements of the breast tissue are directly compared to established breast density assessment methods from mammography and MRI. The team are being supported in this effort by vital grant funding from the Government Office for Technology Transfer, a new unit within the UK Government's Department for Business, Energy & Industrial Strategy whose objective is to unlock the value of public sector knowledge assets to deliver economic, social and financial benefit for the UK economy and taxpayers. A larger in-person study will help to build evidence of the clinical efficacy of the technique and de-risk the technology for future investment.

New ultrasound technologies are providing unique solutions to many long-standing challenges in healthcare. Ultrasound offers safe and convenient measurement and imaging over modalities that use ionising radiation and require large, dedicated facilities. In the aftermath of the COVID-19 pandemic, there is a growing need to provide healthcare options outside of a hospital setting. It is anticipated that measurement solutions developed by the NPL ultrasound team will offer a path to meet this growing need.

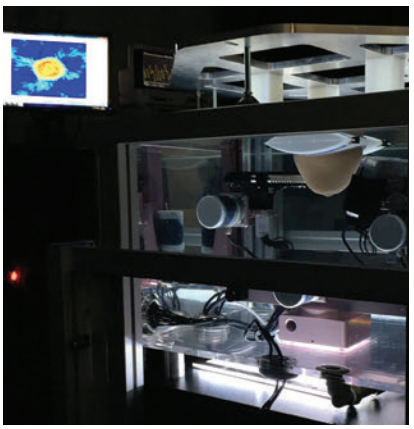

Figure 2. NPL's Q-UCT scanner being used to quantitively measure the acoustic properties of a breast phantom test object.

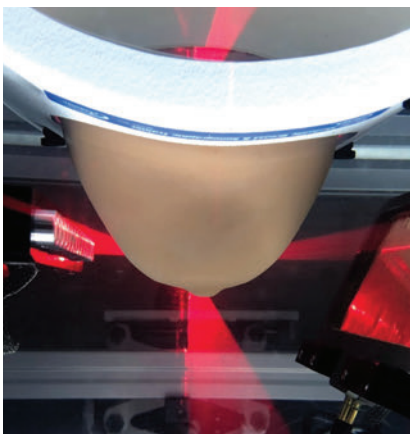

Figure 3. NPL's Q-UCT scanning head, with the ultrasound transmission array on the left and novel ultrasound sensor on the right.

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ULTRASONIC NON-INVASIVE FLOW MEASUREMENT ELIMINATES PIPE DAMAGE AND CONSERVES WATER

Clamp-on ultrasonic flowmeters are proving to be an essential water management tool in the targeted water loss initiatives of water and wastewater service providers around the globe.

Because measurement is carried out safely from the outside of the pipe, there is no risk of costly and disruptive pipe damage due to the invasive techniques involved in the installation of conventional wetted flowmeters.

With up to four measuring channels, which in reflect mode provide eight paths through the fluid, the flowmeter is able to reliably average the result of four planes.

Performing under even the most challenging conditions and finely tuned to low flow velocities, ultrasonic flowmeters are simply attached to the outside of the pipe wall, offering a highly versatile and accurate measurement solution for the water and wastewater industries.

Curbing the flow of non-revenue water

A major headache for many water utilities, non-revenue water is water that has been treated but lost before it reaches the consumer, through issues such as leaks or even theft from illegal connections in the distribution lines.

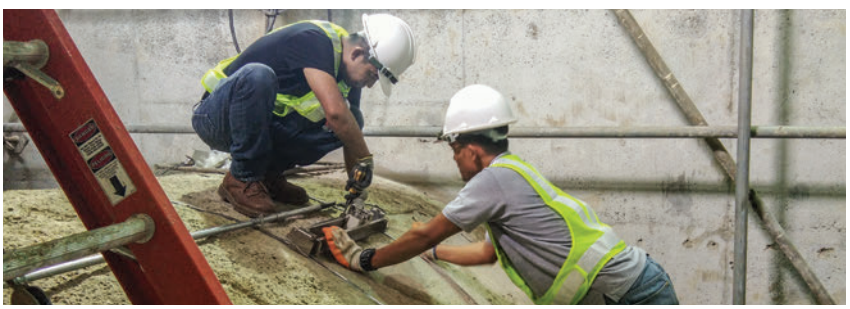
A chief water concessionaire in the Philippines had tasked FLEXIM with flow measurement on a 3.2m concrete pipe at the inflow to a reservoir, as they were keen to greatly reduce non-revenue water. They had already had some success by employing state of the art leak detection equipment but were very much focused on achieving a further reduction.

The 3.2m transport pipe was interconnected with a similar transport pipe in a second plant, so to carry out accurate measurement, conduct water balance and identify any losses within that particular segment, water engineers were looking for a way to retrofit a flowmeter that wouldn't involve having to make modifications to the pipe. Any alterations could potentially weaken or damage the pipe, so non-invasive technology such as clamp-on ultrasonic measurement was the obvious solution. Precise installation of four pairs of transducers would also need to be carried out, which on a 3.2m pipe is not always an easy feat.

Reliable and precise recording of water flow to the reservoir

Following a series of on-site trials and testing to check functionality and appropriate design of the transducers to be used, ultrasonic clamp-on technology was proven to be up to the challenge of delivering reliable and accurate flow measurement on a permanent basis. Precisely recording the water flow to the reservoir, measuring data is relayed to the plant's process control system via HART protocol.

For more information on the benefits of non-invasive ultrasonic flow measurement in the water industry, contact Andy Hammond - www.flexim.co.uk | sales@flexim.co.uk | +44 (0)1606 781 420



Q&A

Elizabeth Donnelly

Elizabeth Donnelly, Chief Executive Officer at the Women's Engineering Society (WES) shares her thoughts on the past, present and future of engineering.

What was the root of your interest in Engineering?

In the early 80s my dad brought home a Sinclair ZX81 which had 1KB memory, used the TV as its screen and cassette tapes as external storage. I really wanted to learn to program, but I had to fight my three brothers to get my turn. This was the start of my interest in computers, though I didn't have a plan or even think I could ever work in IT.

I used computers from 1987 onwards, but I only had an IT career by accident. In 1996, without having anything more than an interest in how computers work, I was asked to install "the internet" (Internet Explorer) on the staff computers and teach everyone in the company I was working for how to use email. I still meet young engineers today who are astonished that the computers didn't come with these already installed, and that people had to be taught how to use email!

This eventually led to a job as a database administrator, where I installed large-scale databases for local authorities to manage council tax payments. I returned to study in the early 2000s with the Open University by studying web development and databases. I came upon Systems Thinking as a final course to complete my degree and assumed it was about computer networks, but it was the wonderful theoretical basis for Systems Engineering and changed my life.

Around the same time, I was closely involved in politics and diversity in the trade union movement and was invited to work with the union at Rolls-Royce in Derby to lobby government. I learned about aerospace engineering on the job and I was successful in laying the foundations of a project to build three new UK factories and securing 800 jobs. As a result, I was invited to become the Head of Skills at the aerospace trade organisation where I stayed until I was made redundant in 2013. After that I set up my own consultancy while I studied for an MSc in Systems Thinking in Practice, and applied systems engineering to changing governance at charities and universities.

When the opportunity came to combine my skills in engineering, charities and women as the Chief Executive Officer of the Women's Engineering Society, it was the perfect job for me.

What is your vision of Engineering in Britain for the next ten years?

WES' vision is of an engineering industry that employs the diversity of the society it serves to solve the biggest societal issues of our time. WES' mission is to support women in engineering to fulfil their potential and support the engineering industry to be inclusive.

Currently only 16.5% of engineers are women, and I would love to see that percentage rise to 35-40%. I want to see more women employed as engineers, more women in engineering apprenticeships, more women studying engineering and more companies hiring more women engineers because their productivity and profitability will increase as a result.

In an ideal world I want to see women to be as likely to be engineers as men. It will take time and that's why we have been running International Women in Engineering Day for the last nine years. Each year our profile rises and we reach more people around the world, so I'm eager for that to translate into more women in

engineering over the next decade. I'm ambitious for the Women's Engineering Society, too. We may have been around for 103 years, but we're really just getting going in the 21st century. I want all women engineers to join us so they can get support throughout their careers and I want as many engineering organisations as possible to work with us to be more inclusive.

What should the UK government do to address the shortage of UK engineers?

The government really needs to invest in skills for carbon net zero and prepare us for a hotter climate. They should embark on a major recruitment and retraining apprenticeship programme for anyone who wants to become an engineer.

They could start by creating a programme to properly insulate homes across the country. This would reduce energy bills and simultaneously create a skilled workforce that could then go on to install heat pumps, solar panels, electric charging points and develop new technologies to combat climate change.

This will revitalize the economy with the resulting higher wages, increase productivity and revive communities that have lost out since the demise of heavy industries like mining and steel.

What do you do in your free time to relax?

I enjoy making scented candles, though I have yet to master the craft as I'm too impatient to wait for the wax to cool to pouring temperature. I enjoy blending scents and recently created a rosemary and pineapple scent that I use in diffusers around the house. Neither my partner nor his daughter has a sense of smell, so I sometimes wonder if it's a pointless activity!

I also read a lot of fiction, though nowadays it's via audiobooks while I'm doing other things as I don't have much free time to sit and read. I think the instant gratification of screens, whether phones, tablets or the TV has shortened our attention spans and I find it hard to settle to watch TV without also having a second screen at my side. When I go on holiday, I usually buy some paperbacks so I can properly relax and not get distracted by electronic notifications.

Given one wish what would that be?

That engineering was viewed by everyone to be an exciting career suitable for women as much as men.

> In an ideal world I want to see women to be as likely to be engineers as men. It will take time and that's why we have been running International Women in Engineering Day for the last nine years.

SOFTWARE HUT

TACKLING REAL WORLD PROBLEMS TO ENHANCE STUDENTS' EMPLOYABILITY PART 2

BY JOSHUA HAWORTH, YR 3 COMPUTER SCIENCE, UNIVERSITY OF SHEFFIELD (CURRENTLY COMPLETING A YEAR IN INDUSTRY PLACEMENT WITH BAE SYSTEMS)

In Issue 24 of Precision (June 2022), I detailed my experience of working on a cross-faculty real-world project under the banner of 'Engineering - You're Hired' at the University of Sheffield.

This project brought students together from a range of engineering disciplines (including, in my project group, from the departments of Civil and Structural Engineering, Mechanical Engineering and Computer Science) to address the real-world challenges of reducing energy waste and meeting net zero targets through biomimetic solutions (i.e., by mimicking natural biological processes) in building design and construction. The project was designed to enable students to develop and demonstrate a range of transferable skills to enhance their employability and make their way in the world of work.

In this second article, I will examine how this experience was taken forward in my second year of study through a module entitled 'Software Hut', the purpose of which was to enable us to put the various skills we had learned on the course so far to practical use.

The Software Hut Project

The Software Hut module gave students the experience of working with a real-world client to meet a genuine need that they had, and which required an effective software engineering solution. To this end, and together with other students in my group, I worked for a company that owned and managed wind farms, and who required a web-based application to allow them to handle user complaints.

The project was divided into several stages and was carried out over a 12-week period to achieve this particular goal. These stages were: the initial meetings with the client to ascertain their needs and scope their requirements for a solution; designing and creating mock-ups of our particular solution based upon the outcomes of this meeting; and finally implementing and presenting our finished solution to the client.

In the first stage, we had regular weekly meetings with the client (alternating between in-person and online contact) over a period of four weeks. The first meeting consisted of a detailed conversation to try and work out the general outline of the system they wanted us to implement on their behalf. The outcomes from this initial meeting formed the basis of the requirements for the project, with the remaining meetings clarifying the client's requirements and refining them based on their feedback.

Once this was done, an interactive prototype was constructed to help demonstrate how we thought the final product would look for the client as end-user. The design was then sent to the client so that we could

receive feedback and make any adjustments they required based on our prototype.

Following the prototyping stage, we developed the system using our design as the basis and employing the 'Ruby on Rails' framework to help build the app. During this process, we had occasional meetings with the client to ensure they were happy with what we were doing and to check if we had included all the features they required.

Once we had thoroughly tested the app to ensure everything worked as intended, we conducted a live demonstration to show the client the finished system. At this point, we did a walk-through of how different types of users would engage with the system, showed off the various security features we had built in, and answered any questions the client had.

```
require 'rails_helper'
require 'function_helper'

describe 'Deleting a user' do

    context 'as an admin' do

        specify 'deleting a user as an admin', js: true do
            regular_user()
            admin_user()
            sign_in_admin()
            visit '/users'
            within(:css, 'td') {expect(page).to have_content('user@testuser.com')}
            click_link 'edit'
            expect(page).to have_content('Edit User: user@testuser.com')
            click_on 'remove user'
            page.driver.browser.switch_to.alert.accept
            expect(page).to have_content('user has been removed')
            destroy_regular()
            destroy_regular()
        end
```

Figure 1. Excerpt of code used in the testing stage of the app

Once this had been achieved, the final stage of the Software Hut project was for us to present our solution to the client in a 'pitch' to win their business in competition with other student groups who had been working to the same ends.

Opportunities afforded by Software Hut for enhancing employability skills

The essential difference between the Software Hut project and the previous one I reported on in Precision, was that here we were working with an actual business client from outside the university who had a genuine practical need for an effective software engineering solution, as opposed to a project set internally by the Engineering Faculty staff.

In terms of employability skills development, this project had more of a focus on strong collaboration and effective team working, as well as clear, productive and professional communication, both within the project team and with the client themselves. This was made all the more important, and challenging, given the differing degrees of knowledge and understanding that each party had of the software development process, and the need to 'win' the client's business and for them to 'buy' our solution. Hence the stakes here were much higher, with an obvious business imperative.

From my perspective, the project enabled me to improve my own awareness of the problems that can hinder teamwork and understand more the precautions that can be taken to mitigate against 'team failure', as well as to improve team performance and focus. My own personal goals which were met by the module were to improve my overall communication skills, contribute better to a team and its productivity, to work to create a nurturing environment for my team members and to help improve their experience of the overall project - all valuable skills when looking to get on the ladder of employment in the engineering (or, indeed, in any other) sector. For a successful outcome we had to delegate working on the different aspects of the system (i.e. front-end, back-end and testing). Again, being able to delegate tasks like this proved to be a valuable skill and one which then allowed me to gain useful experience in an area which I was less familiar with - testing, having previously concentrated on front-end and back-end roles on previous projects.

Working with a business client on a real-world project proved more challenging than I initially expected. For example, we had to establish good working business relations with the client from the outset, communicate clearly and effectively with them to ascertain their needs, be able to adjust our plans as the project unfolded based upon client feedback, and prepare clear, concise and professional final documentation to satisfy the client's wishes. These aspects of the Software Hut project all provided excellent opportunities for honing particular skills that will prove useful for future employment. In my case, it gave me the experience and confidence to secure my first employment in engineering through a 'Year in Industry' placement with BAE Systems prior to commencing my final year at university from September 2023.

Acknowledgements

I would like to thank the staff in the Department of Computer Science at the University of Sheffield who were involved in the Software Hut module, my fellow students who worked together to deliver the project for the client and, of course, the client themselves who gave us this real-world experience.

Reference

Haworth, J. (2022) Tackling Real World Problems to Enhance Engineering Students' Employability. Precision, June 2022, Issue 24, 16-17. The Institute of Measurement and Control.

INSTMC ATTENDS 2022 WWEM CONFERENCE

InstMC recently attended the 2022 Water, Wastewater & Environmental Monitoring conference held in Telford on 12th & 13th October, which saw 2,697 attendees over the two days.

> InstMC were also one of the sponsors of the Instrumentation Apprentice competition at the event

We were given slots in the Learning & Development zone for InstMC Special Interest Group members to give a range of presentations and are pleased to report that the following sessions were successfully delivered:

- Martin Bragg (DT SIG) Development of Measurement Competencies
- Dr Carl Wordsworth (Flow Measurement SIG) Flow Measurement Masterclass
- Trevor Thompson (Measurement SIG) Measurement Uncertainty
- Oliver Grievson (DT SIG) Digital Transformation in the Water Industry

InstMC staff also ran an exhibition stand and spoke to a wide range of attendees about membership, professional registration and the varied work of the InstMC SIGs. We were also really pleased to meet and chat to a number of our Companion Company Scheme (CCS) members who were in attendance as Exhibitors including: VEGA, Siemens UK, Valmet, ABB and Flexim.

InstMC were also one of the sponsors of the Instrumentation Apprentice competition at the event, with a prize of a year's membership awarded to all entrants. We are delighted to welcome the winners, Alex Ward and Dan Alty of United Utilities, along with the 10 other entrants, to the InstMC!

Instrumentation Apprentices

Carl Wordsworth

Oliver Grievson

Trevor Thompson

Annie KOU Wai Chu, Exceptional Early Career Engineers award winner & Martin Belshaw, InstMC President

A SUCCESSFUL INSTMC AWARDS NIGHT

We had a fantastic night celebrating our 2022 InstMC Award winners on 19th October. Around 55 attendees gathered at the Royal Academy of Engineering's Prince Philip House to celebrate their achievements with prizes presented by Martin Belshaw, InstMC President and Kenneth Grattan, Prizes & Awards Committee Chair.

Professor Stephen O'Connor, winner of the Callendar Award, gave us a fascinating guest lecture on 'Biomedical Engineering – Improving Patient Outcomes', highlighting how implantable devices are saving lives, particularly in young people. We were delighted that Annie KOU Wai Chu, winner of the inaugural 'Exceptional Early Career Engineers' award flew over especially from Hong Kong, to receive her award! During the evening we were also able to honour previous winners from 2020 & 2021 who missed out on collecting their awards due to the covid pandemic.

Congratulations to all our winners and we look forward to seeing you next year!

Professor Eric Benoit

NPL Cornish Award sponsored by WCSIM (L to R: Martin Belshaw, Jonathan Pearce, NPL; Aubrey Dunford, WCSIM)

Professor Stephen O'Connor

Inst MC

Awards Night 2022

CONGRATULATIONS TO OUR AWARD WINNERS

2022

Professor David Richardson
Professor Stephen O'Connor
Professor Eric Benoit
National Physical Laboratory (NPL) Thermometry Team
Miss Annie KOU Wai Chu
Mr Mike Verran
Mr Andy Hudson
Dr Graeme Philp

2021

Professor Graham Machin
Dr David Angeli
Professor Adrian Long
Professor P A Muhammed Basheer
Professor Frank Härtig
City University of London Team
Professor Eddie Lock
Professor Ron Summers
EurIng John Morley

2020

Dr James Olthoff
Professor Sheila Rowan
Professor Andy Augousti
Professor Lisa Hall
Dr Gary Tse
Mr Harvey Dearden
Dr Beverley Stanford
Dr Jan Maciejowski

InstMC Learning and Engagement Talks Programme

InstMC is delighted to announce the launch of a brand-new programme of engaging and diverse talks.

Created by the InstMC HQ in response to feedback from our members, this fascinating collection of talks will feature speakers from within InstMC and from the Women's Engineering Society and the National Physical Laboratory.

Join us from 11am – 12pm on 16 November 2022 for the inaugural talk by InstMC Fellow Paul Fairclough titled Higher Apprenticeships and the Integration of the Academic and Vocational.

Paul is the Dean of Higher Education and the Director of Higher Engineering, Science & Nuclear, both at Lakes College West Cumbria and the National College for Nuclear Northern Hub. He is a Chartered Control Engineer and has designed a number of higher and degree apprenticeship programmes.

Book your free ticket via Eventbrite:

www.eventbrite.co.uk/e/higher-apprenticeships-and-the-integration-of-academic-and-vocational-tickets-453869464787 or email jane.chandler@instmc.org.

Further confirmed talks include:

Talk	Speaker	Date
The History of SI Prefixes	Richard Brown, Head of Metrology at the National Physical Laboratory.	11 January 2023
Data Science and Digitalisation	Louise Wright, Head of Science for Data Science at National Physical Laboratory.	11 January 2023
Contaminated Land – Is Redevelopment Sustainable in the Future?	Jo Strange, Technical Director at CGL a geotechnical and geoenvironmental consultancy.	08 March 2023
Re-defining How We Measure the Micro Particle	Victoria Sheldon-Bell from Drax, a renewable. energy company	22 March 2023
Musculoskeletal Modelling to Examine Tendon Transfer Surgery	Joanna Laing, an Aberdeen University Engineering Ph.D. student.	03 May 2023

Members will be notified by email when tickets for talks are available to book.

We will be announcing more talks soon! Keep an eye on your emails for details.

Why should you attend these talks?

- Hear from your peers working in a diverse range of engineering roles.
- Enrich and expand your knowledge.
- Be inspired.
- Engage and network, create contacts.

Tickets

Tickets are available to both InstMC members and the public and, unless stated otherwise, are free to attend.

All talks are online to facilitate accessibility.

If you would like further information, please email Jane Chandler at jane.chandler@instmc.org

LOCAL SECTION NEWS

CENTRAL NORTHWEST

Annual Dinner 2022

On Thursday 20th October 2022 Central Northwest section hosted their annual dinner at The Edwardian Hotel in Manchester.

This year we had a new social secretary, Samantha Gower of GPEC and the continued support of HTS Engineering Group, particularly from Maria Tabiner who organised the advertising, company interaction, invoicing and chasing. Thanks to both Maria and Samantha who helped make the event a great success.

The numbers were slightly down on last year, however, we had a very respectable 150 actual attendees at the event, with 173 tickets sold (we lost 23 people in the last 24 hours, due to uncontrollable reasons). It was great to see some new companies attending for the first time including many younger engineers, particularly graduate engineers from Jacobs and Endress & Hauser who invited four women working together to encourage more females into engineering.

The event was supported by our master of ceremonies, Paul Boardman with Billy Flywheel providing the entertainment. The mix of comedy and visual entertainment was different to previous years and appeared to be enjoyed by the room.

Sponsors of our most recent Central North West InstMC Annual Dinner held in October 2022

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I shared in my welcome speech how things had changed within the section over the last four years as section chair, with improved communications to members (newsletters, social media etc) and

switching to online technical talks due to Covid. Ron Bell OBE was my personal guest and I highlighted the contribution that Ron has personally made in Functional Safety, thanking him for his dedication over the last three decades before he retires this year. I challenged attendees to consider how they could be someone in the future that people quote as making a difference and initiating change, whilst enabling safer operations and activities for everyone. In addition to reminding people that we are still searching for our next section chair!

Manchester University attended for our 2022 awards which were presented on the night. There was a great presentation on how the team were prepared in the first workshop of the robot building, even accepting the challenge on the day of the race to reduce their time by 3 seconds, actually shaving 2.5 seconds off their first run. The Liverpool John Moore's university award winners were out of the region and will be presented with their award at a later date.

The networking between companies, clients and the committee members was fantastic to see and we had some great feedback from the post-event survey.

So now it begins, review and go again in 2023!

Dave Green, Chair
Central Northwest.

NORTH OF SCOTLAND

Annual Dinner 2022

North of Scotland Local Section hosted their Annual Dinner in October with 181 attendees, raising £3,200 for local charity, Maggies.

LOCAL SECTION NEWS

NORTHEAST

Visit to Essity – Prudhoe Paper Mill

Essity Prudhoe generously hosted the InstMC North East Local Section for a Technical Visit. Arranged before the Covid pandemic the visit was originally organised to take place in Autumn 2020!

Cath Frost and Lyn Hogarth of Essity welcomed our members and guests on Thursday 20th October 2022. We were given a history of paper making on the site, the various owners of the business over the years and the products they make.

We were then given a tour of the tissue making process, starting with the paper machine where the tissue is formed from the liquid stock. We then followed the process into the Converting Section where the 2.5m diameter rolls of tissue are processed into the toilet rolls we are familiar with.

We thank Essity for their time and supporting the local Section of the InstMC in hosting this visit.

Mike Vowell, Honorary Secretary
North East Local Section

FUNCTIONAL SAFETY SIG WEBINAR

On 26th September 2022, a webinar was hosted by the Functional Safety Special Interest Group on the subject of 'Process Safety Time and SIF Response Time Specifications'. The event attracted a lot of interest, and the live event was attended by over 150 people. The presentation was given by Harvey T. Dearden, chair of the FS-SIG, who is known to many through his involvement with professional engineering bodies, his many published technical articles and his books 'Functional Safety in Practice' (now in its 4th Edition) and 'Professional Engineering Practice'.

The webinar explored the significance of Process Safety Time (PST) as a key parameter for many Safety Integrated Functions (SIF) and pointed to the problems with the commonly cited 'rule of thumb' that the SIF response time should be no more than 50% of the PST. This 'rule' takes no account of the mission time during which SIF response may grow and conversely may be too restrictive for those SIF where no significant response time growth is anticipated. An alternative approach was outlined, using anticipated growth rate (with either a linear or exponential characteristic) and the mission time for each subsystem.

The webinar is now available to view on the InstMC YouTube channel and a supporting SIG Briefing Note with further technical details is also available from the InstMC website.

https://www.instmc.org/sigs/functional_safety/members_resource.aspx

THE STORY OF PLANCK AND THE CHAUFFEUR – BASIC UNDERSTANDING VS TRUE COMPETENCE

BY HARVEY DEARDEN

There is a story (which I don't believe for a moment, but in time honoured style let's not allow truth to get in the way…) of a lecture tour undertaken by the renowned German physicist and Nobel laureate, Max Planck. After repeatedly witnessing the same lecture on quantum mechanics, Professor Planck's chauffeur says (in German presumably), "I have heard your lecture so many times I know it off by heart. Why don't we swap places; I'll deliver the lecture and you can sit in the audience wearing my chauffeur's cap". The swap is agreed and the chauffeur successfully delivers the lecture. A member of the audience then asks an obscure question concerning quantum mechanics (aren't they all?). The chauffeur says, "I'm surprised that you should ask such a basic question; I'll allow my chauffeur to answer it!"

The joy of this story is that it highlights the distinction between 'Planck knowledge' and 'chauffeur knowledge'; between real knowledge and understanding, and mere show; between being able to navigate, and steering an assigned set course; between true competence, and unthinking handle cranking. Here lies the value of registration; it demonstrates that a review by your peers has found you to possess 'Planck knowledge'.

There are increasing calls for demonstration of competence, largely driven by regulatory pressures (whether real or imagined) in relation to activities that might impact on safety. For the registered engineer, much of this appears redundant; to achieve registration an engineer must demonstrate underpinning knowledge and understanding (UK&U), a core set of competencies, and a commitment to continuing professional development (CPD). The codes of conduct, observance of which are a condition of membership of the professional engineering institutions, explicitly require engineers not to undertake work which lies beyond their competence.

Given these established requirements, it might be reasonably considered sufficient that a registered engineer demonstrates appropriate experience and an ongoing commitment to CPD in relation to the work he undertakes. Nevertheless, it might be useful for a registered engineer to have his competence and commitment in a given field formally evaluated by his peers in order to substantiate his 'Planck knowledge'.

It is for this reason that the InstMC has developed discipline specific professional qualifications (Registered Functional Safety Engineer, RFSE and Registered Explosive Atmospheres Engineer, RExE), each based on a peer review process analogous to that for original registration. For each of the qualifications, the pre-requisite is registration since this demonstrates the necessary UK&U. Beyond that, the requirement is to demonstrate extensive experience and engagement at a professional level in the chosen discipline – attendance on a short course will NOT be sufficient.

For further details on the RFSE & REXE qualifications, visit the InstMC website https://www.instmc.org/careers_learning/professional_registration/rfse_rexe_qualifications.aspx

There are increasing calls for demonstration of competence.

IMEKO AND THE INSTMC

BY PROFESSOR T V KENNETH GRATTAN
OBE FINSTMC FRENG

IMEKO, the International Measurement Confederation, is a world-wide body bringing together a wide range of organisations, all with a focus on measurement, sensing and instrumentation and its promotion and development in their respective countries. IMEKO was founded in 1958 and, at that time, played a key role in bringing a divided Europe together to focus on developments in the field and enable scientists and engineers from both sides to meet and exchange ideas. Since then, IMEKO has expanded from Europe to include the Americas and Asia, yet it still retains that focus on bringing the best together across the breadth of the exciting field that is measurement and instrumentation today, as well as looking to future directions and synergies with other areas.

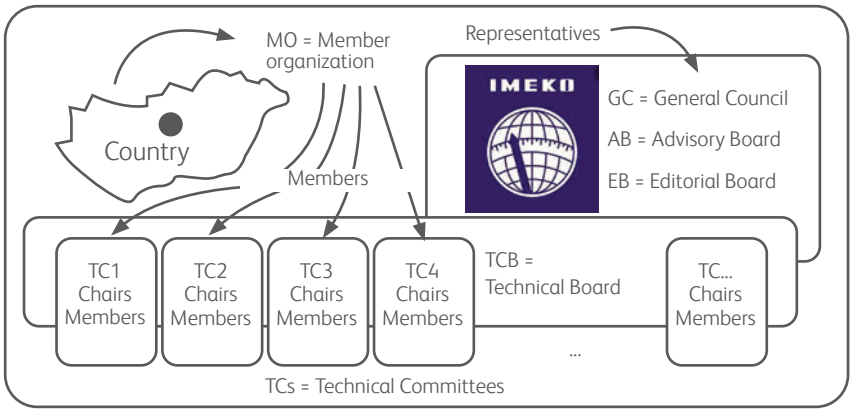
IMEKO is primarily concerned with 'the advancement of measurement technology', focusing on the promotion of:

- international interchange of scientific and technical information in the field of measurement and instrumentation
- the enhancement of international co-operation among scientists and engineers from research and industry.

How IMEKO is structured

The aims of the 1950's resonate in today's world. To achieve these, IMEKO is structured, as shown in Figure 1, around its 25 Technical Committees (TCs), each taking responsibility for different aspects of measurement and instrumentation.

Figure 1.



It draws on scientists and engineers from 42 countries each of which is represented by a Member Organisation. The Member Organisations each have a representative on the General Council, IMEKO's governing body, which meets usually annually at a venue often linked to a Technical Committee Symposium. Reporting to the General Council is the Presidential Board which is the executive group. This meets monthly and is supported by the Advisory Board which is elected by the General Council.

The Chairs and Secretaries of the various TCs form the Technical Board, a group reporting to the General Council with the brief for planning Symposia and meetings. These will often link several TCs in a single event to reflect the breadth of the subject area.

The UK's Voice

The InstMC has, for many decades, been the UK member organisation. A unique position that gives it the same voice at the General Council table as other major countries in the field, many of which are represented by the key national measurement organisations. Thus, the globally recognised National Institute of Science & Technology (NIST) represents the United States, the Physikalisch Technische Bundesanstalt (PTB), the national metrology institute of Germany, (with a focus both on scientific and technical service tasks) has been a member since the beginning and the Chinese Society for Measurement is the delegate for that major player in the field. There are close links also with UK's National Physical laboratory (NPL). For example Professor Graham Machin FREng, holding the senior role as Fellow at NPL, was InstMC President from 2018 to 2020.

A number of InstMC Members and Fellows will have participated in the work of IMEKO through one of its Technical Committees, representing a very wide range of subjects from the traditional to the most up-to-date. Examples include the fundamentally important measurement of force, mass, torque and gravity (Technical Committee TC3); pressure and vacuum (TC16); and hardness (TC5). The technical committees on flow measurement (TC9); and temperature measurement (TC12)

run the two biggest conferences in the field, in FLOMEKO and TEMPMEKO respectively, attracting many hundreds of delegates to their biennial events. Education (TC1) and Measurement Science (TC7) are two critically important areas represented by these technical committees and they regularly come together to run a symposium – the most recent being in Porto in Portugal in August 2022.

Topicality

Showing that IMEKO aims to be highly topical and up-to-date in its reflection of the changing field of measurement, two new TCs have been formed in the last few years – TC6 on digitalisation and TC25 on quantum measurement and quantum information, the latter chaired by the representative from NIST in the USA. Past Presidents of the Institute such as Professor Ron Summers have chaired the Technical Committee on measurements in biology and medicine (TC13) for many years and Professor Ludwik Finkelstein was an IMEKO Vice President and Technical Committee chair for many years. Most recently, Inst MC Fellow, Professor Yong Yan FREng has become Scientific Secretary of the Technical Committee (TC20) on Measurements of Energy and Related Quantities, reflecting its major importance today.

IMEKO's Strengths

What are IMEKO's strengths and what is the key advantage for the InstMC to be involved? As can be seen, IMEKO gives the Institute an international reach and enables it to partner with the major players across the world in the measurement field. On two occasions (in 1976 and 2018) the Institute has hosted the IMEKO triennial world congress, bringing together all the technical committees in an event where typically five or six hundred delegates from over 25 countries can interact with presentations, lectures, workshops and technical committee meetings.

A further success story of IMEKO is its publications. Working with Elsevier, the global publisher and information analytics company, IMEKO currently publishes four journals: Measurement; Measurement: Sensors; Measurement: Food and Acta IMEKO. A new journal, Measurement: Energy is planned for launch at the end of 2022. Measurement is a particular success story, having been launched by the Institute of Measurement & Control for IMEKO in the early 1980s, before its transfer to Elsevier. It has now become a 'Quartile 1' journal in the areas of instrumentation; electrical and electronic engineering; education and applied mathematics. In its core 'instrumentation' field, it ranks 7th in a field of 136 journals, above journals in that field from the Institute of Physics, IEEE, ISA and IET, for example. In addition to bringing IMEKO to the attention of tens of thousands of authors, reviewers and conference attendees annually, its agreement with Elsevier brings a major financial benefit which supports a wide range of IMEKO's activities. This is a model that the Institute could study in light of its own publication strategy

The Future

What is the future for IMEKO – and its relationship with the Institute? This has always been strong, with the Institute having two of its Past Presidents in Sam Carlisle (President 1965-66) and Ken Grattan (President 2000-1) being Presidents of IMEKO from 1973-76 and 2015-18 respectively, as well as Past Presidents Ludwik Finkelstein (1980-1) and Ron Summers (2007-8) being Vice Presidents of IMEKO. The current IMEKO President, Professor Frank Härtig, has been awarded the Institute's Finkelstein Medal, reflecting his international activities. Many Institute Fellows are – or have been – Chairs or Scientific Secretaries of TCs, bringing their expertise to that international forum. Professor Graham Machin (InstMC President 2018-2019) has been actively involved in the organization of the highly successful TEMPMEKO Conference series reflecting his – and the UK's – expertise in temperature measurement and temperature standards.

There are many other examples that could be quoted.

Above all, the InstMC can take advantage of its unique position as the UK member organisation of this highly successful international community and continue to engage with its technical committee work and events, to mutual benefit. As the Institute's representative on the IMEKO General Council, I would be happy to provide any further information that may be helpful and answer any questions you may have – feel free to get in touch at K.T.V.Grattan@city.ac.uk.

COMPANION COMPANY SCHEME (CCS) SHOWCASE

The InstMC Companion Company Scheme has been running since 1992, enabling companies to raise their profile amongst our membership of 3,000 professional engineers in the measurement, automation and control sectors.

There are opportunities to network with other businesses, InstMC accredited universities and with individual members, at local and regional level, through Local Sections and Special Interest Groups. We currently have 70 active CCS members and are pleased to introduce some of them to you here.

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MEASUREMENT QUALITY MATTERS: ASK TREVOR

In this issue we "Ask Trevor" to briefly summarise a talk he gave for us at the recent Water, Wastewater and Environmental Monitoring (WWEM) and Air Quality and Emissions (AQE) conference held at Telford International Centre in October 2022.

Everyone has some measurement uncertainty (MU). It is just a description of how uncertain or how much doubt one has, about a measurement. Typically, expensive work with special equipment and skilled staff leads to a lower value of MU. Cheaper, more common equipment, easier environmental conditions and lower skilled staff, often with quicker procedures can lead to a greater figure for MU. Both extremes have their valued roles. There is no need to spend more time or money on a test or calibration than is necessary for you to make proper use of the result.

The choice of test or calibration with its associated MU therefore depends on what you are going to do with the result of a measurement, what further work or tests depend on the precision of the value obtained and very notably, what confidence you need to have in any pass or fail statement made.

Measurement Uncertainty - What is it?

- It is the doubt we have about how well we can make a measurement. Not to be confused with a specification or tolerance
- Called Measurement Uncertainty (MU), or sometimes (previously) Uncertainty of Measurement (UoM) but not Measurement of Uncertainty!
- It is not a measurement, it is an estimate, calculation or evaluation to describe our uncertainty about the result of a measurement.

Let's take an example measurement made of 998 l/min flow rate with an MU of 10 l/min.

If the upper limit for pass is 1000 l/min then you might say that your result indicates a pass, but this would be a very risky dangerous assertion to make because there is a very high likelihood that in fact the product failed because your MU is too large and the result too close to the limit.

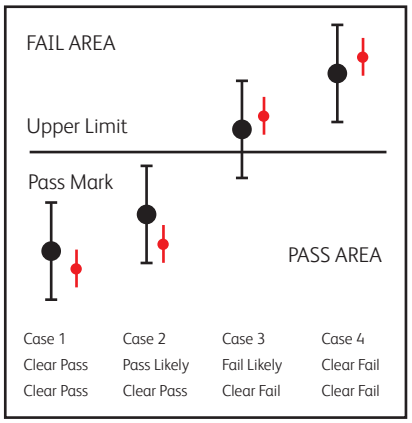
Measurement Uncertainty - Why do we need it?

- To make a valid pass/fail decision
- In order to make use of the measured value in a credible way
- To distinguish between precise and less precise measurement
- To make value judgements of measurement work
- To 'get the right (valid) result' in further calibration, testing or manufacturing..

So, the choice of a lab to make a measurement, or the choice of which equipment to use, environment or staff to deploy may depend on how close typically your results are found to be relative to a pass/fail mark. In practice it is often quite close because no one wants to make a product "better" than is necessary to pass, nor do they want to spend more than necessary on the test or calibration.

If we compare the two results in the following diagram (where the dots represent the result and the vertical lines the extent of uncertainty) then it becomes clear that if high confidence is required, the more expensive red lab is needed, but if high risk of false accept or reject is tolerable then the black lab could be used.

How sure are we? Spend more? 2% and 10% capability labs?



That takes us to the issue of "Decision Rules". This is a rule that states how MU is accounted for in making a pass/fail statement. All measurements that are made and compared with a limit condition need such a rule to describe what one does with the MU when stating pass or fail.

Looking at the black example above, in cases 2 and 3 they might wish to state that the product passes but would need to describe the risk of false accept or reject. This is known as "Simple Acceptance" and always needs an awareness of the risk involved in making such compliance statements.

In the red example the lab may safely state pass/fail even in cases 2 and 3 because there much smaller MU and all results (within a stated confidence level, typically 95%) are well outside the area of doubt.

A safe and easy way to handle MU with pass/fail statements is to deduct or add the MU to the measured value before stating a pass. This is called "guardbanding" and gives a high confidence safer situation but may result in wasted product in some situations of failure.

In order to develop measurement uncertainty budgets and decision rules it is necessary to understand the science involved in the work and have a reasonable ability to use spreadsheets or formulae to make the calculations leading to the MU figure and to calculate the risks, as discussed.

BIPM's JCGM100 and JCGM106 are the ultimate reference docs but are a "heavy" read.

UKAS M3003 and LAB48 are easier for many readers.

NPL's GPG11 is an easy starting point.

Trevor Thompson is a metrologist specialising in laboratory management systems. He worked for the United Kingdom Accreditation Service (UKAS) for many years, assessing laboratories, managing technical staff and representing internationally, notably in the writing of ISO/IEC 17025:2017. He has now "retired" and offers training and consultancy for UKAS and others as www.bestmeasurement.com

Ever wondered what the difference is between precision and accuracy?

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steff.smith@instmc.org

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ernest.kyei@instmc.org

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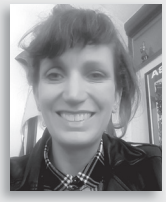
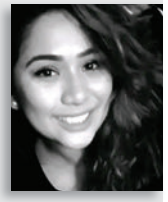


Membership Development Manager
Jane Chandler
+44 (0)20 7387 4949
jane.chandler@instmc.org



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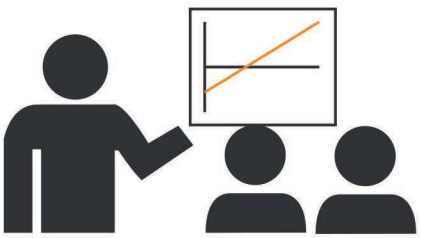

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