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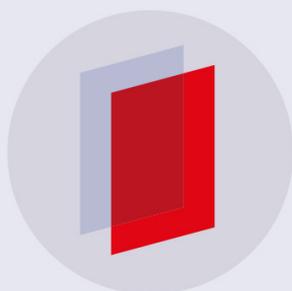
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PAPER • OPEN ACCESS

## XXII World Congress of the International Measurement Federation (IMEKO 2018)

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Knowledge through  
Measurement



Proceedings of the

# XXII World Congress of the International Measurement Federation (IMEKO)

3 – 6 September 2018

Belfast Waterfront Conference & Exhibition Centre, Belfast, UK

With co-located conferences:

<p><b>Optical Fibre and Photonic Sensors for Industrial and Safety Applications (OFSIS2018)</b></p>	<p><b>XIX Sensors and their Applications Conference (S&amp;A 2018)</b></p>
	

Hosted by the Institute of Measurement and Control



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## Welcome from the Chair of the Organising Committee



It is my great pleasure to welcome you to the XXII IMEKO World Congress, our premier international triennial conference, this year being held in Belfast, UK. The history of this event shows that it has been held previously in different locations around the world, hosted most recently by national IMEKO organisations in Lisbon, Portugal (2009); Busan, South Korea (2012); and Prague, Czech Republic (2015). The Institute of Measurement and Control (InstMC) – the UK national IMEKO member – has had the privilege of hosting this conference once before, in 1977 in London, so I am delighted to have this opportunity to welcome you back to the UK shores on this occasion.

In the coming days you will find a scientific programme that allows each of the technical committees at least one oral session in which papers are presented. The poster presentations are co-located with the exhibition and take place in the space designated for coffee and lunch, aiding a meeting of minds in a relaxed environment for learning. Equally you will find a social programme that shows off the best of Belfast and its environs, as well as opportunities to travel further afield to more distant parts of Northern Ireland – though no location is more than two hours away from Belfast's Waterfront Convention Centre.

The organisers have brought together a stellar cast of keynote speakers who, when taken together, cover academia, industry and the national measurement organisations. In our planning meetings for this event we kept in mind its unique timing to coincide with the launch of the new SI system of measurement in 2019. The InstMC joins these two events together by launching its 'Festival of Measurement'; commencing with the start of the World Congress and culminating in a public event at the Science Museum in London close to World Metrology Day, May 20<sup>th</sup> 2019.

As IMEKO continues to strive to represent measurement matters around the globe, its triennial World Congress continues to grow which perhaps indicates its increasingly high quality and impact. All of the submitted papers were subject to peer review by at least two members of the technical committees, though the vast majority of papers received three to seven reviews. It is at this juncture that I would like to thank all members of the Organising Committee, members of staff from the Professional Conference Organisation employed for operational matters, and all peer reviewers for their part in processes that have made this event happen.

Again, welcome to IMEKO WC2018 Belfast. On behalf of the Organising Committee I would like to thank you for your participation and hope that you find both the scientific and social programmes intellectually stimulating, rewarding and enjoyable. Have fun!

A handwritten signature in black ink, which appears to read 'Ron Summers'. The signature is written in a cursive style and is underlined.

Professor Ron Summers

Institute of Measurement & Control, United Kingdom



## Knowledge through Measurement

### Welcome by the President of IMEKO, Professor Kenneth Grattan



I am delighted, on behalf of the International Measurement Confederation (IMEKO) to give you a warm welcome to the XXII IMEKO World Congress being held in Belfast, in Northern Ireland. The UK is the host for this World Congress, the first time in over 40 years that it has been held there and IMEKO is very pleased to be working with the Institute of Measurement and Control, the UK Member Organization of IMEKO and the National Physical Laboratory to create what promises to be an excellent, highly international event, bringing together experts from industry, business, national measurement laboratories and academia.

The theme of the conference comes from a quotation from Lord Kelvin, a pioneer in the field of scientific measurement, and is 'knowledge through measurement'. Lord Kelvin was born in Belfast in 1824. Kelvin, best known to us today as absolute temperatures are stated in units of kelvin in his honour, was an early academic entrepreneur, active for many decades in industrial research and development. With nearly 500 papers accepted across the wide range of themes in measurement science and technology covered by the IMEKO Technical Committees, this will be one of the largest and most comprehensive IMEKO World Congresses held. We are also honoured that two Nobel Prize Winners – Professor Bill Phillips of USA and Professor Klaus von Klitzig of Germany – will give keynote lectures in Belfast, together with other invited and keynote speakers from industry, national measurement laboratories and academia. The World Congress also features a major exhibition of new technologies in the field from companies based in the UK and internationally. IMEKO is also pleased to partner with colleagues from the UK Institute of Physics in including the long running XIX Sensors & their Applications Conference and also the 3rd International Conference on Optical Fibre and Photonic Sensors for Industrial and Safety Applications (OFSIS) as parallel events in Belfast, enabling all attendees to enjoy the greater breadth of coverage that this provides. I would, in particular, like to thank the many sponsors of the World Congress for their generous support

I hope that you will enjoy attending this World Congress, benefit from the wide range of papers presented and be an active participant in presenting your own research, be it as a poster or an oral paper. The Waterfront Hall in Belfast is a world-class venue and is a multi-purpose conference and entertainment centre that provides excellent facilities for the attendees. The social programme has been designed to allow delegates to meet and network and dine at Titanic Belfast, a visitor attraction opened in 2012 and a monument to Belfast's maritime heritage – it has quickly established itself as a world-leading tourist attraction.

On behalf of IMEKO, I look forward to meeting you in Belfast at the XXII IMEKO World Congress and hope that your visit to Northern Ireland will be a memorable experience – and an excellent centre to explore the beautiful countryside and historic landmarks to be seen across Ireland.

A handwritten signature in blue ink, which appears to be 'K. Grattan', written over a light blue horizontal line.

Professor Kenneth T V Grattan OBE FEng,

President of the International Measurement Confederation (IMEKO)



## Knowledge through Measurement

### Preface

The XXII World Congress of the International Measurement Confederation (IMEKO) is held in the UK in 2018 for the first time in over 40 years. Hosted by the Institute of Measurement and Control, the UK's specialist Professional Engineering Institute in the fields of measurement, automation and control and supported by the Institute of Physics, the World Congress covers all aspects of current research in the field of measurement and attracts some of the world's largest companies from the sensor, instrumentation, automation and 'Internet of Things' (IoT) industries.

Belfast, the capital city of Northern Ireland, sees delegates from across the world come together for an interesting and scientifically challenging World Congress, bringing together leading experts from many countries to report on the latest exciting developments in their fields. The city is also an excellent centre to explore the beautiful countryside and historic landmarks to be seen across Ireland

**'Knowledge Through Measurement'**, a theme from the work of Lord Kelvin, the great scientist, engineer and entrepreneur who was born in Belfast, is the strap-line for IMEKO 2018.

Held only every three years this World Congress is an unmissable opportunity to demonstrate an organization's presence in this field to an influential and senior audience. The invited speakers are some of the most distinguished internationally and many sessions held during the week will provide real insight into what is new in this most topical and economically important of fields. The exhibition showcases some of the leading developments in industry from the UK, Europe and indeed across the world. In that way, the World Congress allows its delegates

- to hear two Nobel laureates and senior figures from industry internationally giving keynote speeches
- to network more effectively and to establish new strategic partnerships and build opportunities with colleagues and industry
- to hold face-to-face meetings, to hear about the latest scientific work, to make new contacts and for exhibitors to generate new business opportunities
- to see new products and services showcased, to allow exhibitors to build market share, position their companies as industry leaders and for all delegates to develop new and sustainable relationships

In this way, the World Congress allows visibility for all delegates at an event with true international status and association with the world of measurement, the driving force behind the Internet of Things and the Fourth Industrial Revolution (Industry 4.0).

The World Congress is the forum to showcase the 'Festival of Measurement' where the Institute of Measurement and Control launches the first ever Festival of Measurement at the start of the IMEKO World Congress. Its aim is to promote a culture of accurate measurement in the engineering industry, raise Public awareness of the importance of measurement in daily life and promote metrology as a career – highlighting its importance in STEM subjects. The Festival runs for exactly 23 million seconds, ending just after World Metrology Day on 20 May 2019. From this date the entire SI system of units is defined with reference to universal constants rather than physical artefacts. The lead up to World Metrology Day allows a greater than normal focus and stimulates discussion around the science of measurement in industry and the wider media.



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## Co-located conferences

The IMEKO XXII World Congress is pleased to be co-located with two other major Conferences this year in Belfast.

The 3rd International conference on **Optical Fibre and Photonic Sensors for Industrial and Safety Applications (OFSIS2018)** is a biennial conference jointly organised with the IMEKO World Congress and the Shandong Academy of Science, China and Queensland University, Australia.

The key feature of the conference series is to bring together stakeholders in the important field of industrial applications, hearing from experts and researchers in optical fibre sensors and photonics to provide solutions for a variety of industrial and safety applications. The 1st Conference (OFSIS2015) held in January 2015 in Jinan, Shandong Province, China and the 2nd Conference (OFSIS2017) held in January 2017 at the University of Queensland, Brisbane, Australia, drew several hundred experts from across the world from industrial sectors such as coal mines, the power grid, mineral mines, oil and gas, chemical plant and the sensors and instrumentation fields. This conference provides a unique platform for the research and industrial communities to discuss developments in fibre-optic and photonic sensing technology, their laboratory and field trials and investigate new insights into their advanced manufacturing techniques and applications.



The **XIX Sensors and their Applications Conference (S&A 2018)** is the biennial Conference organised by the Instrument Science & Technology (ISAT) Group of the Institute of Physics in the United Kingdom and has regularly been co-sponsored by the Institute of Measurement & Control. It was first held in 1983 and brought together experts from across the country in the field of measurement, sensors and instrumentation, being the first major Conference in the United Kingdom to deal with these subjects as a systematic discipline. It has been co-located on several occasions with other major Conferences: in 1987, in Cambridge UK, it was also the first of the well-known Eurosensors Conferences and, in 2001, it co-located in London UK with the IMEKO International Symposium on Measurement and Control in Robotics (ISMCR 2001), organised by IMEKO Technical Committee TC17. The Conference has focused on a variety of new developments in instrumentation and measurement, both laboratory and industrial, over the last 35 years.





## Knowledge through Measurement

### Keynote Speakers

#### Professor Klaus von Klitzing



Klaus von Klitzing is a German physicist known for discovery of the integer quantum Hall Effect, for which he was awarded the 1985 Nobel Prize in Physics. He studied physics at the Braunschweig University of Technology, where he received his diploma in 1969 and undertook postgraduate study at the University of Würzburg on the Galvanomagnetic Properties of Tellurium in Strong Magnetic Fields in 1972. He became a Professor at the Technical University of Munich in 1980 and has been Director at the Max Planck Institute for Solid State Research in Stuttgart since 1985. His research focuses on the properties of low-dimensional electronic systems, typically in low temperatures and in high magnetic field.

On Tuesday 4th September 2018 Professor Dr von Klitzing will receive the InstMC Hartley medal in the InstMC Hartley prize lecture

#### Professor William D. Phillips



Bill Phillips is an American physicist who shared the 1997 Nobel Prize in Physics with Steven Chu and Claude Cohen-Tannoudji for their work on laser cooling, a technique to slow the movement of gaseous atoms in order to better study them. He received his physics doctorate from the Massachusetts Institute of Technology and in 1978, he joined NIST, the National Institute of Standards and Technology, where he has worked since. He is also a Fellow of the Joint Quantum Institute and a Professor of Physics at the University of Maryland.

On Monday 3 September 2018 Professor Phillips will receive the InstMC Sir George Thomson medal in the InstMC Sir George Thomson prize lecture.

#### Pete Loftus



Pete has spent his 37 year career in Instrumentation and Measurement at Rolls-Royce.

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.

He is currently Head of Measurement Engineering with accountability for ensuring the creation, maintenance and improvement of all forms of measurement capability for the company world-wide.

He holds a Bachelors' Degree in Applied Physics and a Masters in Gas Turbine Engineering.

He is President of the European Virtual Institute for Gas Turbine Engineering; and is active in the ASME International Gas Turbine Institute, The Institution of Engineering and Technology, and NCSLI.

He is passionate about the contribution of measurement engineering to real-world problems and a tireless advocate of professionalism in this evolving discipline.

He is married with grown up children and in his spare time is a scout leader and Engineering Ambassador.



## Knowledge through Measurement

### Dr Martin JT Milton



Dr Milton is the Director of the Bureau International des Poids et Mesures.

Martin joined the National Physical Laboratory from Oxford University in 1981. His early work included being a co-inventor and pioneer of the Differential Absorption Lidar technique for range resolved remote gaseous pollutant sensing. He subsequently provided scientific leadership for the Analytical Science Team and took an internationally-leading role in the application of new physical principles to the measurement of gases in the atmosphere and establishing the comparability of gas measurements around the world.

He chaired the Gas Analysis Working Group of the Consultative Committee for Amount of Substance where he was instrumental in improving the worldwide comparability of gas standards and gas measurements worldwide and was active in standardisation of these methods through ISO.

Martin published more than 70 peer-reviewed papers is a Fellow of the Institute of Physics and a Fellow of the International Union of Pure and Applied Chemistry. Martin spent 31 years at NPL, rising to be NPL Fellow and Science Leader for the Gas Metrology and Trace Analysis Group. He left NPL in October 2012, to be Deputy Director and Director Designate of the Bureau International des Poids et Mesures and then Director at the beginning of 2013. This is a high profile international role which Martin undertake with aplomb combining his considerable scientific, leadership and diplomatic skills.

Martin is Honorary Professor in the Department of Chemistry at the University of York, UK, in recognition of his contribution to gas measurement.

### Dr James K Olthoff



Dr. James Olthoff is the Director of the Physical Measurement Laboratory (PML) of the National Institute of Standards and Technology (NIST). As Director of PML, Jim is responsible for the operation of the Laboratory that consists of over 1000 staff members located on multiple campuses. PML's research program covers an extensive range of topics including advanced metrology, quantum measurements, photonics, quantum information, advanced manufacturing, and biophysics. The PML is responsible for the realization of all the physical measurement units for the United States and for all related NIST calibration activities.

Dr. Olthoff's international metrology responsibilities have included serving as the Chair of the Sistema Interamericano de Metrologia (SIM) Quality System Task Force and the Chair of the SIM Technical Committee, representing SIM on the Joint Committee of the Regional Metrology Organizations and the BIPM (JCRB), serving as the Chair of the Conference on Precision Electromagnetic Measurements, and representing NIST on the Consultative Committee on Electricity and Magnetism. Jim is currently the President of the Board of the NCSL International, and the U.S. representative to IMEKO.

Jim received his Ph.D. in physics from the University of Maryland in 1985 in the area of atomic and molecular physics. He then held an appointment at The Johns Hopkins School of Medicine before moving to NIST. Jim was hired at NIST in 1987 to perform research related to electrical breakdown in gases of interest to the electric power and semiconductor industries, and to perform calibrations of high voltage transformers and capacitors. In 2001 he became Chief of the Quantum Electrical Metrology Division. In 2007 he was appointed Deputy Director of the Electronics and Electrical Engineering Laboratory which then became part of PML in 2010. Jim was selected as the Director of PML in 2014. Jim has published over 120 publications and has co-authored/edited four books.



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**3rd International Conference on Optical Fibre and Photonic  
Sensors for Industrial and Safety Applications (OFSIS-2018),  
Keynote Speakers**

**Dr Vincent Handerek**



Vincent Handerek, of Fotech Solutions Ltd., Fleet, United Kingdom, is an expert in the industrial applications of optical and optical fibre sensors and measurement. He studied electrical engineering at Imperial College London, gaining a B.Sc.(Eng.) in 1975 and a PhD on polarised light in optical fibres. After researching fibre measurements in UK industry, he moved to the USA to work on polarisation maintaining components and fibre gyroscopes. In 1988, he joined King's College London, concentrating on distributed optical fibre sensor research. In 1999, he returned to industry, developing optical amplification, communication, and sensing systems. Dr. Handerek then joined Fotech Solutions Ltd. in 2008 to develop distributed acoustic vibration sensing systems. He has authored over 90 publications, three book chapters and holds a range of patents.

**Professor Perry Shum**



Professor Shum of Nanyang Technological University (NTU), Singapore, received his PhD degree in Electronic and Electrical Engineering from the University of Birmingham, UK, in 1995. In 1999, he joined the School of Electrical and Electronic Engineering, NTU. In 2014, he was appointed as the Director of Centre for Optical Fibre Technology and was the chair, committee member and international advisor of many international conferences. He was also the founding member of IEEE Photonics Society Singapore Chapter (formerly IEEE LEOS). He is currently the Chairman of OSA Singapore Chapter. Prof Shum has published more than 500 journal and conference papers with his research interests being in the areas of speciality fibres and fibre-based devices. His h-index is 38. In recent years, his publications have been cited about 500-800 times per year. He is SPIE Fellow and OSA Fellow.



## Knowledge through Measurement

### Welcome to Belfast!

Belfast has blossomed from very humble beginnings... It started out as a small hamlet with fertile land along the mouth of the Lagan. Soon, marauders and pirates realised our lough was deep and our shores were safe from the north Atlantic storms. The perfect haven for repairing sea ravaged ships. From these early stages the industrious locals developed a boat building trade. And the rest is our history.

So what's Belfast like today? Well, it's packed with history, culture, exciting events, great food, super shopping... you might even spot a ship or two. You'll also find some of the friendliest people you'll ever meet. Have a look around and learn more about the city we're so proud of.

Did you know...

- Belfast's Sirocco Works invented air conditioning and the Royal Victoria Hospital became the first building in the world to be fitted with air conditioning.
- Mary McAleese of Ireland is not the only state president to have been born in Belfast – Chaim Herzog, Israel's first president was the son of a Belfast rabbi.
- Milk of Magnesia was invented in Belfast, as were the pneumatic tyre and the tractor.
- London's Sloane Square and Sloanies are named after County Down born and Belfast educated Sir Hans Sloane, the man responsible for first creating milk chocolate.
- Shorts Aircraft Factory pioneered Vertical Take Off and Landing (VTOL) aircrafts in the 50's when Sir James Martin invented the aircraft ejector seat.
- The expression "The Emerald Isle" was first coined by Belfast poet William Drennan in 1796.
- A tunnel, which carries the river Farset under High Street and into the River Lagan, is so big it can accommodate a double decker bus.
- The unbeaten record for hammering the most rivets in a working shift was set by James Moir at Harland & Wolff shipyard. He slammed 11,209 red-hot rivets into metal plates of a warship in nine hours in June 1918.
- Joseph Black, son of a Belfast wine merchant discovered carbon dioxide and his principles were used by James Watt to develop the steam engine.
- Belfast poet Michael Longley in 2000 and 2001 won four top literary prizes, something never before achieved by any living poet in the British Isles. (Prizes included: Queen's Gold Medal for Poetry, TS Eliot Award, Hawthornden Award and a Whitbread Award.)
- The 'Holy Land' of Belfast is so named after a devout Christian developer gave the names of Damascus, Carmel, Jerusalem and Palestine to the streets he built.
- Professor Sir Frank Pantridge invented the portable defibrillator, which saves thousands of lives each year.
- Belfast's Crown Bar was the first pub ever owned by the National Trust.

# visit Belfast



## Knowledge through Measurement

### IMEKO XXII Congress Organising Committee

Prof Ron Summers	InstMC	Chair of Committee
Prof Kenneth Grattan	City, University of London	President, IMEKO
Colin Howard	InstMC	World Congress Treasurer
Prof Sanowar Khan	City University of London	Chair, National Programme Committee
Dr Graeme Philp	GAMBICA	Exhibition and Sponsorship Co-chair
Dr Patrick Finlay	InstMC	Project Manager
Prof Alistair Forbes	NPL	Scientific Programme Web Co-chair
Prof Graham Machin	NPL	Publications Co-chair
Prof Tong Sun	City, University of London	Publications Co-chair
Daniele Dragoni	MCI Group, UK	PCO Representative, Project Director
Rebecca Hill	MCI Group, UK	PCO Representative, Project Manager
Prof Andy Augousti	Institute of Physics	IoP Representative
Claire Garland	Institute of Physics	IoP Representative
Prof Yong Yan	University of Kent	Scientific Programme Web Co-chair
Prof Tongyu Li	Shandong Academy of Science	OFSIS Representative
Gary Menary	Queen's University	Belfast Local Co-ordinator

### IMEKO XXII National Scientific Programme Committee (NPC)

Prof Sanowar Khan	City University of London	Chair
Prof Graham Machin	NPL	Publication co-chair
Prof Ron Summers	InstMC	Congress Chairman
Prof Ken Grattan	City, University of London	President, IMEKO
Prof Tong Sun	City, University of London	Scientific Programme Web co-chair
Claire Garland	Institute of Physics	IoP Representative
Prof Alistair Forbes	NPL	Scientific Programme Web co-chair
Prof Yong Yan	University of Kent	Scientific Programme Web co-chair



## Knowledge through Measurement

### IMEKO XXII International Scientific Programme Committee

Chair: Prof Roman Morawski, Warsaw University of Technology, Poland

Membership: the chairs of the 23 IMEKO Technical Committees and supporting members

Claire Bartoil	France
Prof. Eric Benoit	France
Dr. Lajos Borbas	Hungary
Thomas Bruns	Germany
Dr. Isabel Castanheira	Portugal
Prof. Marcantonio Catelani	Italy
Rafael Celestre	France
Dr. Anna Chunovkina	Russia
Dr. Lorenzo Ciani	Italy
Dr. Valnei Smarcaro da Cunha	Brazil
Prof. Dominique Dallet	France
Paul-Gerald Dittrich	Germany
Prof. Dante J. Dorantes-Gonzales	Turkey
Dr. Ivana Durickovic	France
Prof. Ravi Xavier Fernandes	Germany
Prof. Alistair Forbes	United Kingdom
Dr. Kenichi Fujii	Japan
Dr. Koichiro Hattori	Japan
Dr. Jay Hendricks	USA
Prof. Olfa Kanoun	Germany
Mr. Andy Knott	United Kingdom
Dr. Tokihiko Kobata	Japan
Prof. Yasuharu Koike	Japan
Prof. Rolf Kumme	Germany
Prof. Aimé Lay-Ekukille	Italy
Mr. Samuel Low	USA
Dr. Renato Reis Machado	Brazil



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Prof. Luca Mari	Italy
Dr. Detlev Markus	Germany
Pawel Mazurek	Poland
Dr. Maria Nieves Medina Martin	Spain
Mr. Febo Menelao	Germany
Dr. Bodo Mickan	Germany
Prof. Janusz Mindykowski	Poland
Dr. Elisabeth Costa Monteiro	Brazil
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Prof. Sergey Muravyov	Russia
Dr. Yon-Kyu Park	South Korea
Dr. Franco Pavese	Italy
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Dr. Michael Reader-Harris	United Kingdom
Dr. Francesco Righini	Italy
Dr. Gustavo Ripper	Brazil
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Dr. Dirk Roske	Germany
Prof. Giovanni Battista Rossi	Italy
Prof. Alexandru Salcenu	Romania
Prof. Georg Schitter	Austria
Dr. Michela Segal	Italy
Dr. João A. Sousa	Portugal
Prof. Ron Summers	United Kingdom
Qiao Sun	China
Prof. Susumu Tachi	Japan
Prof. Shigeru Takatama	Japan
Prof. Yasuhiro Takaya	Japan
Dr. Zsolt Janos Viharos	Hungary
Dr. R White	New Zealand
Dr. Yong Hyeon Yim	South Korea
Prof. Bernhard Zagar	Austria
Dr. Nien-Fan Zjang	USA
Mr. Davor Zvizdic	Croatia



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### IMEKO Technical Committees (TC's)

TC	Title	Chair
TC1	Education and Training in Measurement and Instrumentation	Dr.-Ing. Maik Rosenberger
TC2	Photonics	Prof. Bernhard Zagar
TC3	Measurement of Force, Mass and Torque	Dr. Rolf Kümme
TC4	Measurement of Electrical Quantities	Prof. Dominique Dallet
TC5	Hardness Measurement	Renato Reis Machado
TC7	Measurement Science	Prof. Giovanni B. Rossi
TC8	Traceability in Metrology	Dr. Michela Segà
TC9	Flow Measurement	Dr. M. J. Reader-Harris
TC10	Technical Diagnostics	Prof. Marcantonio Catelani
TC11	Metrological Infrastructures	Prof. Dr. Mladen Boršić
TC12	Temperature and Thermal Measurements	Davor Zvizdic
TC13	Measurements in Biology and Medicine	Prof. Ron Summers
TC14	Measurement of Geometrical Quantities	Prof. Yasuhiro Takaya
TC15	Experimental Mechanics	Prof. Dr. Zoltán Major
TC16	Pressure and Vacuum Measurements	Dr. Tokihiko Kobata
TC17	Measurement in Robotics	Prof. Dr. Susumu Tachi
TC18	Measurement of Human Functions	Prof. Yasuharu Koike
TC19	Environmental Measurements	Prof. Aimé Lay-Ekuakille
TC20	Measurements of Energy and Related Quantities	Prof. Ravi Xavier Fernandes
TC21	Mathematical Tools for Measurements	Dr. Franco Pavese
TC22	Vibration Measurement	Gustavo Ripper
TC23	Metrology in Food and Nutrition	Dr. Isabel Castanheira
TC24	Chemical Measurements	Dr. Yong Hyeon Yim



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## Festival of Measurement

The first ever national Festival of Measurement is being hosted by the Institute of Measurement and Control from September 2018 to May 2019.

The aims of the Festival are to:

- promote a culture of accurate measurement in industry,
- raise public awareness of the importance of measurement in daily life,
- promote metrology as a career and highlight its importance in STEM subjects.

The Festival of Measurement is using the build-up to the historic changes in the definitions of the SI units in May 2019 as an opportunity to promote measurement awareness, and excellence. During the Festival InstMC will be highlighting the pervasive nature of measurement in daily life and its importance in industry, commerce, and research.

The Festival is being officially launched by Nobel prize-winner Professor William Phillips on the opening day of the IMEKO 2018 Congress, following his inaugural plenary lecture on Monday 3 September "Time, Einstein and the coolest stuff in the universe". After the talk Professor Phillips will start a countdown timer for 23 million seconds – the duration of the Festival. This event will be witnessed by over 300 physics students from local schools, who will have an opportunity to meet Professor Phillips and other leading figures from the world of metrology.

There are a range of activities throughout the 9 months of the Festival, involving outreach to schools and universities, networking with industry and engagement with the general public through lectures and broadcasts. If you are organising a measurement-related event during the Festival, please contact us and we can help to publicise it on the Festival website. If your organisation would like to discuss how to take part in the Festival or become one of its official supporters, please contact Project Manager Steff Smith ([festival@instmc.org](mailto:festival@instmc.org)) or visit the Festival stand in the registration foyer of the Waterfront Centre.

You can also find out more about the Festival and see a full listing of events and activities at [www.festivalofmeasurement.org](http://www.festivalofmeasurement.org)





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## Welcome to IMEKO from the Institute of Measurement and Control



The Institute of Measurement and Control is the professional membership body for engineers and scientists in the measurement, automation and control fields. Founded in London in 1944, we aim to promote high standards of professional competence, to support our members in their careers, to provide a bridge between academic research and industrial practice, to encourage students into engineering and science, to engage with the wider public and to inform government policy.

In one word, our area of expertise is *sensors*: we are concerned to measure and control industrial processes, infrastructure networks and digital platforms. Our members' interests range from control and instrumentation in nuclear power, oil and gas and the transport network, through to enabling technology for the Internet of Things, driverless cars and personal health monitoring. This is underpinned by academic and industrial metrology research into new types of sensor and calibration methods.

We have a network of regional sections in the UK and internationally, and we run special interest groups (SIGs) across eight key subject areas. Among these are a Measurement SIG and a Standards SIG which bring together academic researchers, national measurement laboratories and industrial users, testifying to the Institute's keen interest and influence in metrology, calibration and standards.

InstMC is the host organisation for IMEKO 2018 and we are delighted to welcome you to the Congress. We hope you find it to be stimulating, professionally relevant and a great opportunity to network with colleagues. You may like to further this process by joining InstMC yourself. Individual membership is available in several grades, from student through to corporate Member and Fellow. We also have a companion company scheme offering a range of corporate benefits. Please visit our stand in the exhibition area, or our website [www.instmc.org](http://www.instmc.org)

A handwritten signature in blue ink, which appears to read 'P. Finlay'.

Patrick Finlay  
Chief Executive



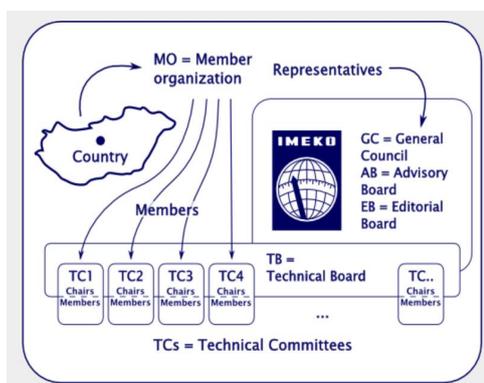
## An Introduction to the International Measurement Confederation (IMEKO)

**The International Measurement Confederation (IMEKO)** is a non-governmental federation of 42 Member Organizations (including a supporting member) individually concerned with the advancement of measurement technology.

IMEKO was established in 1958 and is a non-governmental confederation of measurement-related organizations and institutions (Member Organizations, MOs) from **42 countries**: Albania, Austria, Belgium, Brazil, Bulgaria, Canada, China, Democratic Republic of Congo, Croatia, Czech Republic, Egypt, Finland, France, Germany, Greece, Hungary, India, Italy, Jamaica, Japan, Kazakhstan, Kenya, Republic of Korea, Nigeria, Poland, Portugal, Romania, Russia, Rwanda, Serbia, Slovakia, Slovenia, South Africa, Spain, Switzerland, Thailand, Turkey, Uganda, Ukraine, United Kingdom, United States of America and Hottinger Baldwin HBM Messtechnik GmbH (as a supporting Member Organization).

The principal objectives of IMEKO are to promote the exchange of scientific and technical information in the field of measurement science and instrumentation technology; to enhance the co-operation among scientists and engineers, both from research and industry. These objectives are basically carried out by **24 Technical Committees (TCs)** of the Confederation. (A detailed description of TC is available from the website: <http://www.imeko.org/index.php/organization/committees> ).

IMEKO is governed through the **General Council (GC)** the supreme governing body, supported by an **Advisory Board (AB)** and the **Technical Board (TB)**. Their duties are defined in the **IMEKO Constitution and By-laws** (these can be seen from the IMEKO website at <http://www.imeko.org>). The structure is shown schematically below.



The **GC** consists of one of two delegates from each Member Organization (MO); however each MO has only one vote. The GC is the major forum for discussion and decision making for IMEKO.

The **AB** nominates officers for election and formulates recommendations to the GC on general policy, long-term planning, relations with international organizations, publication activities and procedural matters and guidelines.

The **TB** oversees the activities of **24 IMEKO Technical Committees (TCs)**, taking key decisions about the events (conferences, symposia, workshops etc.) organised by those committees.

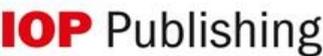
A number of IMEKO Technical Committee meetings take place during the World Congress and attendees are welcome to attend these meetings, which allow Technical Committees members to come together and discuss future planning for its activities.

The IMEKO Secretariat in Hungary can be contacted through Mrs. Judit Faragó, IMEKO Secretary, at e-mail [imeko@t-online.hu](mailto:imeko@t-online.hu) or phone: +36 1 353 1562.



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