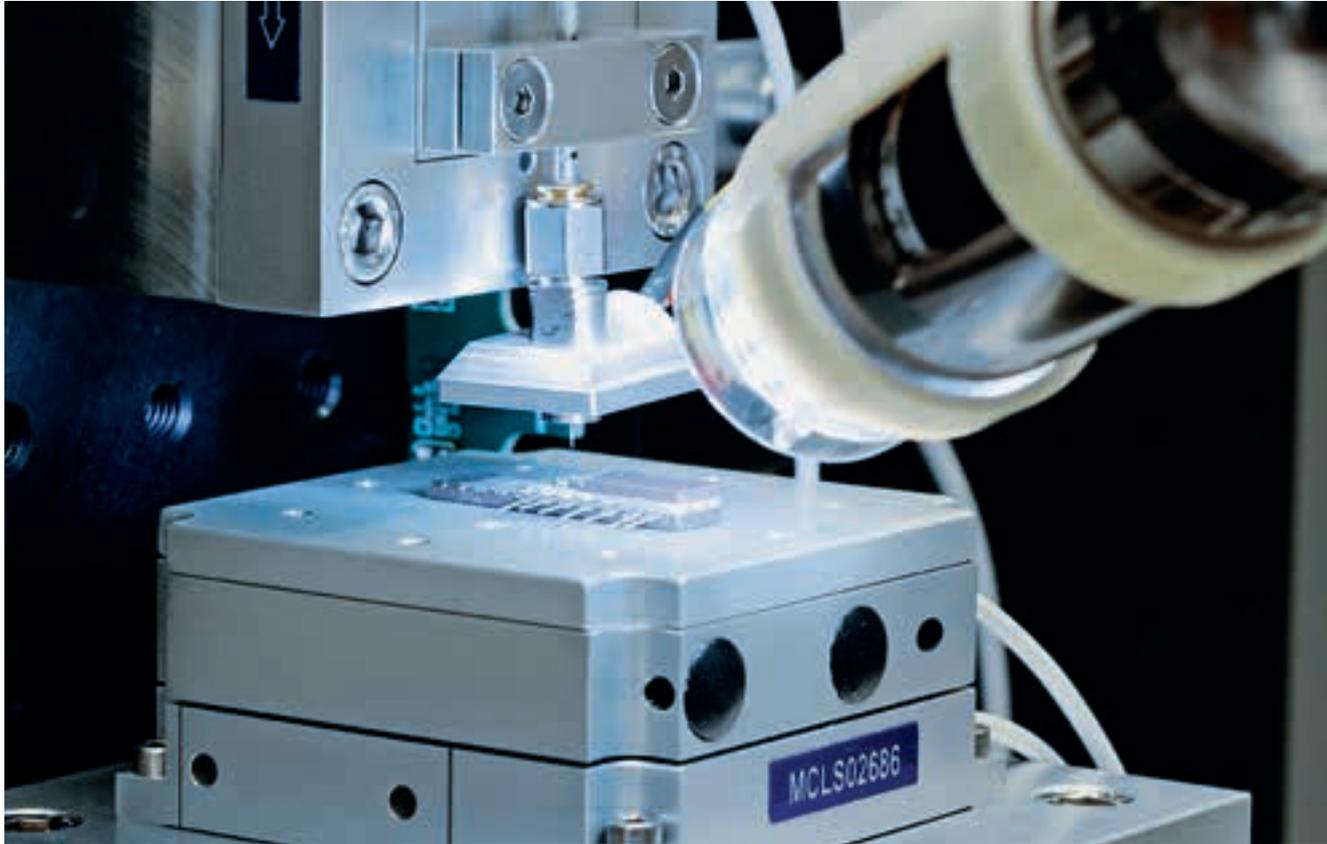




Schweizerische Eidgenossenschaft  
Confédération suisse  
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Federal Institute of Metrology METAS

Swiss Confederation



## METAS in 2014

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The near-field scanning microwave microscope (NFSMM) is a new type of measuring instrument that uses microwaves to characterise materials at the nano level (see p.14)



## Opening up new areas



At the beginning of 2013, METAS became the Federal Institute of Metrology. This was also the time it was recognised as a research institution entitled to receive contributions from the Commission for Technology and Innovation (CTI). This means that METAS is in a position to support the innovation process and the competitive-

ness of the Swiss economy not only with its expert knowledge and metrological infrastructure, but also with application-oriented research projects. Thanks to the well-founded metrological know-how that METAS possesses in the most diverse subject areas it is an attractive collaboration partner for Swiss industry. This can be seen in particular in the fact that six new application-oriented CTI projects could be agreed with industry partners in 2014.

Research and development form an important basis for the services offered by METAS. After all, scientific and technological progress as well as economic and social development constantly pose new challenges for metrology and its basic principles.

Above all, it is vital to identify future developments and the challenges for the metrological infrastructure arising from them in good time, in order to build up expertise and be able to undertake the necessary adjustments. At the same time, it is important to establish priorities and systematically deploy the available resources in a goal-oriented manner. Taking into account the clarifications submitted to it on developments in metrology, the general environment as well as the opportunities for METAS, the Institute Council has approved the building up of expertise in three new areas. The opening up of new areas is an important contribution to ensuring that METAS can continue to prosper in the years to come.

Prof. Dr. Martina Hirayama  
President of the Institute Council

« It is vital to identify future developments and the requirements for the metrological infrastructure arising from them in good time. »

## The second financial year



METAS has completed the second successful year of operations. The number of calibrations again increased with a corresponding growth in sales revenue. METAS performed very well in the tendering procedures for the European Metrology Programme for Innovation and Research EMPIR and is also successful with CTI projects. In order to build up expertise in new areas, the Institute Council has approved the financing for the coming four years. At the international level, we were able to strengthen our presence in the executive committees of international organisations.

In the field of legal metrology, we have undertaken the supervisory activity comprehensively and at the same time with measured judgement. Preparation for the amendment of legal provisions took place in close contact with interested parties and always with the good will of all concerned to seek out the best solution.

The success of METAS is attributable to a large number of factors:

- motivated and dedicated employees
- a good governance structure in which the Institute Council establishes an operational framework for METAS and at the same time expresses clear expectations
- the legal structure as a decentralised administrative unit of the federal government
- the freedom of action necessary to be able to respond quickly and flexibly
- good contact with the Federal Department of Justice and Police (FDJP)

In this annual report, we offer an insight into the work of METAS in 2014 and its exciting development.

Dr. Christian Bock  
Director

« METAS is able to look back on another successful financial year. »

## Guiding METAS: the Institute Council and the Executive Board

*At the head of METAS is the Institute Council. Composed of five members, it is responsible for guiding the business. The operative management is in the hands of the Executive Board.*

The five members of the Institute Council possess in-depth management experience and extensive experience in research and development in both sciences and technology spanning many years. Its president is Professor Dr. Martina Hirayama. The duties of the Institute Council are defined in the Institute Act. It applies to the Federal Council for the monies for services to be provided by the Federal Government and authorises the research and development programme. It exercises a supervisory role over the Executive Board and issues the personnel regulations.

### Defining the strategic orientation

Among the Institute Council's most important tasks is to define the strategic orientation of METAS which it carries out in conjunction with the Executive Board. In so doing, it follows the Federal Council's guidelines set out in the strategic goals for METAS. The Federal Council expects METAS to provide industry, the scientific community and the public administration with an effective metrological infrastructure together with the necessary measurement principles and metrological services.

Responsibility for the management of the institute lies with the Executive Board of METAS. It represents the institute to the outside world and is made up of the Director, Dr. Christian Bock, and the two Deputy Directors, Dr. Philippe Richard and Dr. Gregor Dudle.



The members of the Institute Council, from left to right: Dr. Matthias Kaiserswerth, Member; Dr. Tony Kaiser, Member; Prof. Dr. Ulrich W. Suter, Vice-President; Prof. Dr. Martina Hirayama, President; Prof. Dr. Thierry J.-L. Courvoisier, Member.

## Internationally binding: the General Conference on Weights and Measures

*The 25<sup>th</sup> General Conference on Weights and Measures took place in Versailles in November 2014. The Deputy Director of METAS, Dr. Philippe Richard, was elected to the International Committee for Weights and Measures (CIPM).*

The General Conference on Weights and Measures is the highest organ of the Metre Convention signed in 1875, of which Switzerland was one of the founding nations. It meets every four years as a general rule.

### Improvement in governance

From the Swiss perspective, the 25<sup>th</sup> General Conference was a success. The process aimed at improving governance initiated three years ago in which Switzerland played a leading role has borne fruit:

- The International Committee for Weights and Measures (CIPM), the "Administrative Council" of the international organisation of the Metre Convention, is now directly elected by the member states.
- There is a consensus that the International Bureau of Weights and Measures retirement scheme requires restructuring. The General Conference agreed on guidelines for this purpose.

Dr. Philippe Richard, the Deputy Director of METAS, was also elected in the ballot to choose the 18 members of the CIPM. This means that Switzerland is again represented in this executive body.



The Director of the International Bureau of Weights and Measures, Dr. Martin Milton, (right) in conversation with the Director of METAS, Dr. Christian Bock.

### Redefinition of the International System of Units SI

No decision on a redefinition of the International System of Units SI has yet been reached. Although it is still too early for this at the present time, the roadmap intended to lead to a redefinition was elucidated. The next General Conference will be held in 2018 – a redefinition of the SI units will probably be decided on at that time.

Other decisions of the General Conference in Versailles concern the contributions by member states and the revision of the agreement on mutual recognition of measurement and calibration capabilities (CIPM MRA).

# Measurement for industry and society: The role of METAS

*The most accurate place in Switzerland is in Wabern (BE). It is home to the Federal Institute of Metrology METAS – the metrological reference centre of Switzerland.*

METAS is the Swiss national metrology institute. It serves as the federal centre of competence for all issues related to measurement and for measuring equipment and measuring procedures. Through its activities in research and development and its range of services, METAS is instrumental in ensuring that measurements can be performed in Switzerland at the level of accuracy demanded by industry, research, administration and society.

#### Authoritative reference standards

METAS realises the Swiss reference standards, ensures their international recognition and disseminates them with the requisite degree of accuracy in each case. In this way it provides industry and society with a basic metrological infrastructure that is important wherever measurements are made.

METAS oversees the market launch process, use and control of measuring equipment in the retail trade, traffic, public safety, health and environmental protection. It makes sure that the measurements required for the protection of people and the environment can be carried out correctly and in the prescribed manner.

#### Metrology

*Metrology* is the science and technology of making measurements (from the Greek word *metron*, meaning “measure”). *Metrology* is frequently confused with *meteorology*. However, these two fields are clearly distinct. *Meteorology* is the study of weather phenomena (from the Greek word *meteoros*, meaning “raised from the ground”).

#### Progress demands precision

Reliable manufacture and monitoring is only possible with the aid of accurate measuring systems. New scientific and technological developments are therefore dependent on constantly evolving metrological principles and processes. Important branches of the Swiss economy such as micro and medical technology or applications such as measuring and control procedures call for measuring methods with an accuracy that may lie in the order of millionths of a millimetre.

METAS keeps up with scientific and technological developments in order to maintain its place at the cutting edge. It is engaged in research and development with a view to improving measuring stations and metrological services. It regularly reviews its range of services and adapts it to market needs.



The most accurate place in Switzerland: METAS in Wabern.

## New measurement areas: building up new expertise

*METAS is aiming to accumulate new expertise in three areas over the course of the coming years. In this way, it is laying the groundwork to meet the challenges of the future.*

It is important for METAS to identify future developments and the resulting demands on the metrological infrastructure. Only then will it be able to adapt its activities to the changing environment. Based on an analysis of development trends in metrology, the general environment and METAS's capabilities, three areas were identified in which new expertise is to be developed over the course of the coming years. Here, METAS is making use of its freedom as a decentralised administrative unit and is financing the development out of its own resources.

### Dependable data for climate models

Climate change poses fresh challenges for metrology. Both scientists and decision-makers from politics and public administration are reliant on dependable and comparable data. All the more so on account of the fact that changes have to be recorded over very long periods of time. In order to support the work of international climate research, 50 essential climate variables (ECVs) are being systematically monitored all over the world. Among these is the chemical composition of the atmosphere. Measurements are being made of the proportions by volume of carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and other persistent greenhouse gases as well as ozone (O<sub>3</sub>), aerosols and their precursors. In order to be able to compare the collected measurement data over long periods of time all over the world, standardised measurement methods are needed and measurements that are traceable to the International System of Units (SI). With this aim in mind, an intensive collaboration has been underway between the World Meteorological Organization (WMO) and the *International Bureau of Weights and Measures* (BIPM) since 2001.

One of METAS's core competencies lies in the production of dynamic gas mixtures. This is being used as a basis with which to build up measurement and calibration capabilities for very low mole fractions of so-called "chemical ECVs" in collaboration with national and international partners. Due to either their reactivity or adsorption phenomena, these gas mixtures of new components in very low concentrations cannot be stored in gas bottles and are thus not amenable to production with traditional methods.



### New measurement techniques for production technologies

A successful economy that develops and utilises innovative products and new production technologies, needs a reliable metrological infrastructure. METAS is building up its expertise in the field of micro-component measurement with a view to being able to offer additional services for the Swiss microtechnology industry in future.



Metrological fundamentals for climate change: reliable gas analysis.

Switzerland is a leader in microtechnology. During the development and quality control of micro-components it may be necessary to make traceable measurements in hard-to-reach places or even within previously produced sub-assemblies – for example in watch movements or in connectors for use in telecommunications. Techniques such as X-ray computed tomography are being used today for quality control. METAS is equipping itself with the necessary instruments and developing the appropriate measurement methodology, enabling traceable measurements in hard-to-reach places.

#### Optical properties of surfaces

Two objects may have the same shape and colour and yet appear different. The appearance is characterised by additional optical and mechanical properties such as lustre, texture, transparency, grain and sparkle. The interplay between these visual properties determines a surface's appearance.

The visual impression of a product often determines whether it will be chosen by the customer. That is why it plays a major role in many business sectors – from the car industry to the packaging industry. In use today are surfaces that create special effects and whose colours change according to the viewing angle for example. The task of metrology is to provide the measurement techniques, measurement procedures and measurement conditions with which to be able to evaluate optical properties of this kind.

Reflectometric measuring principles are typically employed for this purpose. There is need for improvement here because the current measurement uncertainties in this area are still greater than the differences perceptible to the human eye. In addition, there is a need for theoretical efforts in order to link the structural parameters of the surfaces with physical effects such as the interaction with optical radiation and with the perception and with aesthetic properties.

METAS possesses many years of experience in light measurement and is well-placed to make an important contribution in the field of optical characteristics of surfaces.



Enabling traceable measurements in hard-to-reach places:  
X-ray computed tomography.

## Measurement projects: Research and development at METAS

*METAS chiefly conducts its research and development work within the framework of the European metrology research and development programmes EMRP and EMPIR.*

In parallel with the work on EMRP research programme projects, the first invitation to tender for the follow-up programme EMPIR took place in 2014. METAS participated with nine project submissions on the core theme "Metrology for Industry" of which five were successful – an above-average success rate of 60 per cent. EMPIR is part of the new EU research framework programme "Horizon 2020". On account of Switzerland's partial association in this programme, METAS's financing is being provided by the State Secretariat for Education, Research and Innovation SERI and not by the EU.

### Reliable determination of fine particulate pollution

Soot particles from motor vehicle engines are regarded as harmful to health. The goal of the EMRP project "PartEmission" completed in 2014 was to develop principles for the measurement of vehicle exhaust gases. Up to now, the traceability of particle measurements in diesel exhaust gases has been an unresolved problem. The measurement of nanoparticles of this type calls for new methods and reference particles with defined properties: they have to be thermally stable, spherical and soot-like. The smaller the particles, the greater the challenge. METAS is heading one of the work packages and is concentrating on the definition of a calibration aerosol for the calibration of particle measurement instruments for particles in the range below 100 nanometres. Here it has succeeded in producing silver particles with defined properties ranging from a few nanometres up to 120 nanometres. This is an important step on the road to establishing a metrological basis for comparable measurement of particle numbers in diesel exhaust gases.

### Characterisation of novel materials

Materials with defined electromagnetic functionality play an important role in the semiconductor and electronics industry and are used in process control and energy generation. Techniques for traceable characterisation of such materials have been developed in the "EMINDA" EMRP project. In this project, METAS was involved with the measurement of dielectric properties of materials with a spatial resolution of less than a micrometre. The measuring instrument employed was a type of atomic force microscope that uses microwaves to make measurements. METAS has developed algorithms and measurement procedures that permit traceable determination of the dielectric constants in minute blocks of material.



### EMRP and EMPIR

The EMRP research programme (European Metrology Research and Development Programme) and the follow-up programme EMPIR (European Metrology Programme for Innovation and Research) were developed by EURAMET, the European Association of National Metrology Institutes, and the EU commission. Their goal is to coordinate the research conducted by the national metrology institutes more effectively and to strengthen metrological collaboration.



Determining fine particulate pollution reliably: reference particles with defined properties.

## Measurement in the service of product development: cooperation projects with industry

Since 2013, METAS as a research institution is entitled to receive contributions from the Commission for Technology and Innovation (CTI). Companies can utilise its research and development expertise for their own innovation and development work and carry out projects in application-oriented research and development in conjunction with METAS.

The scientific and technical know-how built up by METAS may be utilised by Swiss industry not only in the form of calibration and measurement services but also directly for product and process development. This makes METAS an attractive collaboration partner in various areas. Through the services, the METAS laboratories are able to maintain close contact with measurement engineers and development departments in industry. Numerous ideas for innovation projects arose within a very short time of the recognition of METAS as a CTI research partner. To date seven project proposals – six of which in 2014 – have been submitted and approved.

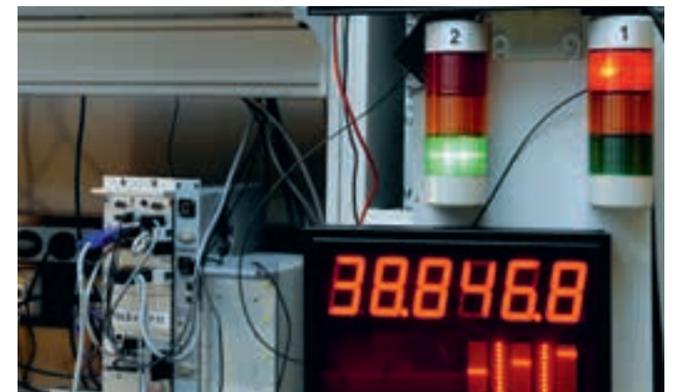
### Better market opportunities thanks to recognised testing technology

Speed measurement systems based on laser scanner technology play an ever more important role in traffic monitoring. Armed with innovative ideas and products, the company *ces complete electronic systems AG* has been able to establish a leading position for itself in the Swiss market in this sector within a very short period of time. In order to open up the European market and in particular that in Germany as well, the laser scanners must be approved by the respective public authorities. At the present time, however, no suitable test procedures and techniques have been established in the potential sales markets. The systems still have to be tested on the road with real traffic in comparison with a reference system. Tests of this type are

time-consuming and dangerous and barely able to encompass all speeds. The goal of the joint project between *ces AG* and METAS is to develop a simulation system with which the traffic monitoring laser scanner can be reliably tested and validated in the laboratory. The entire speed range and vehicle categories should be freely selectable. The simulations should also enable investigation of behaviour during speed changes – during heavy braking or rapid acceleration – and above all in complex vehicle constellations, something that is not currently possible to ascertain in quantitative terms.



With the compact, METAS-validated simulation system, test laboratories will be able to test the *ces AG* laser scanner in accordance with the requirements of the public authority concerned. It is thus a key to market expansion for this Swiss industry partner of METAS.



Traffic in the lab: simulation procedure for testing traffic monitoring systems.

## Measurement in the service of product quality: metrology for industry

*Thanks to the services provided by METAS, countless organisations in different industrial sectors are able to measure correctly. This allows them to satisfy the quality requirements placed upon their products.*

METAS provides industry with calibration services and other services for measurement and testing. In 2014, METAS issued almost 4,000 calibration certificates as well as measurement and test reports, generating revenues of 4.3 million Swiss francs in the process. The most important customers segments are the mechanical engineering, electrical and metalworking industries as well as the medical and communications technologies.

### At the start of the calibration chain

Calibrated measuring instruments and standards ensure that the correct measurement is imparted in the form of internationally harmonised and recognised reference values. A reference value imparted by METAS is crucial to a large number of other measurements because the calibrated measuring instruments or standards are often to be found at the start of a calibration chain. The measurement and testing services serve primarily to confirm the conformity of industrial products with prescribed specifications, normative requirements or legal guidelines.

### Railway tracks in the laboratory

With the increase in traffic volumes and the commissioning of new high speed lines, increasing attention needs to be paid to the question of noise protection in rail traffic. The noise is generated on the rail and can be reduced by good rail grinding. There are highly specialised measuring devices that measure the grinding pattern of railway tracks dynamically in accordance with normative requirements in order to be able to estimate the noise generated. Measuring devices of this type require validation with the aid of measurement standards. METAS calibrates standard rails for customers at home and abroad. These are sections of railway

track, just over three metres in length, weighing around 240 kg with a grinding pattern as well-defined as possible. The rail profile is measured in 800 mm lengths using an instrument for determining straightness with inductive sensor and air-cushioned slides and then amalgamated over the entire length with overlaps. The customer receives a calibration certificate and a data set with all measurement points on the profile being examined.

Calibrated standard rails enable measurements to ascertain the roughness of railway tracks to be traced back to national standards and to qualify and validate measuring devices. In this way, the METAS services help to enable comparable and standard-compliant measurements of railway tracks to be carried out in the interest of noise reduction.



A contribution to noise reduction: calibrated standard rails.

## Light and lighting: the METAS Optics laboratory

*The METAS Optics laboratory deals with all aspects of measurement and evaluation of free optical radiation. It calibrates, tests, characterises and evaluates optical sources, receivers and materials.*

2015 has been proclaimed the International Year of Light and Light-based Technologies by UNESCO. This choice emphasises the immense importance of light in technical applications of every kind. In order to be able to develop and implement them, ever more reliable measurement capabilities and measurement principles are needed. The METAS optics laboratory is responsible for the national realisation of the candela base unit and ensuring the internationally recognised measurement basis for measurements in the visible light range and the infrared and ultraviolet ranges. Optics is one of the three areas in which METAS is planning to build up new expertise in the coming years (see p. 12).

### Lighting

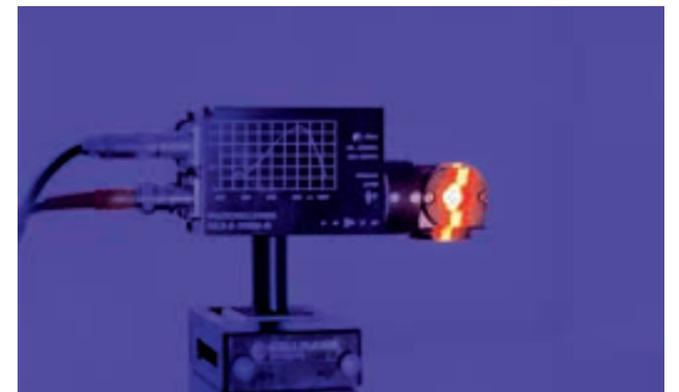
Lighting accounts for around a fifth of global energy consumption. The search for energy-saving lamps has kick-started enormous development in the field of lighting technology in recent years. The replacement of conventional incandescent lamps by energy-saving light-emitting diodes (LEDs) is creating fresh challenges for optical measurement methods. Reliable and comparable methods with which to be able to measure characteristic parameters such as the luminous flux, luminosity, colour temperature and quality of colour rendering of LEDs are called for.

### Protection thanks to light

Lighting is often provided in the interest of safety: tunnel lighting, runway guidance lighting for pilots or motor vehicle headlights, reversing lights and indicator lights. In order to be able to test the properties of lighting, the Optics laboratory has an extensive array of photometric measurement equipment. These include goniophotometers, integrating spheres and luminance measuring cameras.

### Protection against light

Light may also be irritating or even dangerous. Laser pointers and laser beams used for decoration or visual effects may be dazzlingly bright at times and can result in serious eye injuries. Even laser shows therefore pose a potential risk. The Optics laboratory has developed a new appraisal system for laser shows in collaboration with the Federal Office of Public Health. It enables a planned show to be measured on-site in real time, thereby checking and ensuring compliance with safety limits.



Measurement and evaluation of light: the Optics laboratory.

## Measurement across borders: international metrology organisations

*International cooperation plays an essential role in metrology. Collaboration and exchange are important – worldwide within the framework of the Metre Convention and within Europe through research programmes.*

METAS enjoyed an exceptionally successful year at the international level in 2014. Its Deputy Director, Dr. Philippe Richard, was elected to the International Committee for Weights and Measures (CIPM) (see p. 7).

### Chairperson of EURAMET

Dr. Beat Jeckelmann, Chief Science Officer of METAS, was elected Chairperson of EURAMET. EURAMET is the European Association of National Metrology Institutes. It has launched important metrological research and development programmes, namely EMRP and its follow-up programme EMPIR (see p. 15). EURAMET plays an important coordination role within the European research community in the field of metrology.

While EURAMET fosters technical and scientific cooperation between the national metrology institutes, the European Cooperation in Legal Metrology (WELMEC) looks after international cooperation in legal metrology. In this way, it helps to eliminate technical barriers to trade. Among those involved in the development of a new strategy for WELMEC was Dr. Gregor Dudle, Deputy Director of METAS.

### Well-represented at the international level

Measured against the size of our country and the institute, METAS's international commitment is above the norm. It demonstrates that the staff and METAS enjoy international repute as competent and dependent partners.



Dr. Beat Jeckelmann, Chief Science Officer of METAS.

## Regulating measurement: adapting to new legal frameworks

*Because EU directives on measuring instruments have been changed, Swiss regulations also have to be adapted.*

Part of the bilateral treaties between Switzerland and the EU are rules governing the requirements for a number of measuring instrument categories and the procedures for putting them on the open market. This enables mutual recognition of conformity assessments and means the elimination of barriers to trade.

In 2008, the EU set out to codify a new legislative framework for the marketing of products. In accordance with the provisions of this *New legislative framework for marketing of products*, existing EU acts governing the marketing of products are to be gradually revised and new rules enacted. Among its activities in 2014, the EU concluded revised versions of two directives concerning measuring instruments. The revised versions contain more precise definitions, a more differentiated provision on the duties of the economic players and more detailed rules on conformity assessment bodies.

### Prepared for implementation

In order to be able to maintain the mutual recognition of the rules concerning measuring instruments, the corresponding Swiss rules relating to measuring instruments have to be adapted. In 2014, METAS, together with the State Secretariat for Economic Affairs (SECO), began to prepare for the implementation of the recast guidelines in Swiss law. The changes are to be agreed upon in 2015 and enter into force in 2016.



The rules for scales are among those being adapted.

## Regulating measurement: legislation concerning metrology

Among METAS's statutory duties is participation in the preparation of enactments in the field of metrology.



Individual sale of fruit and vegetables.

In 2014, a number of Federal Department of Justice and Police (FDJP) ordinances relating to measuring instruments as well as the FDJP Ordinance on Quantity Indications were revised and expanded in certain points.

Changes were made to the following ordinances:

- Ordinance on Quantity Indications: some provisions concerning the sale of loose goods were stated more precisely and the individual sale of fruit and vegetables in prepacks regulated.
- Ordinance on Breath Alcohol Measuring Devices: the scope was updated.
- Ordinance on Taximeters: an additional method for testing taximeters was introduced.
- Ordinance on Audiometry: a clearer regulation for the calibration of audiometers was implemented.
- Ordinance on Exhaust Gas Measurement Equipment for Internal combustion Engines: the procedures for the maintenance of measurement stability were partially revised and technical details relating to measuring instruments for nanoparticles from internal combustion engines amended.

### Preparations for 2015

Changes for the coming year were already in preparation in 2014. These include the adaptations to the EU *New legislative framework* (see p. 23). In addition, two ordinances were totally revised. These include the FDJP Ordinance on Measuring Instruments for Electrical Energy and Power and the Ordinance on Breath Alcohol Measuring Devices: Their comprehensive revision will be necessary for the implementation of measures in the Via Sicura programme. These include the introduction of evidential breath alcohol measurement devices and the use of breath alcohol ignition interlock devices.

## Assessing the conformity of measuring instruments: METAS-Cert

The METAS-Cert conformity assessment body has received accreditation.

METAS-Cert is notified and approved as a conformity assessment body in the area of measuring instruments. Since the beginning of 2013, the designating authority has been the General Secretariat of the Federal Department of Justice and Police (FDJP). Product certifications and inspections

The basis for the accreditation of METAS-Cert's work as a notified body for conformity assessments in the area of measuring instruments consists of the ISO/IEC 17021 standard for the certification of quality management systems and the ISO/IEC 17065 standard for the certification of products. METAS-Cert was audited by the Swiss Accreditation Service according to these standards and an accompanied audit carried out at a manufacturer. Because METAS-Cert also carries out inspections, particularly of weather stations, the scope of the accreditation was extended with the ISO/IEC 17020 standard relating to the operation of inspection bodies.

### Expanded area of activity

The amendment of the provisions to the EU *New legislative framework* (see p. 23) will also require METAS-Cert to be renotified. The accreditation will make it possible to set about the renotification more easily. It will also make it possible to expand the area of activity and, for example, to become an appointed authority for German national conformity assessments or for private certifications.



Conformity assessment body in the measuring instruments area: METAS-Cert.

## Measurement as a career: METAS as a place of work

*METAS's work is characterised by the scientific and technical backgrounds of the majority of its personnel and the tasks of a national metrology institute.*

METAS employs more than 180 persons from different professional disciplines as well as apprentices and interns. The majority of staff have a technical and scientific background, quite a few a university degree. Each member of staff, whether or not holding an academic qualification, makes its own contribution to enable METAS to carry out its tasks in highly technical and complex areas of work. The members of staff act in a constructive, dependable and open-minded manner in their respective functions. A particular challenge for METAS is the ability to attract and promote women as employees especially in the male-dominated scientific and technical professional fields and specialist areas. For this reason METAS offers among other things an internship in metrology specially addressed to women and promotes family-friendly working arrangements.

METAS offers a challenging and demanding professional environment characterised not least by the interplay between research and development on the one hand and the provision of services on the other. Working closely with partners in Switzerland and abroad is an intrinsic part of working routine in many functions in METAS. Change and adaptation to new challenges determine the working environment.

METAS is committed to being an attractive training location. It offers six different apprenticeships in the areas laboratory, electronics, information technology, engineering and commerce as well as university internships.

### Huge wealth of expertise

METAS possesses an immense wealth of expertise from various scientific and technical disciplines. It is the institute's capital. An important aspect is that the employees take an interest in topics outside their own field of activity and exchange ideas with others outside their own disciplines. In this way, METAS's know-how is constantly updated and its capabilities can be further developed.

### Career and family

METAS attaches great importance to family-friendly policies and flexibility as demonstrated in the conditions of employment. The modest size of the organisation lends itself to flexible working arrangements tailored to individual needs. This includes the possibility to undertake an agreed proportion of the working time from home. Its support of the career / family balance contributes to METAS's excellent standing in the competition for well-qualified specialists.



Geared to technology and science: the working environment at METAS.

## Finances

*METAS ended the 2014 financial year with a profit of 4.4 million Swiss francs. Expenditures amounted to 41.2 million Swiss francs and revenues (including payments received) to 45.6 million Swiss francs.*

METAS's reporting is carried out in accordance with the International Public Sector Accounting Standards (IPSAS) and complies with statutory requirements. This accounting standard was chosen in close consultation with the auditors, the Swiss Federal Audit Office.

### Balance sheet

(in TCHF)	31.12.2014	31.12.2013
<b>Assets</b>		
Cash	8 995	6 636
Trade receivables	3 265	1 718
Receivables for research projects	2 152	1 643
Other receivables	158	44
Prepaid expenses and accrued income	698	615
<b>Working capital</b>	<b>15 268</b>	<b>10 656</b>
Tangible fixed assets	20 463	21 659
Intangible fixed assets	1 295	1 231
<b>Fixed assets</b>	<b>21 758</b>	<b>22 890</b>
<b>Total assets</b>	<b>37 026</b>	<b>33 546</b>
<b>Liabilities and equity</b>		
Current liabilities on trade accounts payable	702	907
Liabilities in respect of research projects	2 852	2 356
Other liabilities	697	729
Accrued expenses and deferred income	395	92
Short-term provisions	610	618
<b>Short-term borrowed capital</b>	<b>5 256</b>	<b>4 702</b>
Provisions for pension fund liabilities	32 603	34 062
Provisions for service awards	1 318	1 371
<b>Long-term borrowed capital</b>	<b>33 921</b>	<b>35 433</b>
Net loss	-6 589	-10 612
Profit	4 438	4 023
<b>Equity capital</b>	<b>-2 151</b>	<b>-6 589</b>
<b>Total liabilities and equity</b>	<b>37 026</b>	<b>33 546</b>

### Profit and loss account

(in TCHF)	2014 1.1.2014–31.12.2014	2013 1.1.2013–31.12.2013
<b>Net revenue</b>	<b>45 593</b>	<b>45 426</b>
<b>Profit from sale of fixed assets</b>	<b>0</b>	<b>29</b>
<b>Expenditure on materials and third-party services</b>	<b>-483</b>	<b>-539</b>
Personnel expenses	-24 998	-25 800
Other operating expenses	-11 803	-11 619
Depreciation	-3 796	-3 491
<b>Operating expenses</b>	<b>-40 597</b>	<b>-40 910</b>
Financial revenue	45	40
Financial expense	-120	-23
<b>Financial result</b>	<b>-75</b>	<b>17</b>
<b>Profit</b>	<b>4 438</b>	<b>4 023</b>

In the reporting year, METAS was able to finance 47.1 percent of its activities (preceding year 45.5 percent) out of its own resources. The following means contributed to the self-financing level: fees, payments for taking over other tasks and external funds.

The auditors have confirmed without reservation that the accounts have been properly prepared.

The detailed, IPSAS-compliant annual accounts can be downloaded on the Internet at [www.metas.ch](http://www.metas.ch) or requested from METAS.

# Telling the measurement story: METAS publications and papers

*The research and development work is also reflected in publications and papers authored or presented to a live audience by METAS researchers.*

In 2014, METAS personnel again presented the results of their research and development work at symposiums, conferences and in scientific publications. They collaborated in specialist organisations and committees at national and international levels, contributing their know-how and experience there. They made metrology accessible to a wide audience including those beyond the immediate specialist group and were actively involved in courses for students at universities.

## Measurement, a constantly recurring theme

METAS personnel authored over 30 publications and presented more than 40 papers in 2014. A series of lectures was also given in the course of events at METAS itself.

In 2014, METAS published two issues of "METInfo", the technical journal for metrology. The articles are as a general rule written by METAS personnel.

The list below provides an overview of the most important publications authored by METAS personnel and the papers presented by them. When giving the authors' names, those of the METAS employees are shown in bold.

### Publications: Technical articles

- H. Andres** et al.: *Measuring soot particles from automotive exhaust emissions*. EPJ Web of Conferences 77, 2014, 00020.
- H. Bissig**, **M. Tschannen**, **M. de Huu**: *Micro-flow facility for traceability in steady and pulsating flow*. Journal of Flow Measurement and Instrumentation, 2014, doi: 10.1016/j.flowmeasinst.2014.11.0081.
- T. Bergen, **P. Blattner**: *Photometry Standardization Developments for OLEDs and LEDs*. LED professional Review, 41, 2014, pp. 24-28.
- J.-P. Braun**, **Ch. Mester**: *Power-Quality- und Synchrophasor-Messtechnik*. M. Kahmann, P. Zeyer (Hrsg.): Handbuch Elektrizitätsmesstechnik: Vorschriften Gerätetechnik Prüftechnik Systeme. 2. vollst. überarb. Aufl. Berlin: VDE, 2014 (ISBN 978-3-8007-3571-6), pp. 557-576.
- D. Corminboeuf**, **F. Overney**: *Inductive voltage divider calibration with sampling method*. EPJ Web of Conferences 77, 2014, 00014.
- F. Cosandier**, **A. Eichenberger**, **H. Baumann**, **B. Jeckelmann** et al.: *Development and integration of high straightness flexure guiding mechanisms dedicated to the METAS watt balance Mark II*. Metrologia, 51, 2014, pp. 88-95.
- J. Hoffmann**, G. Gramse, J. Niegemann, **M. Zeier**, F. Kienberger: *Measuring Low Loss Dielectric Substrates with Scanning Probe Microscopes*. Applied Physics Letters 105, 2014, Issue 1, pp. 013102-4.
- M. Kasper, G. Gramse, **J. Hoffmann** et al.: *Metal-oxide-semiconductor capacitors and Schottky diodes studied with scanning micro-wave microscopy at 18 GHz*. Journal of Applied Physics 116, 2014, pp. 184301-8.
- A. Küng**, **F. Meli**, **A. Nicolet**, **R. Thalmann**: *Application of a virtual CMM for measurement uncertainty estimation of aspherical lens parameters*. In: Meas. Sci. Technol. 25, 2014, 094011.
- F. Overney**, **A. Mortara**: *Synchronization of Sampling-Based Measuring Systems*. IEEE Trans. Instrum. Meas. 63, 2014, Issue 1, pp. 89-95.
- F. Pythoud** et al.: *Final report on EURAMET supplementary comparison EURAMET.EM.RF-S27: 'Antenna factor for loop antennas'*. Metrologia, 51, 2014, Tech. Suppl., 01007.
- R. Högstrom, P. Quincey, D. Sarantaris, **F. Lüönd** et al.: *First comprehensive inter-comparison of aerosol electrometers for particle sizes up to 200 nm and concentration range 1000 cm<sup>-3</sup> to 17000 cm<sup>-3</sup>*. Metrologia 51, 2014, pp. 293-303.
- A. Mindel A.**, **A. Marti**, **S. Perrin**: *METAS untersucht Methanolbildung in Obstbränden*. C<sub>2</sub>H<sub>5</sub>OH - Alkohol und Politik, 2014, Issue 1, pp. 14-15.
- S. Zihlmann**, **F. Lüönd**, **J. Spiegel**: *Seeded growth of monodisperse and spherical silver nanoparticles*. Journal of Aerosol Science, 75, 2014, pp. 81-93.

### Publications: Conference proceedings

- H. Andres**: *Field Measurement, Measuring Instruments Ordinance: Calibration, Certification, Measurement Cycle*. Proceedings of the 18th ETH Conference on Combustion Generated Particles, 2014, p. 4.
- A. Nowak, **H. Andres**: *Measuring Soot Particles from Engines: Recommendations from EMRP-ENVo2 Project in WP1*. Proceedings of the 18th ETH Conference on Combustion Generated Particles, 2014, p. 37.
- T. Arnold, **H. Baumann**, H. Bettin, F. Bielsa, A. Eichenberger et al.: *European metrology research programme: Advance on the realization of the kilogram redefinition*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 426-427.
- Ch. Bock**, **W. Fasel**: *Quelle est la fiabilité des contrôles de vitesse par la police?* F. Werro, T. Probst (éds.), Journée du droit de la circulation routière 26-27 juni 2014, Bern: Stämpfli; 2014, pp. 71-126.
- Ch. Bock**, **W. Fasel**: *Wie zuverlässig sind polizeiliche Geschwindigkeitskontrollen?* T. Probst, F. Werro (Hrsg.), Strassenverkehrsrechts-Tagung 24.-25. Juni 2014, Bern: Stämpfli; 2014, pp. 39-94.
- H. Bissig**, **M. Tschannen**, **M. de Huu**: *Micro flow standard for steady and pulsating flow*. 2nd International Conference on Microfluidic Handling Systems, Freiburg, Germany, 2014, pp. 45-48.
- J.-P. Braun**, **S. Siegenthaler**: *Calibration of PMUs with a reference grade calibrator*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 678-679.
- G. Rietveld, **J.-P. Braun** et al.: *Smart grid metrology to support reliable electricity supply*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 680-681.
- P. S. Wright, **J.-P. Braun** et al.: *Smart grid power quality and stability measurements in Europe*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 70-71.
- D. Zhao, G. Rietveld, **J.-P. Braun**, **F. Overney**, T. Lippert, A. Christensen: *Traceable measurement of the electrical parameters of solid-state lighting products*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, 650-651.
- A. Eichenberger**, **H. Baumann**, **F. Cosandier**, **B. Jeckelmann** et al.: *The METAS watt balance Mark II experiment: Progress report*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 714-715.
- J. Hoffmann**: *Nearfield scanning microwave microscopes*. Conference on Precision electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 218-219.
- J. Hoffmann**, **J. Ruefenacht**, **M. Zeier**: *The propagation constant of coaxial offset shorts with rough surfaces*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 14-15.

- A. Bounouh, G. Almuneau, H. Baumgartner, A. Cuenat, N. Gambacorti, **J. Hoffmann** et al.: *The EMRP project Metrology for III-V-materials based high efficiency multijunction solar cells*. Conference on Precision electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 318-319.
- M. de Huu**, **B. Wüthrich**: *Gravity wave effects on the calibration uncertainty of hydrometric current meters*. 7th International Conference on Fluvial Hydraulics, Lausanne, Switzerland, 2014, pp. 284-289.
- F. Ahlers, J. Kucera, W. Poirier, **B. Jeanneret** et al.: *The EMRP project GraphOhm - Towards quantum resistance metrology based on graphene*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 548-549.
- J. Kohlmann, R. Behr, O. Kieler, J.D. De Aguilar Rois, M. Sira, A. Sosso, **B. Jeanneret**, **F. Overney** et al.: *A quantum standard for sampled electrical measurements - main goals and first results of the EMRP project Q-WAVE*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 522-523.
- G. Rietveld, D. Jarrett, **B. Jeckelmann**: *Accurate high-ohmic resistance measurement techniques up to 1PΩ*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 290-291.
- A. Küng**, **F. Meli**, **A. Nicolet**: *A 5 degrees of freedom μCMM*. Proc. 14th Int. Conf. of the European Soc. for Precision Engineering and Nanotechnology (euspen), Dubrovnik, Croatia, June 2014, V1 pp. 269-272.
- K. Thodkar, C. Nef, W. Fu, C. Schonenberger, M. Calame, **F. Lüönd**, **B. Jeanneret**, **F. Overney**: *CVD graphene for electrical quantum metrology*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 540-541.
- F. Overney**, **B. Jeanneret**: *Impedance simulator for automatic calibration of LCR-meters*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 86-87.
- F. Overney**, **F. Lüönd**, **B. Jeanneret**: *Digitally assisted coaxial bridge for automatic quantum Hall effect measurements at audio frequencies*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 226-227.
- J. Nissila, K. Ojasalo, M. Kampik, J. Kaasalainen, V. Maisi, M. Casserly, **F. Overney** et al.: *A precise two-channel digitally synthesized AC voltage source for impedance metrology*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 768-769.
- P. Richard**, R. Davis: *Redefinition of the kilogram in 2018*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 428-429.
- M. Zeier**, **J. Hoffmann**, **P. Hürlimann**, **J. Rüfenacht**, **M. Wollensack**, R. Judaschke, K. Kuhlmann: *Stability tests of electronic calibration units*. Conference on Precision Electromagnetic Measurements CPEM, Rio de Janeiro, Brazil, 2014, pp. 16-17.

### Papers (without publicised proceedings)

- H. Andres**: *Measuring soot particles from automotive exhaust emissions*. 30th PMP Meeting, Brussels, Belgium, 4.4.2014.
- H. Bissig**: *Traceability in micro flow for steady and pulsating flow*. IMRET13, Budapest, 25.6.2014.
- H. Bissig**: *Primary standards for flow rates from 100 nL/min to 1 mL/min - Gravimetric principles*. 8th Workshop on Low Flows in Medical Technology, Lübeck, 24.9.2014.
- P. Blattner**: *Mesopische Photometrie / photométrie mésopique*. SLG Vorabendseminar, Granges-Paccot, 6.2.2014.
- P. Blattner**: *Candela, Lumen, Lux – Alternativen zu Glühlampen*. Volkshochschule Rheintal, Heerbrugg, 13.3.2014.
- P. Blattner**: *Devices for characterizing the wavelength scale of UV spectrometers*. Newrad, Espoo, 24.6.2014.
- P. Blattner**: *Wavelength scale devices*. UV Workshop Davos, 15.7.2014.
- P. Blattner**: *Measurement uncertainty & testing – part 2*. CIE Symposia "Measurement uncertainty for industry", Wien, 11.9.2014.
- P. Blattner**, **F. Rinderer**: *Lasershow: Notions de base & bases légales*. Cours interentreprise – Artos, Bienne, 8.10.2014.
- P. Blattner**: *Beleuchtung und Lichtmessung – neuere Entwicklungen*. Seminar GNI Gebäude-Netzwerk-Initiative, Wabern, 28.11.2014.
- Ch. Bock**: *Der Umgang des Staates mit «technischen» Normen*. Rechtsetzungslehre: Private Normen und staatliches Recht, 14. Tagung, Zentrum für Rechtsetzungslehre der Universität Zürich, 11.9.2014.
- J.-P. Braun**, **S. Siegenthaler**: *The Metrological Characterization of PMUs*. Workshop Synchrophasor estimation processes for Phasor Measurement Units: algorithms and metrological characterization, EPFL, Lausanne, 9.12.2014.
- W. Fasel**: *Geschwindigkeitsmessgeräte*. SVG-Tagung 2014, Fribourg, 24.6.2014.
- Ch. Hof**: *Metrologie im Bereich Vibration am METAS*. Kalibrier-Seminar, Spektra, Dresden, 8.10.2014.
- Ch. Hof**: *Measurement setup for the efficient... Calibration of tapping machines at METAS*. Get-together of NMIs at SPEKTRA, Dresden, 4.12.2014.
- J. Hoffmann**: *Connector effect and ripple method*. ANAMET Seminar and Workshop, Braunschweig, 17.12.2014.
- M. de Huu**: *Uncertainty budgets for environmental instruments*. Workshop Uncertainties in metrological measurements, MeteoSwiss, Payerne, 14.11.2014.

- B. Jeanneret**: *CVD Graphene for Electrical Quantum Metrology*. Graphene Workshop, NPL, Teddington, 12.11.2014.
- B. Jeckelmann**: *EMPIR: European Research Programme for Innovation and Research*. Programmleiter-tagung BFE, Bern, 12.11.2014.
- A. Küng**, **A. Nicolet**, **F. Meli**: *Study of diamond coated probe tip wear when scanning on different materials*. Macroscale 2014, Wien, 29.10.2014.
- F. Lüönd**: *DC and AC quantum Hall effect measurements with graphene*. Graphene Week, Universität Göteborg 25.6.2014.
- F. Lüönd**: *DC and AC quantum Hall effect measurements with graphene*. Graphene Workshop, NPL, Teddington, 12.11.2014.
- F. Meli**: *Economic high resolution fringe counting for heterodyne interferometers using FPGA technology*. Macroscale 2014, Wien, 29.10.2014.
- B. Niederhauser**, **H. Haerri**, **A. Ackermann**, **C. Pascal**: *NO<sub>2</sub> Traceable mobile permeation generator (TMPG) and 2-step dilution system*. Final Conference MACPoll, Delft, 13.5.2014.
- B. Niederhauser**, **H. Haerri**, **A. Ackermann**, **C. Pascal**: *Traceable Dynamic Generation of Reactive Air Pollutants at Limit Values*. Final Conference MACPoll, Delft, 13.5.2014 (Poster).
- F. Pythoud**: *Einführung in die EMV*. EMV-Fachtagung, SwissT.meeting, Bern, 21.1.2014.
- P. Richard**: *The Watt Balance Route & CCM Perspective*, 80 Years of Italian Metrology, Turin, 5.12.2014.
- J. Rüfenacht**: *Best Measurement Practice in VNA Measurements – Hints for the Practitioner*. ANAMET Seminar, Delft, 27.6.2014.
- D. Schwaller**: *Abgasmessmittel für Feuerungsanlagen: Anforderungen und Praxis*. SVG Weiterbildungsstadium, Zürich, 19.11.2014.
- A. Steiner**: *Audits am METAS – Erfahrungsbericht eines Grosslabors*. EURALAB SNV Seminar, Olten, 19.11.2014.
- R. Thalmann**: *Scientific metrology versus customer satisfaction: Challenges for the METAS length laboratory*. 11th IMEKO Symposium LMPMI 2014, Laser Metrology for Precision Measurement and Inspection in Industry, Tsukuba, Japan, 3.9.2014.
- R. Thalmann**, **D. Kündig**: *Which diameter matters? Macroscale 2014, Wien, 29.10.2014.*
- M. Wollensack**, **M. Zeier**: *VNA Characterization Data in the Uncertainty Evaluation of S-Parameter Measurements*. ANAMET Seminar, Delft, 27.6.2014 (Poster).
- M. Zeier**: *The new EURAMET cg-12 guide*. ANAMET Seminar and Workshop, Braunschweig, 17.12.2014.
- M. Zeier**: *A simplified method of VNA uncertainty estimation*. ANAMET Seminar and Workshop, Braunschweig, 17.12.2014.



