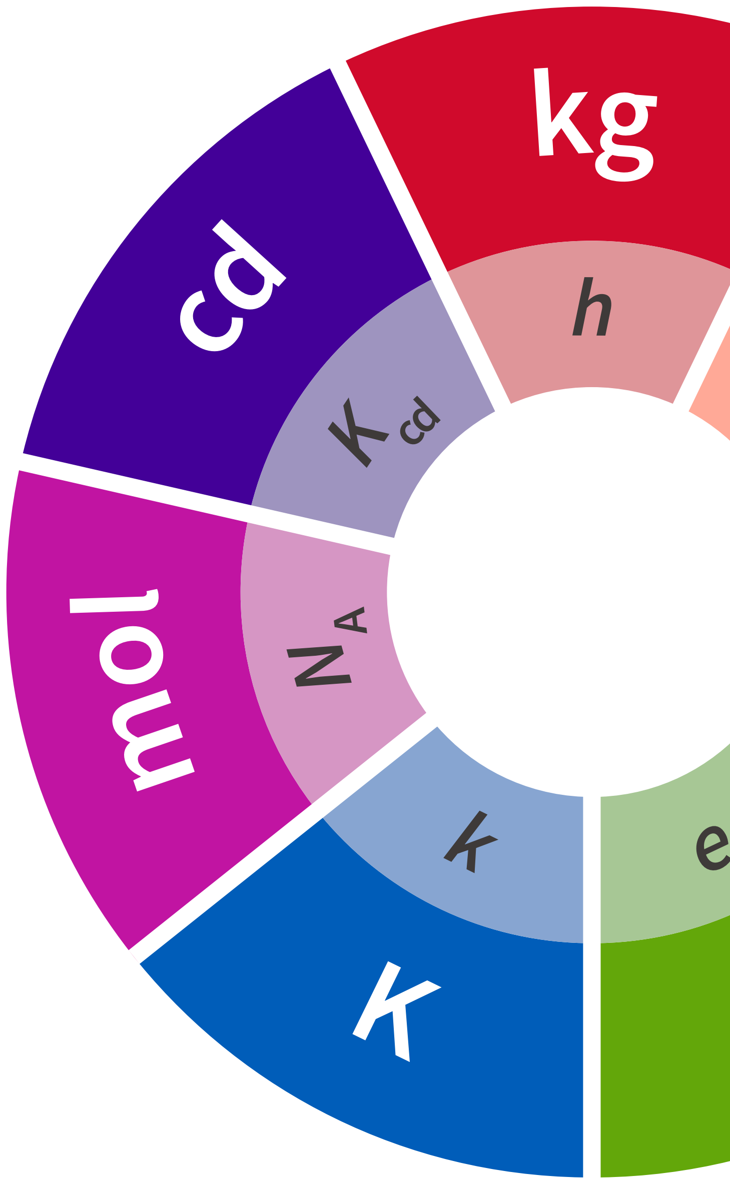


中国计量科学研究院
National Institute of Metrology,China

ANNUAL REVIEW 2017–2018

National Institute of Metrology, China

Director's Message

The year 2017 marked the start of a phase in which the country's economy will transform from rapid growth to high-quality development. The same year also marked an exciting event in which the conditions were all met for the expected revision of the International System of Units (SI). Metrology, the science of measurement that underpins the advance of the global economy and society at large, is about to make a historic leap forward, thereby bringing a new order to the international measurement system and providing a bridge for future innovation.

At this transitional point, the National Institute of Metrology, China (NIM), once honorably labeled as a "National Treasure," has lived up to its expectations by making substantial contributions to the SI revision and providing increasingly more advanced and responsive measurement solutions to support scientific and technological innovation and economic transition.

The *Annual Review 2017–2018* presents some of our major achievements and contributions made in the past year. This report consists of four chapters focusing on basic research, capacity building, projects supporting national strategies and industrial development, and our involvement and collaborations on both the domestic and international scales. The year 2018 marks the 40th anniversary of China's reform and opening up and will also see the adoption of the new SI. Taking advantage of this time under the new leadership of the State Administration of Market Regulation (SAMR), NIM will bear the soul of metrology, the spirit of craftsmen, and the unity of knowledge and practice to work for better measurement and a better future.

Start small, think big.

Fang Xiang
Director of NIM

Contents

1

Basic Research

Basic research pushes back the frontiers of science and paves the way for original innovation, accumulation of intellectual capital, and building core competence for the development of economy and society. History has demonstrated that all scientific and technological innovation relies on the support of measurement technologies. Three technological revolutions in the past provide explicit evidence of technical breakthroughs being closely related to breakthroughs in measurement technology. The proposed changes to the SI will use physical fundamental constants to define international measurement units. It is expected that these changes will be approved at the General Conference on Weights and Measures (CGPM) in November 2018 and will be implemented on May 20, 2019. “Quantum standards” and “a flat traceability chain” will likely become core features of the new system of units. The revision will mark an important and historic step forward to provide a bridge for future innovation and to greatly promote developments in science, the economy, and society.

1.1 Toward the future second

The strontium optical lattice clock is presently the most accurate atomic clock among the various ion and atom candidate species under investigation at National Metrology Institutes (NMIs) worldwide. The best strontium clocks are two orders more accurate than the best cesium clocks, the current primary standards for realizing the SI second. The strontium optical lattice clock is considered the most competitive candidate for redefining the SI second in the future.

The strontium optical lattice clock developed by NIM has already contributed to the International Bureau of Weights and Measures (BIPM) as a data source for secondary representation of the SI second. This clock is currently the only optical clock used in China;

NIM has further updated the local oscillator of the strontium optical lattice clock. This has greatly improved the clock's stability, with its differential measurement stability reaching the 10^{-18} scale for the first time. Such remarkable stability boosts existing confidence in a future optical definition of the SI second and will provide a new tool for cutting-edge research in fundamental physics.

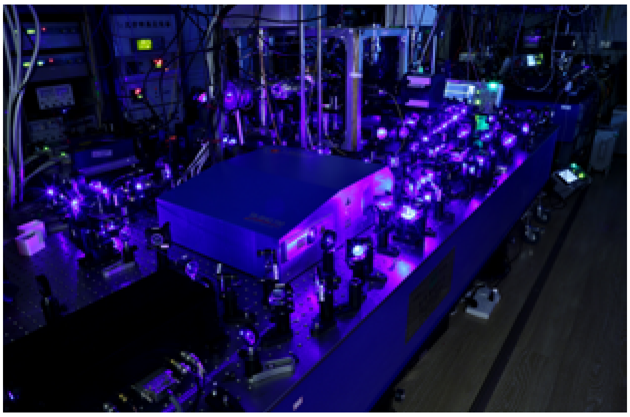


Figure 1 - NIM strontium optical lattice clock

1.2 China's contribution to redefining the unit of temperature

The accurate determination of the value of the Boltzmann constant is key to the redefinition of the SI unit of thermodynamic temperature - the kelvin. During the past decade, two independent methods for measuring the Boltzmann constant have been developed by NIM: the cylindrical acoustic gas thermometer (c-AGT) and the Johnson noise thermometer (JNT).

Figure 2 - NIM cylindrical acoustic gas thermometer used to measure the Boltzmann constant

Both of these primary thermometers contributed to the Committee on Data for Science and Technology (CODATA) for 2014 and 2017 adjustments of the Boltzmann constant *k*. The results of the Johnson noise thermometry (JNT) measurement met the second requirement of the Consultative Committee for Thermometry (CCT) for a redefinition of the kelvin. This stipulated that the determination of *k* be based on at least two fundamentally different methods, of which at least one result for each shall have a relative uncertainty of less than 3×10^{-6}. The CODATA 2017 recommended value of the Boltzmann constant has been used for the revision of the unit of temperature. NIM has played a unique role in being the only institute contributing to this revision that has offered two primary methods of independent principle.

On the basis of these new technologies, it is possible for related thermophysical parameters such as temperature, pressure, and density to be measured by using the Boltzmann constant. The implementation of the new kelvin will open a new era for measuring thermodynamic temperature using multiple methods *in situ*.

1.3 Good results of silicon molar mass measurement

Another of the seven SI base units, the mole, measures the amount of substance. This unit will be redefined in 2018 on the basis of the Avogadro constant, the value of which is determined by measuring the number of atoms in 1 kg single-crystal spheres highly enriched with the ^{28}Si isotope. In the experiments concerned, the molar mass of enriched silicon is a key quantity to be measured in addition to the sphere volume and oxide layers.

At the Consultative Committee for Amount of Substance (CCQM) meeting in April 2017, the results were published for the CCQM-P160 study "Isotope ratios and molar mass of highly enriched silicon" organized by PTB (NMI of Germany). As one of the participants, NIM is the only NMI that has used two different methods to measure both the silicon isotopic abundances and the silicon molar mass, the results of which lay closest to the reference values. This work has contributed to Avogadro constant measurement and has thus supported the redefinition of the mole.

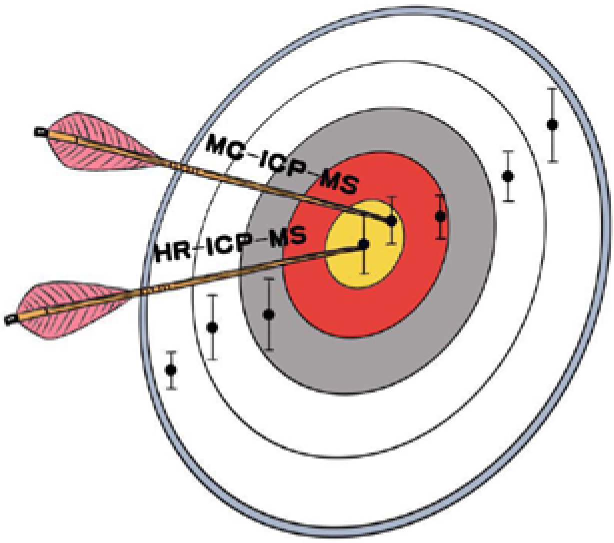


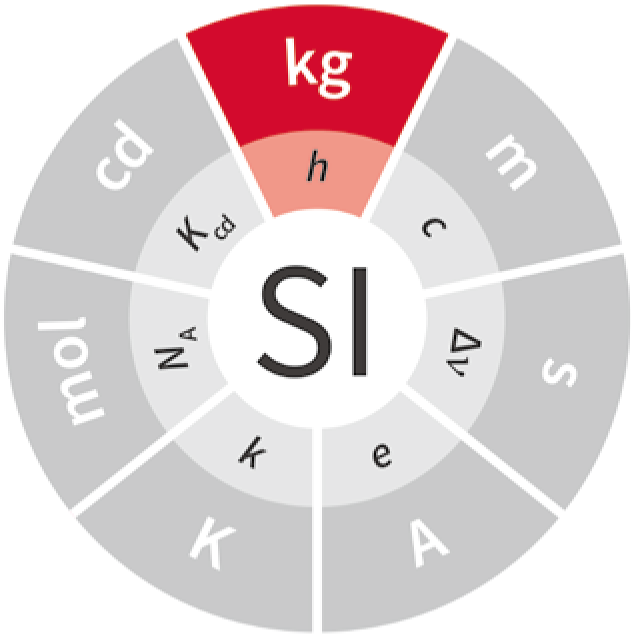
Figure 3 - Good results from two different methods

1.4 Joule balance for redefinition of the kilogram

The kilogram, the unit of mass, is the last of the seven SI base units still defined and realized by a material artefact: the International Prototype of Kilogram (IPK) made from platinum–iridium alloy. One of the major disadvantages of this definition is the fact that the amount of material constituting the IPK has been shown by comparison with other standards to change with time. Moreover, owing to the lack of a higher level and more stable mass reference, the exact variation in IPK itself cannot be known.

For this and other reasons, the International Committee for Weights and Measures (CIPM) has recommended the redefinition of the kilogram by fixing the numerical value of the Planck constant h and has called on every NMI to conduct measurements of h. To avoid possible systematic error from one method, more experiments focusing on different principles are expected and encouraged for final determination of the Planck constant. The Consultative Committee for Mass and Related Quantities (CCM) required that at least three consistent results be obtained prior to the redefinition. Since the 1970s, experiments using the Kibble balance, formerly known as the watt balance, have been conducted by NMIs and organizations such as NPL in the United Kingdom, NIST in the United States, METAS in Switzerland, LNE in France, as well as at BIPM. Other NMIs such as the PTB in Germany, NMIJ in Japan and NMIA in Australia used the X-ray crystal density (XRCD) method to measure the Avogadro constant, from which a value of the Planck constant can also be obtained. In 2006, to make a contribution to the redefinition of the kilogram, NIM proposed a joule balance method, inspired by that of the Kibble balance but somewhat different from the watt balance method. The joule balance method replaces the moving phase of the Kibble balance with a flux linkage measurement phase, in which limitations of the dynamic measurement can be avoided.

In 2013, a model apparatus NIM-1 was built to verify the principle of the joule balance. NIM then began building a new improved joule balance, NIM-2, operating under vacuum, with the aim of determining the Planck constant with uncertainty at the 10^{-8} level. Measurements with NIM-2 began in December 2016. In May 2017, the NIM-2 result was submitted to *Metrologia* and accepted by the CODATA Task Group on Fundamental Constants (TGFC) as input data. However, this result was not used for the CODATA 2017 special adjustment because its uncertainty is greater than 6×10^{-8}. At present, the joule balance research team of NIM, in collaboration with the Harbin Institute of Technology and Tsinghua University, is still working to improve the joule balance apparatus. A relative uncertainty at the 10^{-8} level is expected within the next two years, as is the quantum mass standard of NIM.



1.5 Breaking the limit of ultra-trace substance measurement

Many substances of extremely low abundance can have a marked effect on life processes, environmental security and the maintenance of material property. For example, even at a level as low as 10^{-9} g/g, or a billionth of a gram per gram, many residual pesticides, veterinary drugs, and mycotoxins present in food can cause serious harm to human health. The analysis of substances down to the 10^{-9} g/g level is generally defined as ultra-trace analysis. Currently, the development of ultra-trace analysis is heavily inhibited by the complexity of samples and insufficient sensitivity of conventional analytical techniques.

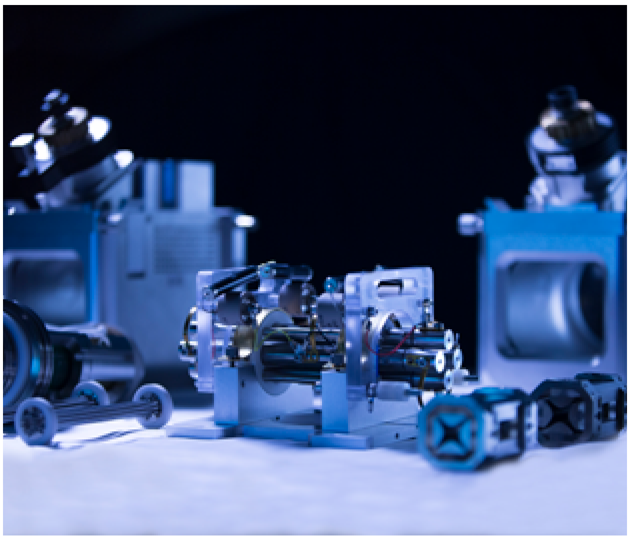


Figure 4 - High-precision measurement of ultra-trace substances

NIM has completed a research program entitled "Development and Applications of Key Techniques for Accurate Analysis of Ultra-Trace Substances." This program has further reduced the detection limit of investigated analytes to the 10^{-15} g/g level or even lower, which is nearly one thousandth of that obtained by conventional methods. The success of this program will enable new methods for accurate analysis of ultra-trace substances, thereby providing a sound solution to a worldwide technical problem that exists in many key measurement steps.

The core techniques and analysis systems established by this project will be implementable via the development or upgrade of homemade mass spectrometers. The reference materials developed can be provided to more than 1,000 regional metrology institutes and testing laboratories located in about 30 provinces of China. In this way, the results provide important support to physical science and life science research.

2

Capacity Building

National measurement standards are strategic resources of a country and a symbol of national core competitiveness. Calibration and Measurement Capabilities (CMCs) serve as the basis of mutual recognition of national measurement standards and of calibration and measurement certificates issued by NMIs. A well-established national measurement standard and reference material system underpins a country's scientific innovation and particularly its manufacturing competitiveness.

2.1 Tenth International Comparison of Absolute Gravimeters in Beijing

Absolute gravity measurements with relative uncertainty better than 5 parts in 10^9 are necessary for the Kibble Balance experiments used to redefine and realize the mass unit as well as in geodetic research. The International Comparison of Absolute Gravimeters (ICAG), known as the "World Championship" for gravimeters, is an important periodic CIPM key comparison for providing the traceability of absolute gravity measurements and defines the measurement standard point worldwide. In 2017, the 10th ICAG was held at the NIM Changping campus with the participation of 32 absolute gravimeters from 14 countries including China, the United States, France, Germany, Japan, Korea, Switzerland, Austria, Finland, Czech, Turkey, Luxembourg, Saudi Arabia and Thailand.

Two absolute gravimeters (AGs) developed by NIM and based on different principles participated in this program: the NIM-3A Free-Fall AG and the AGRb-1 Atom AG. Both have an uncertainty of better than 5 ugal, which is a world-class level.

This key comparison marked the first ICAG organized out of Europe in its 36-year history and has officially confirmed the NIM Changping campus as the new primary standard point.

2.2 Tracing the stealth killer in agricultural products

Mycotoxin, a stealth killer more dangerous than mildew, has infiltrated almost all types of food and agricultural products. Based on the cooperation project "Reference Material Development for Mycotoxins in Food" with the BIPM, NIM conducted the project "Standard Measurement Techniques and Traceability Systems of Mycotoxins in Grain" partnering with NMIs of South Africa, Vietnam and Cambodia, as well as several countries participating in the Belt and Road Initiative to cope with the challenge of grain food safety.

By solving the technical problem of accurate measurement for mycotoxins in agricultural products, the project aims to promote the establishment of a traceability system for mycotoxin measurement and enhance the mycotoxin measurement capabilities in partner countries. The results are expected to provide a technical basis for food safety and facilitation of the agricultural product trade.

2.3 Accurate dosimetry for reliable radiotherapy

NIM has developed a primary standard for absorbed dose to water at the radiotherapy dose level. The standard is based on a water calorimeter and is designed to operate in both Co-60 gamma rays and megavoltage photon beams from the NIM linear accelerator (linac). The water calorimeter is operated at 4°C to eliminate the problems associated with convection in water phantoms at room temperature. In this system, a low-noise temperature measurement circuit is able to resolve temperature differences at the microkelvin level. Using open and sealed vessels, the calorimeter has the capability to investigate different water purities and determine the heat defect caused by dissolved gases.

The set-up operates with the horizontal photon beams from the linac. The absorbed dose to water measured by the water calorimeter for 10 MeV photons has an uncertainty of 0.35% (k = 1). The BIPM.RI(I)-K6 comparison was completed, and the report was published in *Metrologia*.

Partnering with the Medical Physics Society of China, NIM has trained medical physicists to support quality control for more than 2,000 accelerators nationwide.

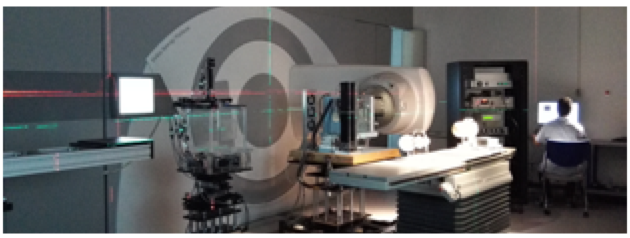


Figure 5 - Linac primary standard for radiotherapy dosimetry

2.4 Reducing the risk of lung cancer

Radon, a radioactive gas present in the atmosphere, is one of the biggest causes of lung cancer and has induced 3–14% of lung cancer cases worldwide, according to the World Health Organization (WHO). Radon and its radioactive decay products are easily deposited on cells lining the airway, which poses a steady radiation hazard.

Accurate measurement of radon activity per unit volume is extremely important for protecting human health against radiation.

NIM has established a primary apparatus for detecting radon activity based on condensation technology of radon gas and the Defined Solid Angle (DSA) method. This technique has greatly improved the capability of radon activity measurement with a standard relative uncertainty less than 0.3%. A metrological traceability chain for radon and its decay products has been established as well, which will provide strong support for indoor air quality control, radon detection in engineering constructions and in national defense tunnels, disease control and prevention, earthquake research, and other applications.

Figure 6 - Primary standard for radon activity

2.5 Fine clothing, traceable cotton

Making a cotton shirt requires a series of processes such as planting, spinning, weaving, dyeing, and tailoring. The quality of cotton has a strong influence on that of the clothing product made from it.

A good planting environment and control of the picking time helps to produce high-quality cotton that has high brightness with strong fiber microstructures that will result in fine clothing with excellent strength and thermal insulation performance as well as low bleaching cost and bright colors. Therefore, color is a key criterion for evaluating the quality of cotton.

NIM has partnered with the China Fiber Inspection Bureau to conduct joint research on cotton color measurement and has established device to measure cotton color with results that are directly traceable to the SI. It can provide measurement support for the inspection and classification of more than 5 million tons of cotton annually in China and helps to improve the quality of cotton, thus aiding the cotton industry.

2.6 Unique Chinese traditional colors

The International Commission for Color in Fashion and Textiles regularly selects and publishes annual fashion colors to provide guidance for color selection by industries, which increases the value of clothing. Among these colors, Chinese traditional colors that condense the essence of 5,000 years of Chinese civilization are important.

NIM has partnered with the Institute of Psychology, Chinese Academy of Sciences (CAS) and Beijing Institute of Fashion Technology to retrieve the names of 1,134 Chinese traditional colors from ancient books. After performing experiments and data assessment, 166 color names were retained and representative color samples produced with colorimetry values traceable to the Chinese primary colorimetry standard. The national standard "Chinese traditional color names and color characteristics" has been documented, which preserves the color elements of Chinese traditional culture. In the culture, art, and design sectors, traditional colors can be reproduced accurately and rapidly on the basis of color characteristics. These unique Chinese traditional colors could serve as a guide for fashion color selection, such as Royal Pink shown in Figure 10.

Figure 7 - Royal Pink, one of the Chinese traditional colors

3

Support for National Strategies and Industrial Development

It is a key mission and target of NIM to support national strategies and industrial development. In the global context, we have entered a challenging era for metrology, with the redefinition of several SI base units. In addition, measurement and calibration services are likely to face revolutionary changes, while new metrological areas are constantly emerging.

NIM is committed to utilizing its expertise and resources to enlarge its service scope, diversify service categories, provide customized measurement solutions and promote technical transfer. Direct support has been provided to national critical infrastructures and projects including the upgrade of industrial structure and competitiveness, energy saving and emission reduction, and emergency response to a series of accidents and disasters.

3.1 New time transfer approach based on BeiDou

Coordinated Universal Time (UTC), the international reference time scale, is generated from International Atomic Time (TAI) in collaboration with about 80 institutes that regularly contribute clock and clock comparison data to the BIPM. At present, more than 80% of time transfer links between the timekeeping laboratories and UTC use the Global Positioning System (GPS).

By utilizing a Navigation Satellite System independently developed by China – the BeiDou system and BeiDou time and frequency transfer equipment developed by NIM, NIM has implemented time and frequency transfer over a baseline of more than 8,200 km between Beijing and Paris. This process has achieved a nanosecond accuracy that is in excellent accordance with results obtained via the GPS-based common-view and all-in-view modes. Now NIM, BIPM, and several other laboratories participating in TAI have agreed to conduct pilot experiments to evaluate the performances of BeiDou time and frequency transfer over multiple baselines to contribute to UTC. This will create a new method for time transfer used in TAI and serve as a foundation for expanding the service of the BeiDou system worldwide.

3.2 Brighter eyes to explore the universe

The first astronomical satellite of China, a Hard X-ray Modulation Telescope (HXMT) satellite known as Huiyan, or Insight, was launched in 2017. The main scientific objectives of HXMT are to scan the galactic planes to locate new transient sources and monitor the known variable sources as well as to observe X-ray binaries to study the dynamics and emission mechanisms in strong gravitational or magnetic fields.

NIM and the CAS Institute of High Energy Physics jointly developed the Hard X-ray Detector Calibration Facility (HXCF) for calibration of energy resolution and to detect the efficiency of the high-energy X-ray telescope. The research team produced the highest monoenergetic X-rays for HXCF and solved the problem of measuring the fluency of parallel X-ray beams. In order to monitor the performance of the high-energy X-ray telescope in orbit, the team developed a technology for producing an embedded nuclide source for all high-energy X-ray telescopes to ensure the validity of ground calibration results.

Figure 8 - Simulated image of the satellite Huiyan in outer space

3.3 Guiding the safe landing of aircraft

Landing accidents account for more than one third of all general aviation accidents. In order to ensure a safe landing in harsh weather conditions such as rain, fog, or snow, an instrument landing system (ILS) based on electromagnetic waves is used to provide precision guidance to pilots during the landing phase. This demonstrates the importance of assessing the quality of electromagnetic waves; however, accurate measurement of electromagnetic wave quality far from an airport is difficult.

In response to calibration requests from civil aviation industries, NIM has developed a measurement standard for an instrument landing system that can easily and intelligently calibrate the conformal antennas mounted on special aircraft. This calibration has been provided to many domestic airline companies.

The new NIM standard has also been used by the Civil Aviation Administration of China (CAAC) Flight Inspection Center and Beihang University for research projects, which supports the robust development of China's civil aviation industry.

3.4 Support for next-generation communications

High speed, high bandwidth and large capacity are development trends of the electronic information industry. To meet the need for new technology measurement, NIM has developed standards for the terahertz pulse waveform parameter, wideband complex signal measurement, and high-definition video measurement.

These standards have played an important role in highway performance monitoring by the Ministry of Communications as well as the urban video surveillance system of the Ministry of Public Security, the manufacturing of electronic instruments in electronic and communications industries, and unmanned aerial vehicle (UAV) manufacturing industries. In addition, these standards provide strong support for mobile communications, high-speed digital communications and high-definition video industries in China.

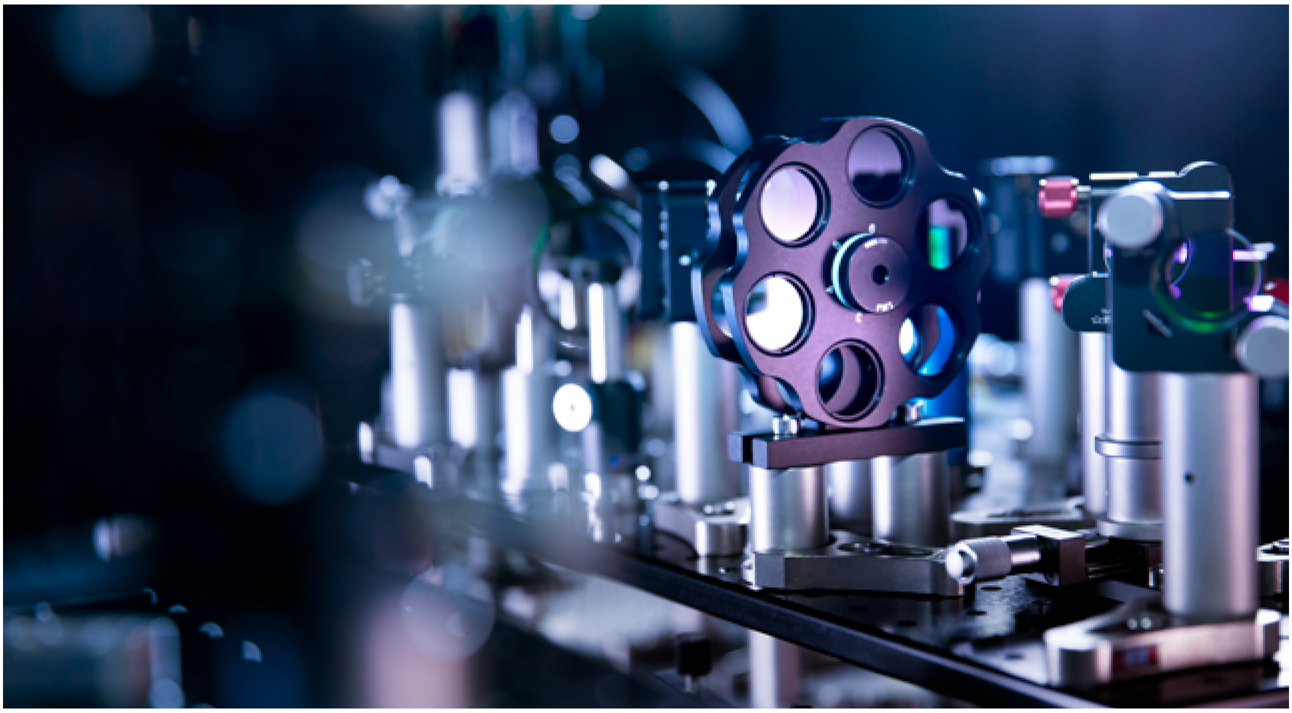


Figure 9 - Support for next-generation communications

3.5 Accurate measurement for smart life

Our daily life is becoming increasingly affected by intelligent terminals such as smart phones and wearable devices that require magnetic components and magnetic measurement techniques. In general, a smart phone needs 20 pieces of rare earth magnets, and nearly 100 pieces of rare earth magnets are installed in a new electric vehicle.

The magnetic moment is a critical property of rare earth magnets, the accurate measurement of which determines the precision and application scope of various intelligent magnet-material-based terminals.

To provide traceability for magnetic moment measurement, NIM has established a new calibration technology based on a quadrature Helmholtz coil. The calibration apparatus developed on this basis has been purchased by many world-famous instrument suppliers such as Goertek, AAC Technologies, Merry Electronics and Bose, which provide smart living components for consumers.

3.6 Enabling independent quality control for clinical diagnostic equipment

Medical equipment for measuring, maintaining and restoring vital signs is of vital importance for human health; so quality monitoring and control of such equipment is crucial. At present, medical equipment such as ventilators, hemodialysis equipment, infant incubators, infusion pumps, multi-parameter patient monitors and pulse oximeters rely largely on imported devices for quality monitoring and control, and the traceability chains for many associated measurements are not established in China.

In 2017, NIM established numerous stations and the associated technical regulations for calibrating medical equipment in which the quantity values are traceable to national standards. These stations can provide traceability to the measurements of several key parameters of many high-risk medical devices and thus provide support for their quality assurance.

NIM has already provided these calibration services directly or indirectly to more than 1,000 medical centers such as the Peking University Third Hospital, the Beijing Cancer Hospital, and the Jinan Military General Hospital.

A series of research activities has been conducted in past years by NIM to reduce the dependence on imported devices for quality assurance of medical devices used in China. NIM has successfully developed calibration stations for ventilator testers, hemodialysis equipment testers, and SpO2 simulators. This measure provides integrated, responsive and reliable calibration services for medical devices used in China, which also reinforces China's independent supply of quality control equipment for medical devices.

4

Collaboration and Partnership

4.1 International collaboration and partnership

Historical opportunities have broadened our horizons and enabled us to become a world-class NMI. To benefit from this era of unprecedented opportunity, we are devoted to building and expanding our global cooperation and partnerships. In the past year, notable achievements were made, particularly in assuming more roles and responsibilities in regional and international organizations, updating scientific cooperation with advanced NMIs, and providing technical cooperation to developing NMIs.

More up-take in metrology organizations

Dr. Yuning Duan, NIM Vice Director, currently serves on the CIPM, which is the directive and supervisory body of the BIPM and consists of 18 members. One NIM expert serves on the Executive Committee of the Asia Pacific Metrology Programme (APMP), and three experts serve as respective Chairs of the APMP Technical Committee for Amount of Substance (TCQM), Technical Committee for Ionizing Radiation (TCRI), and Technical Committee for Time and Frequency (TCTF). NIM signed a cooperation agreement with the BIPM, taking the lead in a research project to provide mycotoxin reference material and its calibration method. Under the BIPM Capacity Building and Knowledge Transfer (CBKT) Programme, this project aims to develop and provide reference materials to enable traceable measurements of mycotoxins in food consumed in African countries.

An expanded international partnership

NIM has signed a new Memorandum of Understanding for Cooperation with the National Institute of Metrology, Standardization and Industrial Quality (INMETRO) of Brazil and Ulusal Metroloji Enstitüsü (UME), the National Metrology Institute of Turkey. This brings the number of NIM's effective bilateral cooperation agreements to 20, which includes most advanced NMIs.

NIM's cooperation activities are being updated. To give a few examples, NIM and NPL have jointly identified environment, medicine, underwater acoustics for marine science, nanometrology and material measurement as their new focuses of cooperation. In addition, their collaboration on Mobile Differential Absorption Lidar (DIAL) is progressing favorably. NIM and PTB have agreed on a new round of more than 20 cooperative projects in many fields. NIM and NIST directors met in 2017 to discuss a possible cooperation in quantum metrology and other fields. Moreover, 15 of NIM's young scientists took part in the 3rd China–Japan–Korea Emerging Scientist Workshop held in Japan. The NIM Visiting Scientist Program has continued throughout the year, with about 20 scientists sent to other NMIs for joint research or study. In total, 150 have participated in this program.

Technical cooperation with developing NMIs

NIM initiated its technical assistance to several developing countries such as Cambodia, Mongolia, and South Africa as a new direction of its international cooperation and has successfully applied for and secured government funding for these activities. During 2017 and 2018 several projects were approved by different ministries including the Training Project for Cambodia on Measurement Standards in Priority Areas, funded by the Ministry of Commerce (MOFCOM); the Technical Transfer Platform of Metrology for Lancang Mekong Countries, funded by the Ministry of Foreign Affairs (FMPRC); and the China–Mongolia Cooperation on Measurement Standards and Technologies in Energy Field, funded by MOST. This funding has provided substantial resources for NIM to carry out technical assistance activities.

NIM has also successfully organized two Asia Pacific Economic Cooperation (APEC) training workshops, a self-funded one on solar cell and light-emitting diode (LED) measurement and an APEC-funded one on measurements for grain safety. In total, 116 funded participants from 23 APEC and APMP member economies attended these two workshops.

New contribution to legal metrology

One of the major tasks facing the International Organization of Legal Metrology (OIML) is to help developing Member States to develop national metrology systems compatible with their own interests and needs, creating a solid foundation for these states to compete in international trade. In the 48th International Committee of Legal Metrology (CIML) conference, the OIML established an OIML Advisory Group (AG) in a bid to encourage more developing member states to actively participate in technical activities held by the OIML.

As a proactive response to the new OIML Certification System (OIML-CS), NIM has been designated as the new Issuing Authority in China under the OIML-CS, as authorized by the former General Administration of Quality Supervision, Inspection and Quarantine of the People's Republic of China (AQSIQ), a representative of China in the OIML that has merged with the State Administration for Market Regulation (SAMR). Accordingly, NIM has set up its Certificate Issuing Office at its Changping campus and has developed its associated quality management system. A China Management Committee of the OIML Certification System was also established. In this capacity, NIM will play a more important role in improving Chinese legal metrology and promoting the development of domestic measuring instrument manufacturing industries. NIM will also provide support to the OIML AG.

4.2 Domestic partnership

NIM has signed strategic collaboration agreements with many provincial and municipal administrations of quality and technical supervision as well as local metrology institutes in Shanghai, Fujian province, Zhejiang province, Hainan province, Qinghai province, and other regions.

In addition, NIM has signed strategic collaboration agreements with local governments in Nanjing and other localities to expand collaborative efforts in the fields of high-end equipment manufacturing and bio-manufacturing metrology. Projects to develop the Sanya Research Center and Metrology for Commodity Logistics have also benefited from such collaboration.

Moreover, NIM has cultivated and dispatched 44 qualified metrologists to metrology institutes at various localities, totally more than 600 by the end of 2017.

NIM Science and Technology Week to focus on industrial metrology

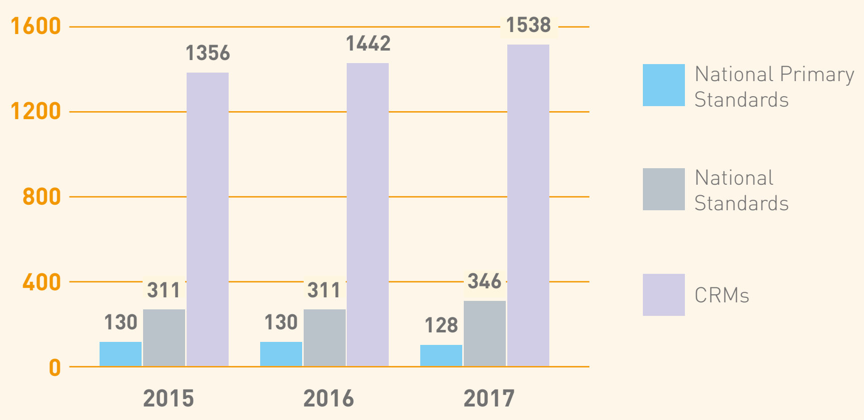
NIM organized a host of activities for the Science and Technology Week May 21 to 26, 2017, to celebrate the 2017 World Metrology Day. In total, more than 30 programs were incorporated including seminars on industrial metrology, international dynamics of cutting-edge metrology fields and research professionals, NIM labs Open Day, metrology salons and speeches for a metrology dissemination campaign titled "My Research Laboratory." These programs attracted more than 500 participants.

During the seminar on industrial metrology, representatives from NIM, China National Institute of Standardization, State Grid, and Commercial Aircraft Corporation of China, Ltd. (COMAC) delivered keynote reports on quality and metrology in industrial development and on high-tech industries such as metrology in aerospace and aircraft, high-speed rail, smart grids, and solar photovoltaics (PV). The presenters shared real-world scenarios and solutions associated with their working experiences and put forward impressive thinking and suggestions on foreseeable development strategies to meet the urgent need of metrology in relevant industrial sectors.

5

Facts and Figures

NIM currently maintains 128 national primary standards, 346 national standards and 1,538 types of certified reference materials (CRMs).



NIM has 1523 Calibration and Measurement Capabilitites (CMCs) entries in the BIPM key comparison database (KCDB) as of January 2018.

NIM has participated in or carried forward 98 international or regional comparisons, piloting and co-piloting 25 of them.

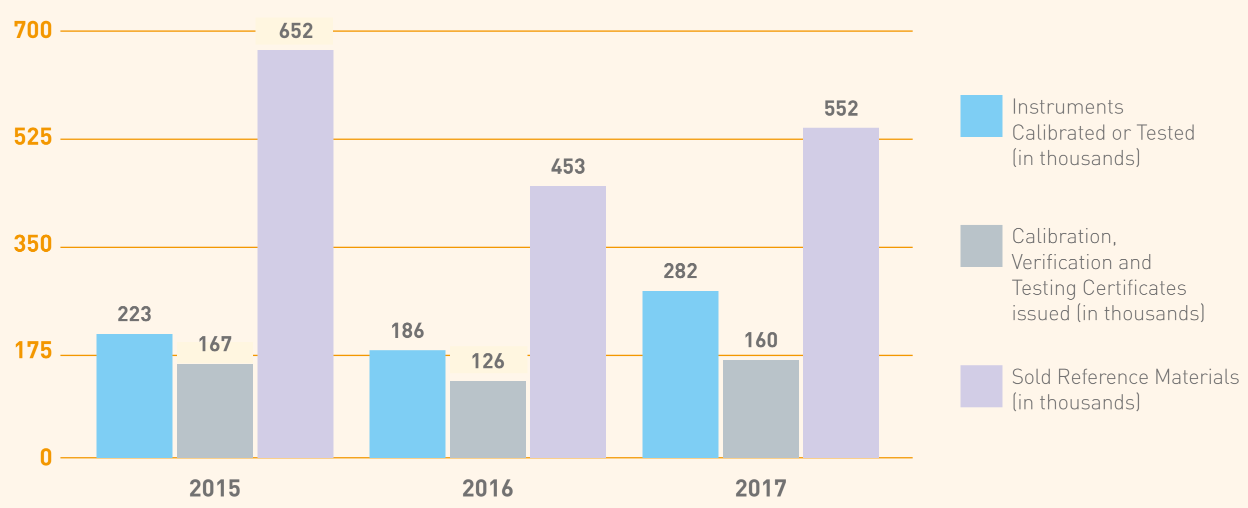
NIM currently has 543 research projects in progress, including 223 started in 2017. Its main projects include The National Quality Infrastructure Program, international cooperation projects, and the Natural Science Foundation projects.

• Facts and Figures

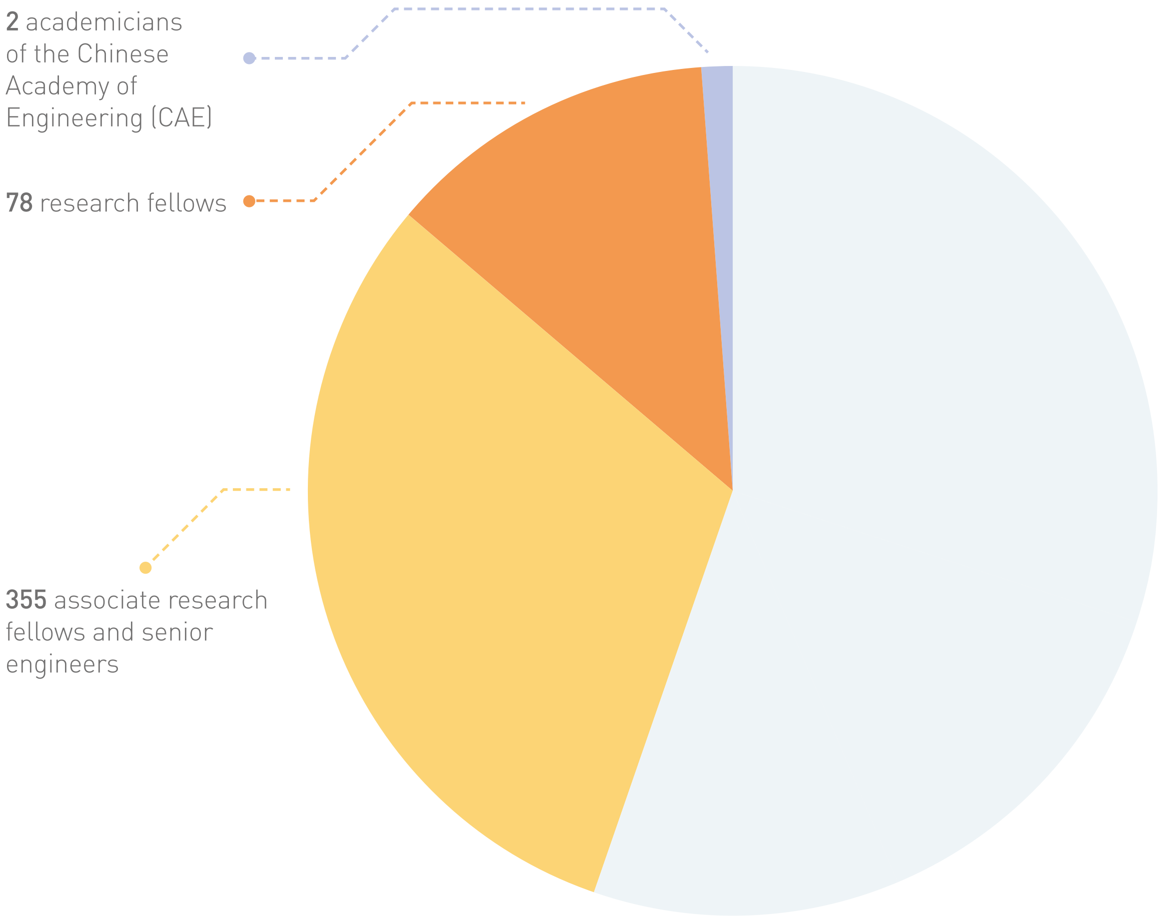
NIM was awarded the second prize of the 2017 National Science and Technology Progress Award with it project "Development and Applications of Key Techniques for Accurate Analysis of Ultra-Trace Substances." This marks the 13th national top science award won by NIM since 2006, including three first prizes and ten second prizes.

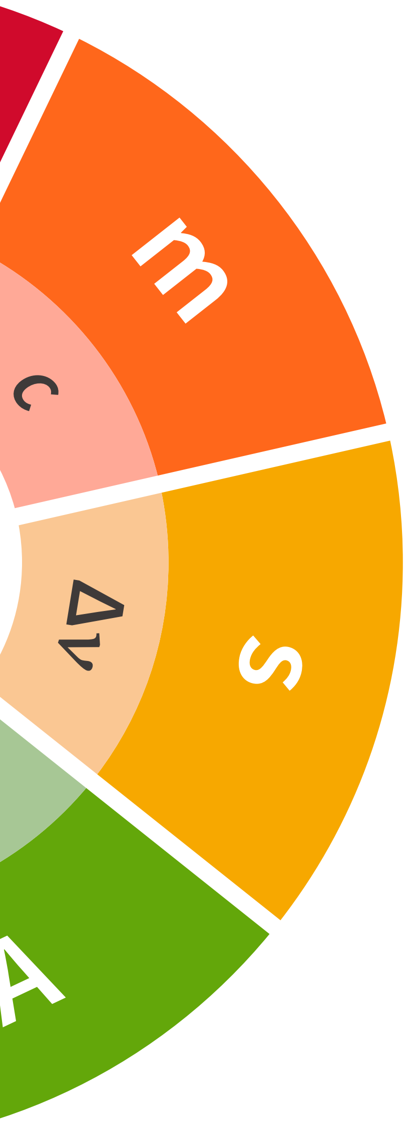
2017	Scientific Papers				Patents and Software Copyrights	
	Total	SCI-indexed	EI-indexed	SCI and EI indexed	Patents	Software Copyrights
	488	66	75	51	88	18

NIM has calibrated or tested 282,000 measuring instruments, issued 160,000 calibration, verification and testing certificates and sold 552,000 units of reference materials in 2017.



NIM has 750 permanent employees and 250 contracted staff and students including two academicians of the Chinese Academy of Engineering (CAE), 78 research fellows, 355 associate research fellows and senior engineers. Currently, 206 hold PhDs and 227 have master's degrees, accounting for 60% of NIM's scientific and technical staff.





National Institute of Metrology, China
18, Beisanhuandonglu, 100029, Beijing
http://en.nim.cn