# ANNUAL REPORT
# of Chairperson of TC 1.5 "Length and Angle"

Much organizational work was done in the reporting period. Several COOMET projects were completed; the final results and CMC-entries were published in the KCDB.

There is a long list of comparisons of national measurement standards. They are given below.

**Completed projects**

| No. | Project ID | Project name |
|---|---|---|
| 1 | **265/UA/02** | Conducting of comparisons of highest accuracy interferometers for gauge blocks measurements (100 mm) |
| 2 | **277/UA-a/03** | Conducting of comparisons of highest accuracy interferometers for gauge blocks measurements (up to 1 m) |
| 4 | **390/BY/07** | International comparison of length standards in the range measurement of gauge blocks (up to 100 mm) |
| 5 | **507/BY/10** | Comparison of standards of unit of length to measure parameters of gear wheels |

**265/UA/02** Conducting of comparisons of highest accuracy interferometers for gauge blocks measurements (100 mm)

Project was completed; report was published in the KCDB. CMC-entries of NMI corresponding to this comparison were subscribed for confirmation. In the course of comparisons the participants confirmed CMC-entries they had, Ukraine ([20 + 0.2L] nm, L in mm). KazInMetr registered and published a new CMC in the KCDB ([20 + 0.35L] nm, L in mm).

**277/UA-a/03** Conducting of comparisons of highest accuracy interferometers for gauge blocks measurements (up to 1 m)

Project was completed; report was published in the KCDB. CMC-entries of NMI KazInMetr corresponding to this comparison were subscribed for confirmation. In the course of comparisons the participants confirmed CMC-entries they had, Ukraine ([20 + 0.2L] nm, L in mm), Russia ([30 + 0.20L] nm, L in mm). KazInMetr registered and published a new CMC in the KCDB, ([15 + 0.207L] nm, L in mm).

**390/BY/07** International comparison of length standards in the range measurement of gauge blocks (up to 100 mm)

Project was completed; the documents are being prepared for the publication in the KCDB. In the course of comparisons the participants confirmed CMC-entries they had.

Belarus ([30 + 0.2L] nm, L in mm),

Ukraine ([20 + 0.2L] nm, L in mm),

Poland ([34 + 0.44L] nm, L in mm),

Kazakhstan ([20 + 0.35L] nm, L in mm).

**507/BY/10** Comparison of standards of unit of length to measure parameters of gear wheels

Project was completed; Report A was prepared. The final report and registration in the KCDB are being prepared.

During 2011 there were published CMC-entries of UNIIM (Russia) (0.2L μm, L in m) and of RGP "KazInMetr" (Kazakhstan) (0.2L μm, L in m) on linearity; comparison was completed in 2010, however a prolonged assessment didn't allow publishing the entries by the last meeting of the TC. BelGIM (Belarus), being a participant of the comparisons has confirmed his values of CMC-entries (0.2L μm, L in m).

**Agreed (on-going) comparison projects:**

| No. | Project ID | Project name |
|---|---|---|
| 1 | **524/UA-RU/11** | Comparison of national measurement standards of plane angle unit |
| 2 | **501/UA/10** | Comparison of measurement standards of flatness of optical surfaces |
| 3 | **450/UA/09** | Comparison of reference instruments of unit of length for parameters of roughness |
| 4 | **278/UA-a/03** | Conducting of comparisons of line scales comparators |
| 5 | **440/RU/08** | International comparison of stabilized He-Ne/$I_2$ lasers at 633 nm |

**524/UA-RU/11** Comparison of national measurement standards of plane angle unit

Technical protocol of the comparisons was agreed and measures were transferred to SE "Ukrmetrteststandart", Ukraine, and they are being measured. The timetable of comparisons is the following:

| NMI | Country | Date of conduction |
|---|---|---|
| SE "Ukrmetrteststandart" | Ukraine | November 2011 |
| RGP "Kazakhstan Institute of Metrology" | Kazakhstan | December 2011 |
| RUE "Belarussian State Institute of Metrology" | Belarus | February 2012 |
| Slovak Institute of Metrology,<br>Centre for Length, Time and Acoustics | Slovakia | March 2012 |
| Physikalisch-Technische Bundesanstalt | Germany | April 2012 |

Cuba is expected to be a participant of the comparisons.

**501/UA/10** Comparison of measurement standards of flatness of optical surfaces

The measurements were conducted by two participants of the comparisons, an issue as for further shipment of measures is being decided.

**450/UA/09** Comparison of reference instruments of unit of length for parameters of roughness

The measurements are conducted by two participants of the comparisons, an issue as for further shipment of measures is being decided.

**278/UA-a/03** Conducting of comparisons of line scales comparators

The project was prolonged since RGP "KazInMetr" expressed his wish to participate in the comparisons. However, technical difficulties in the RGP "Kazakhstan Institute of Metrology" don't allow conducting measurements for the moment. One plans to close the project.

**440/RU/09** International comparison of stabilized He-Ne/$I_2$ lasers at 633 nm

Project was completed; Report A was prepared and the results are being agreed. The final report and registration in the KCDB are being prepared.

The Technical Committee prepared a list of proposed comparison projects.

**Proposed projects**

| No. | Project ID | Project name |
|---|---|---|
| 1 | 370/RU/06 | Interlaboratory comparison of length standards in the nanometer range |
| 2 | 527/RU/11 | Additional comparisons of surface density of coatings |
| 3 | 529/RU/11 | International comparison of interferometers for measuring 20-meter long tapes |

**370/RU/06** Interlaboratory comparison of length standards in the nanometer range

NSC "Institute of Metrology" (Ukraine) and NIICPV (pilot organization, Russia) have confirmed their participation in this comparison.

**527/RU/11** Additional comparisons of surface density of coatings.

The project is open, it replaces the **Project 443/RU/08** "Comparisons of national standards in the area of measuring surface density of coatings within the range of (0.001-1.000) kg/m$^2$ and coating thickness within the range of (1-100) μm", UNIIM should finalize the registration of the project as agreed.

**529/RU/11** International comparison of interferometers for measuring 20-meter long tapes

Comparison is being prepared. Technical protocol was prepared.

Doing its work the committee faced a problem connected with the analysis of CMC-files obtained from different NMIs. Great attention should be paid to the issue of uncertainty budgets and further calculations.

It's reasonable to conduct training workshops and to train specialists on this issue involving the leading specialists in this field.

It's also reasonable to organize more accurate coordination of the activities of the CMC experts in order to avoid prolonged delays in the CMC analysis.

With the aim to increase the amount of CMC-entries for COOMET Member Countries, the Technical Committee 1.5 "Length and Angle" submits for consideration a proposition concerning the organization of new comparisons, which would provide an opportunity for Member Countries to get new CMC-entries in the KCDB.

It's proposed to organize comparisons on the following measurement facilities from the CMC classifier:

| | | |
|---|---|---|
| L.2.1.2. | Electronic Distance Measurement (EDM) instrument: error of indicated distance | Электронные измерения расстояния: погрешность индицируемого расстояния |
| L.2.3.9. | Engineer or machinist scale, steel: line spacing | Инженерная или слесарная линейка, сталь: линейный интервал |
| L.3.3.1. | Autocollimator: error of indicated angle, axes orthogonality | Автоколлиматор: погрешность показыва-емого угла, ортогональность осей |
| L.3.3.2. | Electronic level: error of indicated inclination angle | Электронный уровень: погрешность показываемого угла отклонения |
| L.3.3.3. | Clinometer: error of indicated inclination angle | Инклинометр: погрешность показываемого угла отклонения |
| L.3.3.4. | Spirit (bubble) level: error of indicated inclination angle | Уровень со спиртовым пузырьком: погрешность показываемого наклонного угла |
| L.4.1.3. | Surface plate: flatness | Поверочная плита: плоскостность |
| L.6.1.1. | External micrometer: error of indicated size | Внешний микрометр: ошибка показываемого размера |
| L.6.1.2. | Micrometer head: error of indicated displacement | Микрометрическая головка: погрешность показываемого смещения |
| L.6.1.3. | Depth micrometer: error of indicated depth | Микрометр-глубиномер: погрешность показываемой глубины |
| L.6.1.4. | Caliper: error of indicated size | Штангенциркуль: погрешность показываемого размера |
| L.6.1.5. | Depth gauge: error of indicated depth | Глубиномер: погрешность показываемой глубины |
| L.6.4. | Long distance | Большие длины |
| L.6.4.1. | Geodetic baseline: interval distances | Геодезическая базовая линия: растояния между базисами |
| L.6.5.2. | Sieve or mesh opening: size or shape of the aperture | Сито или размер ячейки (сита): размер или форма отверстия |

**From the interesting events in 2011:**

On 27 May, 2011 in Prague, Czech Republic, there was held the 3rd final Workshop on the project EMRP JRP 3.1 "Long distance measurement in air", which was being conducted in terms of European research program EURAMET under financial support of European NMIs of European Commission.

The main purposes of this project were:

- developing and assessment of a new technology and measurement apparatus, exceeding reached modern level to measure long distances in air. Given accuracy is $10^{-7}$;
- reliable and traceable system to estimate an effective refractive index for measurement in the open air higher than 1 km;
- interferometer and pulse systems for measuring long distances in the open air and under shop conditions;
- new systems for calibration of geodesic bases.

Resulting material and complete information about this project is available on the web-site www.longdistanceproject.eu/.

Obtained results from the project are planned to use in the production of large-size products and to provide traceability of measurements when verifying global mapping systems.

In accordance with the purposes of the project issues examined at the workshop concerned the following directions:

- refractive index of air and spectroscopic measurements;
- interferometry with a synthesized wavelength;
- measurement of the distance using femtosecond lasers;
- apparatus for measurement in the open air;
- comparisons of the results of calibrations of geodesic bases.

From the topics of reports and presentations presented by the scientists from European NMIs of Germany, France, Finland, Italy, Spain, the Netherlands, Czech Republic and Austria one can mark out the following ones:

- compensation of the refractive index using laser spectroscopy;
- absolute distance measurements with the help of high resolution spectral interferometry;
- four-wave interferometer with a compensation of the refractive index;
- extensiometer with submicron resolution on the basis of interferometry with a synthesized wavelength;
- distance measurement on the basis of interferometry using femtosecond frequency comb and Fourier transformer;
- system for measuring long distances using modulator in the capacity of femtosecond laser;
- refractometry using helium;
- conception and realization of universal calibration of geodesic basis;
- stability of the geodesic monuments of global satellite systems;
- role of refractive index in the satellite laser distance measuring;
- two-laser distance meters for submicron absolute measurements of distances in a space.

Taking into account long-term experience of the NSC "Institute of Metrology" on the developing of precision measuring instruments for long distances, workshop program had a special place for the report of the workers of the laboratory "Measurements of geometrical quantities" of the NSC "Institute of Metrology" V. Kupko, S. Kovshova, I. Lukina on the topic of development of reference interferometer for measurement of long distances and for report about the achievements of the institute in the field of distance measuring.

From 4 to 6 October, 2011 in Bern, Switzerland, there was held an international conference "MacroScale 2011" which was devoted to space-dimensional measurements in the macroscopic scale which was organized by the Federal office of metrology METAS, Switzerland, and by the Federal Physico-Technical Institute (PTB), Germany.

At the conference there were presented about 50 reports of the scientists of NMIs from 20 countries of Europe, America, Asia, and Africa. Subject matter of these reports concerned the following directions:

- interferometry, including interferometry of high resolution;
- coordinate metrology, including optical coordinate metrology;
- micro-coordinate metrology;
- metrology of angle measurement and shape measurement;
- calibration of measurement standards of length;
- measurement of surface structure ;
- technology on the basis of femtosecond lasers.

At the conference Ukraine was represented by the presentation of the report "Reference comparator for length measurement" of the workers V. Kupko,

V. Boroha and S. Kovshov of the laboratory "Measurements of geometrical quantities" of the NSC "Institute of Metrology". The subject matter of the reports and discussions concerned actual issues of providing the uniformity and traceability of space-dimension measurements. There were considered methods, algorithms and methodology of conduction of measurements, the issues of determination and recording of measurement uncertainties, application of the measurement instruments and also there were discussed the results of international comparisons.

The participants of the conference had an opportunity to visit the laboratories of Swiss institute of metrology (METAS).

At large, the conference as a forum for scientists and specialists in the field of metrology contributed to sharing of experience and information about the up-to-date achievements of the leading NMIs of the world in the field of space-dimension measurements in macroscopic scale.

The proposition about the creation of two working groups within TC 1.5 in the direction of nanometrology and long lengths measurement is submitted for the consideration.

It's proposed to assign P. Todua, the director of NICPV, as the head of the Working Group (WG) in the direction of nanometrology. It's proposed to assign A. Kostrikov, a scientific associate of NSC "Institute of Metrology", as the head of the WG on long lengths measurements.

The Technical Committee according to time limit of the work makes a proposition about holding the regular meeting in 2012-2013 in Germany on PTB, as it was proposed before on the meeting of TC in Astana, Kazakhstan.

Vladimir Kupko
Chairperson of TC 1.5