

EUROMET TC-Length Chairman's Annual Report 2005-2006

1. Projects

In the period under review (from 1 April 2005, to 1 April 2006) in TC-Length there were a total of 28 active projects (14 comparisons, 1 consultation, 8 cooperation, 5 traceability). In the period, 3 projects were completed, 6 proposed and 2 agreed. In total, across all projects, there were 196 participations and 14 different NMIs acted as project coordinators.







2. Status of comparisons in length metrology

The current status of key and supplementary comparisons in length is shown in the following tables.

The first (and only round) of CCL comparisons is completed, though final reports are not yet all received or approved. Since the instigation of the first round of CCL comparisons, the CCL decided to stop running CCL comparisons, and to ensure inter-RMO linking through a new style of CCL-RMO key comparisons (see below). It has also re-classified the main topics for these comparisons, combining K2 (long gauges blocks) with K1, removing K6 (2D CMM) as a topic and adding K7 (linescales) and K8 (surface texture).

CCL key comparisons

Number	Subject	Status	Report
CCL-K1	Gauge blocks	Complete	Metrologia paper
CCL-K2	Long gauge blocks/length bars	Complete	Metrologia paper
CCL-K3	Polygons	Complete	Draft A
CCL-K4	Ring & Plug gauges(a:internal, b:external)	Complete	Draft - B2
CCL-K5	1D CMM artefacts	Complete	Draft - B4a
CCL-K6	2D CMM artefacts	Complete	Draft A

The CCL has also been running several comparisons in nanometrology, though as these were not all operating as measurement services at the time of planning or artefact circulation, these were initially decided to be classed as 'pilot studies', i.e. similar to a cooperation style project. However, they were all run under MRA comparison guidelines and have been so successful, to date, that completed comparisons have been re-classified by the CCL as supplementary comparisons which can support CMC claims.

CCL NANO pilot studies

Number	Subject	Status	Report
NANO1	Linewidth	Starts in 2006	-
NANO2 (CCL-S2)	Step height	Complete	Final report
NANO3 (CCL-S3)	Linescales	Complete	Final report
NANO4 (CCL-S1)	1D gratings	Complete	Final report
NANO5	2D gratings	Running	-

EUROMET has either completed or is about to complete a large range of RMO key comparisons, aligned with the CCL comparison topics. K1 and K2 are completed, K4, K5 and K6 are running. K7 is in planning. K3 is awaiting decisions in other RMOs. Additionally, EUROMET has available the results from recent (previous) comparisons in subjects K1 through K5, which can be used for CMC evidence.



EUROMET key comparisons

Number	Subject	Project no.	Report/status
EUROMET.L-K1	Gauge blocks	471	Final report
EUROMET.L-K1.1	Gauge blocks	643	Final report
EUROMET.L-K2	Long gauge blocks/length bars	602	Final report
EUROMET.L-K3.2006	Angle		Consider in 2006
EUROMET.L-K4.2005	Diameter	812	Running
EUROMET.L-K5.2004	1D CMM artefacts	777	Running
EUROMET.L-K6	2D CMM artefacts	743	Running
EUROMET.L-K7.2006	Linescales (up to 100 mm)	882	Planning

Of note are comparisons EUROMET.L-K5.2004, EUROMET.L-K4.2005 and EUROMET.L-K7.2006 which are all of the new style of CCL RMO key comparisons. Two of these are running already and the third is at the planning stage. These are RMO comparisons (run by EUROMET) with inter-RMO participation, which replace the old style of CCL key comparison.

EUROMET supplementary comparisons

Number	Subject	Project no.	Report/status
EUROMET.L-S1	Linescales	252	BNM/LNE, 1995
EUROMET.L-S2	Thermal expansion of gauge blocks	275	Metrologia paper Final report
EUROMET.L-S3	Depth setting standards	301	Metrologia paper
EUROMET.L-S4	Wires (diameter)	308	Metrologia paper
EUROMET.L-S5a	Roundness	BCR	Metrologia paper
EUROMET.L-S5b	Roundness	361	Metrologia paper
EUROMET.L-S6	Thermal expansion of long gauge blocks	390	PTB Report
EUROMET.L-S7	Surface plates	BCR	EUR 14059 EN, 1992
EUROMET.L-S8	Nd YAG lasers	Bilateral	Metrologia paper
EUROMET.L-S9	Grid plates	BCR 3442	3442/1/0/189/91/7
EUROMET.L-S10	Squares	570	Metrologia paper
EUROMET.L-S11	Surface texture	600	Metrologia paper Final report (web), 6MB 6MB
EUROMET.L-S12	Gauge blocks by comparison	601	Draft - A
EUROMET.L-S13	Cylindrical artefacts	369	Final Report (PTB)
EUROMET.L-S14	Steel tapes	677	Final report
EUROMET.L-S15	Step heights by SPM	707	Final report
EUROMET.L-S16	Gauge blocks by comparison	797	Running

Comparison EUROMET.L-S11 on surface texture is accepted as EUROMET's alternative to the new CCL



topic CCL-K8 on surface texture. EUROMET.L-S14 on steel tapes is sufficient to cover most EUROMET NMIs in the subject of long line scales, part of CCL-K7 (the remainder being covered by EUROMET.L-K7.2006, currently under planning).

In summary, with the completion of EUROMET.L-K6 in early 2006, EUROMET will have completed matching comparisons for all first round CCL key comparison topics, plus the two additional topics added recently by the CCL. EUROMET is also running or about to run 3 of the new style CCL-RMO key comparisons. Progress in other RMOs has not been so great and EUROMET TC-L is holding back the planning of EUROMET.L-K3.2006 due to the current high workload in the region. It hopes that another RMO will take the initiative in planning an inter-RMO key comparison in angle.

3. Notes on the new style of CCL-RMO key comparisons in length

Original scheme of CCL and RMO Key Comparisons

The original scheme of key comparisons comprises a worldwide comparison with the leading labs, run by the CC, and several regional comparisons run by the TCs of the RMOs. All regional comparisons are linked to the CC comparison by a well selected number of laboratories participating in both levels.



It has been realised by the CCL-WGDM, that the above scheme has some inherent problems and drawbacks and is not best suited for comparisons in dimensional metrology, for the following reasons:

- In dimensional metrology key comparisons the KCRV is always based on usually several artefacts and their particular properties. It does not represent a realisation of an SI unit, but the value of a particular device which is possibly unstable and often damaged to some extent during the course of a comparison. It is therefore difficult and often meaningless to transfer the KCRV from one comparison to another. The link is established only by the competence and performance of the linking laboratories, often based on expert judgment.
- In a strict sense of the MRA, all dimensional metrology key comparisons are in fact supplementary comparisons, i.e. supporting the CMC claims of Appendix C, but not the equivalence of national standards and their SI realisations.
- Running an (additional) CCL comparison is very costly (organisation, artefact) and volunteering pilot labs are more and more difficult to find.
- The size of the regional comparisons is by far not well balanced. Usually EUROMET comparisons are much larger than those of the other regions, and not all regions are running their own comparisons, but their labs are participating only at the CCL level or in another region.
- The above scheme represents a double workload for the linking labs.
- Some labs prefer to participate only in the CCL loop for prestige, which may lower the quality of the regional loops.
- The above scheme is idealised: the linking is **by far not simultaneous**, but the time delay between the different comparisons is very long, sometimes comparable to the repetition frequency of the KC, many times it is actually longer (for example EUROMET is now starting



some second round key comparisons, but other regions have yet to start some of their first round comparisons.

The WGDM proposed therefore to adopt wherever possible a modified scheme, which makes best use of the available resources, is more flexible and efficient, still respecting the basic rules of the MRA and serving the purpose of testing the principal techniques in dimensional metrology by a well defined set of comparisons. This scheme was adopted by the CCL in 2003.

New style of CCL-RMO key comparisons

The new scheme of CCL-RMO comparisons follows the same idea of several comparisons linked together, but in a much more flexible way. A CCL comparison is no longer needed for the linkage, but instead, in the regional comparisons, laboratories from other RMOs take part. This assures the required links on a worldwide scale. It may also better cope with the different size of the RMOs, and in some cases all labs from one region may participate in the key comparison of another region, which reduces again the number of comparisons needed. This scheme offers in addition the possibility to run two regional comparisons at the same time with the same protocol, but at different levels of uncertainty, as it is actually done in EUROMET.L-K4.2005.



Comparison EUROMET.L-K5 is a special case. In this comparison, two laboratories (PTB and METAS)



do not participate in the EUROMET comparison, but in the planned corresponding APMP comparison. It seems therefore, that the two comparisons will not be linked properly. However, the before mentioned labs were carefully selected as two participants with good performance in both, the last EUROMET K5 comparison and the very recent CCL.K5 (data to be published soon on the KCDB), thus providing an excellent link to both these comparisons.

4. CMCs

The third set of length (& angle) CMCs, EUROMET.L.3.2003, was approved by inter-RMO review and entered the KCDB in March 2005, bringing to end 24 months of reviewing process. No issues were raised and no changes requested, by the other RMOs.

Data collection for the fourth set of CMCs, EUROMET.L.4.2006 was immediately started and these were collated and sent for internal EUROMET review in May 2005. EUROMET review was completed in January 2006 and the inter-RMO review process is now underway. This set contains 24 minor updates and 35 new submissions. Additionally about a dozen minor updates were sent directly to the KCDB manager, under categories (a) and (b) of document JCRB-8/10 (*Procedure for modifying CMCs already in Appendix C*).

Designation	Comment	EUROMET review date	Status
EUROMET.L.1.2000	Initial top level service submission from most of EUROMET NMIs.	2000	Complete - on KCDB, 2001
EUROMET.L.1.2001	Full submission, almost all services, most EUROMET NMIs, update on .L.1.2000 .	2001	Complete - on KCDB, 2001-10-30
EUROMET.L.2.2002	Minor updates/submissions from GB and FI.	Jun 02	Complete - on KCDB, 2003-01-09
EUROMET.L.3.2004	Submissions from AT, CH, CZ, DE, HU, IT, NO. Also first submission from BG, LT, LV, RO, SI, YU.	Jul 03 - Jun 04	Complete - on KCDB, 2005-03-23
EUROMET.L.4.2006	24 minor updates and 35 new submissions.	May 05 - Jan 06	Approved & about to enter KCDB

EUROMET Length CMCs

Aside from the submission and review of EUROMET CMCs, this past year has seen a slowing down of submission from other RMOs for review by EUROMET. Just one set of length CMCs has been submitted by APMP. Normally, only the TC-Length chairman is involved in the review of other RMO's CMCs, only delegating the work to the nominal CMC experts, where necessary.





Other RMOs' CMCs in length

Designation	Comment	EUROMET review date	Status
SADCMET.L.1.2001	First main submission from SADCMET.	N/A	Abandoned
COOMET.L.1.2002	First main submission from COOMET. Re-examined in early 2004.	Oct 02 - Dec 03 and Jan-Mar 04	Complete - on KCDB, 2004-04-06
APMP.L.1.2003	MY, TW submissions. Reviewed by EUROMET TCL Chairman.	Nov 03 - Dec 03	Complete - on KCDB, 2004-02-19
SIM.L.1.2003	Major submission from NIST. Reviewed by EUROMET TCL Chairman.	Sep 03 - Nov 03	Complete - on KCDB, 2004-01-15
SIM.L.2.2003	Submissions from BR, MX, USA.	Dec 03 - Feb 04	Complete - on KCDB, 2004-06-15
COOMET.L.2.2004	Second main submission from COOMET. Ukraine. (Belarus temporarily removed).	Jan 04 - Apr 04	Complete - on KCDB, 2005-01-10
APMP.L.2.2004	Major submission from JP. Review by EUROMET TCL Chairman.	May 04 - May 04 and Mar 05	Complete - on KCDB, 2005-05 - 25
COOMET.L.3.2005	Next main submission from COOMET. Belarus (was part of COOMET.L.2.2004).	Mar 05	Complete - on KCDB, 2005-06-17
APMP.L.3.2006	23 new CMCs from NPL-India	Feb 06	Undergoing inter-RMO review

5. Meetings and workshops

Previous

- 10th Meeting of the CCL-WGDM: 12-13 September 2005, BIPM, Sèvres •
- 12th Meeting of the CCL 15-16 September 2005, BIPM, Sèvres •
- CCL-WGDM workshop on analysis of key comparisons: 13-14 September 2005, BIPM, Sèvres •
- 2005 TC-L CP Meeting: 17-18 October 2005, INM, Bucharest, Romania •
- 2005 TC-L CP Workshop: 'Nanotrends': 18-19 October 2004, INM, Bucharest, Romania •
- Micro CMM workshop: 7-8 April 2005, METAS, Bern, Switzerland •
- TC-Length roadmapping: 31 Jan 1 Feb 2006, NPL, UK

Upcoming

- 2006 TC-L CP Meeting: 2-4 October 2006, Croatia
- 11th Meeting of the CCL-WGDM: 30-31 October 2006, CENAM, Mexico •



6. TC-Length website

TC-Length has a very active web site, hosted by NPL and run by Andrew Lewis (current TC-Length chairman). The website hosts some 900 files across about 130 web pages. The site is used for storing documents for the annual TC contact persons meeting, iMERA roadmaps, project forms, project reports, restricted access files, photographs, CMC review information, annual reports, details of contact persons, and workshop presentations.

In the last year, the projects list has been converted to a database (MySQL/PHP) to make it easier to maintain and to provide project statistics.

7. TC-Length iMERA roadmapping

An ad hoc roadmapping sub group was assembled by invitation from the TC-Length chairman. The group met at NPL in late February over two half-days. The roadmaps concentrated on the dimsnional metrology aspects of length metrology, since the Time & Frequency roadmaps would probably contain sufficient details of future primary wavelength (frequency) standards. Three roadmaps were originally formulated after a brainstorming session, however one of these roadmaps proved to be too large and so it was split into two separate roadmaps. The four roadmaps are:

- Dimensional metrology for Micro- & nano-technology
- Dimensional metrology as enabling technology for long-term fundamental research
- Dimensional metrology for advanced manufacturing technologies
- Long range dimensional metrology

The roadmaps were refined in the weeks following the brainstorming meeting, and were then sent to the wider TC-Length audience for comments.

8. Other news

The next CCL-WGDM chairman will be Ruedi Thalmann from METAS. He will take charge immediately after the next WGDM meeting in October, when Nick Brown (NMIA) will step down.

The CCL's Working Group on the *Mise en Pratique*, has merged with the CCTF Working Group on secondary realisations of the second. The CCL-WGDM has taken over formal responsibility for MRA matters in the CCL, becoming the *de facto* WG on CMCs. Much of the previous work of the CCL-WGDM on MRA matters was unknown outside the group, leading to some questions from the JCRB on whether or not the CCL had set up a working group to deal with CMCs and other MRA matters.

9. Impact of nanotechnology in TC-L

Recent TC-Length work in nanometrology

NANO pilot studies

Several CCL nano pilot comparisons have been undertaken, paving the way for future CMCs in these areas (some already).

NANO Initiative project

Survey of CMCs and measuring capabilities in the NMIs. Several workshops on recent nanometrology advances in length. Contribution to the EU FP5 MEMSTAND project (standardisation roadmap for MEMS/MST).



Submissions to FP6 (NANOMET, MEMSTAND2010 : unsuccessful; NANOREF through to next round).

NANOSCALE

Series of SPM oriented seminars and workshops held yearly, proceedings published.

µCMM workshop

Workshop on the design, construction, operation and calibration of micro CMMs. Identified probing and machine design as possible iMERA candidate collaborative projects.

Roadmaps

Specific micro-nanometrology roadmap in TC-Length.

Consultation

CCL has tasked the WGDM's Discussion Group on nanometrology to submit a report to the next CCL meeting of the traceability route for dimensional nanometrology – this may include suggestions to use atomic-lattice standards (e.g. silicon).

Projects

Aside from the generic nano-initiative project (#630), some of collaborative projects have been or are being undertaken:

#659 - The combination of scanning probe microscopy optical interferometry and x-ray interferometry

#672 - Determination of form/topography of high-quality flats

#866 - Interferometric calibration of microdisplacement actuators

#868 - Tip sample interactions in scanning probe microscopy

Considerations or issues in nanometrology - TC-Length viewpoint

Very few measurements using scanning probe microscopes are actually traceable – only a few NMIs worldwide have Metrological AFMs (traceability on the x, y, z positioning). The force applied by the tip to a specimen is not traceable – this could be important with soft (bio) specimens. Actual detailed study of tip interactions is missing.

Top down approaches can only go so far (macro CMM -> micro CMM -> nano CMM?) – at some point the metrology will have to be built bottom up – nano assembly. This can be very expensive and the lifetime of processes or equipment is measured in months rather than decades. This leads to severe financial barriers to NMIs wishing to use advanced nano fabrication – in house processing is a too expensive for the short lifetime, whereas external fabs are not so interested in one-offs.

Nanotechnology covers a wide area but there is a distinction between nano-scale metrology and nanometrology. Nano-scale metrology often means metrology of macro or micro sized items, but with nanometre resolution or accuracy. True nanometrology means measurement at scales where conventional metrology tools and techniques have to be completely re-thought or abandoned.

Vertical processes (i.e. all performed in house, in-line) are commonplace, so there is little interchangeability required or desired. This leads to in-house standards and no need to comply with national or international specifications. It is also seen as protective as it keeps the IPR in-house. 'Scrap mentality' commonplace – if you can make thousands of devices very cheaply, and half of them fail, then is there pressure to improve the process by metrology (probably only in leading edge fabrication, where the needs of the next generation are pushing the bounds of achievability – but are Intel and AMD going to want to standardise together?). It is more likely to be the medium range manufacturing where metrology can help – in this realm, the manufacturer is concerned with reducing costs, rather than shrinking everything by 10x.

Metrology needs identified by various NMIs' customers include: Measurement of linewidth, overlay and spacing on IC structures and DVDs Linescale and photomask metrology up to 600 mm x 120 mm CD calibrations



Film thickness of coatings and paint Traceability of 3D measurements for complex structures Shape and form of moulds Dimensional requirements of MEMS/ MST Deep and narrow structures Diffraction grating metrology for optical communications AFM roughness calibration Soft metrology (in vivo, in vitro) Mechanical properties of coatings Quality assurance for specialist glass structures (e.g. self cleaning glass) Micro and nano-hardness standards and artefacts Particle standards

Andrew Lewis TC-Length Chairman, 5 May 2006