Use of Nummela Standard Baseline in Present-day European Metrology Research

Dr. Jorma Jokela
Department of Geodesy and Geodynamics
Finnish Geospatial Research Institute (FGI)
Kirkkonummi, Finland
Services of Nummela Standard Baseline

• Results of interference measurements as an (inter)national standard for metrological research and practical purposes
  – Scale traceable to the SI unit metre with known uncertainty

• Highest accuracy calibrations of EDM instruments

• Scale transfer measurements and comparisons
  – Within European Metrology Research Programme (EMRP)
    • PTB, UniBW, CNAM; Metsähovi
  – Bilateral
    • Finland–Lithuania as an example
Traceability chain in geodetic length measurements utilizing a Väisälä Baseline

- Definition of the metre and its realization
- Quartz gauge system
- Measurement of a standard baseline using the Väisälä interference comparator
- Calibration of a transfer standard (or other EDM equipment) at a standard baseline
- Scale transfer measurements at another baseline or test field
Time series 1947–2013 of Nummela Standard Baseline lengths

- Typically 0.02 mm to 0.09 mm standard uncertainties; < 0.7 mm variations in 70 years
- Large uncertainty in 2013 caused by severe weather conditions
- Much of the variation is probably due to challenges in working with the quartz gauge: 100 nm uncertainties at 1 m would accumulate to nearly 0.1 mm at 864 m

2013: 432 095,37 mm ± 0.14 mm (expanded uncertainties in traceability chain)

2013: 864 122,91 mm ± 0.24 mm (expanded uncertainties in traceability chain)
European Metrology Research Programme (EMRP) Joint Research Project (JRP) tasks at Nummela

- "Absolute Long Distance Measurement in Air" 2008–2011
- "Metrology for Long Distance Surveying" 2013–2016
  - PTB, Germany, tested TeleYAG, a refractivity compensated EDM based on interferometry with four different wavelengths using YAG lasers at 1 064 nm and frequency doubled radiations at 532 nm
  - CNAM, France, tested Telediode, a refractivity compensated EDM based on diode lasers
European Metrology Research Programme (EMRP) Joint Research Project (JRP) tasks at Nummela

- "Metrology for Long Distance Surveying" 2013–2016
  - VTT-MIKES, Finland, tested spectroscopic temperature measurement for geodetic measurements
  - FGI determined the traceable scale in the GNSS test field and local ties network for global geodesy applications at FGI’s Metsähovi Geodetic Fundamental Station
European Metrology Research Programme (EMRP) Joint Research Project (JRP) tasks at Nummela

- Using the Nummela scale and high-precision EDM as transfer standard, FGI calibrated the geodetic baselines of PTB, Braunschweig, and UniBW München, Neubiberg in Germany
- Observation data from traditional and novel instruments from the selected baselines computed and analyzed uniformly by TUBS, Germany (not published yet)
New good practice guides

- EMRP JRP SIB60 deliverables
- for calibration of electro-optic distance meters on baselines
  - requirements for reference baselines
  - recommendations for calibration measurements
  - data processing
  - measurement uncertainty
  - presentation of results
- for high accuracy GNSS based distance metrology

http://www.ptb.de/emrp/sib60-home.html
Calibration (using scale transfer from Nummela) of Kyviškės calibration baseline (VGTU, Lithuania), time series 1996–2014

Lengths with expanded uncertainties, \( k = 2; 95\% \)
Outcome – Use of Nummela Standard Baseline in Present-day European Metrology Research –

- World-class geodetic measurement standard maintained
  - New absolute calibration results of quartz gauges
  - New interference measurement results using the Väisälä interference comparator
  - Regular projections keep the Nummela Standard Baseline continuously usable for the highest accuracy distance measurement applications
  - Prerequisite for participation in international metrological R&D projects (EMRP, EMPIR)

- New distance measurement instrument prototypes tested
- New good practice guides for surveyors composed
- Dissemination of the SI unit system by transferring the traceable scale
  - For scientific and practical purposes
  - For international comparisons and for development of national calibration services