Implementation of ISO 17025:2000 in the Geodetic Metrology Laboratories and Their Role in the National Metrology System

Vaclav SLABOCH, Jiri LECHNER and Miloslav PIZUR, Czech Republic

Key words: Geodetic Metrology, national standards for long distances, angles, position and gravity, mutual recognition arrangement.

SUMMARY

Czech system of National Standards is decentralized. National Standards are maintained by the Czech Metrology Institute (majority of them) and (exceptionally) by other authorized subjects. This system is applied also in activities related to the Mutual Recognition Arrangement on National Standards and certificates issued by National Metrology Institutes (MRA) as well as to BIPM and EUROMET key comparisons.

Associated laboratories complete the highest level of the traceability chain in the country in special fields where some aspects promise more efficient satisfaction of needs then establishment of relevant laboratory in the National Metrology Institute (NMI). Reasons are for example:

1. Marginal values of the quantity
2. Rare requirements for service
3. Limited number of service users
4. Top level qualification of the laboratory

Every laboratory outside the NMI, dealing with National Standards and/or key comparisons and/or CMC presentation in MRA is subject to a special agreement with the NMI.

Additionally, laboratories maintaining a National Standard have to be authorized by the Czech Office for Standards, Metrology and Testing (COSMT).

Associated laboratories meet following obligations covered by the agreement:

1. Competence of the laboratory is verified either by accreditation according to EN ISO/IEC 17025 standard or by an assessment executed by a NMI expert committee.
2. The laboratory is represented by the NMI in MRA and EUROMET activities.
3. The laboratory accepts the NMI quality system elements concerning national standards, key comparisons, CMC presentation and EUROMET contact persons.
4. The laboratory accepts the commitments concerning the national standard maintenance based on COSMT requirements by the Directive No. 4/2000 COSMT as last amended.

To National Standards maintained by an Associated Metrological Laboratory outside the Czech Metrology Institute are also standards for long distances, angles, position and gravity.

Implementation of ISO 17025:2000 in the Geodetic Metrology Laboratories and their Role in the National Metrology System

Vaclav SLABOCH, Jiri LECHNER and Miloslav PIZUR, Czech Republic

1. BRIEF HISTORY OF THE QUALITY SYSTEM (QS) IN THE VUGTK

The activity of the Research Institute of Geodesy, Topography and Cartography (VUGTK) is directed to solution of research and development tasks in the branch of geodesy, surveying, cartography and cadastre. These tasks are gaining on importance especially in connection with the gradual integration of the Czech Republic into the structures of the European Union.

VUGTK also ensures on high professional level verification, calibration and testing of all kinds of geodetic instruments including their accessories. VUGTK is able to offer these services to general public for areas of lengths, angles, positioning and gravity.

VUGTK runs an Authorised Metrology Centre (AMC) for verification of determined measuring tools. Non-determined working measuring tools are calibrated in the Accredited Calibration Laboratory (ACL) that is one of the associated calibrated laboratories of the Czech Metrology Institute (CMI). AMC is authorised by the Czech Office for Standards, Metrology and Testing (COSMT) for verification of determined measuring tools in the area of length. In the period of 1998-1999 AMC went through Inter-laboratory comparison Tests (ICT) in the area of geometrical quantity measurement of length - measuring tapes.

The ACL of VUGTK was created in 1999 as in order to satisfy the needs of professional surveying public of calibration of geodetic instruments according to a uniform conception. In year 2000 ACL passed an accreditation process at the Czech Accreditation Institute (CIA) which issued the Accreditation Document for areas of length and angle, as required by European Standard EN 45001. The ACL uses length and angle standards for the calibration.

In 2001 VUGTK linked these standards to the international standards of the UniBw München (Germany) in the framework of international inter-comparison tests (ICT). Evaluation of these ICT has confirmed a high quality and accuracy of VUGTK standards. Their future exploitation for calibration of all types of geodetic angle and length measuring instruments ensures a substantial rise of quality in general practice as required by international standards EN ISO 9000 series. In 2002 the Calibration Laboratory of the VUGTK was accredited also according the International Standard ISO/IEC 17025 for verification measuring.

2. PRESENTATION OF THE QUALITY SYSTEM IN METROLOGY

2.1 Policy

The mission of the VUGTK is stated by the decree of the President of the Czech Office of Surveying, Mapping and Cadastre (CUZK) issued on 25 October 1994 No. 5006/1994-1.

Among the main activities in the field of basic and applied research of the VUGTK ensures also development of metrology, standardisation and quality management systems oriented first of all on the needs of surveying, mapping and cadastre (including geodesy, cartography and geographic information).

VUGTK runs the Authorised Metrology Centre (AMC) according to the Czech Law No. 505/1990 on Metrology. Part of the AMC is the Accredited Calibration Laboratory (ACL). The ACL is responsible for length and angel standards and their national and international comparison.

VUGTK participates in the work of the Expert Group on Quality (EGQ) of EuroGeographics, which associates National Mapping Agencies in Europe and co-operates with Czech Metrology Institute (CMI) in activities of EUROMET (European Collaboration between the Measurement Standards).

The vision of the VUGTK in the field of metrology is to ensure accreditation for national standards in areas of length, angle, position and gravity, i.e areas required mainly by surveying activities.

2.2 Structure of the of the metrological activities of the VUGTK

See fig. 1

2.3 QS Structure

Responsibilities
The VUGTK prepares introduction of QS according to EN ISO 9001.

Documentation
The accredited calibration laboratory (ACL) has introduced QS according to ISO/IEC 17025.

3. INFORMATION ON QS DEVELOPMENT AND ISO/IEC 17025 IMPLEMENTATION IN THE CALIBRATION LABORATORY OF THE VUGTK

3.1 Annexes to the Quality Manual:

1. Organigram of the VUGTK and of the Calibration Laboratory
2. Example of a calibration certificate
3. Program and procedure of internal audits – example
4. Personnel of the CL and their qualification
5. List of calibrations
6. Declaration of employees
7. Metrological traceability
8. List of revision and modifications
9. List of calibration and measuring equipment

10. Delegation of necessary powers concerning the CL of AMC of the VUGTK

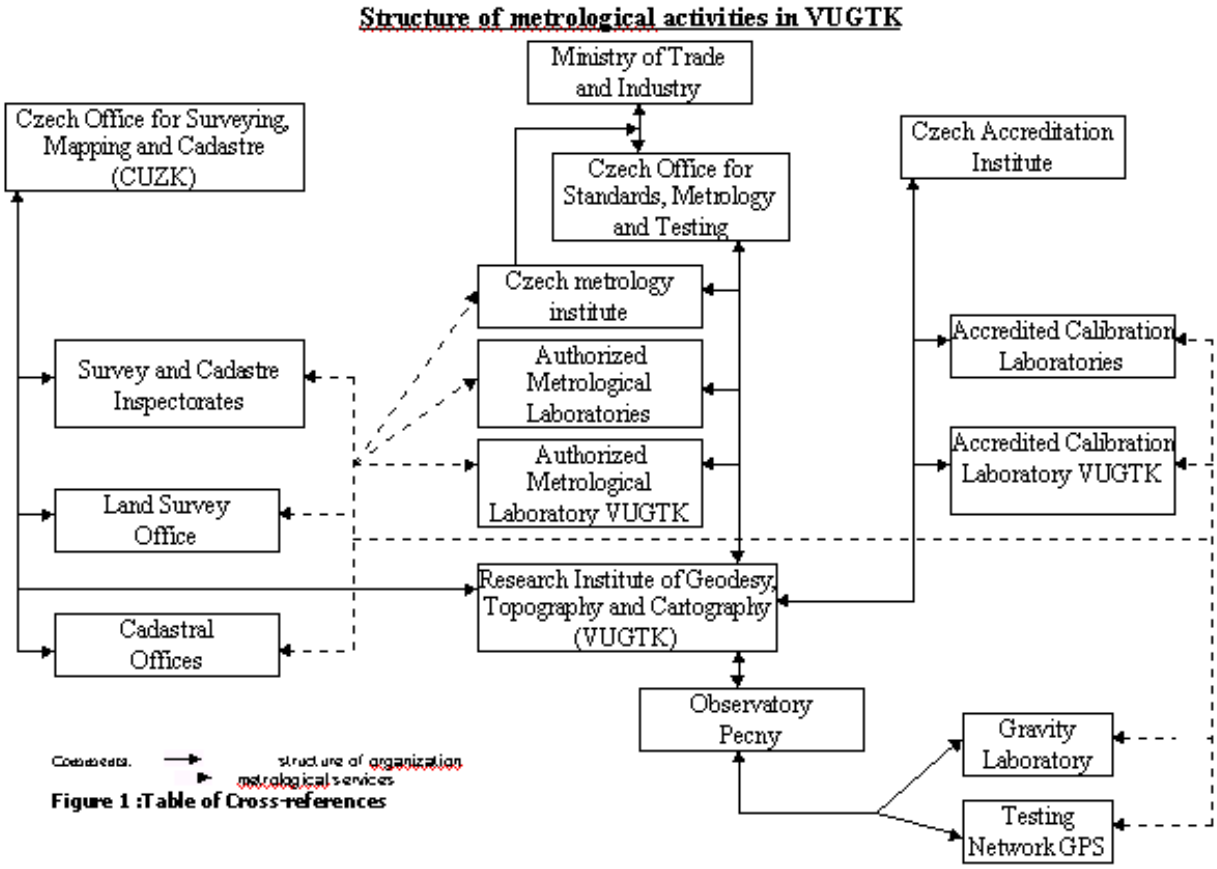

Figure 1 :Table of Cross-references

3.2 List of Administrative or General Procedures:

Quality Manual
Foundation certificate of the VUGTK
Organisation rules of the VUGTK
Statute of the VUGTK
CIA accreditation certificate with the annex
Authorisation certificate , decision 66/2000 of the COSMT
Working contracts of duties of employees of CL of the AMC of the VUGTK
Quality policy declaration
List of metrological cards
Metrological cards
Program of professional development and training programs
Confirmation of qualification
Discarding rules
Program for development and introduction of new methods of the laboratory
List of all suppliers of services and goods influencing the quality and their evaluation
Record about inspections of the measuring and testing equipment

Program and procedure of the inter-calibration tests
Record inter-calibration tests
Orders of the calibration services
Book of the orders
Book of the wishes and complaints
Program of the training of new workers
Records about the training of workers
Records about the calibration measurements
Calculation records of the calibrated equipment
Minutes from internal audits starting 2002
Minutes form verification by management starting 2001
Time program of the regular inspection visits by CIA
Summary reports of CIA inspectors on external laboratory verification
Records of disagreements by CIA resulting from external verifications
List of employees of ACL with their qualification, practical experience and education
Record on changes of Quality Manual reported to CIA
Documentation on the inter-laboratory verifications and their evaluation
Record of traceability of the laboratory standards
Calculation of uncertainties
Corporate rules of metrology

3.3 List of Technical Procedures

The Czech Accreditation Institute (CIA) which is the National Accreditation Body revised all documents in January 2002 during re-accreditation procedure:

- Calibration method no. 1/99 - Measuring tapes
- Calibration method no. 4/99 - Angles by theodolites and total stations
- Calibration method no. 5/99 - Lengths by electronic distance-meters an total stations
- Procedure no. 1/01 - Testing of GPS equipment (HW, SW, Personnel)

3.3.1 Metrological Standards at VUGTK

3.3.1.1 Area of Lengths

3.3.1.1.1 Laser Interferometer

The laser interferometer uses helium-neon laser (Hewlett Packard) This instrument is metrologically linked to the Standard of Primary Metrology in the CMI (Czech Metrology Institute). The laser interferometer is the main standard of VUGTK and basic measuring and calibration equipment of the Institute. This laser interferometer is located in a separate, air-conditioned laboratory protected from noise, vibrations and electromagnetic interference. The laboratory is equipped with a continuous monitoring of temperature and atmospheric pressure, and with electronic fire alarm system. Conditions for safety and health protection are ensured. The laser interferometer allows to verify and calibrate length measuring

equipment up to 30 meter of length with uncertainty of ± (0.25 + 0.2*$L_{(m)}$)µm.

3.3.1.1.2 Length Standard "HVEZDA"

The standard is represented by stations no. 1 to 7 of the geodetic baseline located in the garden of the summerhouse Hvezda in Prague 6 - Brevnov. The individual stations are monumented by concrete blocks 40 × 40 × 110 cm with the bronze bolts marked with centric holes of 1.5 mm diameter on their tops. The lengths of all the sections of the baseline were determined by measurement in all combinations adjusted by the method of least squares characterised by uncertainty of ± 1.0 mm. The total length of the baseline is 960.8725 m. The baseline Hvezda is used mainly for calibration of electronic distance meters.

3.3.1.1.3 Length Standard "KOSTICE"

This standard is represented by stations no. 1 to 15 of the calibration baseline for long distances, which is situated near the village of Kostice in Northern Bohemia along straight stretch of a road leading to the North. The stations are monumental by concrete pillars encored 5 to 9 meters deep below the Earth surface. The construction of the pillars is equipped with for forced centring of measuring equipment to minimise the random errors in centring and for elimination of inherent deviations. Individual sections of the baseline were determined in all combinations. The lengths vary from 24 to 10466 meters. The uncertainty of length determination of individual sections resulting from the least square adjustment is from ± 0.3 mm to ± 3.4 mm. The baseline Kostice is used also mainly for calibration of electronic distance meters.

3.3.1.2 Area of Angles

3.3.1.2.1 Azimuth Standard "ZIDOVSKE PECE"

The main station of the Azimuth Standard Zidovske Pece is situated in the public park of Zidovske Pece in Prague 3 – Zizkov. It is monumented by a concrete block 20×20×80 cm with a bronze bold with centric hole of 1.5 mm diameter. Individual directions of the Azimuth Standard (in total 4 directions) are marked by targets on building walls equally distributed in the range of 400 gon. The Azimuth Standard Zidovske Pece is used mainly for calibration of theodolites, gyrotheodolites and magnetic compasses. The uncertainty of the directions is ± 0.6 mgon.

3.3.1.3 Area of Positioning

3.3.1.3.1 Testing Network for GPS (TNGPS)

Determination of position by GPS (Global Positioning System) is one of the main activities of the VUGTK Geodetic Observatory Pecny. The Observatory is situated near Ondrejov 35 km south-east from Prague at the top of the hill Pecny. The Observatory is also in charge of a permanent GPS station belonging to the IGS (International GPS Service) and EUREF (European Terrestrial Reference System). The station was established in 1992 and permanent

observations by GPS technology started 1995. The observation data are stored, archived and made available on demand by the Observatory.

TNGPS was established in 1999 to 2000. The Testing Network consists of 3 parts: inner, outer, and connecting networks. *Inner Network* is made by 5 pillars equipped by forced centring which enables fixing of different types of antennas by means of screws placed into the fixed part of forced centring. *Outer Network* is made of 5 granite block stones with a brass bold with a 1.5 mm hole on the top. The stations are placed in the distance of 30 m, 150 m, 500 m, 1 km and 11 km from the inner network. *Connecting Network* is used for connecting the base into the ETRF co-ordinate system. It is made of 3 stations: permanent IGS and EUREF station and 2 eccentric stations.

In the year 2000 the whole of the GPS Testing Network was surveyed by GPS static method. The stations of Inner network were observed in 4 seances of 24 hours. The stations of Outer Network were observed in 1 seance from 3 to 8 hours and each point has been surveyed at least 3 times. 10 GPS instruments that were used alternatively – with the exception of the connecting base made the measurement. Inner base and 2 nearest stations of the outer base have been surveyed also by geodetic methods. The results of GPS data processing are in ETRF89 co-ordinate system and transformed into the JTSK system. The results of geodetic methods are both in JTSK system and height system Bpv (Baltic Height System after Adjustment) and in local co-ordinate system in order to compare the results of geodetic and GPS surveys. The results of reference measurement for Inner Network using forced centring resulted in uncertainty of ± 1.5 mm in the position and ± 1 mm in high determination and for outer base ± 0.5 to ± 3 mm in the position and ± 5 to ± 6 mm in the height. For practical comparison these surveys have been compared with geodetic survey made by total stations. The differences at the position between these measurements were not greater than 1.2 mm on the inner base station and 2.7 mm at the outer station. The differences in the high were not greater than 4.2 mm. This result has confirmed a sufficient quality of the base. The TNGPS is regularly re-surveyed in order to determine the stability and eventually time changes of individual stations.

The goal of testing the GPS complexes (receivers and antennas, software, survey procedures and of the operating team) is to prove that the GPS complex is able to achieve the required quality of measurement and eventually to determine the sources of errors.

3.3.1.4 Area of Gravity

3.3.1.4.1 Absolute Gravimetric Station

The VUGTK Gravimetric Laboratory at Pecny ensures this activity. The Gravimetric Laboratory ensures also calibration and adjusting of gravimeters e.g. calibration of scales by tilt and testing of magnetic field influence. Influence of temperature of gravimeters is tested in thermo-chamber. From 1978 the gravity measurements are made by absolute gravimeters.

The laboratory is equipped by 2 facilities for testing of gravimeters by tilting. The first one has been developed in VUGTK. It enables to calibrate also larger instruments as e.g. gravimeters Ascania. This equipment cannot ensure the thermostatic environment and tilting angles are measured by autocollimation by theodolite Wild T3. The second one is soviet equipment UEG-GAE-3 that has been completed in VUGTK by a thermostat. It can be used for quartz gravimeters like Sharpe and Worden. For investigation of influence of magnetic field on gravimeters the Helmholtz coil of 1.2 m in diameter. Testing of influence of magnetic field is carried out for gravimeter LaCoste-Romberg.

The Laboratory uses 2 baselines: Micro Baseline Pecny and Baseline Pecny – Chocerady. The *Micro Baseline Pecny* is established at the stairs of the main Observatory building. It consists of 19 stations. The total height difference is 5.7 meters, the total difference of gravity at the end stations is 1.75 mgal, i.e. 17.5 μms^{-2}. The baseline is used for calibration of measuring screws of gravimeters. The *Baseline Pecny – Chocerady* is also a vertical baseline and is used for calibration of gravimeter scales and for the determination of periodic errors of measuring screws. The total difference in height is 263 m and the total gravity difference is 49.2 mgal, i.e. 492 μms^{-2}.

Since 2001 the Gravimetric Laboratory has been equipped by Absolute Gravimeter FG5 No. 215 by Micro-g-solutions. Starting September 2001 the Observatory provides observation data in 2 weeks periods for detection of time variations of the gravity at the Observatory. From 2003 the absolute gravimeter will operate in international co-operation in the framework of European absolute gravity network.

Further information is available at:
http://pecny.asu.cas.cz -> observatory -> GPS test base -> gravimetrical bases

4. QS AND COVERED CALIBRATION CAPABILITIES

ID MET	IDENTIFICATION	NAME	VALIDATION	RANGE	CMC	NOTE
4029	VUGTK 1/99	Measuring tapes	Inter-comparison	0.001mm-30m	(6+0.7L)µm	L=m
4030	VUGTK 4/99	Angles by theodolites and total stations	Inter-comparison	0.0001–360^{o} 0.0001-400^{g}	1.0” 0.30 mgon	
4031	VUGTK 5/99	Legths by EDM and total stations	Inter-comparison	0.1m-1km	(0.6+1.4L)mm	L=km
4032	VUGTK 7/99	Levelling rods			(6+0.7L)µm	L=m (not yet accredited)
4033	VUGTK 41/99	Geodetic baselines (long dista)	Inter-comparison		(0.6+1.4L)mm	L=m (not yet accredited)

5. QS LIFE

5.1 Complaints

Management of complaints is performed according to the QM clause 4.8. Clients are informed about this procedure during the receipt of the calibration items. The Quality policy is based on prevention of complaints from clients ant other parties.

5.2 Non-conforming Work

Control of non-conforming work is described in the QM, clause 4.9. The quality policy is based on prevention of occurrence of any non-conforming work. Staff members, internal or external audits, management reviews or client complaints and observations can detect non-conforming work. In all the cases the non-conforming work is documented on a special form including the responsibilities and authorities for the management of non-conforming work, immediate response to the problem and corrective actions. The records are controlled documents.

5.3 Internal Audits

Internal audits are performed according to the QM clause 4.13 with agreement of plan.
Finding of each internal audit are recorded into protocol. Internal audits cover all aspects of the quality system in one year. The records are controlled documents.

Year	**Nunber of Audits**	**Number of**		
		QS elements	**nonconformities**	**corrective acctions**
2000	3	16	1	2
2001	3	16	0	0
2002	3	16	0	0

5.4 Management Reviews

Reviews are performed according to the QM clause 4.14. Reviews are carried out once a year. by the Head of the Metrological Laboratory.

REFERENCES:

HEISTER, Hans, SLABOCH, Vaclav**:** Report on Standards, Quality Assurance and Calibration – FIG, WG 5.1 Activities in 1988 – 2002, XII FIG International Congress, April 19 – 26, 2002, Washington, DC USA.

BECKER, Jean-Marie**:** Recommendations Concerning Survey Instruments Maintenance and quality specifications, TS 5.11, XII FIG International Congress, April 19 – 26, 2002, Washington, DC USA.

HEISTER, Hans**:** The Term Uncertainty of Measurement and Concept of Its Determination, TS 5.11, XII FIG International Congress, April 19 – 26, 2002, Washington, DC USA.
ILLNER, Michael**:** Investigations Concerning the Reliability and External Accuracy of GPS Real Time Measurements, TS 5.11, XII FIG International Congress, April 19 – 26, 2002, Washington, DC USA.
HEISTER, Hans, LANG, Martin, LECHNER, Jiri, SLABOCH, Vaclav**:** Metrological Comparison of Length and Azimuth Standards between German and Czech Geodetic Laboratories According to ISO Standards, TS 5.12, XII FIG International Congress, April 19 – 26, 2002, Washington, DC USA.
ISO/IEC 17025:2000 General requirements for the competence of testing and calibration laboratories.

BIOGRAPHICAL NOTES:

Vaclav Slaboch - Director of the Research Institute of Geodesy, Topography and Cartography, Vicechairman of the Czech Union of Surveyors and Cartographers Studied geodetic surveying at the Czech Technical University in Prague, worked with Fairey Surveys Ltd., in England. In 1979 as consultant for a UNDP Project in West Africa, and later in Malta. Former Chairman of FIG WG 5.1 Quality Assurance. Quality Control and Standards, and teacher of Engineering Surveying at the Czech Technical University in Prague.

Jiri Lechner – Head of the geodetic metrological laboratory at the Research Institute of Geodesy, Topography and Cartography in Prague. Studied surveying at the Moscow Technical University and worked with a German engineering surveying company in Leipzig, Specialised in engineering surveying and standardisation of surveying in construction.

Miloslav Pizur – Manager of quality at the Research Institute of Geodesy, Topography and Cartography in Prague. Studied surveying at the Czech Technical University in Prague, surveying practice with several private survey companies in Czech Republic.

CONTACTS:

Vaclav Slaboch, Jiri Lechner and Miloslav Pizur
Research Institute for Geodesy, Topography and Cartography (VUGTK)
CZ – 250 66 Zdiby 98
Praha - východ
CZECH REPUBLIC
Tel. + 420 284 890 907
Fax + 420 284 890 056
Email: http://www.vugtk.cz