Metrological Assurance of Geodetic Measurements: From the Czech Geodetic Baseline Kostice to the Ukrainian - Yavoriv

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Key words: metrological traceability, standard, geodetic baseline, calibration, geodetic measurements

1. SUMMARY

Accurate and metrologically traceable measurements are the primary criterion for the quality of geodetic surveying activities, especially in geometric control of construction where compliance with prescribed tolerances is decisive. Although the theoretical and normative issues for geometric precision are already well established, harmonised with ISO practice and aligned across the European Union (EU) their incomplete adoption in practice has historically produced disputes between contracting parties. Therefore, strong emphasis is placed on meeting the Metrology Act and EU legislation, ensuring uniformity and accuracy of measurements and instruments. In the field of lengths, this creates a demand for high-precision geodetic baselines and corresponding measurement instruments.

Based on the many years of experience of the Czech Research Institute of Geodesy, Topography and Cartography (VUGTK, v.v.i.) in metrological assurance of geodetic measurements, the paper considers the possibility of a practical implementation of converting the unit of length from the Kostice geodetic baseline, which serves as the Czech state length standard since 2008, to the Yavoriv geodetic baseline in Ukraine.

The current state of knowledge in the field of the geodetic concept of converting the unit of length was verified through an international interlaboratory comparison carried out in 2018 by experts from the VUGTK at the Finnish base in Nummela, where the achievable accuracy of this traceability was confirmed. Further cooperation was also developed with the Lviv Polytechnic National University at the geodetic baseline in Yavoriv. Independent measurements on this base in Ukraine have already been initiated; however, practical implementation is currently limited by security restrictions and regulatory prohibitions arising from the ongoing armed conflict in Ukraine.

Beyond its technical dimension, this initiative has strategic significance. For Ukraine, strengthening metrological traceability in geodetic surveying supports post-war reconstruction by ensuring the reliability of measurements used in infrastructure, industry, and urban development. It reduces risks of error, fosters trust in engineering processes, and enhances alignment with European and global measurement systems. In this way, the initiative contributes not only to scientific advancement, but also to sustainable reconstruction, long-term resilience, and, in particular, to the establishment of a seamless cross-border communication infrastructure.

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2. INTRODUCTION

The quality of geospatial data has become increasingly critical as modern society advances toward digitalization and cyber-society development. Metrological traceability – the property by which measurement results can be related to reference standards through an unbroken chain of calibrations – provides the fundamental foundation for confidence in geodetic surveying activities. This metrological assurance is particularly essential in geometric control of construction, where compliance with prescribed tolerances determines the reliability of engineering projects and long-term infrastructure stability (Lechner et al., 2008).

The key pillars of the modern metrological framework include national measurement institutes, reference geodetic baselines, instrument calibration programs, and systematic evaluation of measurement uncertainty following international guides (e.g., GUM/JCGM). Over the last two decades, European countries have increasingly harmonized their metrological practices within the European Association of National Metrology Institutes (EURAMET) framework, promoting a coherent and interoperable measurement infrastructure across borders (Pendrill, 2009; Lechner et al., 2022).

The establishment of geodetic baselines as state length standards represents a crucial infrastructure element within national metrological systems. These baselines serve as working standards for the calibration of electronic distance meters (EDMs) and other precision surveying instruments (ISO, 2012). Their importance has grown in parallel with the rapid expansion of geospatial applications that demand higher precision and traceability. The harmonization of such standards across European nations, and increasingly between Europe and neighboring regions, requires not only technical excellence but also adherence to international normative frameworks established by bodies such as the International Bureau of Weights and Measures (BIPM) (Newell & Tiesinga, 2019).

The Czech Republic established its state length standard in 2008, fulfilling government requirements for metrological equivalence with EU countries. This baseline has served as the Czech state long length standard for over fifteen years, providing calibration services to the geodetic surveying community and supporting numerous international collaborations. Simultaneously, developments in Ukraine resulted in the creation of the Yavoriv scientific geodetic test field, including the geodetic baseline as an integral element. Convergence of these initiatives represents an important opportunity for strengthening metrological infrastructure across Central and Eastern Europe (Lechner et al., 2008; Trevoho et al., 2024).

This paper provides a review of metrological assurance developments across the past two decades, examining the Czech state length standard, the Yavoriv geodetic baseline infrastructure in Ukraine, and the strategic importance of conversion the unit of length between these reference baselines.

3. THE CZECH STATE LENGTH STANDARD

3.1 Historical Context and Establishment

The establishment of a Czech state length standard was driven by legislative requirements and the need for metrological equivalence with other European Union member states, which, in the context of the Metrology Act and increasing EU harmonization pressures, created an urgent demand for a dedicated, metrologically traceable facility capable of calibrating geodetic instruments across extended measurement ranges. The Research Institute of Geodesy, Topography and Cartography (VUGTK – Vyzkumny ustav geodeticky, topograficky a kartograficky, v.v.i.), founded in 1954 as the primary research institute for the Czech Office for Surveying, Mapping and Cadastre, was tasked with designing and implementing this national standard. Drawing on international best practices observed at geodetic baseline facilities such as the Nummela baseline in Finland, VUGTK developed specifications for a facility that would serve both national calibrations needs and international metrological comparisons. Kostice was designated as the Czech State Long Distances Measuring Standard in 2008, serving as the principal practical realization of the metre within the nation's geodetic network. Continuous calibration activities at Kostice geodetic baseline reflect global trends in geodetic metrology, where long-term stability, environmental control, and rigorous uncertainty assessment are key prerequisites for reliable metrological infrastructure (Lechner et al., 2008; Kosarev et al., 2023).

3.2 Physical Configuration and Instrumentation

Over the past two decades, the Kostice geodetic baseline has been systematically maintained and modernized. The site selection process identified a location in Northern Bohemia, approximately 60 kilometers northwest of Prague, where geological conditions, accessibility, and available infrastructure permitted the construction of precision pillars with minimal disturbance. The location, between the villages of Kostice and Libceves, offered longitudinal alignment suitable for extended distance measurements while maintaining the elevated stability required for metrological work. The Kostice geodetic baseline comprises twelve pillars numbered from 1 to 12, arranged in a linear configuration along an existing roadway. Each pillar consists of a vertical steel pile driven deep into the ground, providing mechanical stability and minimizing seasonal ground movement effects. Above ground level, each pillar terminates in a round steel plate approximately one meter above the surface, specifically designed for precise centering of geodetic instruments through forced-centering devices. The baseline generates sixty-six distinct horizontal distance measurements between the twelve pillars (Lechner et al., 2008).

Metrological traceability of the Kostice baseline has been established through calibration of the laser interferometer against the Czech Metrology Institute's primary standard, which maintains the SI realization of the meter through laser wavelength standards. This unbroken chain of

calibrations, documented through formal certificates and quality management records, ensures that all distance measurements at Kostice are traceable to the international SI definition.
Currently Czech state length standard at the Kostice facility is realized through a reference baseline in combination with Renishaw laser interferometer, Leica AT401 laser tracker, and Leica NOVA MS50 total station, ensuring measurement traceability. In its initial stage, the standard consisted of the Kostice geodetic baseline and a Leica TCA 2003, which was subsequently expanded and refined.
This combined use of different technologies allows cross-validation of results and identification of instrument-specific effects (e.g., additive constant, scale factor, cyclic errors). Atmospheric parameters (temperature, pressure, humidity) are systematically monitored to apply precise corrections for refractive index effects on distance measurements – a crucial factor in maintaining traceability over long baseline sections.

3.3 Instrument Calibration Methodology and Uncertainty Evaluation

Ensuring reliable traceability requires proper operation of the entire measurement chain, including instruments, environmental sensors, and data processing algorithms.
The typical calibration workflow at Kostice involves:

1. Environmental data acquisition – monitoring of air temperature, pressure, and humidity.
2. Reference distance measurement – using the laser interferometer to establish reference lengths under controlled conditions.
3. Instrument testing – comparing distance measurements from electronic EDM-based instruments against reference values over multiple baseline sections.
4. Uncertainty assessment – applying internationally recognised frameworks (e.g., GUM) to derive combined standard uncertainty for each instrument's measured values.

For each instrument type, both additive and multiplicative uncertainty components are quantified, including effects of centring errors, refractive index variations, etc. This systematic approach enables certification of instruments with stated uncertainties significantly smaller than their operational tolerances, underpinning quality assurance in surveying practice.
Long-term stability of the Kostice geodetic baseline has been periodically assessed through repeated measurement campaigns. The pillar displacement monitoring program, initiated in conjunction with the establishment of the Kostice geodetic baseline and continued through the present, has documented residual movements typical of deep-set concrete structures in continental European climatic regions (Lechner et al., 2022). The measured pillar displacements generally remain within a tenth of a millimeter per year, representing the combined effects of seasonal thermal cycling, groundwater fluctuations, and minor seismic activity (Lechner et al., 2008). The stability assessment indicates that periodic recalibration of the baseline becomes necessary to account for accumulated pillar movements and to maintain the stated uncertainty specifications (Lechner et al., 2022). VUGTK has implemented a formalized recalibration schedule balancing the costs and operational requirements of comprehensive measurement campaigns against the necessity of maintaining metrological reliability.
The achievable accuracy at the Kostice geodetic baseline depends critically on proper consideration of meteorological parameters during measurement campaigns. The thermal expansion of steel pillars, combined with changes in the refractive index of air affecting EDM

signal propagation, necessitates continuous monitoring of environmental conditions during measurement operations. These measurements are recorded simultaneously with distance measurements, allowing application of environmental corrections based on established physical models of signal propagation through the atmosphere. The complexity of atmospheric refraction effects, particularly under variable atmospheric conditions common to Central Europe, presents an ongoing challenge to achieving sub-millimeter accuracy over extended baselines.

4. THE UKRAINIAN GEODETIC BASELINE YAVORIV

The Yavoriv geodetic baseline, located near Lviv, represents Western Ukraine’s primary practical reference for long-distance geodetic measurements. It was established a comprehensive scientific facility for metrological control of geodetic instruments and testing of new measurement technologies. The initiative emerged from Ukraine's transition to international geodetic standards following independence and represented a commitment to modernizing the nation's geospatial infrastructure in alignment with European practices.

The design of the scientific geodetic test field was initiated in 1996, and the first experimental geodetic measurements were carried out in 1997. As part of this project, the geodetic baseline was established in 2003, when the first calibration was performed using the PLD-1M system, Ukraine’s most precise distance measurement instrument at the time. The geodetic baseline is materialized by 20 metal pillars with foster centering. Eight years ago, centre No. 19 was replaced by a new pillar designated as No. 21 (Trevoho et al., 2024). Its total length of 2260 m exceeds typical state baselines, offering favourable conditions for calibration of instruments across their operational range. This facility enables metrological verification and calibration of electronic distance meters, GNSS receivers, and other precision geodetic instruments across a defined measurement range (Trevoho et al., 2022).

The Yavoriv geodetic baseline supports multiple calibration methodologies adapted to specific instrument types and measurement ranges. A distinctive feature of the geodetic baseline design is that all distances from the initial point to the main reference centers are multiples of 10 m, which allows baseline measurements to be performed at a single phase angle. (Trevoho et al., 2024). The experimental calibration program at Yavoriv has involved systematic measurements using various measurement methods and instruments over extended time periods, establishing a comprehensive database of reference distance values and their associated uncertainties. To date, more than 20 calibration campaigns have been carried out on the baseline, the results of which confirm its long-term stability. These multi-year experimental campaigns represent essential preliminary work for establishing international metrological comparisons and validating the achievable measurement accuracy (Trevoho et al., 2022). The Yavoriv facility represents the first geodetic baseline in Ukraine capable of conducting international interlaboratory comparisons, marking a significant milestone in Ukrainian metrological capacity (Trevoho et al., 2022; Khoptar et al., 2023; Trevoho et al., 2024). These international comparisons are crucial, as they provide objective verification of baseline quality and support Ukraine’s alignment with European metrological practices.

The extensive experimental activities carried out at the Yavoriv geodetic baseline have demonstrated that, from the instrumental and methodological perspectives, the facility is capable of achieving accuracy levels comparable to established European calibration baselines. However, the analysis of long-term measurement results also highlights that, as measurement precision increases, the relative contribution of environmental effects becomes increasingly significant. Among these effects, atmospheric refraction emerges as a critical limiting factor that influences the achievable accuracy of distance measurements, particularly over long baseline sections. Despite the application of standard meteorological corrections, atmospheric refraction remains one of the dominant sources of uncertainty in high-precision distance measurements on long geodetic baselines. Variations of the refractive index along the measurement path, caused by temperature gradients and air stratification near the ground, cannot be fully compensated using conventional point-based meteorological observations.

Consequently, addressing the influence of atmospheric refraction represents a critical challenge for further improvement of metrological accuracy on geodetic calibration baselines. Achieving reliable traceability of length measurements, particularly for the international conversion of the unit of length, requires the development and validation of advanced methods aimed at minimizing or eliminating refractive effects. This includes the investigation of measurement strategies under controlled atmospheric conditions, the application of distributed meteorological sensing along the measurement path, and the use of complementary observation techniques capable of separating geometric and atmospheric influences. The identification and implementation of such methods are essential for enhancing the robustness, repeatability, and long-term stability of high-precision geodetic measurements.

As of 2026, the Yavoriv geodetic baseline represents one of the most sophisticated and internationally comparable metrological infrastructures for geodetic measurements in Ukraine. However, the ongoing military conflict in Ukraine has introduced significant operational constraints. Security restrictions and regulatory prohibitions have limited the conduct of comprehensive measurement campaigns and prevented engagement in planned international collaborative projects. Despite these challenges, preliminary independent measurements at the Yavoriv baseline have been conducted when operational security permits. The facility remains conceptually prepared for resumption of full operational status upon stabilization of the security situation, maintaining its role as a potential anchor point for European metrological infrastructure.

5. CONVERSION OF THE UNIT OF LENGTH

The conversion of the unit of length between geodetic baselines represents a fundamental metrological operation ensuring that measurement standards located in different locations realize the same SI meter definition. This conversion is accomplished through a carefully designed sequence of measurements using calibrated instruments, comparative measurements at common sites, and rigorous uncertainty evaluation, guaranteeing unbroken metrological traceability (Lechner et al., 2022; Trevogo et al., 2020).

The metrological framework for unit conversion is grounded in the principle of unbroken calibration chains. Each measurement linking two baselines must be conducted using instruments whose metrological properties have been previously established relative to higher-order standards. According to ISO/IEC 17025:2017, laboratories must establish and maintain metrological traceability of measurement results through a documented continuous calibration chain, each element of which contributes to the overall measurement uncertainty. The combined uncertainty of the conversion process reflects uncertainties at each step of the calibration chain, including contributions from reference standards, instrument resolution limitations, and measurement repeatability (Khoptar et al., 2024).

For conversion between Kostice and Yavoriv, the measurement sequence involves the following critical stages:

- Calibration of high-precision instruments (laser tracker, electronic total station) at the Kostice baseline using established reference distances and a laser interferometer as a primary standard. Laser interferometers, such as the Renishaw XL-80 system, provide linear measurement at an accuracy of ±0.5 ppm when using the XC-80 compensation system, which corrects for the effects of changes in air temperature, pressure, and humidity. The Leica AT401 laser tracker, with coordinate measurement uncertainty of ±15 μm + 6 μm/m, enables the establishment of highly precise reference distances based on interferometric measurements.
- Transport of calibrated instruments to the Yavoriv geodetic site with controlled transport conditions to minimize instrument drift and potential calibration disruption.
- Independent distance measurements at the Yavoriv geodetic baseline using previously calibrated instruments, with careful recording of meteorological parameters to enable application of atmospheric corrections.
- Comparison of measured results with previously established distances at the Yavoriv geodetic baseline.
- Analysis of consistency and determination of scale corrections, accounting for any systematic differences that may arise from instrument calibration drift, atmospheric effects during transport, and variations in baseline geometry.

One of the most significant challenges in conducting high-precision measurements on geodetic baselines is the accounting for atmospheric effects. Variations in air temperature, atmospheric pressure, and humidity affect the group refractive index of air, which directly influences the wavelength of laser radiation used as the foundation for measurements. For example, a 1°C increase in temperature results in an atmospheric correction of approximately 1 ppm, while a 1 hPa decrease in barometric pressure yields a correction of approximately -0.28 ppm. Without careful measurement and correction of meteorological parameters, measurement uncertainty over multi-kilometer distances can reach 20-30 ppm. Therefore, to achieve accuracy better than 1 ppm, meteorological parameters must be measured at intervals of 200-300 meters along the optical path.

The methodology proposed exploits redundancy in distance measurements to detect and quantify systematic errors introduced by the conversion process. This approach enables identification and correction of instrument calibration drift, residual atmospheric effects not fully accounted for during corrections, and variations in instrument setup between the geometries of the two baselines.

The practical realization of such unit conversion has already been partially validated in an international context. In 2018, VUGTK conducted an interlaboratory comparison at the Finnish Nummela geodetic baseline, which serves as the state length standard for Finland since 1947. At the Nummela baseline, expanded uncertainties at the level of 0.3 mm with coverage factor

k=2 are achieved for distances up to 864 m. The results of this comparison confirmed the achievability of the required accuracy in converting the unit of length between national standards of different countries and demonstrated that proper application of measurement techniques and comprehensive accounting for all sources of uncertainty enable the attainment of reproducible and harmonized results.
Such international collaborations align with the recommendations of ISO/IEC 17025 and promote harmonization of metrological standards within EURAMET and global metrological networks. They also affirm the principles of mutual recognition of the CIPM MRA (Arrangement of the Consultative Committee for Units), which ensures recognition of the metrological competence of national institutes in different countries.
Despite the technical and strategic justification for the Kostice-Yavoriv conversion, practical implementation currently faces significant constraints arising from the security situation in Ukraine. Since 2022, the full-scale armed conflict has resulted in widespread damage to critical infrastructure. Restrictions on international personnel movements in high-risk zones, the necessity of evacuating equipment and personnel, and damage to certain laboratory facilities have significantly complicated the conduct of comprehensive measurement campaigns at the Yavoriv baseline. However, these constraints represent temporary impediments rather than fundamental technical barriers. Upon stabilization of the security situation, the planned measurement procedures are well-established, the required instrumentation is available and previously calibrated, and the international collaborating institutes have committed to resuming the project.

6. CONCLUSIONS AND RECOMMENDATIONS

The metrological assurance of geodetic measurements represents a critical foundation for modern society's infrastructure, scientific research, and commercial activities. The Czech Republic's establishment of the state length standard in 2008 represents a fully operational expression of contemporary metrological science. Almost twenty years of experience with the Kostice facility have demonstrated the technical feasibility and practical utility of establishing national length standards that reliably serve geodetic calibration requirements.
Ukraine's development of the Yavoriv geodetic baseline represents a parallel advance in Eastern European metrological infrastructure. While currently constrained by security limitations, the Yavoriv facility embodies the technical capabilities necessary for international metrological participation and contributes to European metrological integration.
The proposed conversion of the unit of length between Czech and Ukrainian baselines represents an important practical application of contemporary metrological principles, formally demonstrating the equivalence of national standards and establishing metrological comparability across different regions. The international interlaboratory comparison confirmed the achievability of the planned measurement procedures with acceptable accuracy levels. However, special attention must be paid to atmospheric refraction, which currently represents the dominant unresolved source of uncertainty in high-precision baseline measurements. Reducing or eliminating its influence is essential for further improvements in metrological traceability and for the reliable international conversion of the unit of length.

Beyond its technical dimensions, this initiative carries profound strategic significance for Ukraine's post-war reconstruction and long-term integration with European scientific and technological communities. The establishment of metrologically traceable measurement infrastructure supports accurate planning and construction of essential infrastructure, enables participation in international research networks, and affirms commitment to international standards and cooperation.

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REFERENCES

International Organization for Standardization. (2012). ISO 17123: Optics and optical instruments – Field procedures for testing geodetic and surveying instruments. International Organization for Standardization.

Khoptar, A., Lechner, J., & Vanchura, R. (2024, October). Prospects of Geodetic Calibration Baselines for Increasing Geodetic Measurement Accuracy. In International Conference of Young Professionals «GeoTerrace-2024» (Vol. 2024, No. 1, pp. 1-5). European Association of Geoscientists & Engineers.

Kosarev, N. S., Lechner, J., Padve, V. A., & Umnov, I. A. (2023). Results of many years'measurements conducted at the Czech state long distances measuring standard Kostice. Science and technology, 22(1), 13-19.

Lechner, J., Kosarev, N. S., & Trevoho, I. S. (2022). Conversion of units of length from the Czech state standard to the geodetic baseline Yavoriv. Acta Polytechnica, 62(6), 618-626.

Lechner, J., Červinka, L., & Umnov, I. (2008). Geodetic surveying tasks for establishing a National long length standard baseline. Integrating Generations – FIG Working Week.

Newell, D. B., & Tiesinga, E. (2019). The international system of units (SI). NIST Special Publication, 330(1).

Pendrill, L. R. (2009). EURAMET: European Association of National Metrology Institutes. NCSLI Measure, 4(4), 40-44.

Trevoho, I., Tsiupak, I., Vanchura, O., & Chetverikov, B. (2024). 25 years of Yavoriv SGP – structure, usage, research scope, prospects. Modern Achievements of Geodetic Science and Industry, 1(47), 44-50. Lviv Polytechnic National University.

Trevoho, I., Vanchura, O., Khoptar, A., Periy, P., & Tarnavskyy, V. (2022, October). Modern Standard Linear Basis of Original Design for Metrological Verification of Geodetic Instruments. In International Conference of Young Professionals «GeoTerrace-2022» (Vol. 2022, No. 1, pp. 1-5). European Association of Geoscientists & Engineers.

Trevogo, I. S., Lechner, J., Tora, B., Cernota, P., & Stankova, H. (2020). Geodetic activity for compatibility of the unit of length of geodetic bases Kostice (Czech Republic) and Yavoriv (Ukraine). Inżynieria Mineralna.

BIOGRAPHICAL NOTES

Alina Khoptar – completed her higher education at Lviv Polytechnic National University, Ukraine, and obtained an additional Master's degree in Neubrandenburg University of Applied Sciences, Germany, within a double degree programme, before receiving her Ph.D. degree in Geodesy and Land Management from Lviv Polytechnic National University in 2021. She subsequently worked as an assistant at the Department of Higher Geodesy and Astronomy, Institute of Geodesy, at the same university. In 2024, she was awarded the MERIT fellowship (Central Bohemian Mobility Programme for Excellence in Research, Innovation and Technology) and has since been working as a Postdoctoral Research Fellow at the Research Institute of Geodesy, Topography and Cartography (VUGTK, v.v.i.), Czech Republic. Her scientific work focuses on precision length measurement and the conversion the unit of length, with applications in engineering surveying and infrastructure development. She is a member of the FIG Commission 6 "Engineering Surveys" and the FIG Young Surveyors Network.

Jiri Lechner – previously served as Head of the Accredited Calibration Laboratory at the Research Institute of Geodesy, Topography and Cartography (VUGTK, v.v.i.), and currently works as a researcher at the same institute. He studied surveying at the Moscow Technical University and gained professional experience with a German engineering surveying company in Leipzig. His main fields of specialization include engineering surveying, metrology and the standardization of surveying methods in construction.

Ihor Trevoho – Professor and Doctor of Technical Sciences at the Lviv Polytechnic National University, Ukraine. His academic and professional activities are focused on engineering geodesy, geodetic metrology, geodetic networks, and the accuracy of distance measurements using modern geodetic instruments. Based on his project, a scientific geodetic test field was established, which includes the Yavoriv geodetic baseline. He has long served as President of the Ukrainian Society of Geodesy and Cartography. Member of the FIG Commission 2 "Professional Education". Prof. Trevoho has authored numerous scientific publications and has been actively involved in national and international professional cooperation in the field of geodesy.

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