

# The Term Uncertainty of Measurement and the Concept of Its Determination

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**Key words:** Measurement uncertainty, , accuracy, geodetic metrology.

## ABSTRACT

When reporting the results of measurement or instrumental investigations, it is obligatory that some quantitative indication of the quality of the final result or tests and checks are given so that those who want to use it can assess its reliability. Without such an indication, the results cannot be compared, neither among themselves nor with reference values, given in the specifications or standards. Today predominantly the quantity “*standard deviation*” is used to indicate the accuracy of our instruments respectively of the measured quantities. As this value considers more the stochastic, random errors it becomes more and more necessary to regard as well the systematic effects. The reason for this is that due to the clear improvement of the instruments the random component becomes smaller in comparison with the systematic component. It is therefore necessary that we use readily implemented, easily understood and generally accepted procedures for stating the quality of geodetic and surveying instruments, which will be able to consider these both components in *one quantity*. For this reason we have to discuss the concept of *uncertainty* especially in connection with geodetic/ surveying applications. The definition and concept of *uncertainty* as a quantitative attribute to the final result of measurement, considering all systematic and random components of all known input quantities, was developed mainly in the last two decades, even though the error analysis has already long been a part of all measurement sciences. Under responsibility of ISO Technical Advisory Group on Metrology (TAG 4) and in conjunction with six worldwide metrology organizations a guidance document on the expression of measurement uncertainty was compiled with the objective to provide rules for use within standardization, calibration, laboratory, accreditation and metrology services. The *Guide to the Expression of Uncertainty in Measurement (GUM)*, which is well recommended to everybody involved into metrological tasks, was first published as ISO document in 1995. With the *uncertainty of measurement* both a term was created and recommendations for quantifying, which will meet all metrological requests.

Particularly the following references will introduce this new, international accepted concept with regard to geodetic and surveying applications:

HEISTER, H. (2000): The Expression „Unvertainty of Measurement“ in Geodetic Metrology. Proceedings (on CD): Mediterranean Surveyors in the new Millennium, FIG Seminar, Malta

HEISTER, H. (2001): A new Concept for Stating Accuracy in Standards – Exemplified by SI/DIS 17123-6 Rotating Lasers-. Proceedings (on CD): FIG Working Week 2001, 6. – 11. May, Soul, Korea

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FIG XXII International Congress

Washington, D.C. USA, April 19-26 2002

Heister, H.(2001): Zur Angabe der Meßunsicherheit in der geodätischen Meßtechnik. In: Heister H., Staiger R. (Edts): Qualitätsmanagement in der geodätischen Meßtechnik. DVW Schriftenreihe, Vol. 42, p. 108 - 119  
ISO (1995): *Guide to the Expression of Uncertainty in Measurement*. International Organization for Standardization, Genève

## ZUSAMMENFASSUNG

Bei der Durchführung von Vermessungsaufgaben ist es üblich, neben dem Ergebnis auch seine Genauigkeit anzugeben. Speziell bei hochgenauen Anforderungen oder Kalibrierungen ist eine zuverlässige und zutreffende Quantifizierung des Genauigkeitsmaßes gefordert. Benutzte der Vermessungsingenieur bislang vorrangig die *Standardabweichung* als Qualitätskriterium seiner Messungen, so wird zunehmend besonders in den meßtechnischen Nachbardisziplinen der Begriff *Meßunsicherheit* benutzt. Die quantitative Größe Meßunsicherheit ermöglicht die Berücksichtigung und Zusammenfassung zufälliger und systemischer Komponenten zu *einem* Genauigkeitsmaß nach anerkannten Standards.

Das international eingeführte Konzept zur Ermittlung von Meßunsicherheiten wird in der o.a. Literatur speziell im Zusammenhang mit Vermessungsaufgaben, Kalibrierung geodätischer Instrumente und den hiermit verbundenen Normen vorgestellt.

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## BIOGRAPHICAL NOTES

**Hans Heister** received the degree Dipl.-Ing. at the University of Bonn in 1969. During 1970 – 1974 he was assistant at the Geodetic Institute of the TU Munich. 1974 he became director of the Geodetic Laboratory of the Bundeswehr University Munich (UniBwM), 1987 Dr.-Ing.habil., and since 1991 he is apl. Professor for Geodetic Metrology at the same University. Main activities: GPS, land navigation, kinematic survey, gyro-measurements, calibration of geodetic instruments, engineering and industrial surveying. Many professional activities abroad, numerous lectures at foreign universities and congresses. Member of FIG commission 5 "Positioning & Measurement".

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