International Federation of Surveyors
Fédération Internationale des Géomètres
Internationale Vereinigung der Vermessungsingenieure

Commission 5: Positioning and Measurement

FACT SHEET

Calibration and Testing for GNSS and CORS

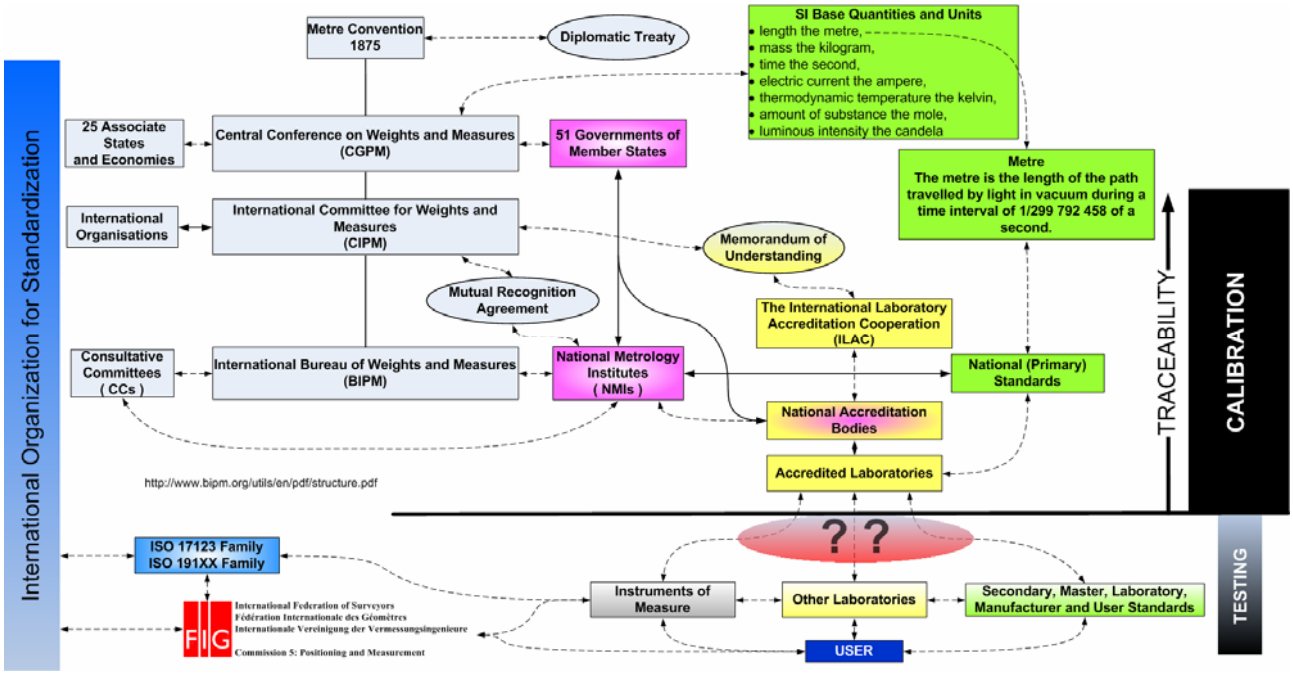
Introduction

Considedrable efforts have been made concerning survey instrument testing. In particular the ISO standard 17123 parts 1 through 8 concerning levels, theodolites, EDM's, total stations and most recently GNSS field measurement systems in real time kinematic (RTK); have been published. Instrument manufacturers often quote these standards when making reference to their instruments precision. Each of the ISO 17123 standards prescribes test procedures aimed at determining if the instrument is functioning correctly and qualifying its precision and performance. These tests should be made on a regular basis.

Instrument Calibration

Instrument testing (ISO 17123) should not be confused with an instrument calibration. Calibration links the instrument directly to international standards (see figure). Calibration is the act of checking or adjusting by comparison with a standard or reference the accuracy of a measuring instrument. A standard or reference is an instrument or method that will measure more accurately and precisely the desired quantity than the measuring instrument itself. For example a laser interferometer measures more accurate distances (relative displacements) than a total station Electronic Distance Meter (EDM).

One of the pillars of instrument calibration is the notion of traceability. Indeed traceability is at the root of all legal metrology and measurement. Traceability is a method of ensuring that a measurement (even with its uncertainties) is an accurate representation of what it is trying to measure. With traceability, it is possible to demonstrate an unbroken chain of comparisons that ends at a national metrology institute (NMI). The figure below illustrates the links through the CGPM, CIPM and BIPM to the NMI's and Accreditation authorities to the user and his/her instrument. Note that traceability is not assured if an instrument is not linked through an accredited laboratory to a national standard.



At present there is no consensus on GNSS calibration. This is because it is a relatively new and complex field and there are differing, valid points of view concerning what exactly needs to be calibrated and how to go about doing it.

ISO 17123 part 8 GNSS field measurement systems in real time kinematic (RTK)

This standard specifies field procedures to be adopted when determining and evaluating the precision (repeatability) of Global Navigation Satellite System (GNSS) field measurement systems (this includes GPS, GLONASS as well as the future systems like GALILEO) in real-time kinematic (GNSS RTK) and their ancillary equipment when used in building, surveying and industrial measurements. Primarily, these tests are intended to be field verifications of the suitability of a particular instrument for the required application at hand, and to satisfy the requirements of other standards. They are not proposed as tests for acceptance or performance evaluations that are more comprehensive in nature.

The results of the test are influenced by several factors, such as satellite configuration visible at the points, ionospheric and tropospheric conditions, multipath environment around the points, precision of the equipment, quality of the software running in the rover equipment or in the system generating the data transmitted from the base point.

The test field consists of a base point and two rover points. The location of the rover points must be close to the area and in time to the task concerned. The separation of two rover points is between 2 m and 20 m. The horizontal distance and height difference between two rover points are determined by methods with precision better than 3 mm other than RTK. These values are considered as nominal values and are used simply to ensure that the GNSS measurements are free of outliers.

The standard proposes two tests: the simplified and the full test procedures. The simplified test procedure consists of a single series of measurements and provides an estimate of whether the precision of the equipment is within a specified allowable deviation.
The simplified test procedure is based on a limited number of measurements so a significant standard deviation cannot be obtained and no statistical tests are applied.

The full test procedure is used to determine the equipments best achievable measure of precision. It comprises three series of measurements and is intended to determine the experimental standard deviation for a single position on and height measurement.
It may be used to determine:

- the measure of the precision of equipment under given conditions (including typical short and long term influences);
- the measure of the precision of equipment used in different periods of time or under different conditions (multiple samples);
- the measure of the capability of comparison between different precision of equipment achievable under similar conditions.

Statistical tests are applied to the test results.

Author of the fact sheet

This fact sheet was produced for FIG Commission 5 by –
David Martin, France, martin@esrf.fr

Feedback and comments are encouraged on the usefulness of the fact sheet.

References

There is a considerable amount of very useful information available on the web.

- http://www.bipm.org
- http://www.ilac.org
- http://www.iso.org ISO 17123 part 8 GNSS field measurement systems in real time kinematic (RTK)