Standards, Best Practice, Testing and Calibration in Global Navigation Satellite System (GNSS)

Outline

- Introduction
- Standards in Surveying
- Best Practice in GNSS
- Testing & Calibration in GNSS
- Review of ISO17123 Part 8
- Conclusion

6th FIG Regional Conference San José Costa Rica
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Chair of Working Group 5.1 "Standards, Quality Assurance and C
Commission 5 Positioning and Measurement

The ESRF

The European Synchrotron Radiation Facility (ESRF) is located in Grenoble, France

It is a joint facility supported and shared by 18 European countries.

It operates the most powerful synchrotron radiation light source in Europe.

For this complex machine to function correctly, alignment is of critical importance.

Science at the ESRF (What is a synchrotron?)

Biology, Concentrating on proteins
Chemistry, Ultra-rapid reactions
Medicine, The inside story
Earth science, Our mysterious planet
Physics, Small is especially beautiful
Materials, Smart stuff
Environment, Maintaining a natural balance
Industry, Tomorrow's technology

The thirst for knowledge drives us to explore the world around us. Some legitimate questions include :

- what is our planet made of?
- what are the processes that sustain life?

Most of these questions cannot be answered without a profound knowledge of the intimate details of the structure of matter. To help in this quest, scientists have developed ever more powerful instruments capable of resolving the structure of matter down to the level of atoms and molecules.

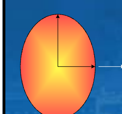
Synchrotron radiation sources, which can be compared to "super microscopes", reveal invaluable information in numerous fields of research. There are about 50 synchrotrons in the world being used by an ever growing number of scientists.

Alignment at the ESRF

Level closure over the 850 m circumference is less than 0.15mm

Point height uncertainty at 2σ (i.e. 95% confidence) is 0.08 mm

Planimetric error ellipse parameters over the 850 m circumference are:
Semi-major axis 0.10 mm
Semi-minor axis 0.07 mm



FOR THE ESRF TO WORK CORRECTLY, ALIGNMENT IS OF CRITICAL IMPORTANCE.

The ESRF ALignment and GEodesy (ALGE) group is responsible for the installation, control and periodic realignment of the ESRF accelerators and experiments. Alignment tolerances are typically less than one millimeter and often in the order of several micrometers.

Alignment at the ESRF

cofrac ETALONNAGE

Under the ISO17025 Standard
Accreditation Number 2-1508

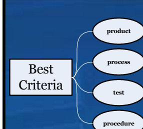
To achieve these results we must get the most we can out of our instruments.

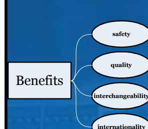
One very important component in alignment at the ESRF is instrument verification and calibration.

Instrument calibration is an integral part of the ESRF alignment group activity.

The ESRF has an internationally recognized calibration laboratory with a French accreditation authority COFRAC accreditation for EDM and Laser Tracker distance meter instruments.

Standards in Surveying



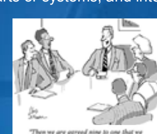


What is a Standard?

A standard is a rule or requirement that is determined by a consensus opinion of users.

It prescribes the accepted and (theoretically) the best criteria for a product, process, test, or procedure.

The benefits of a standard are safety, quality, interchange ability of parts or systems, and international consistency.



Standards in Surveying

Clients want the most from what they pay for.

Legislative authorities as well as private and public companies require confidence that the services rendered are in conformity with globally accepted best practice rules.

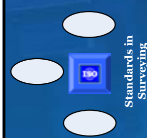
Generally this involves the application of internationally recognized standards.

Surveyors as professionals must fulfill certain legal, regulatory and/or accuracy requirements for their clients.

Typically they will strive to do this in an optimal cost effective way using the most appropriate equipment for the job at hand.

Naturally this requires a good understanding and assurance in the people and instrumentation employed.

Standards in Surveying



What Standards apply to the Surveying Community?

ISO (International Organization for Standardization) is the world's leading developer of International Standards required by business, government and society.

Several ISO standards are applicable to the Geomatics profession:

- The ISO 19XXX family (digital geographic information),
- Of particular interest is ISO 19111 - Spatial referencing by coordinates (i.e. geodesy)
- ISO17123 parts 1 through 8,
- Of particular interest is part 8 "GNSS field measurement systems in real time kinematic (RTK)",
- ISO9000 (quality management).

Best Practice in GNSS

What is Best Practice?

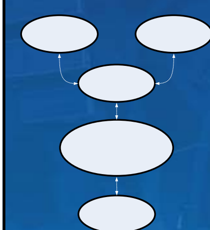
Best Practice is a management idea which asserts that there is a technique or method that is more effective and efficient than any other.

It maintains that with proper processes, checks, and testing, a desired outcome can be delivered with fewer problems and unforeseen complications.

Best practice is generally based on repeatable procedures that have proven themselves over time for large numbers of people.

Best practice can be expected to evolve as new information, instrumentation and methodology becomes available.

Best Practice in GNSS



What is Best Practice in GNSS?

Best practice in surveying and GNSS in particular may colored by some very job specific aspects.

There may be legal imperatives that influence what is the best practice approach to a job.

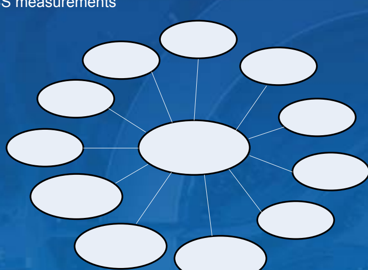
Nevertheless, normally an important objective in a survey is to get the best possible results

This is typically synonymous with the highest attainable precision.

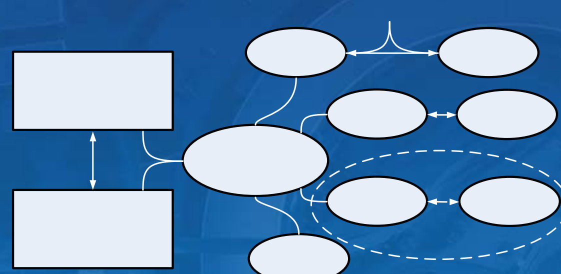
There are several commonly accepted generic guidelines for GNSS to achieve optimal measurement results.

Best Practice in GNSS

These guidelines typically minimize the errors associated with GNSS measurements



Best Practice in GNSS: Guidelines



Testing and Calibration

Testing is intended to verify the suitability of a particular instrument for the required application at hand, and to satisfy the requirements of best practice standards.

The instrument uses its own measurements to qualify and quantify its performance.

Calibration links the instrument by comparison directly to international reference standards and ensures traceability.

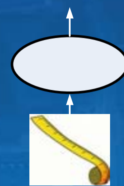
Standard: an instrument or method that will measure more accurately and precisely the desired quantity than the measuring instrument itself

Traceability

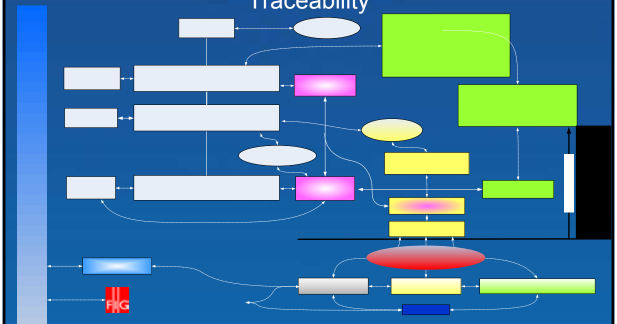
One of the pillars of instrument calibration and all legal metrology is the notion of traceability.

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).



Traceability



ISO17123 part 8
GNSS field measurement systems in real time kinematic (RTK)

September 15 2007

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.

ISO17123 part 8
GNSS field measurement systems in real time kinematic (RTK)

September 15 2007

The standard proposes two tests:

- the simplified
- 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 full test procedure is used to determine the equipments best achievable measure of precision and is intended to determine the experimental standard deviation for a single position and height measurement.

ISO17123 part 8 Simplified Test

Measure the distances and height differences between the two rover points are measured by independent methods to a precision of better that 3 mm.

Five sets of x, y and h coordinate measurements are made.

Distances and height differences are calculated from the measured x, y and h values.

The difference between these measured distances ε_D and heights ε_h and those determined independently must satisfy:

- $|\varepsilon_D| \le 2.5 \times \sqrt{2} \times s_{xy}$
- $|\varepsilon_h| \le 2.5 \times \sqrt{2} \times s_h$

s_{xy} and s_h are a priori uncertainties

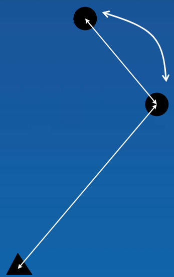
Metre Convention
1875

Diplomatic Treaty

SI Base Quantities and Units

- length the metre
- mass the kilogra
- time the secon

ISO17123 part 8 Full Test

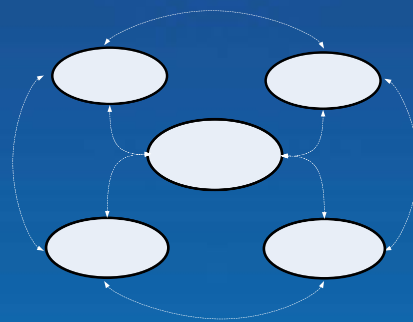


The full test is essentially the simplified test repeated three times each separated by a minimum 90 minute time interval.

The analysis which is considerably more involved with associated statistical tests permits :

- 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.

Conclusion



Base Point