STANDARDS AND TRACEABILITY OF A TERRESTRIAL REFERENCE FRAMES / GNSS – PART I

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What are we going to talk about …

Quality and Standards
Traceability, Calibration and Verification
ISO 17123 Part 8: GNSS field measurement systems in real time kinematic (RTK)
Examples
Organisations are created to fulfil a societal need. They succeed when they satisfy the needs, requirements and expectations of their stakeholders.
Who are Stakeholders

People or organisations that have freedom to provide or withdraw something from an enterprise.
The Customer is a Special Stakeholder

Organisation that receives a product or service.

WHO PAYS?
Customers require quality products and services delivered on time and at a price that reflects value for money.

The customer is the only one who can decide if products or services are satisfactory...
What are Characteristics of Quality?

Products
- Availability
- Security
- Reliability
- Functionality
- Traceability

Services
- Competence
- Responsiveness
- Credibility
- Integrity
- Reliability

Focus on Quality
Quality

Quality is the degree to which a set of inherent characteristics fulfils requirements.

A requirement is need or expectation that is stated, generally implied or obligatory.
How do You Ensure Quality?

Working to recognized quality management standards provides a benchmark for products and services and a best practice model to manage processes.

The ISO 9000 series is the best known set of standards to measure a management system against.
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 have existed for thousands of years. For example, the first long distance roads in Europe were built by Imperial Rome for the benefit of their legions. The ruts created by the Roman chariots were then used by all other wagons. These later became a gauge for laying the first railway lines.

...all roads lead to Rome...
Are Standards Important?
ISO is the largest developer and publisher of International Standards. ISO is a network of the national standards institutes of 162 countries. ISO is an NGO that forms a bridge between the public and private sectors. ISO enables a consensus on solutions for business and society.
The ISO 9000 Family of Standards

ISO 9000 is a family of quality management system standards designed to help organizations ensure they meet the needs of customers and other stakeholders. The ISO 9000 family of standards represents an international consensus on good quality management practices.

ISO 9000 Quality Management Systems fundamentals and vocabulary installation and servicing
ISO 9001 Quality Management Systems requirements
ISO 9004 Quality Management Systems guidelines for performance improvement
ISO 19011 Guidelines on Quality and Environment Management Systems Auditing
ISO 9001:2008 provides the requirements for a quality management system, regardless of what the user organization does, its size, or whether it is in the private, or public sector. It is the standard against which organizations can be certified.
A quality management system provides the framework of processes and procedures used to achieve objectives.
Quality Management System Process

A process is a set of interrelated or interacting activities which transforms inputs into outputs.
A product or service is the result of a process

ISO9004:2005
A generic model identifies four main organization processes

If we analyse all of the organization’s outputs, we are likely to find that they can be placed into one of four processes

Reference Frame in Practice

IAG/FIG Commission 5/ICG Technical Seminar

Rome, Italy 4–5 May 2012

Generic System Process

Interrelated/interacting activities which transforms inputs into outputs

Customer Demand → Input → Activities → Output → Satisfied Customer Demand

Effectiveness: ability to achieve desired results
Efficiency: results achieved vs. resources used

Constraints → Resources

Objectives Measures

Improvement

Reviews

Sponsors:

esri Trimble CIPAG ESRF
Paraphrasing …

The organization shall determine the monitoring and measurement needed to provide evidence of conformity to product requirements.

The organization shall establish processes to ensure that monitoring and measurement are carried out in a manner that is consistent with requirements.

Where necessary to ensure valid results, measuring equipment shall be calibrated or verified, or both, at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards.
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 is an accurate representation of what it is trying to measure.

Traceability ensures an unbroken chain of comparisons that ends at a national metrology institute (NMI).
Traceability

**metrological traceability**

property of a **measurement result** whereby the result can be related to a reference through a documented unbroken chain of **calibrations**, each contributing to the **measurement uncertainty**.

**SI Units**

- length (metre),
- mass (kilogram),
- time (second),
- electric current (ampere),
- thermodynamic temperature (kelvin),
- amount of substance (mole),
- luminous intensity (candela).
For a distance we might have
\[ D = 1.02345 \text{ m}; \ U(D) = 0.0005 \text{ m}; \ k=2 \]
... operation that establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties ... uses this information to establish a relation for obtaining a measurement result from an indication ...
**Measurement Uncertainty – VIM**

**Type A Uncertainty**
- measurement series 1
- measurement series 2
- measurement series n

**Type B Uncertainty**
- reference values
- calibration certificates
- manufacturer’s specifications
- experience

Measurement uncertainty
non-negative parameter characterizing the dispersion of the *quantity values* being attributed to a *measurand*, based on the information used

\[ U = \sqrt{(\text{Type A})^2 + (\text{Type B})^2} \]
Verification: the instrument uses its own measurements to qualify and quantify its performance.

Calibration ensures traceability.
This standard specifies field procedures for evaluating the precision (repeatability) of Global Navigation Satellite System (GNSS) field measurement systems in real-time kinematic (GNSS RTK).

These tests are primarily intended to be field verifications of the suitability of an instrument for the application at hand, and/or to satisfy the requirements of other standards.
Determine the distances and height differences between the two rover points to a precision of better than 3 mm. Five sets of x, y and h coordinate measurements are made.

The difference between these measured distances \( \varepsilon_D \) and heights \( \varepsilon_h \) and those determined independently must satisfy:

\[
|\varepsilon_D| \leq 2.5 \times \sqrt{2} \times s_{xy} \\
|\varepsilon_h| \leq 2.5 \times \sqrt{2} \times s_h
\]

\( s_{xy} \) and \( s_h \) are a priori uncertainties.

There are two variants of this verification: the full test and the simplified test.
Example – Field GNSS Calibration Finland

Example – Legal Traceability and GNSS Calibration Malaysia

Summary

Quality Standards Traceability

all roads …