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Reference Frame in Practice

Rome, Italy 4–5 May 2012



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

D. MARTIN

EUROPEAN SYNCHROTRON RADIATION FACILITY

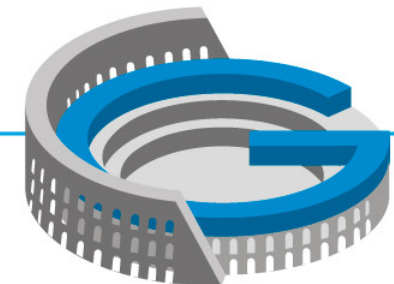
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What are we going to talk about ...

Quality and Standards

Traceability, Calibration and Verification

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

Examples

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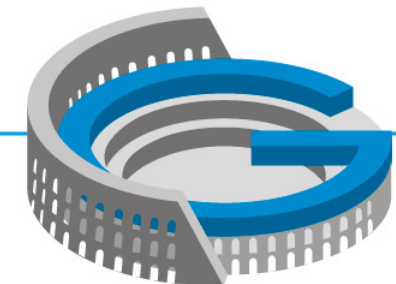
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Quality



Organisations are created to fulfil a societal need. They succeed when they satisfy the needs, requirements and expectations of their stakeholders.

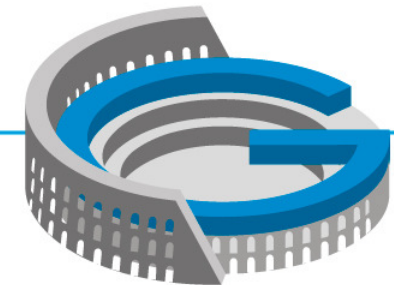
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Who are Stakeholders

People or organisations that have freedom to provide or withdraw something from an enterprise.



Government



Suppliers



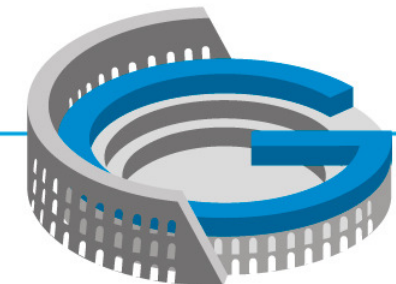
Society



Customers



Employees



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The Customer is a Special Stakeholder

Organisation that receives a product or service.



WHO PAYS?

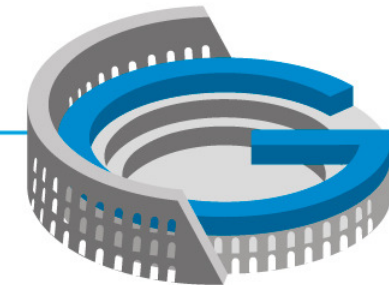
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Customers Require Quality



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 ...

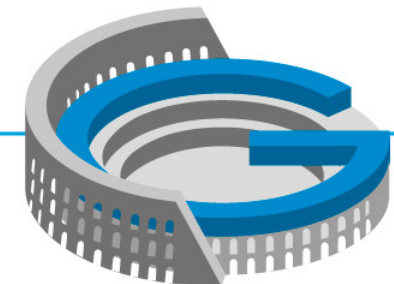
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What are Characteristics of Quality?

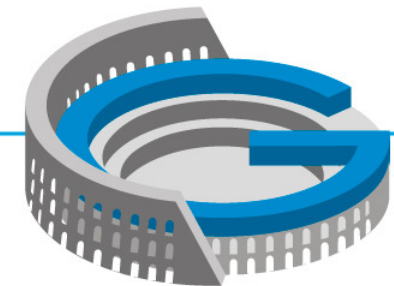
Products

Traceability
Availability
Security
Durability
Reliability
Functionality



Services

Integrity
Competence
Reliability
Responsiveness
Credibility



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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



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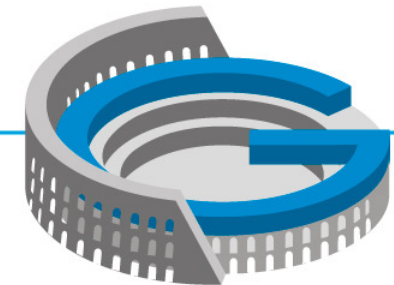
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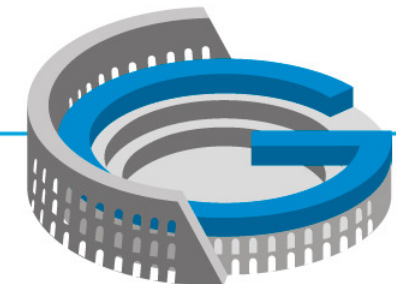
How do You Ensure Quality?

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.



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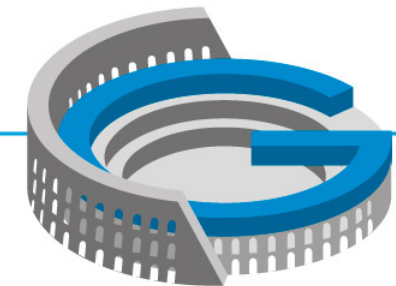


What is a Standard?

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.



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Standards



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...

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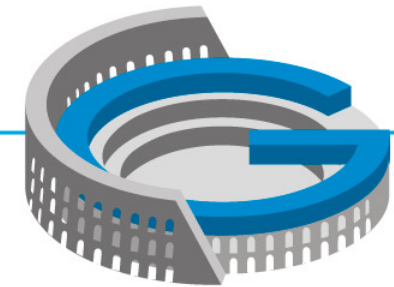
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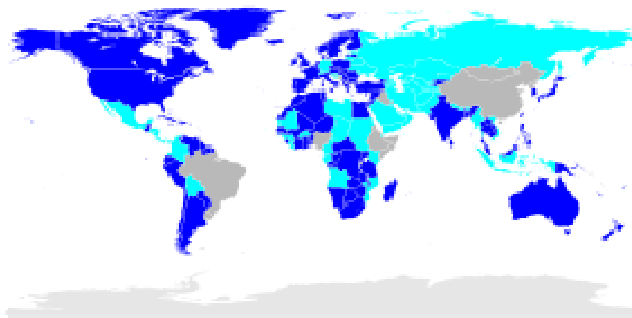
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Are Standards Important?



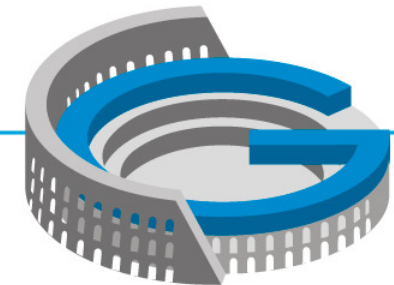
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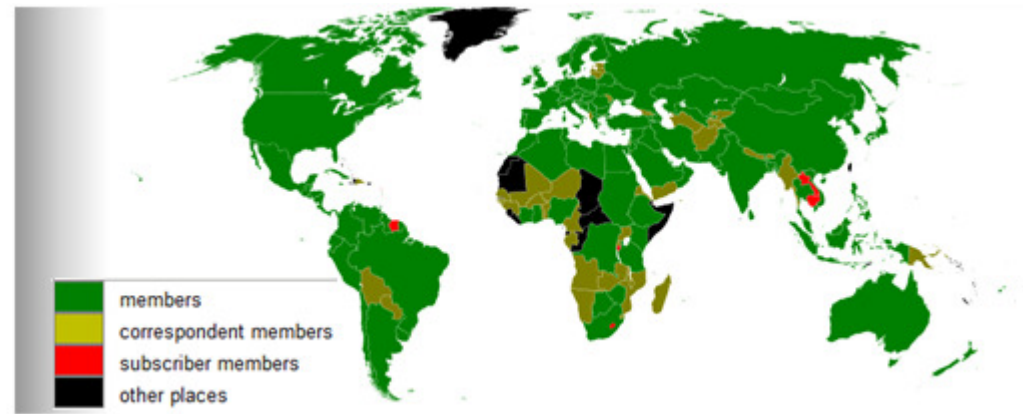
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International Organization for Standardization - ISO



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.

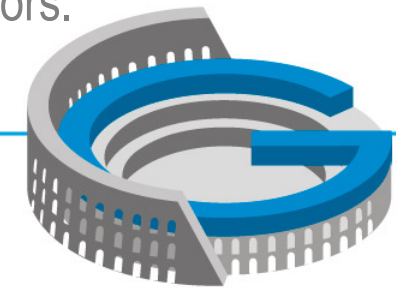
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The ISO 9000 Family of Standards

ISO 9000 family

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 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.

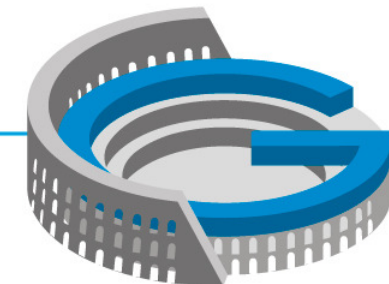
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ISO 9001:2008 Quality Management Systems requirements



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

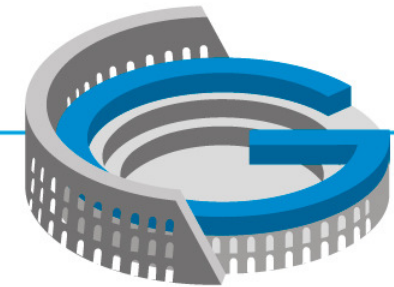
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Quality Management System



A quality management system provides the framework of processes and procedures used to achieve objectives

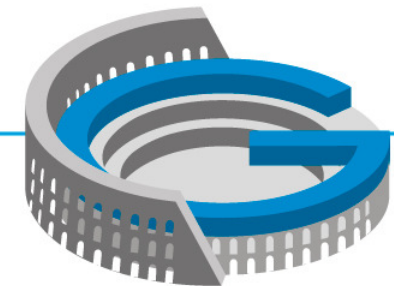
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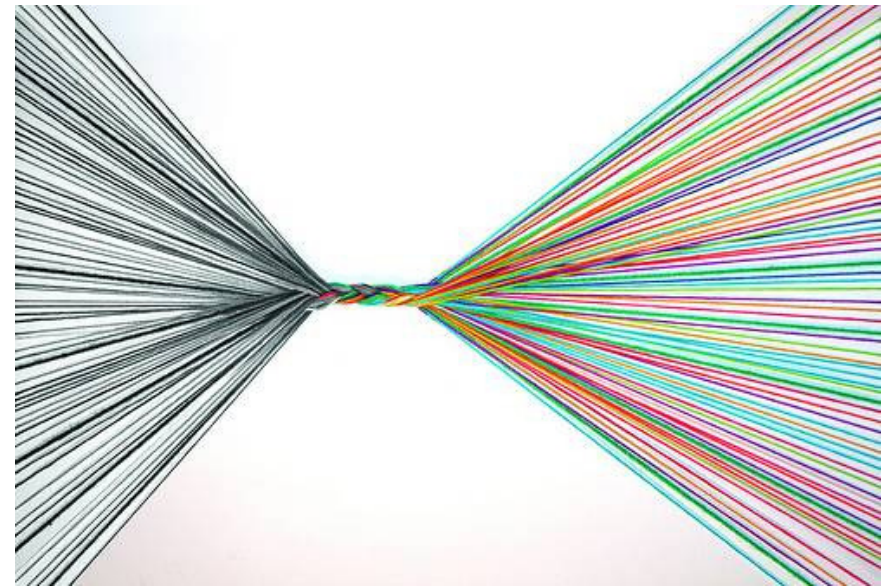
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Quality Management System Process

A process is a set of interrelated or interacting activities which transforms inputs into outputs



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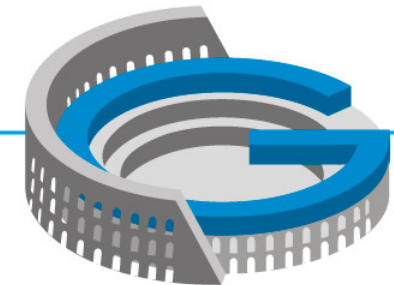
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Product



A product or service is the result of a process

ISO9004:2005

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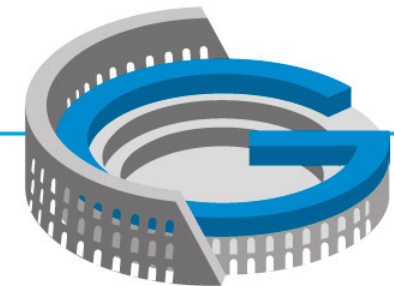
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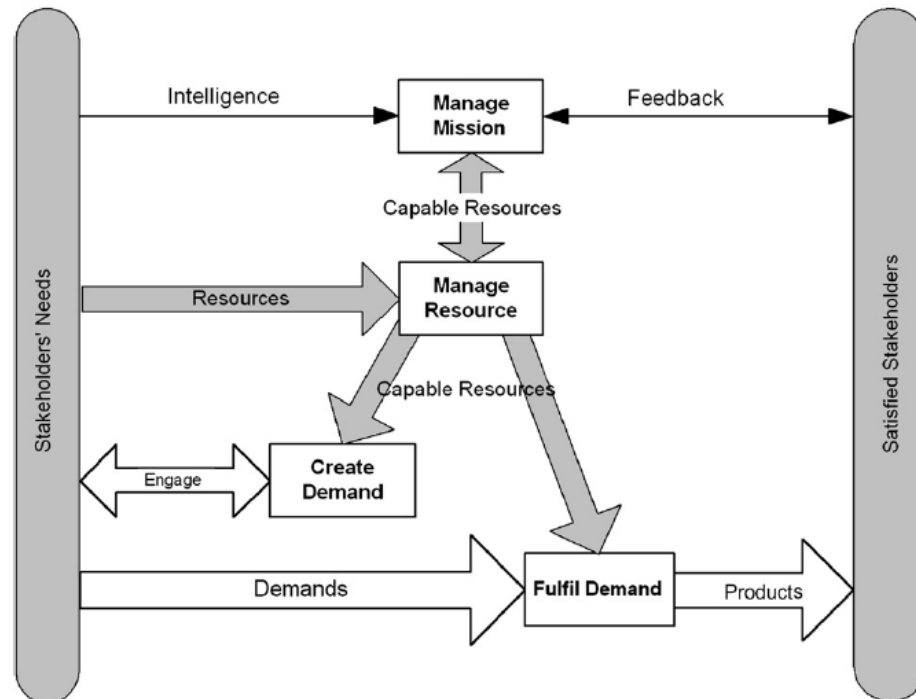


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Quality management system - a system of managed processes



A generic model identifies four main organization processes

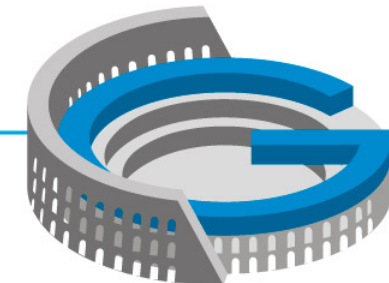
If we analyse all of the organization's outputs, we are likely to find that they can be placed into one of four processes

Hoyle, D, ISO 9000 Quality Systems Handbook - updated for the ISO 9001:2008 standard: Using the standards as a framework for business improvement

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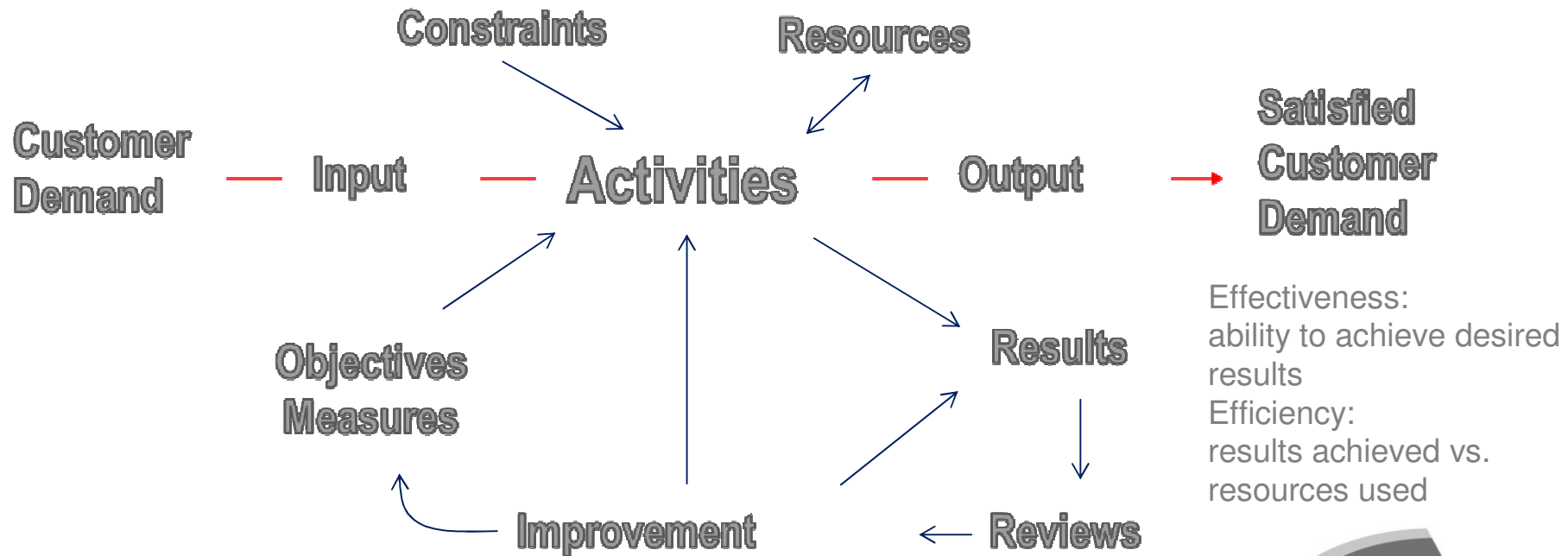


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Generic System Process



Interrelated/interacting activities which transforms inputs into outputs

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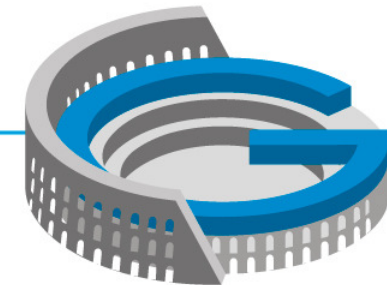
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ISO 9001:2008 7.6 Control of monitoring and measuring equipment

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

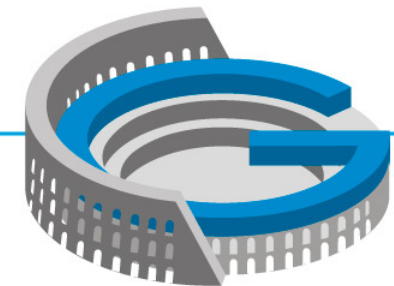
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Traceability



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)

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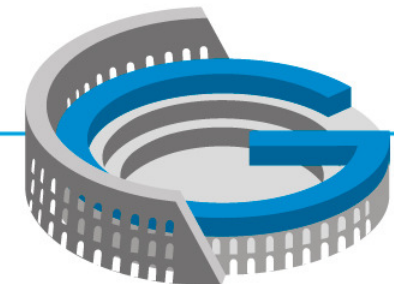
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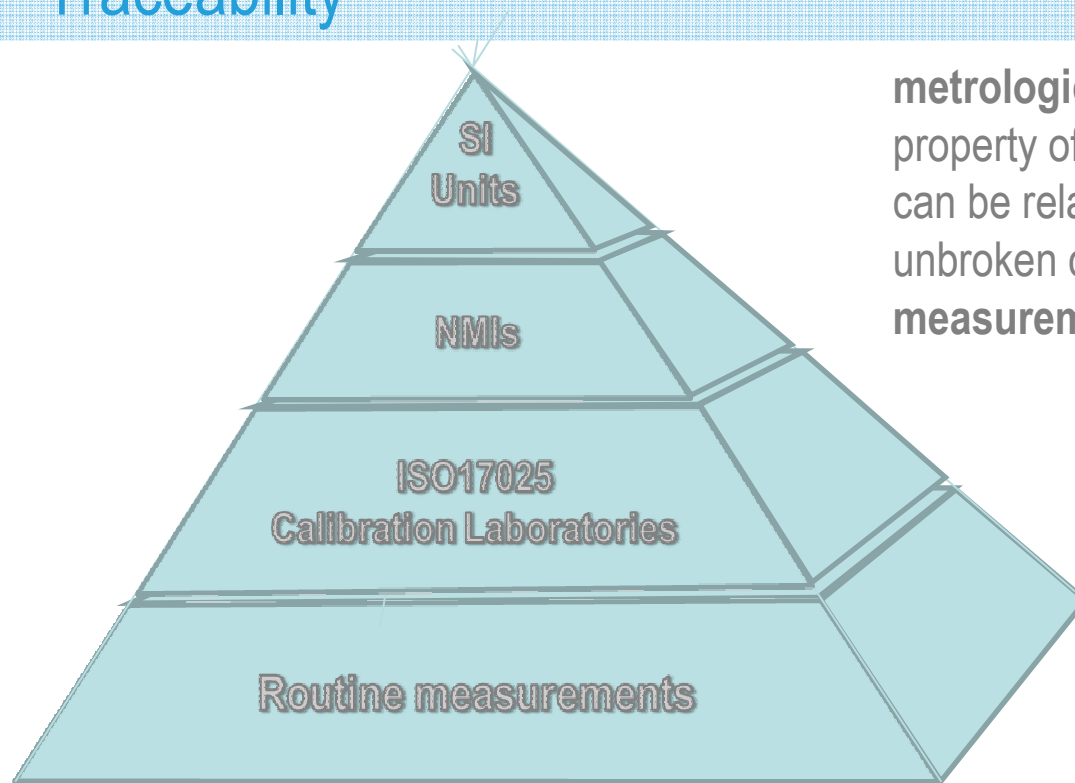


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Traceability

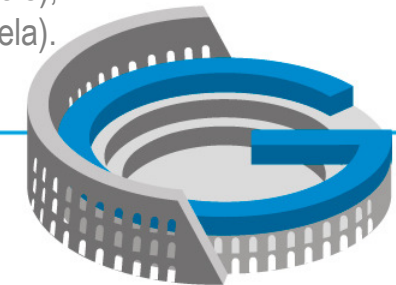


metrological traceability

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).



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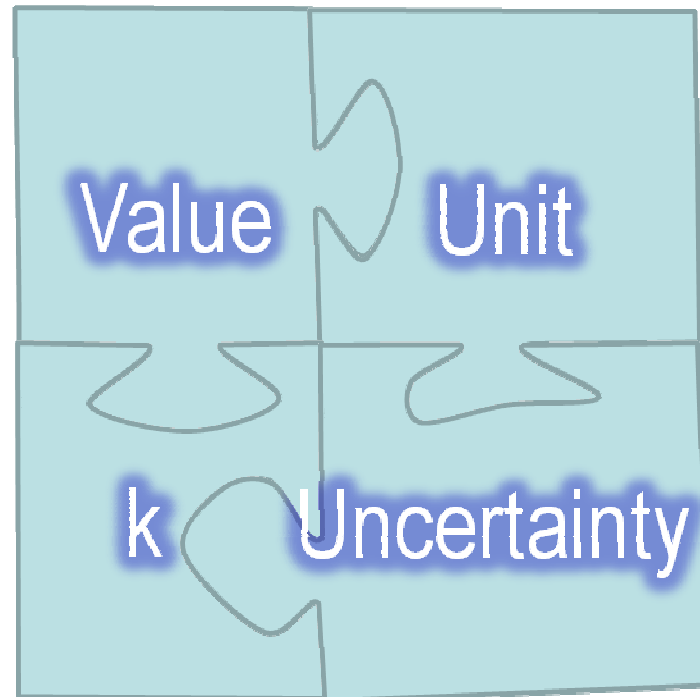
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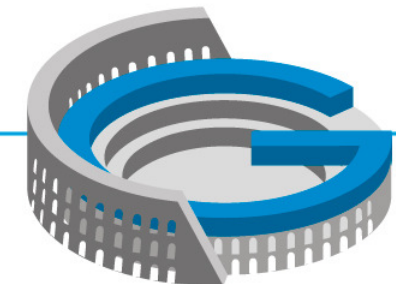
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Measurement



For a distance we might have
 $D = 1.02345 \text{ m}$; $U(D) = 0.0005 \text{ m}$; $k = 2$



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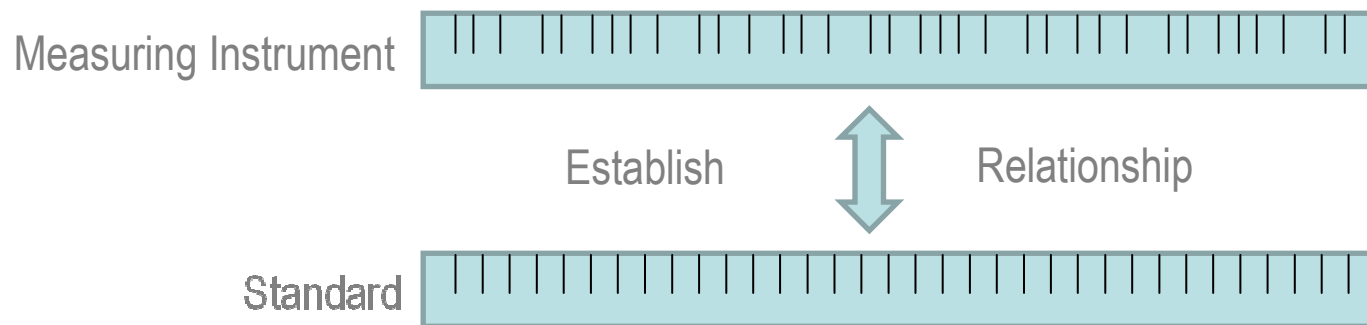
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Calibration – International Vocabulary of Metrology (VIM)

... 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 ...



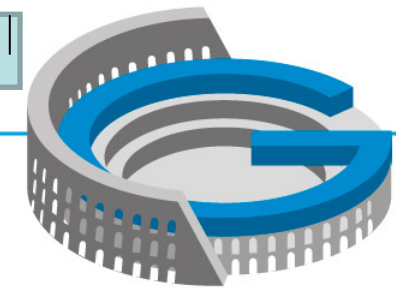
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Measurement Uncertainty – VIM

Type A Uncertainty

measurement series 1
measurement series 2



measurement series n

ref.
values

Type B Uncertainty

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

$$U = \sqrt{(\text{Type A})^2 + (\text{Type B})^2}$$

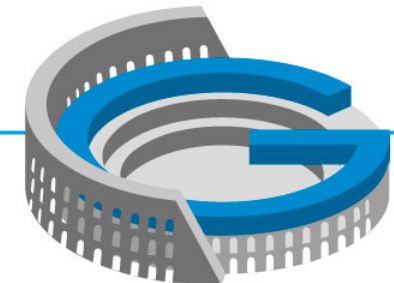
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Verification and Calibration



Verification: the instrument uses its own measurements to qualify and quantify its performance



Calibration ensures traceability

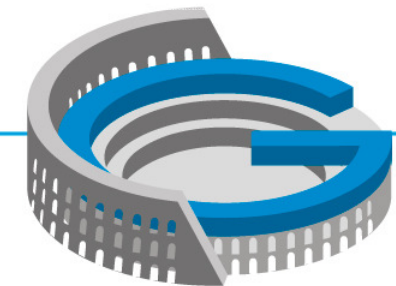
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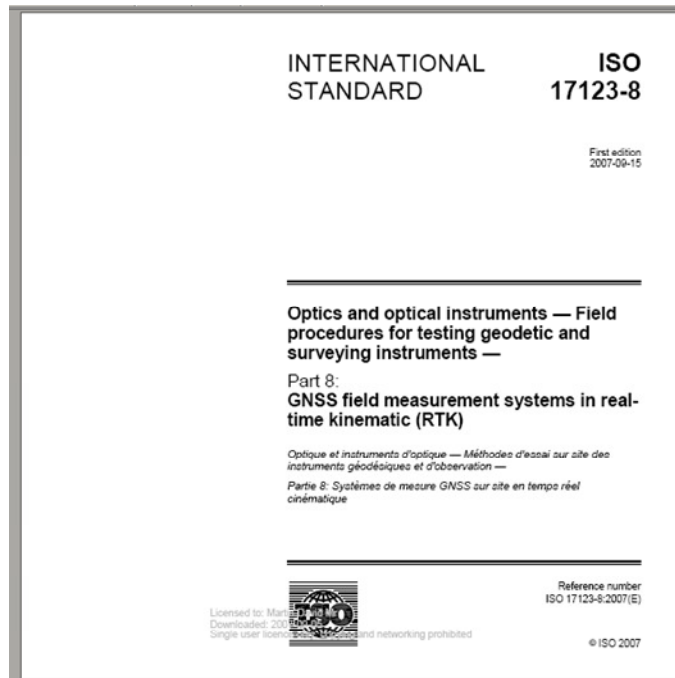


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ISO 17123 Part 8



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.

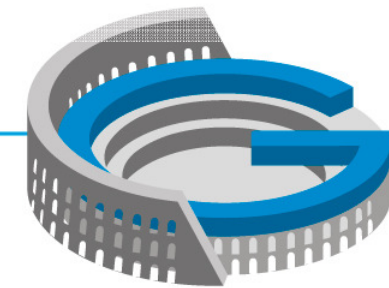
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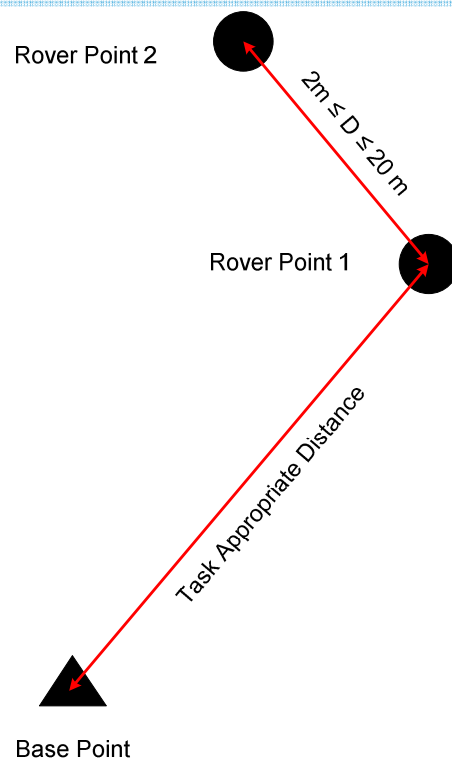


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ISO 17123 Part 8



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

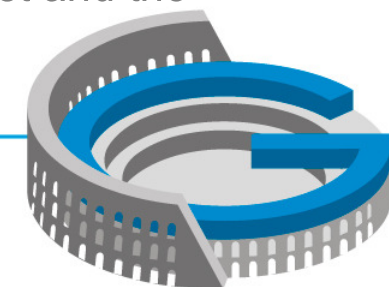
The difference between these measured distances ϵ_D and heights ϵ_h and those determined independently must satisfy:

$$|\epsilon_D| \leq 2.5 \times \sqrt{2} \times s_{xy}$$

$$|\epsilon_h| \leq 2.5 \times \sqrt{2} \times s_h$$

s_{xy} and s_h are a priori uncertainties

There are two variants of this verification: the full test and the simplified test



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Example – Field GNSS Calibration Finland

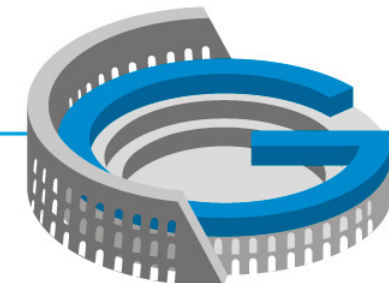


Ahola J., Koivula H., Jokela J., *GPS Operations at Olkiluoto, Kivetty and Romuvaara in 2007*, Finnish Geodetic Institute May 2008.
Jokela J. et al, *On Traceability of Long Distances*, XIX IMEKO World Congress, Lisbon Portugal, September 6-11, 2009.

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Example – Legal Traceability and GNSS Calibration Malaysia

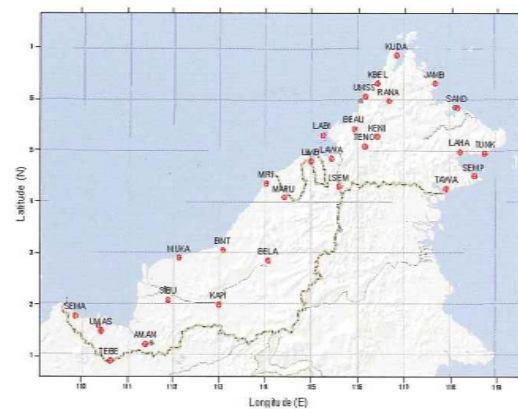
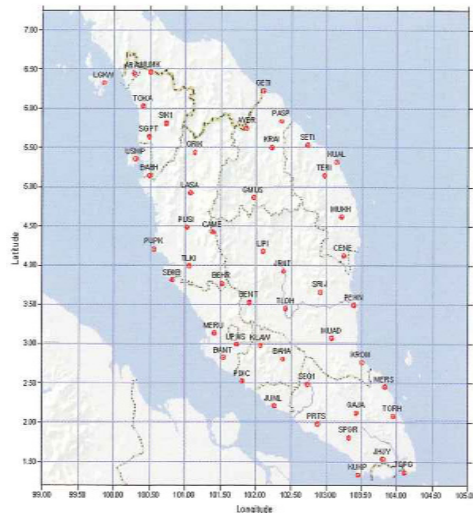
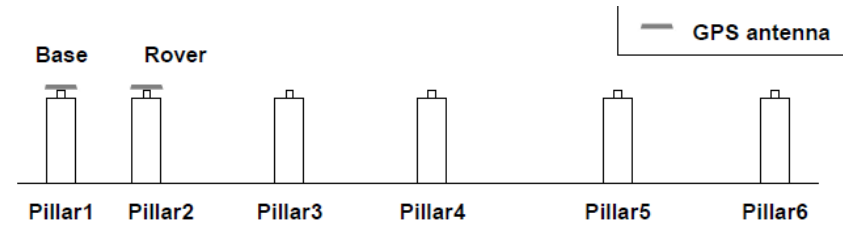
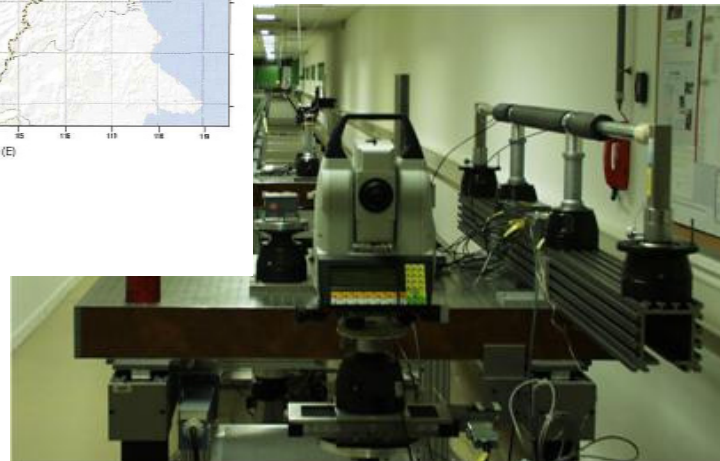


Figure 2, Reference points in Malaysia

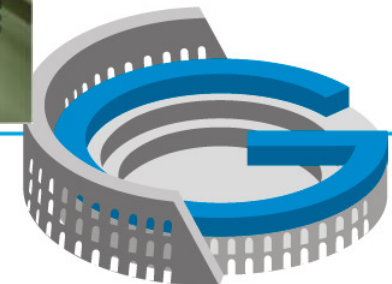


Ses, S., et al., *Potential use of GPS for cadastral surveys in Malaysia*, in 40th Aust. & 6th S.E.Asian Surveyors Congress. 1999: Fremantle, Australia.

Zhang Y., et al., *Cadastral System in Malaysia RTK in Updating Coordinate System*, in GIM International. April 2009.



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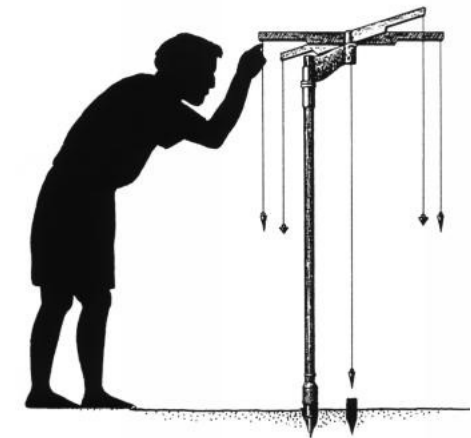


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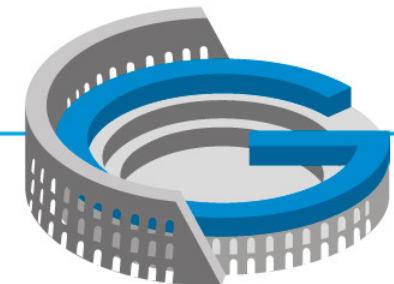
QUALITY

STANDARDS

TRACEABILITY



all roads ...



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