



The European Synchrotron

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An Introduction to the GUM  
TS06B 19 June 2014

WHAT ARE QUALITY, STANDARDS AND TRACEABILITY ALL ABOUT?



## FRENCH TRAIN PLATFORMS ARE TOO NARROW



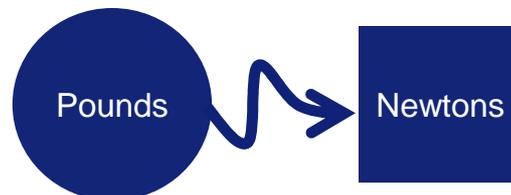
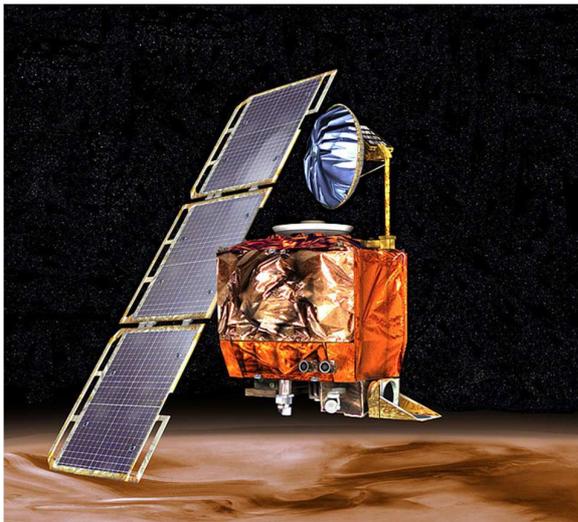
**2,000 TRAINS** ordered in France are too large for their stations

**€50 MILLION** now needed to **WIDEN THE GAP** between platforms



BBC NEWS

## MARS ORBITER CRASHED INTO MARS BECAUSE OF A MIX UP IN UNITS



### Cost of the mission:

- \$ 327.6 million for the orbiter and lander,
- \$ 193.1 million for spacecraft development,
- \$ 91.7 million for launching it, and
- \$ 42.8 million for mission operations...

Wikipedia

Mars Orbiter Fact Sheet, NASA-JPL. October 3, 2012



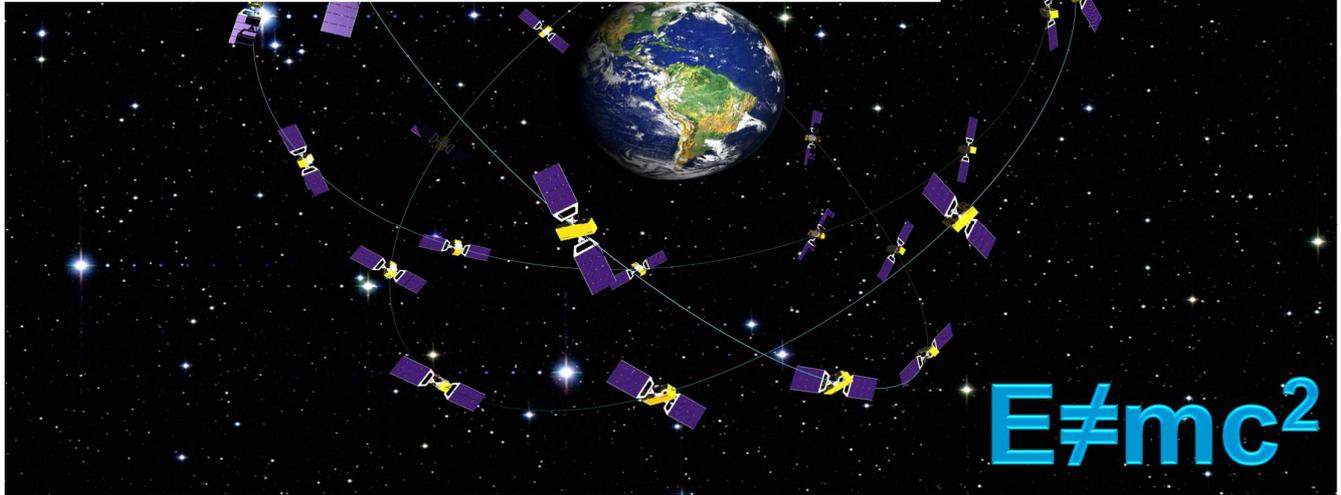
**\$ 655.2 million**

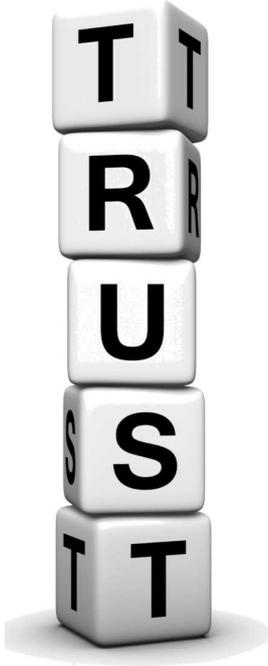
# TIME Science

PHYSICS

## Was Einstein Wrong? A Faster-than-Light Neutrino Could Be Saying Yes

By MICHAEL D. LEMONICK Friday, Sept. 23, 2011





*Quality* is how good or bad something is

A *Standard* is something that is very good and that is used to make judgments about the quality of other things

*Traceability* comes from *trace* which means to find out where something came from

*From <http://www.merriam-webster.com/dictionary>  
Note these are not formal definitions in the quality and standards literature -from the VIM for example*

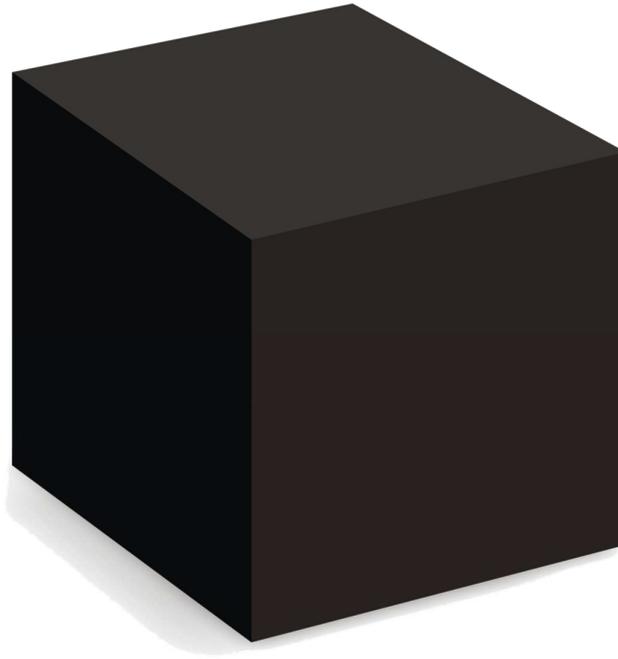


Customers need quality products and services delivered on time and at good value for money.

Suppliers provide products and services that customers need.

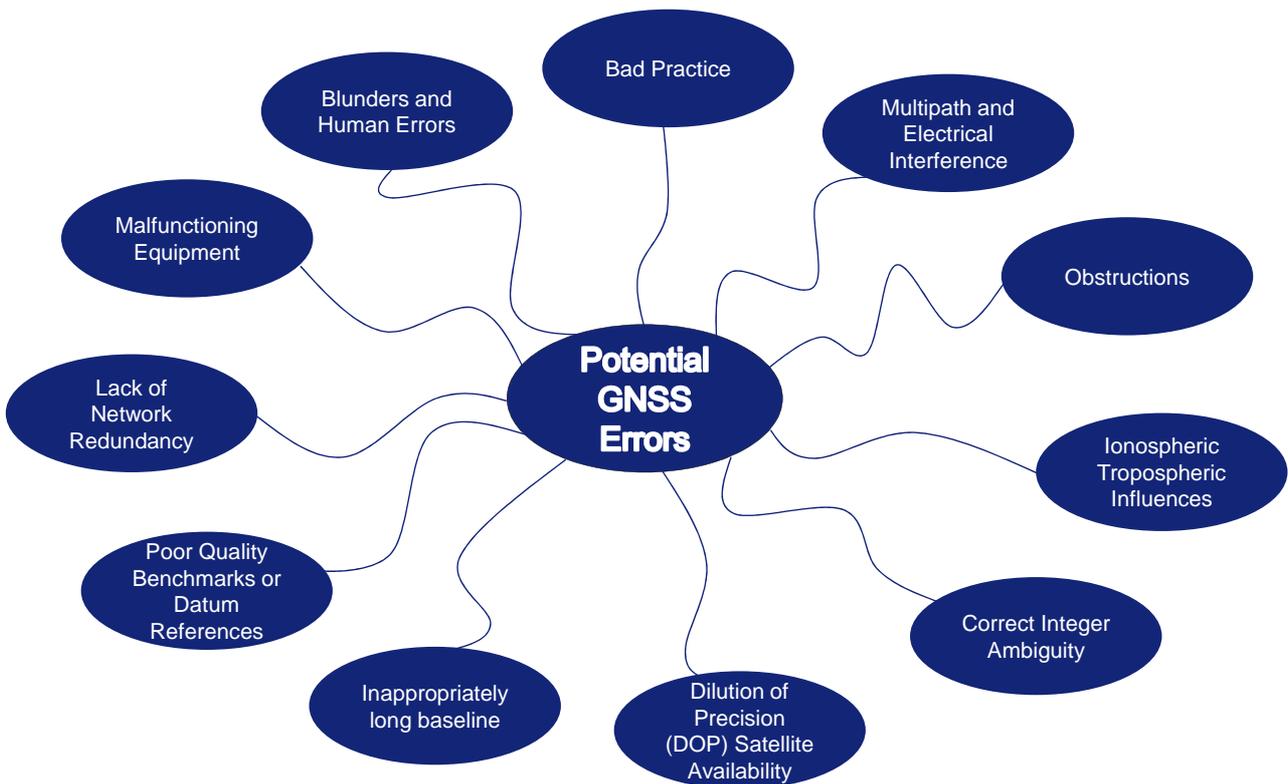
Suppliers succeed when their products and services meet customers requirements.

Customers are the only ones who can decide if products or services are satisfactory.



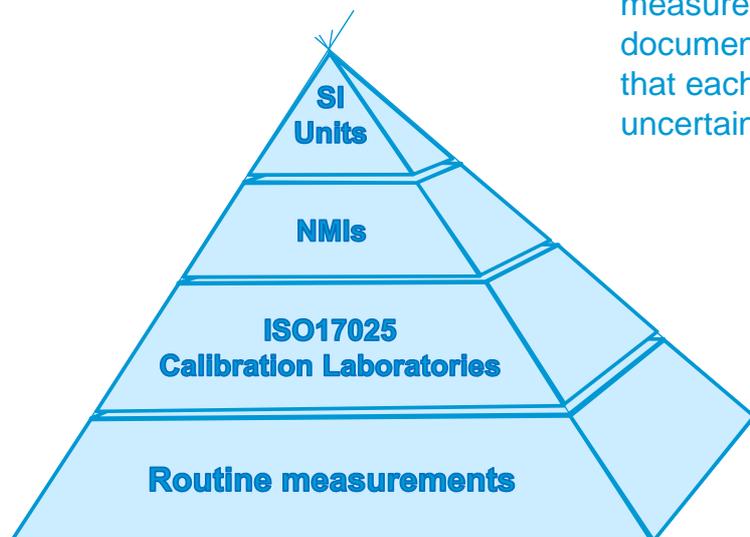
Often we don't fully understand the instruments and the processes we use ...

AND THERE ARE ALL SORTS OF ERRORS IN WHAT WE MEASURE



## TRACEABILITY PROVIDES A WAY TO HELP ENSURE CORRECT MEASUREMENTS

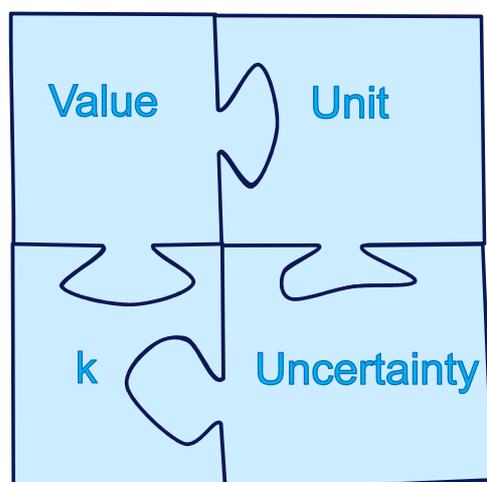
**metrological traceability** links a measurement result to a reference through a documented unbroken chain of calibrations that each contribute to the measurement uncertainty.



### SI Units

- length (metre),
- mass (kilogram),
- time (second),
- electric current (ampere),
- thermodynamic temperature (kelvin),
- amount of substance (mole),
- luminous intensity (candela).

## A MEASUREMENT IS COMPOSED OF FOUR PARTS



For a distance we might have

$$D = 1.02345 \text{ m}$$

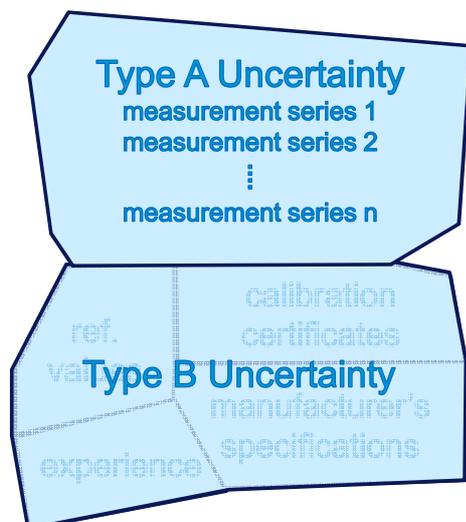
$$U(D) = 0.0005 \text{ m}$$

$$k = 2$$

## CALIBRATION PROVIDES TRACEABILITY



## UNCERTAINTY AS DESCRIBED IN THE GUM



### measurement uncertainty

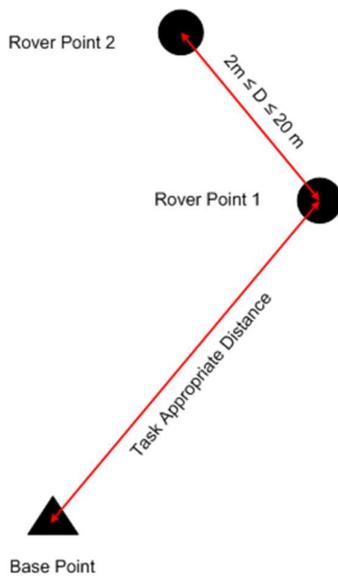
non-negative number that characterises the dispersion of the values being measured, based on the information used

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

# VERIFICATION DETERMINES INSTRUMENT SUITABILITY FOR AN APPLICATION



## ISO 17123 Part 8



Determine *reference* distances and height differences between the two rover points to a precision of better than 3 mm

Five sets of x, y and h measurements are made

The difference between measured and *reference* distances  $\epsilon_D$  and heights  $\epsilon_h$  must satisfy:

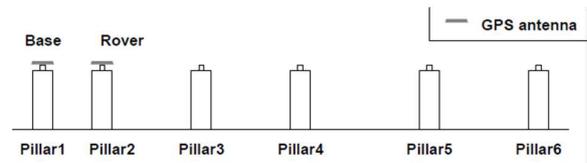
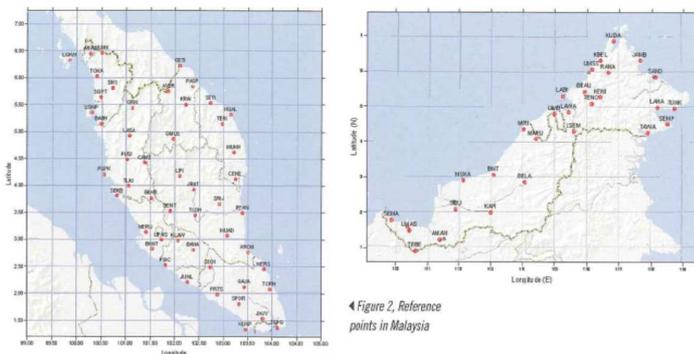
$$|\epsilon_D| \leq 2.5 \times \sqrt{2 \times s_{xy}}$$

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

$s_{xy}$  and  $s_h$  are a priori uncertainties

Two variants: the full test and the simplified test.

# LEGAL TRACEABILITY AND GNSS CALIBRATION 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.



**Traceability and standards make the difference between  
quality products and services**