Hochschule Bochum
Bochum University
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Push the Button - or does the Art of Measurement still exist?

presented
by
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FIG Working Week
Surveyors Key Role in Accelerated Development

Content

Introduction

Why are we measuring?

History of the Instruments

Geodetic Measurements today
- User's view
- Manufacturer's view
- Metrologist's view

Ageless principles in surveying

The Art of Measurement
- yesterday - today
- phases of a surveying project

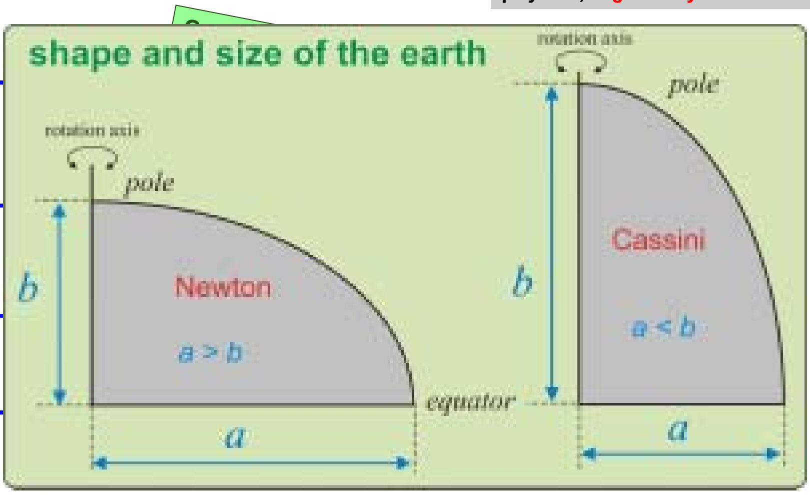
Conclusions

Metrology – the science of measurement

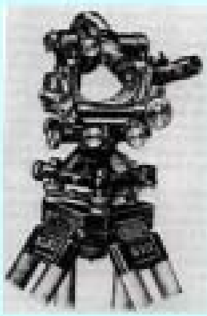
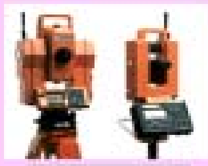
Why are we measuring?

more knowledge and cognition

... astronomy, astrophysics, chemistry, biology, medicine, physics, ...geodesy

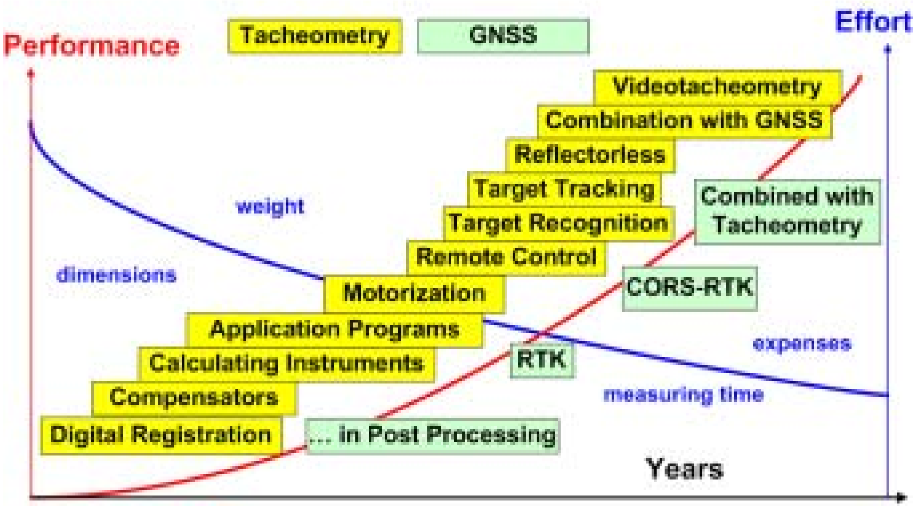


4 phases of surveying instruments

Antiquity	Optical	Electro Optical	Multi-Sensors
 Egyptian Surveyors  Roman Agrimensor with Groma	 ZEISS TH II designed by Heinrich WILD	 ZEISS RegElta 14 Registering Total Station	 GEODIMETER 4000 1-Person-Station  TRIMBLE GPS-Receiver  WILD NA 2000 Digital Level

1590 — 1924 — 1990 — 2009

Technical progress since 1990



The actual surveying equipment

Measurement – the Customer's View

Black box

Read-the-Manual!

The customer is using the instrument like a Black box
… and like an Office-software

80% of our measurements are not controlled !

WILD T2
1929 – 1996

Product life cycles (3 – 5 years) are too short!

The user is convinced that his results are true!

He does not care for a regular check of the entire equipment!

Measurement – the Manufacturer's view

Push the button

Surveying is easy

Market concentration

Product piracy!

Reasons for a new product...?
- New or improved functionality
- Non-availability of electronic components
- Reduction of manufacturing costs

Not every product, which could be developed technically appears … on the market!

1. Fully automated leveling system

2. Highprecision-distance-measurement-device

Kern Mekometer ME 5000

Measurement – the Metrologist's View

All instruments are fulfilling their specifications !

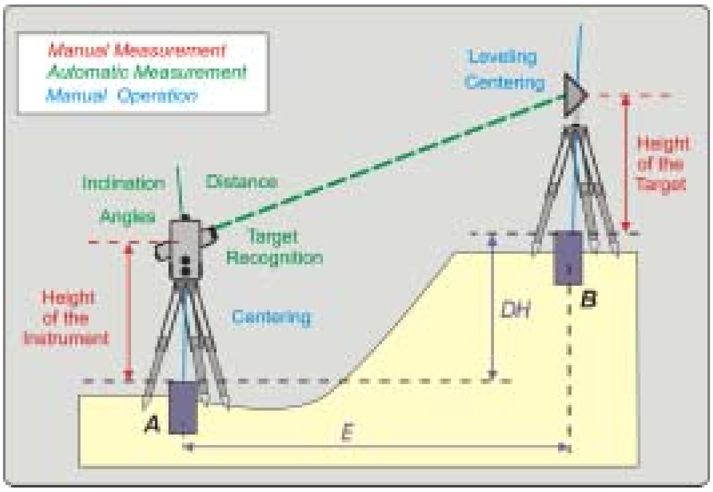
The traceability of geodetic measurements to national standards is not always given!

The measurements are not always carried out with sufficient care!

Geometrical Quality
of our measurements?

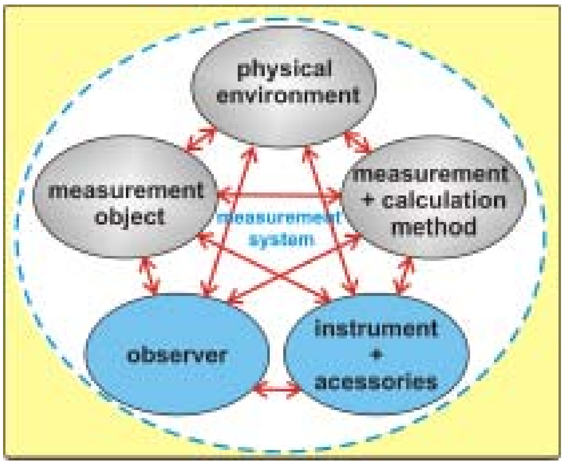
Measurement system

Measurement – the Metrologist's View



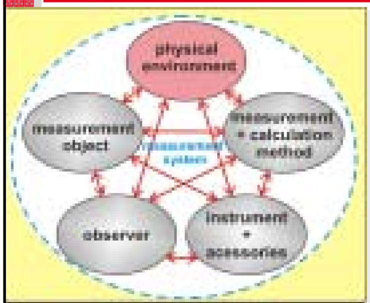
Accuracy of distances *E* and *DH*

The limits of accuracy - yesterday



- **multiple measurements**
- **observer was directly involved in the measurement**

The limits of accuracy- today 1



1. Distances

Speed of propagation of light in the atmopshere

refraction index *n*

error		rel. $\Delta n/n$
$\Delta T =$	± 1 K	$\pm 1 \cdot 10^{-6}$
$\Delta p =$	± 1 hPa	$\pm 0{,}3 \cdot 10^{-6}$
$\Delta e =$	± 1 hPa	$\pm 0{,}04 \cdot 10^{-6}$

2. Heights

vertical refraction

vertical temperature gradient $\frac{dn}{dz}$

desired acquisition: 0,01 K/m

3. Angles

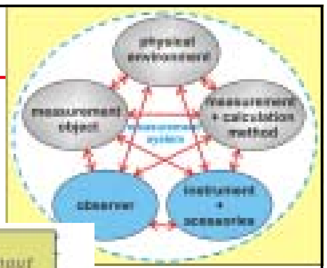
Horizontal refraction

horizontal temperature gradient $\frac{dn}{dx}$

$$\delta(T)[\text{mgon}] = 0{,}033 \cdot D[\text{m}] \cdot grd\, T[\text{K/m}]$$

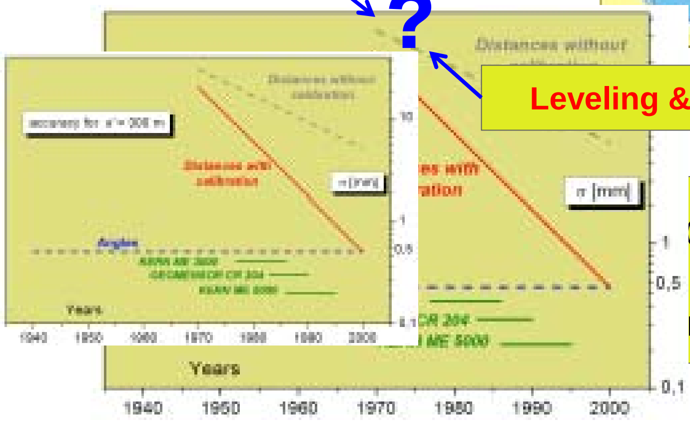
example grd T = 0,5 K/m, D = 500m -> δ **= 8,2 mgon**

The limits of accuracy- today 2



Measurements

Measurements



Leveling & centering

(well adjusted?)

he operator

The quality of GNSS-measurements ?

The i
The r
exact
satell

Accuracy and reliability are depending on a lot of factors
– satellite constellation
– observation time
– visibility
– quality of orbit parameters
– influence of the ionosphere

The following accuracy, indicated as RMS, is based on calculation with….(name of the software-package) …

Extracted from the specifications of GNSS-manufacturer

Accuracy and reliability may be subject to anomalies due to multipath, obstructions, and satellite geometry. Always follow recommended survey practices.

Extracted from the specifications of GNSS-manufacturer

ageless principles of surveying

Application	Behavior	Context

1 First, consider the whole
2 Know the tools
3 Consider contributing errors
4 Record defining parameters
5 Beware the bounds of Convention
6 Build proof into the process
7 Engage the user

„The ABC of x, y, z - 21 Principles for Consideration by Surveyors and other Geospatial Professionals “
P. M. Byrne and G. Kelly, FIG Working week, HongKong 2007

MCO- Mars Climate Orbiter 23.9.1999

NASA lost this satellite after 9 months of flight to the planet mars

Cause for the loss
A sub-contractor (Martin-Marietta) designed and manufactured the steering system (jet engines)...and programmed it in **imperial pounds!**

NASA "thought" that the system is working in **metric pounds**!

Factor = 4,45!!

The problem could have been detected and fixed during the 9-months-flight!

This example is not specific to Aerospace-industry

Similar errors occur in a lot of complex technical projects

the art of measurement in the past

capabilities for carrying out
precision mechanical work

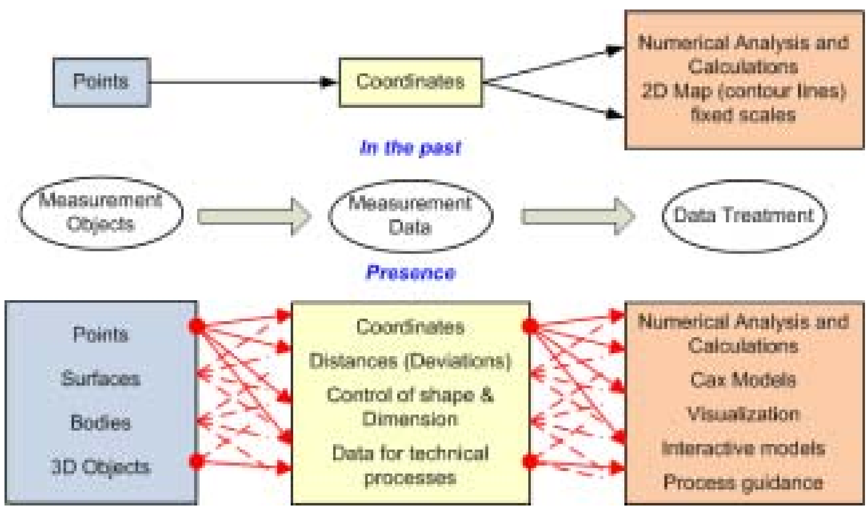
skills in calculating

sharp-sighted eyes

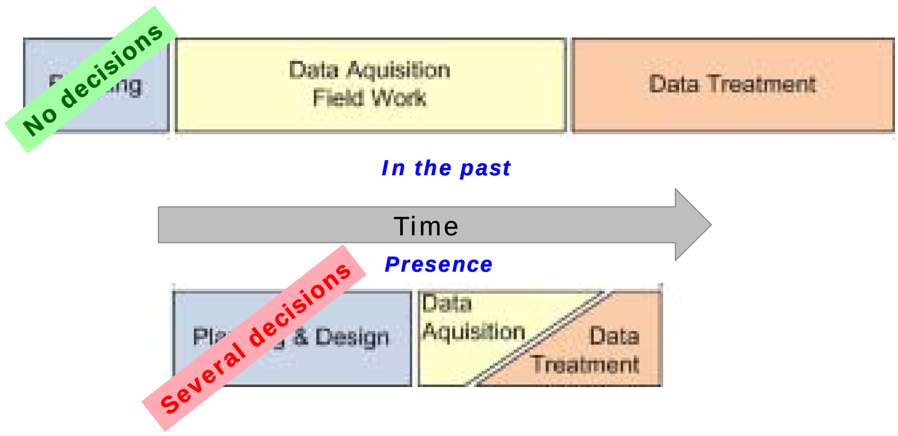
?

John Wayne and Oliver Hardy as surveyors, in „the Fighting Kentuckian“ (1947)

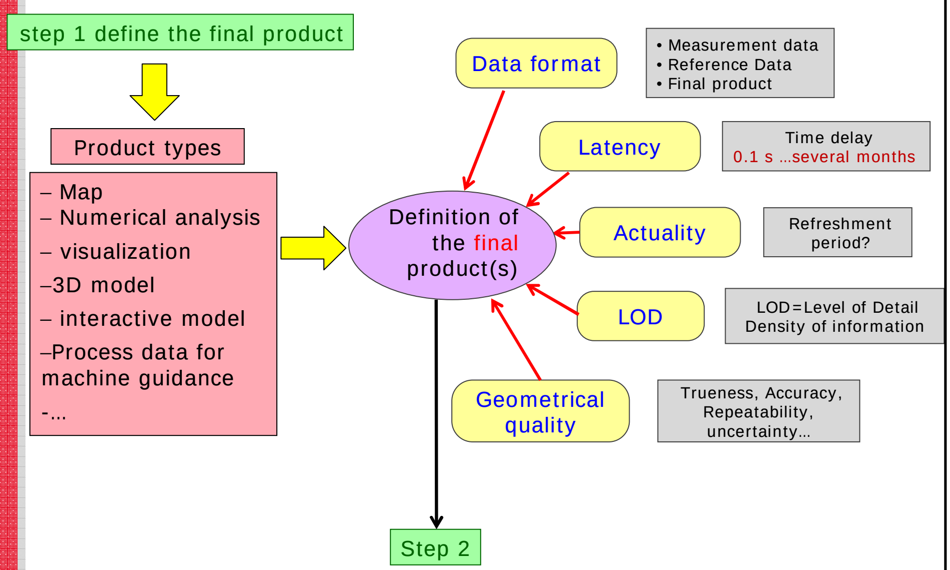
The surveying tasks – in the past and today



The different phases of a surveying project

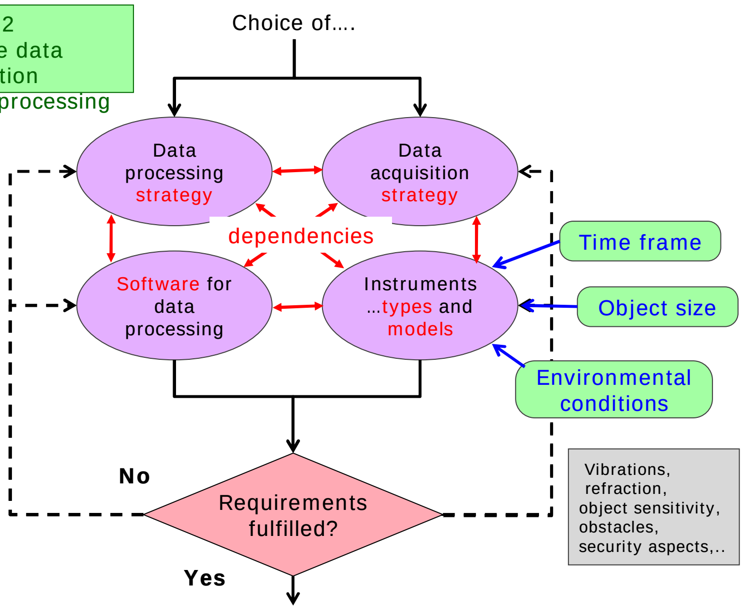


The planning phase today 1



The planning phase today 2

step 2
define the data acquisition
and the data processing



Conclusions

instruments with increased performance & efficiency

Push the button **... but, there are still manual operations!**

different types of instruments for 1 task,
for example DEM=Digital Elevation Model

Choice of the best measurement procedure

Mastering the choosen procedure

- **Know potential perturbations**
- **Evaluate the uncertainty budget with respect to the entire measurement system**
- **Validate the measurements and the final results**
- **Implement independent checks of the entire system**

The art of measurement- today

Master the entire process

- Planification
- Validation
- Uncertainty budget
- yesterday: Master the instrument
- Proof building
- Visualization
- Data treatment
- Data analysis
- Presentation

Screenshot from „Dersu Uzala " Akira Kurosawa, 1975