Introduction

Engineering Geodesy I

Program 2010/2011

- Introduction: Engineering Geodesy I and II
- Monitoring Instrumentation, Beaconing/Realisation of control points (EG I)
- Submission and Contracting (EG II)
- Geodetic Networks and Deformation Analysis (EG I + II)
- EG and Civil Engineering (Swiss and international projects)
  - Staking out and monitoring
    - Building grip line layout
    - Roads and Railways
    - Machine Guidance Systems
  - Structural health monitoring (Deformation and subsidence of buildings)
    - Towers an Bridges (EG I)
    - Dams& Barrages (EG I)
    - Tunnels (EGII)

- EG and Machine Industry including prefabricated building elements
    - Industrial Metrology
    - Powerplants, Accelerators
    - Radiotelescopes
- Natural Hazard Monitoring (EG 1)
    - Landslides and Rockfalls
- Self Learning Project “Engineering Geodesy Project”

Geomatic Engineering and Planning

Lehrveranstaltungen in den Kernmodulen (Vertiefungsrichtungen)

Ingenieurgeodäsie und Satellitengeodäsie

Kernfächer (überschneidungsfrei) WS	SWS	KE	Kernfächer (überschneidungsfrei) SS	SWS	KE
Ingenieurgeodäsie I	3	5	Ingenieurgeodäsie II	3	3
Satellitengeodäsie	3	4	Space Geodesy and Mission design	3	3
total	6	9	total	6	6
Wahlfächer			***Wahlfächer***		

Navigation und Geodynamik

Kernfächer (überschneidungsfrei) WS	SWS	KE	Kernfächer (überschneidungsfrei) SS	SWS	KE
Navigation II (Systems)	3	5	Navigation III (Operational)	3	3
Geodynamik I	3	4	Geodynamik II	3	3
total	6	9	total	6	6
Wahlfächer			***Wahlfächer***		

Photogrammetrie, Fernerkundung und GIS

Kernfächer (überschneidungsfrei) WS	SWS	KE	Kernfächer (überschneidungsfrei) SS	SWS	KE
Digitale Photogrammetrie I	4	6	Digitale Photogrammetrie II	2	2
Fernerkundung und GIS I	2	3	Fernerkundung und GIS II	2	2
			Nahbereichsphotogrammetrie	2	2
total	6	9	total	6	6
Wahlfächer			***Wahlfächer***		

geomETH

in discussion!!! In future, no subject may be required for obtaining the “Geometerpatent”

certificate for legal surveying

(Geometerpatent)

Semester	Kernmodul (Vertiefungsrichtung) **Ingenieurgeodäsie und Satellitengeodäsie**	SWS	KP	Kernmodul (Vertiefungsrichtung) **Navigation und Geodynamik**	SWS	KP
7. Semester	Kernfächer			Kernfächer		
	Engineering Geodesy I	3	5	Navigation II (Systems)	3	5
	Satellite Geodesy	3	4	Physical Geodesy and Geodynamics I	3	4
	Total	6	9	Total	6	9
	Wahlfächer	6	6	Wahlfächer	6	6
	Astro Lab	5	5	Astro Lab	5	5
	Industrial Metrology	4	4	Navigation und Verkehrstelematik	2	2
	Engineering Geodesy Lab	4	4	Control Technology	2	2
	Parameter Estimation Lab	2	2	(Regelungstechnik) (external)		
	Geomatics Colloquium	4	4	Geoprocessing	3	3
	Amtliche Vermessung und GIS	4	4	Parameter Estimation Lab	2	2
	Grundbuch- und Vermessungsrecht	1	1	Geomatics Colloquium	4	4
8. Semester	Kernfächer			Kernfächer		
	Engineering Geodesy II	3	5	Navigation III (Operational)	3	5
	Space Geodesy and Mission design	3	4	Physical Geodesy and Geodynamics II	3	4
	Total	6	9	Total	6	9
	Projektarbeit	6	9	Projektarbeit	6	9
	Wahlfächer	5	5	Wahlfächer	5	5
	GPS Meteorology Lab	5	5	Gravity Lab	5	5
	GPS Lab	5	5	GPS Lab	5	5
	System Theory	5	5	System Theory	4	4
	Geodetic Field Course 3 Wochen		?			
	(auch als Projektarbeit mit 9 KP)		?			

Literature

Möser, M.; Müller, G.; Schlemmer, H.; Werner, H. [2000]: Handbuch der Ingenieurgeodäsie - Grundlagen. 3. Neubearbeitete Auflage, Wichmann, Heidelberg.

SCHWARZ, W. [1990]: Vermessungsverfahren in Maschinen- und Anlagenbau. Schriftenreihe DVW Band 13 Verlag Konrad Wittwer.

DVW-Tagungsbände for special themes, z.B.:

- Geodätische Messverfahren im Maschinenbau, 26. DVW Seminar
- Kinematische Meßmethoden in der Ingenieur- und Industrievermessung, Band 22 der DVW-Schriftenreihe, Wittwer Verlag

Kurse für Ingenieurvermessung (1996 Graz Dümmler Verlag, 2000 München, Wittwer-Verlag, 2004 Zürich)

Conferences on Optical 3-D Measurement Techniques, Wichmann-Verlag

Special articles in the journal Geomatik Schweiz (ehemals VPK), AVN, ZfV, ……

European and international Workshops on Strucutral Health Monitoring (www.onera.fr/congress/shm2002) (www.structure.stanford.edu/workshop); (www.wusceel.cive.wustl.edu/asce.shm); (www.sfb477.tu-bs.de); (www.samco.org)

FIG Congress papers commissions 5 and 6

Literature/References

- Technical monographs
- DIN 1319 [1983]: Grundbegriffe der Messtechnik; Begriffe für die Fehler beim Messen. Beuth Verlag, Berlin.
- DIN 18710 : Ingenieurvermessung Teil 1 - Teil 4. Beuth Verlag, Berlin.
- ISO 1993 : International Vocabulary of Basic and General Terms in Metrology (VIM), Gemeinschaftswerk von BIPM, IEC, IFCC, ISO, IUPAC, IUPAP und OIML, ISBN 92-67-01075-1.
- ISO 1995 : Guide to the Expression of Uncertainty in Measurement (GUM), Gemeinschaftswerk von BIPM, IEC, IFCC, ISO, IUPAC, IUPAP und OIML, ISBN 92-67-10188-9. Nachdruck.
- ISO 3534-1 [1993]: Statistics –Vocabulary and Symbols. Part 1: Probability and General Statistical Terms.
- ISO TC172 SC6 : Geodetic Instruments
- FIG dictionary (s. BKG)

What is Engineering Geodesy?

Engineering Geodesy is an application of geodetic methods in industry and civil engineering. Among the principal tasks of engineering geodesy there is complete **geodetic site management** – from works carried out during the design phase of construction through site surveying to documentation of its as-built version and, in some cases, even long-term **monitoring** of its shifts and deformations.

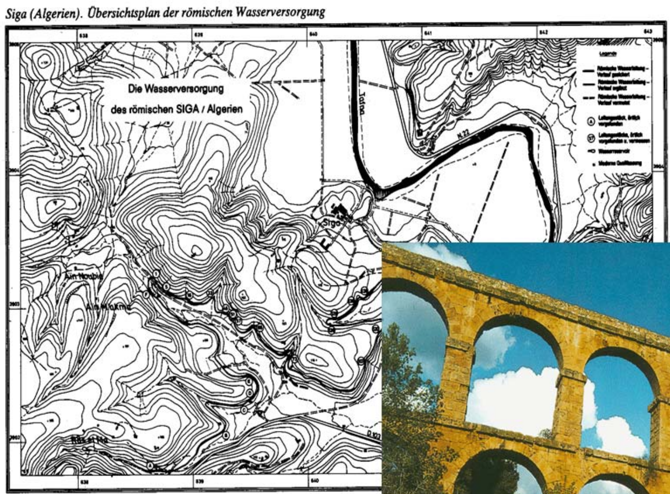
Engineering geodesy is characterized by high demands for measurement **precision** and also by the fact that the measurements are carried out in very difficult conditions. The use of the latest devices is often the only way to fulfil the accuracy requirements.

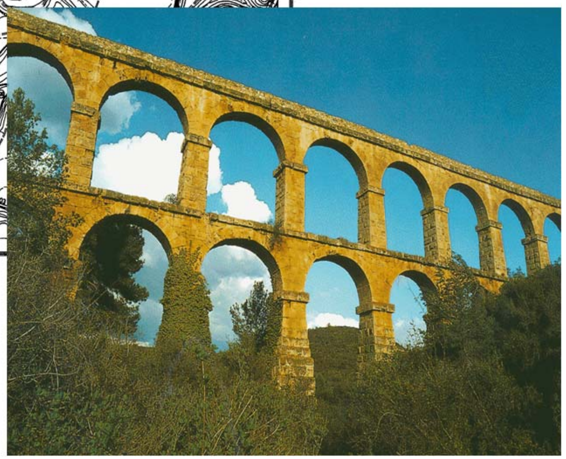
Prof. Leoš Mervart Department of Advanced Geodesy Faculty of Civil Engineering, CTU in Prague
http://geoinformatics.fsv.cvut.cz/wiki/index.php/Applications_of_the_Galileo_System_in_Civil_Engineering

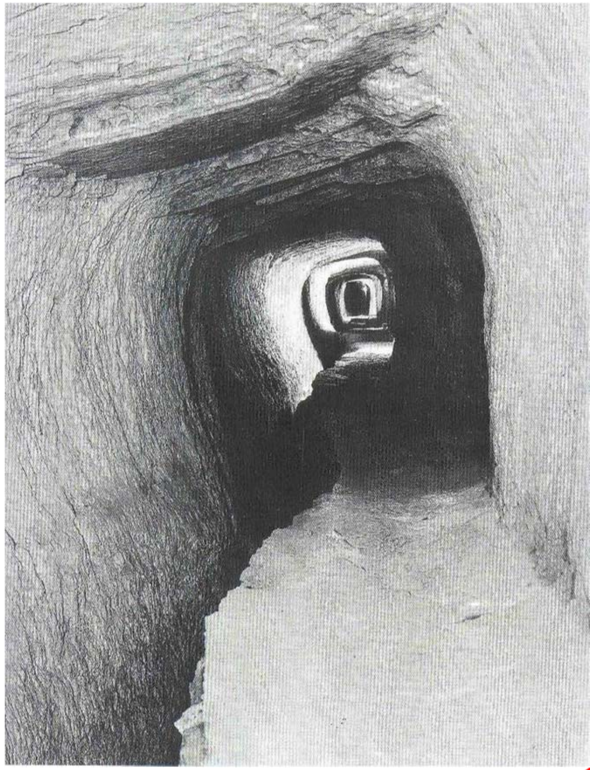
Historical Tasks in Engineering Geodesy

Oldest applications of surveying

- Staking out of objects (Mesopotamia; Pyramids, Egypt; Stonehenge; China………)
- Tunnel Jerusalem, 700 BC: Deviation 1.5 m length 600 m
- Tunnel Epalinos (Samos) 530 BC: Direction transfer via sun and rectangular traversing: Horizontal Deviation 2 m, Height 3 m; length 1 km
- Romans Aqueducts- und Bridges
- Limes: 87 km, 2 m deviation of the straight line







Brake –through Epalinos

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19th Century

Construction of Railway Lines (Tunnels, Bridges, Viaducts)

- 1872-1880: from1850: compound curves (Korbbogen), cubic functions and other transition curves
- 1880: Gotthard-Tunnel Length 15 km, Horizontal Offset 33 cm , Vertical Offset 5 cm

20th Century

Road Construction, Machines (Ships- and Aircrafts, Big Dams)

21th Century

High Speed Traffic Systems with long Tunnels und Bridges

(Transrapid, Maglev, TGV, ICE, X2000, Shinkansen, Slab tracks, …)

Monitoring as a part of a risk management system (structural health monitoring)

Tunnelling the Alps

Mt Cenis

Brenner Base Tunnel

Gotthard 2014

Lötschberg 2007

2000

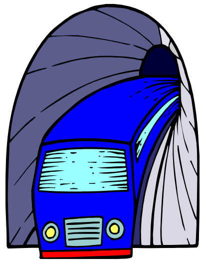
1980 Gotthard / Fréjus

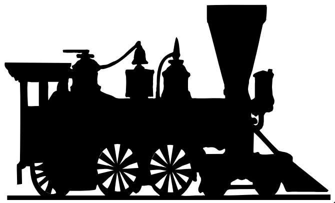
1972 Brenner

1967 San Bernhardino

1965 Mt. Blanc

1950





Lötschberg 1913

Simplon 1906

1900

Gotthard 1882

Mt Cenis 1872

Brenner 1867

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Railways projects

Zurich City link (Durchmesserlinie)

Stuttgart Stuttgart 21

Leipzig City Tunnel

Gotthard Base Tunnel break through 15. Oktober 2010

Now: Staking out tracks

Documentation of accidents in CE

From: “Der Bauingenieur” 2006

Einsturz des Bohrtunnels für die neue Métro in Lausanne VD 2005.

Collapse of a tunnel for the underground in Lausanne 2005

Einsturz einer Tiefgarage während eines Brandes in Gretzenbach SO 2004.

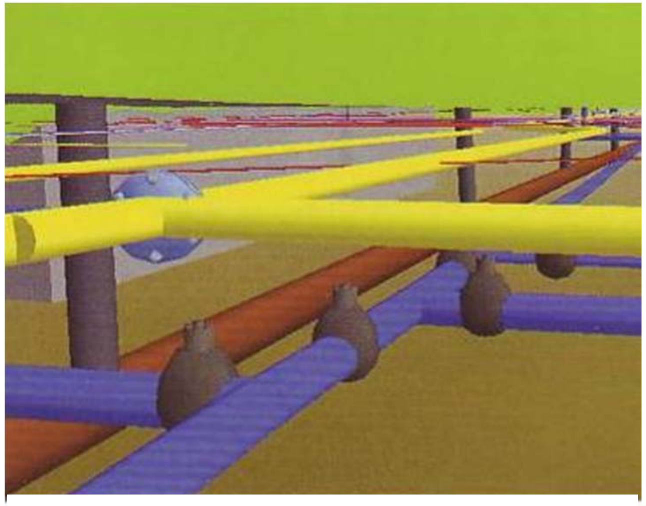
reich. Wir tragen dann die Erkenntnisse aus den verschiedenen Bereichen zusammen und verfas-

Schaden und die Schadenhöhe benennen so die technischen Verantwortlichkeiten klären.

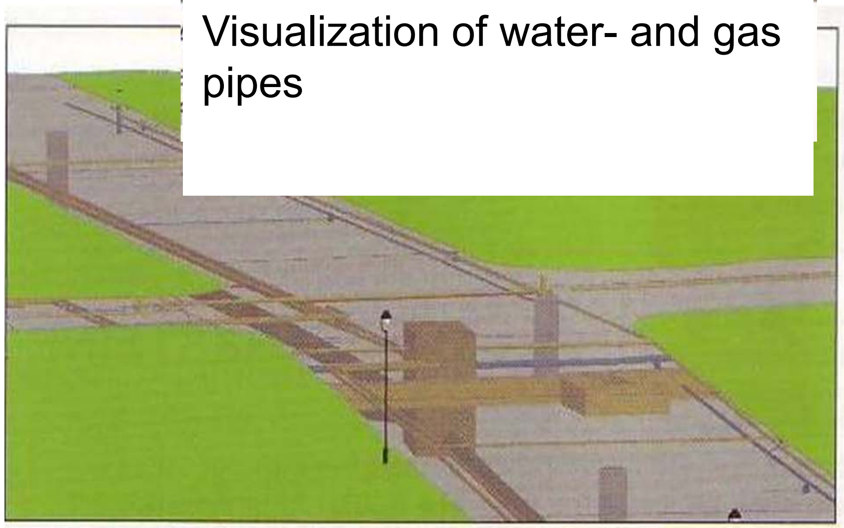
Breaking of an underground car park in Gretzenbach, Bezirk Olten, Kanton Soloturn, 2004

3D Plans/Visualisation for CE tasks

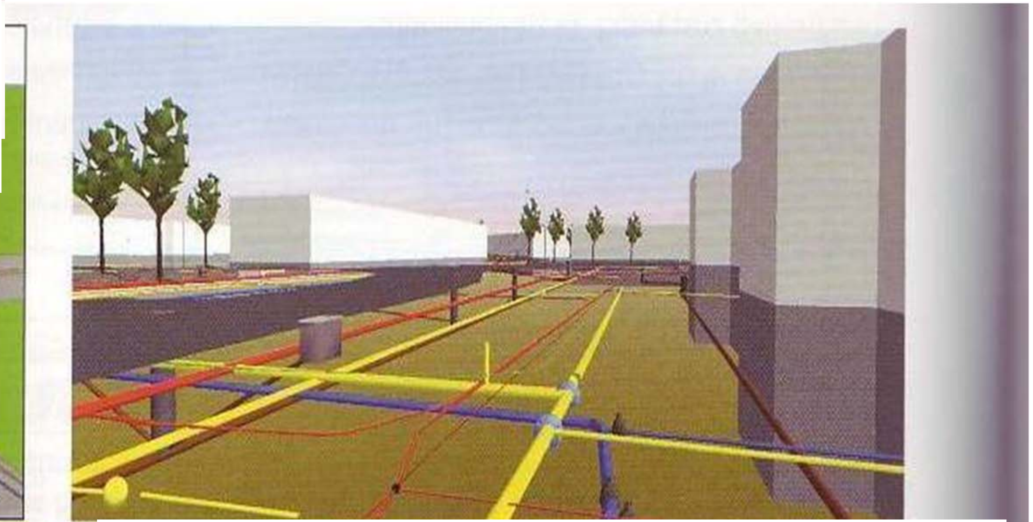
(UNI Hannover)



Visualization of water- and gas pipes



View through a transparent road



Branched, sophisticated underground mains

From Geomatik Schweiz 8/06

- Gurtnellen, Gotthard Motorway A2

31.5.2006

VW Beatle Cabrio, German
Couple killed, Road 4 weeks
Closed


Legende:
1002 bis 1013: Reflektoren
(1002 bis 1004: Befestigung an Baum;
1005 bis 1013: Befestigung an Fels)
T1 bis T7: Wegaufnehmer (Tensometer)
Drehpotentiometer: Überwachung Böschungsstabilität
1003
1005
Drehpotentiometer
Solarpanel
1002
1004
1006
Datenlogger in Schutzhütte
1011
1007
1013
T3
T4
T1
T2
1008
T5
1012
1009
T7
T6
1010

- High Precision Geodetic Metrology Methods
  - high precision/accuracy/reliability
  - measurements under difficult environmental conditions
  - hybrid metrology und and hybrid Networks (sensor integration)
  - problems of the representativeness of capturing objects (what ? Where? how to measure?)
  - permanent metrology applications
  - Metrology of moving objects
  - real time applications
  - ………….
- Interdisciplinary projects with high responsibility and high risks
  - Diverse definitions of requirements (Accuracy, Tolerance, uncertainty, RMS, Sigma levels)
- Involvement in a complex project management process
  - The main task/requirement of the contractor implies many subsequent tasks, which have to be solved by the engineer

  → contrast with surveying

- EG is context, application and customer driven
- The customer defines the task and his requirements
- Accuracy,Precision, tolerances,…….
- The Geomeatic engineer transforms it to an object related solution

Typical Tasks and Techniques of Engineering Geodesy (DMT Advertisement)

Tunnelling, mining and pipe jacking

- Orientation measuring with GYROMAT 2000/3000 and explosion-proof surveying gyroscopes
- Measuring and prediction of break-through points
- Shaft surveying
  - inertial and tachymetric surveying
  - tracking of shaft and cage guidence
  - plumbing and depth measuring
- 3D laser scanning
- Precision traversing
- Check survey, main traverse survey in mining
- Precision levelling

Engineering surveying

- Basic network setups
- Ground control point work
- GPS surveying
- High-precision 3D measuring of ground and building movements with real-time GPS and use of reference network services
- 3D laser scanning
- Special survey
- Customers specific survey

Photogrammetry

Terrain and structure survey

Geodetic inventory

Stake out
in large 2D and 3D seismic projects (>200km²)

Precision levelling

General surveying
GPS and total-station measuring, levelling, laser scanning and interpretation

Consulting and geodetic project management

Gyroscope expert body
„Kreiselmessstelle"

Calibration laboratory of the German Calibration Service (DKD)

DMT GmbH
http://www.dmt.de
http://www.dmt.de/en/services/exploration_geosurvey/geomonitoring.html

Typical Tasks and Techniques of Engineering Geodesy (DMT Advertisement)

Geomonitoring

Structural monitoring

Procuring geodetic evidence
- Measuring of deformation and subsidence
- Observation lines
- Online monitoring with GPS and total stations for permanent surveillance

Monitoring of buildings

Terrain monitoring

Radar interferometry

Immission protection
- Measuring/prediction
- Approval procedures
- Immission reduction measures

Construction vibrations
- Measuring/prediction
- Pile-driving vibrations
- Vibrations from demolition work
- Vibrations from compaction work
- Vibrations from explosions

In traffic vibrations
- Measuring/prediction
- Road traffic
- Rail traffic

Vibrations from industrial plants
- Vibrations from machines
- Dynamic loads
- Site assessment
- Interactions
- Vibrations reduction measures

Engineering seismology, passive seismics
- Time-synchronous seismic networks
- Highest sensitivity seismic instruments
- Localisation
- Fracture analyses
- Measures to reduce or assess seismicity

Inclination monitoring

Convergence measuring

Extensometer measuring

Monitoring of joints and cracks

Sound measuring

Temperature measuring

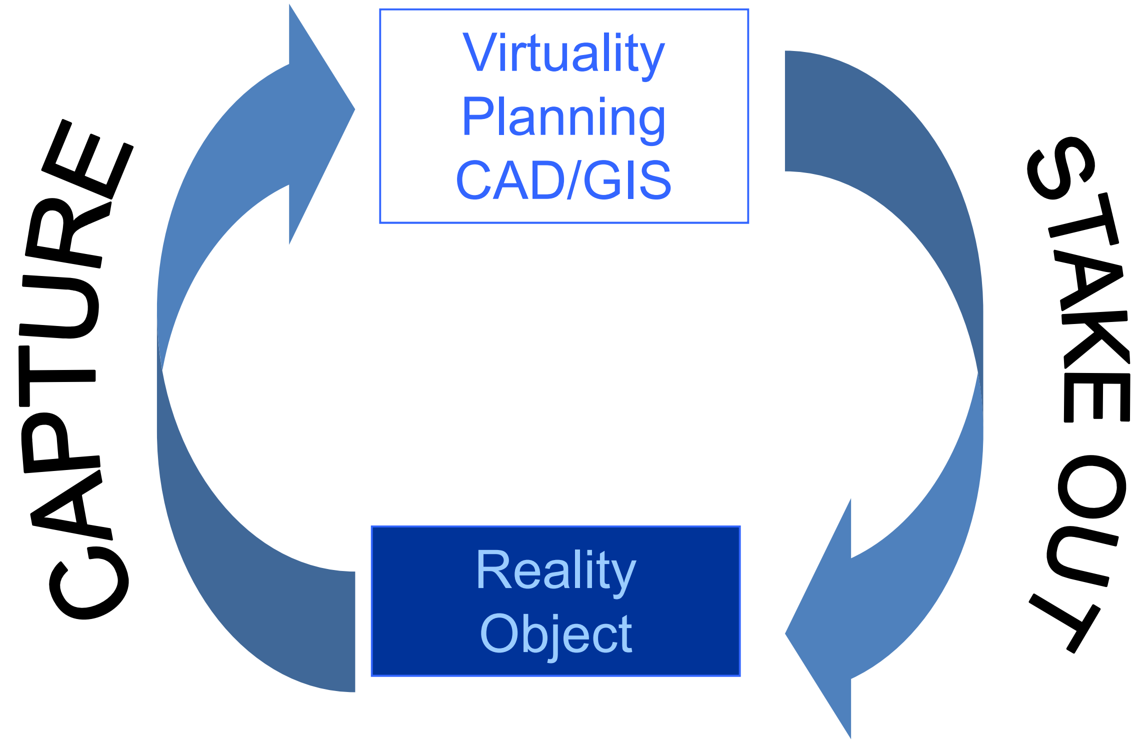
Early warning and alarm systems

Certified control centre approved in accordance with the Federal Immission Control Act (§26 BImSchG)

Schweiz: geoteam.ch (Beckenried, Vierwaldstätter See)

- Lage- und Hohenfixpunktnetze mit GPS / Präz. Theodolit / Präz. Nivellier als Grundlage für Tunnel, Stollen, Hoch- und Tiefbauten .
- Absteckungen von Tunnel, Stollen, Brücken, Hoch- und Tiefbauten .
- Raumprofile im Untertagbau .
- Passpunktbestimmung für Photogrammetrische Aufnahmen .
- Rutschungs- und Setzungsmessungen
- Deformationsmessungen
- Unterwasservermessungen
- Profilaufnahmen für Bachverbauungen,
- Seilbahn- und Werkleitungsbau .
- Präzisionsabsteckungen für Element und Stahlbau
- Pfählungsabsteckungen
- Digitale Terrainmodelle (DTM), inkl. Volumenberechnungen,
- 3D-Ansichten und daraus extrahierte Längs- und Querprofilen
- Gebäudeabsteckungen und Schnurgerüstkontrolle

Basic metrology tasks: Capture / Monitoring and Stake out



Data capture

reality → virtuality

Stake out

Transfer of planned objects (CAD) into reality

Engineering-geodetic measurements are required for:

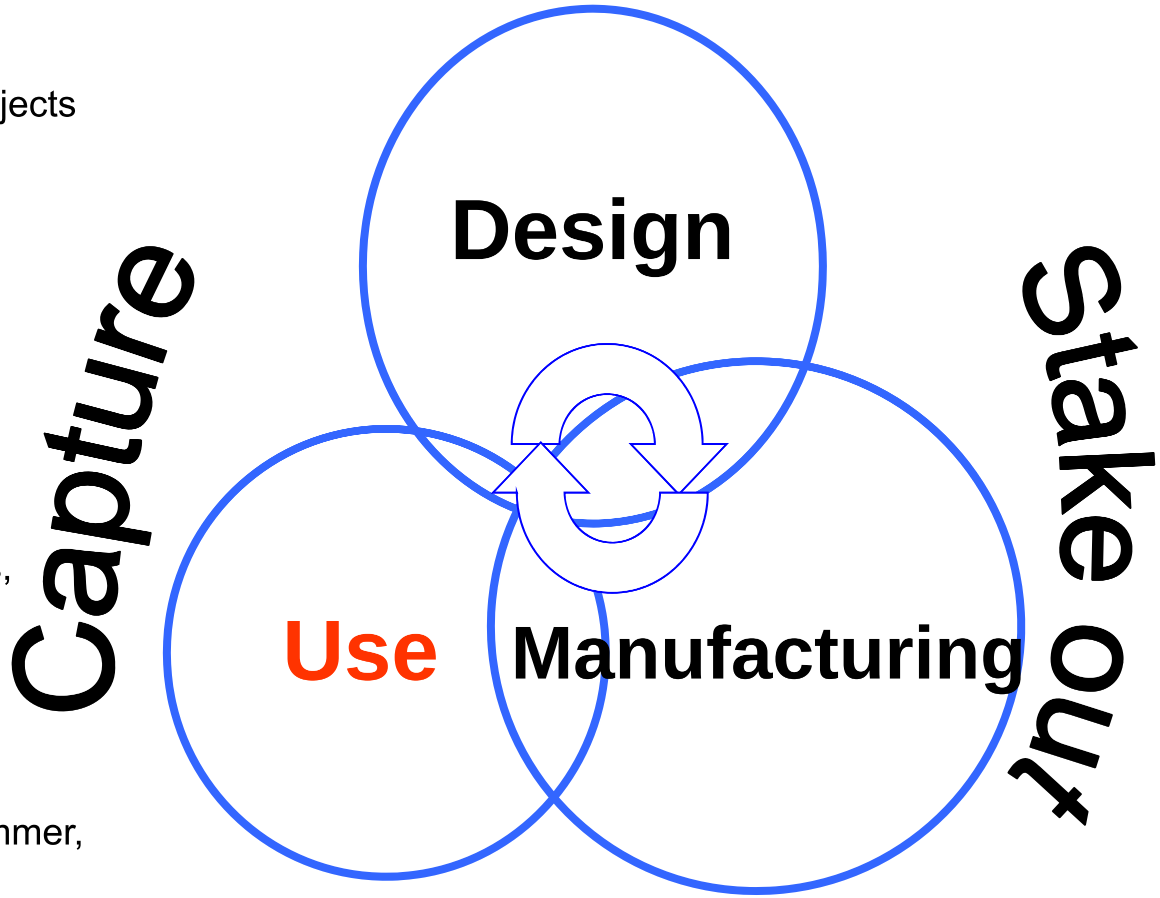
In Civil Engineering

- as a prerequisite for the design of CE projects (plans, maps, 3D DTM, DOM)
- staking out of designed objects
- Machine guidance
- Check and Monitoring of objects
- Structural health monitoring

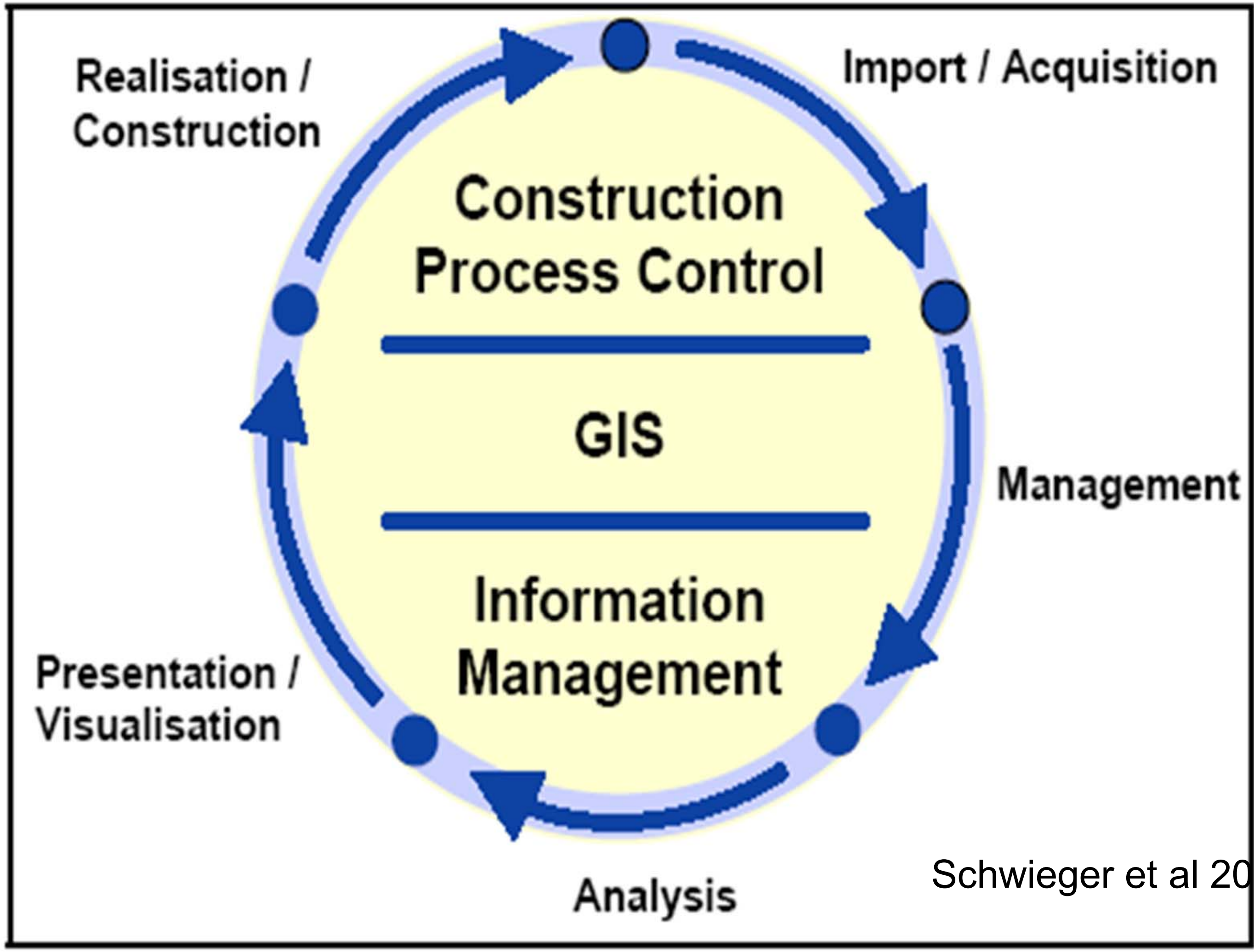
In Machine Engineering

- as a prerequisite for the design
- monitoring during the production process
- Staking out of objects (machines aircrafts, ships, fabrication plants,….)

(according to Möser, Müller, Werner, Schlemmer, 2000)

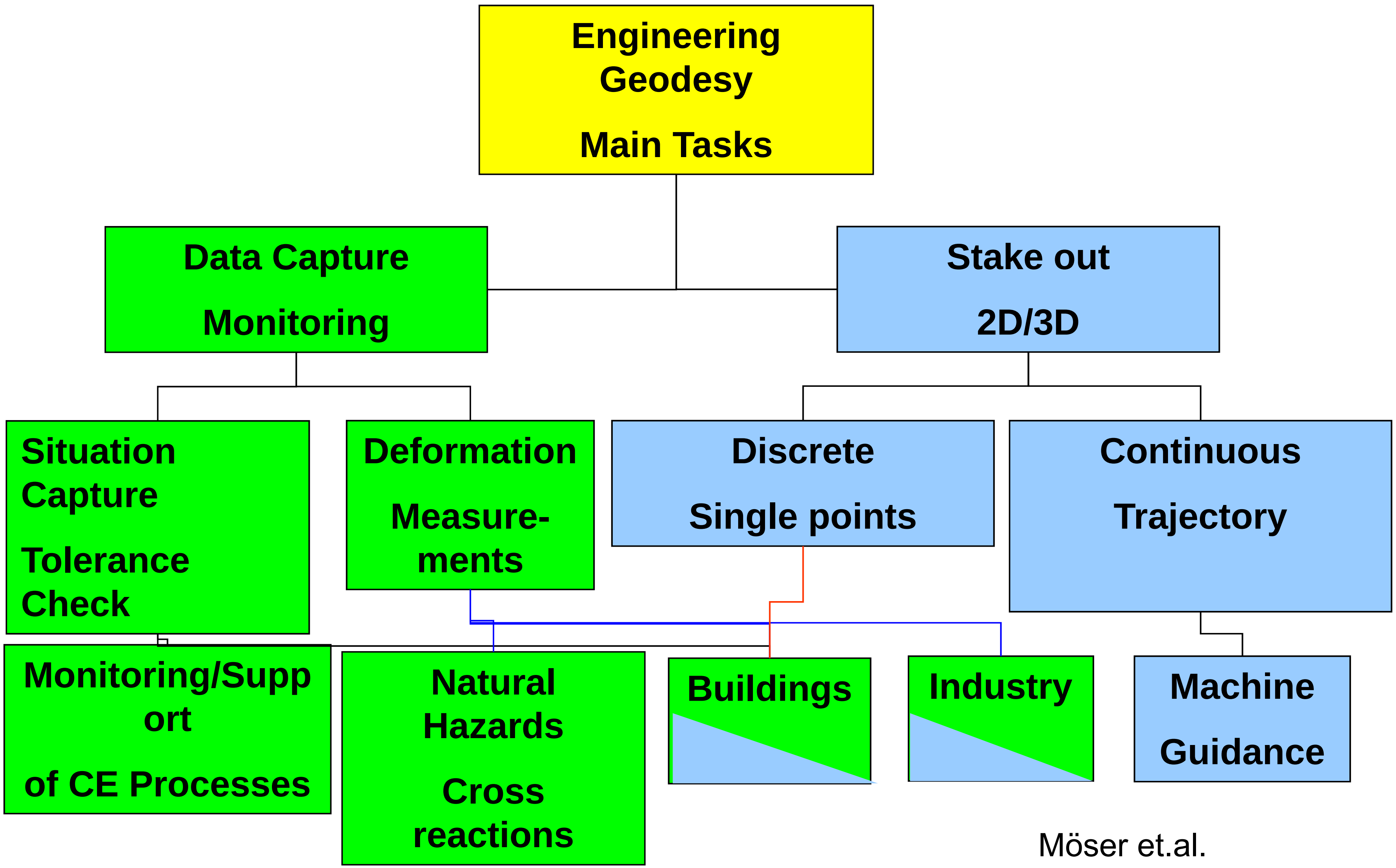


The Construction Circle



Schwieger et al 2006

Main Tasks in Engineering Geodesy



Möser et.al.

<u>from geometric data capture towards whole descriptions of objects</u>

- Civil Engineering: change of material used, damages
- Geotechnics, Geophysics
- Data Capture for GIS as an interdisciplinary basis for decision making
- Building-Information Systems (GebIS) for Facility Management Systems (FM) Controlling of estates, infrastructures, industrial plots

<u>dynamic descriptions</u>

- Real-Time- Deformation Monitoring
- Guidance of construction machines
- driverless transportation systems

<u>new application areas</u>

- Production measurement technology (= Fertigungsmesstechnik)
- navigation, controlling

Interdisciplinarity

Who carries out engineering geodesy tasks ?

- Geodesists, Geomatic Engineers, Surveying engineers at:

  Engineering- / Geometer-offices

  Industry (Car manufacturing, Heavy-machines,...)

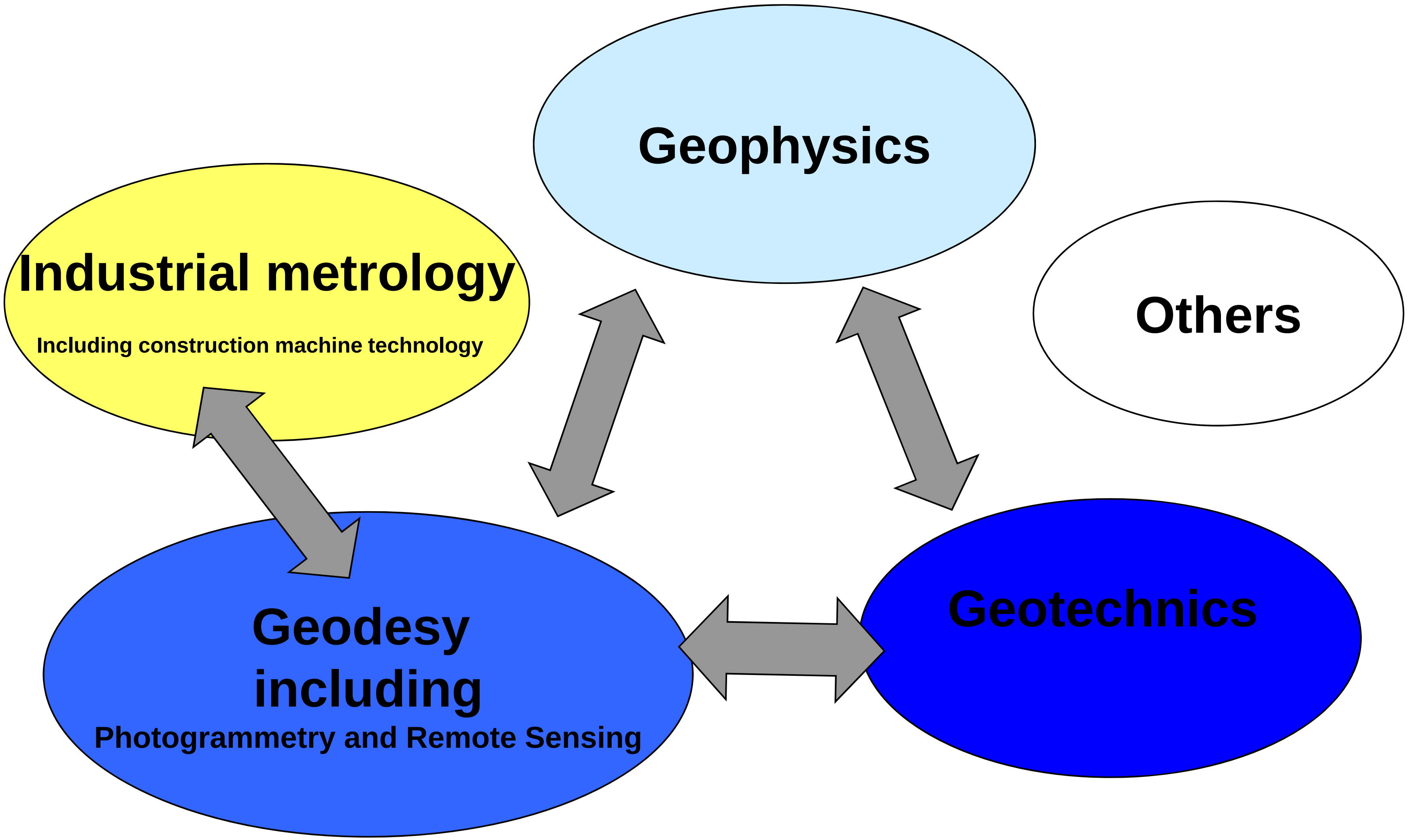
  Research oriented organisations (PSI, CERN, Desy..)

  Cities (land surveying offices)

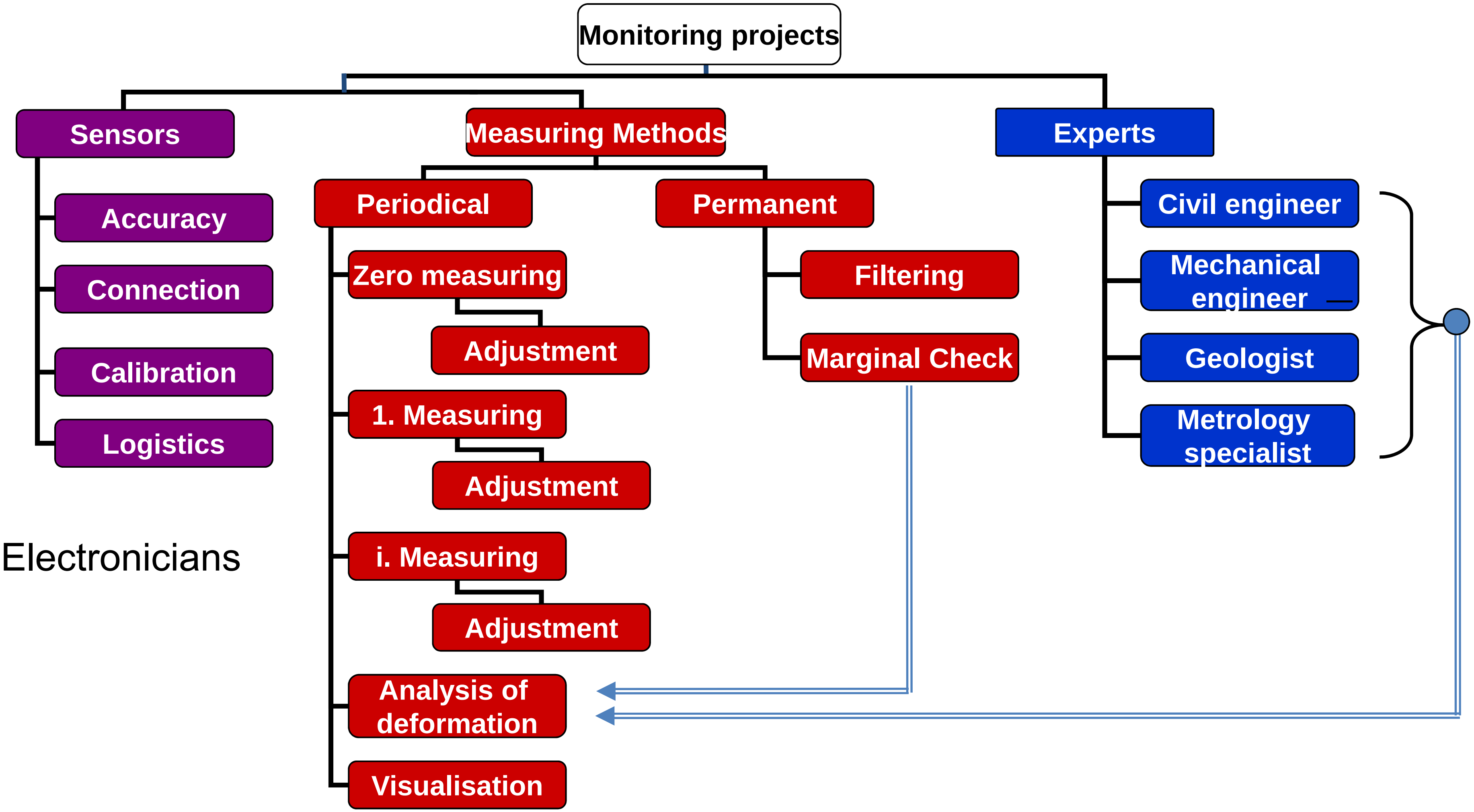
  Country wide level (Swisstopo)

- Furthermore: Mining engineers (Markscheider), Civil Engineers (Hydraulic Engineering), Electro-Engineers, Machine Engineers, Geo-Physisists, Geo-Technicians, Geologists,...

Interdisciplinarity: Metrology of diverse Disciplines



Interdisciplinarity: Sensors – Measuring Methods – Experts



Electronicians

How to find a common language in interdisciplinary tasks?

Quality of “products” in Engineering Geodesy

Geodesists often have their own, sometimes non-compatible, way to describe the quality of geometric data.

Frequently they are restricted to the use of the quality criteria

accuracy, precision,…….

Although other criteria like:

Correctness,
Availability (Real time approach),
Topicality, Timeliness,
Completeness,
Sensitivity, Separability,
Coverage,
Reliability, Integrity,
………………..

are equally important.

- “integrity” is that quality which relates to the trust which can be placed in the correctness of the information supplied by the total system.
- Integrity risk is the probability of an undetected failure of the specified accuracy.
- Integrity includes the ability of a system to provide timely warnings to the user when the system should not be used for the intended operation.
- correctness of information a quantitative value given for a parameter as correct, if the information itself plus the uncertainty attached to it does not violate the accuracy specifications for this particular parameter.

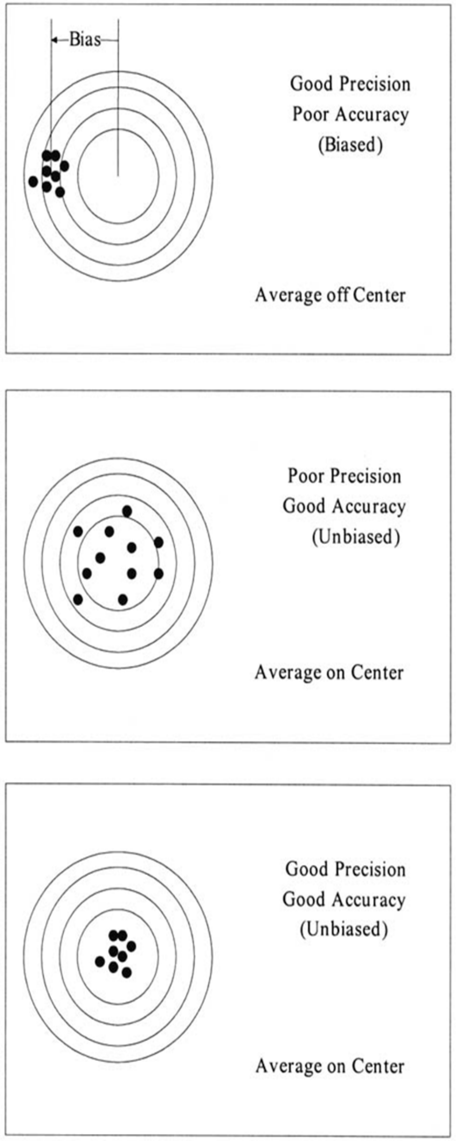
Census Bureau Principle: Definition of Data Quality

- Utility - refers to the usefulness of the information for its intended users.
- Objectivity - refers to whether information is accurate, reliable, and unbiased, and is presented in an accurate, clear, and unbiased manner.
- Integrity - refers to the security or protection of information from unauthorized access or revision.
- Relevance refers to the degree to which our data products provide information that meets our customers' needs.
- Accuracy refers to the difference between an estimate of a parameter and its true value. We characterize the difference in terms of systematic (bias) and random (variance) errors.
- Timeliness refers to the length of time between the reference period of the information and when we deliver the data product to our customers.
- Accessibility refers to the ease with which customers can identify, obtain, and use the information in our data products.
- Interpretability refers to the availability of documentation to aid customers in understanding and using our data products. This documentation typically includes: the underlying concepts; definitions; the methods used to collect, process, and analyze the data; and the limitations imposed by the methods used.

http://www.census.gov/quality/P01-0_v1.3_Definition_of_Quality.pdf

- Absolute accuracy is defined with respect to a global coordinate system.

- Relative accuracy (precision) stands for <u>differences</u> between measured points or observations



German Usage of “Fehler”

- In German Language „Fehler“ is an established expression. It originates from the translation of the Englisch „error“ and is still used in nowadays industrial norms (e.g. DIN1319: Grundbegriffe der Messtechnik;)

- Suggestion: use „Abweichung“ instead of „Fehler“ in order to take into account the systematic components in observations / measurements. Only for gross errors, the expression “Fehler” should be used.

Various Quality Criteria

Begriff	Beschreibung	Synonym	Englisch	Französisch	nicht mehr verwenden

Statistik – Allgemeine Begriffe zu Messreihen und Messergebnissen (z.T. Auswahl aus ISO 3534-1)

Begriff	Beschreibung	Synonym	Englisch	Französisch	nicht mehr verwenden
Abweichung eines Ergebnisses	Testergebnis minus akzeptierter Referenzwert		error of a result	erreur de résultat	~~Fehler~~[1]
Abweichung, systematische	Komponente der Messabweichung, welche im Zuge der Realisierung einer Anzahl von Messergebnissen derselben Charakteristik konstant bleibt oder sich in vorhersagbarer Art ändert.		systematic error, bias	erreur systématique	~~Systematischer Fehler~~
Abweichung, zufällige	Komponente der Messabweichung, welche im Zuge der Realisierung einer Anzahl von Messergebnissen derselben Charakteristik sich in unvorhersagbarer Art ändert.		random error	erreur aléatoire	~~Zufälliger Fehler~~
Auflösung	Kleinste Zähleinheit		resolution	résolution	
Ausreisser	Beobachtung in einer Messreihe, die so weit entfernt von den restlichen Beobachtungen liegt, dass suggeriert wird, die Beobachtung stamme von einer unterschiedlichen Grundgesamtheit oder die Beobachtungen sei fehlerhaft.	Grober Fehler	outlier, blunder, gross error	valeurs aberrantes	
Fehler erster Art	Der Fehler, der beim Verwerfen der Nullhypothese entsteht, obwohl diese zutrifft.		error of the first kind, type I error	Probabilité d'erreur de première espèce	
Fehler zweiter Art	Der Fehler, der beim Annehmen der Nullhypothese entsteht, obwohl diese nicht zutrifft.		error of the second kind, type II error	Probabilité d'erreur de seconde espèce	
Genauigkeit	Ausmass der Übereinstimmung zwischen Testergebnissen und einem Referenzwert	Äussere Genauigkeit	accuracy	exactitude	
Konfidenzellipse, Konfidenzellipsoid	Zwei (n-)-dimensionales Vertrauensintervall				~~Fehlerellipse~~
Konfidenzellipse, mittlere	Konfidenzellipse bezüglich der einfachen Standardabweichung				~~Mittlere Feh-~~

Various Quality Criteria

Begriff	Beschreibung	Synonym	Englisch	Französisch	nicht mehr verwenden
					~~Ierellipse~~
Messunsicherheit	Die Messunsicherheit ist ein Mass für die durch die unvollständige Information hervorgerufene Unvollständigkeit der Kenntnis der Messgrösse[2,3] Die Messunsicherheit setzt sich zusammen aus zufälligen Messabweichungen und unvollkommener Berichtigung des Ergebnisses.		uncertainty in measurement	incertitude	
Präzision	Ausmass der Übereinstimmung zwischen unabhängigen Testergebnissen bei identischen Bedingungen	Innere Genauigkeit	precision	fidélité	
Reproduzierbarkeit	Präzision unter Reproduzierbarkeitsbedingungen		reproducibility	reproductibilité	
Reproduzierbarkeitsbedingungen	Bedingungen, bei welchen Testergebnisse mit derselben Methode bezüglich identischer Testgrössen in unterschiedlichen Laboratorien mit unterschiedlichem Personal, das unterschiedliche Ausrüstung benützt, erhalten werden.		reproducibility conditions	conditions de reproductibilité	
Root Mean Square Error (RMS)	Streuungsmass zur Beschreibung der äusseren Genauigkeit $RMS = \sqrt{\frac{\sum_{i=1}^{n}(x_i - a)^2}{n}}$ a: Wahrer Wert x_i: Beobachtung n: Anzahl Beobachtungen	Standardabweichung (in Abgrenzung zur empirischen Standardabweichung)	root mean square error		
Standardabweichung	Positive Quadratwurzel der Varianz		standard deviation	écart-type	~~Mittlerer Fehler~~
Standardabweichung, empirische	Positive Quadratwurzel der empirischen Varianz		empirical standard deviation		
Varianz	Mass, das die Streuung um einen Referenzwert a beschreibt: $\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - a)^2}{n}$ a: Referenzwert		variance	variance	

[2] WEISE, K, W. WÖGER, 1999: Messunsicherheit und Messdatenauswertung. Wiley-VCH, Weinheim.
[3] Siehe auch: ISO 1995 []: *Guide to the Expression of Uncertainty in Measurement (GUM).*

Various Quality Criteria

Begriff	Beschreibung	Synonym	Englisch	Französisch	nicht mehr verwenden
	x_i: Beobachtung n: Anzahl Beobachtungen				
Varianz, empirische	Mass, das die Streuung um den Mittelwert $\overline{x}$ beschreibt. $\hat{\sigma}^2 = \frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}$ $\overline{x}$: Wahrer Wert x_i: Beobachtung n: Anzahl Beobachtungen		empirical vari-ance		
Wiederholbarkeit	Präzision unter Wiederholbarkeitsbedingungen		repeatability	répétabilité	
Wiederholbarkeitsbedingungen	Bedingungen, bei welchen mittels identischer Methoden bezüglich identischer Prüfgrössen im selben Labor durch identisches Personal, das identische Ausrüstung benützt, innerhalb von kurzen Zeitintervallen unabhängige Testergebnisse erhalten werden.		repeatability conditions	conditions de répétabilité	
Zuverlässigkeit	Begriff zur Aufdeckbarkeit von groben Fehlern in z.B. geodätischen Netzen				

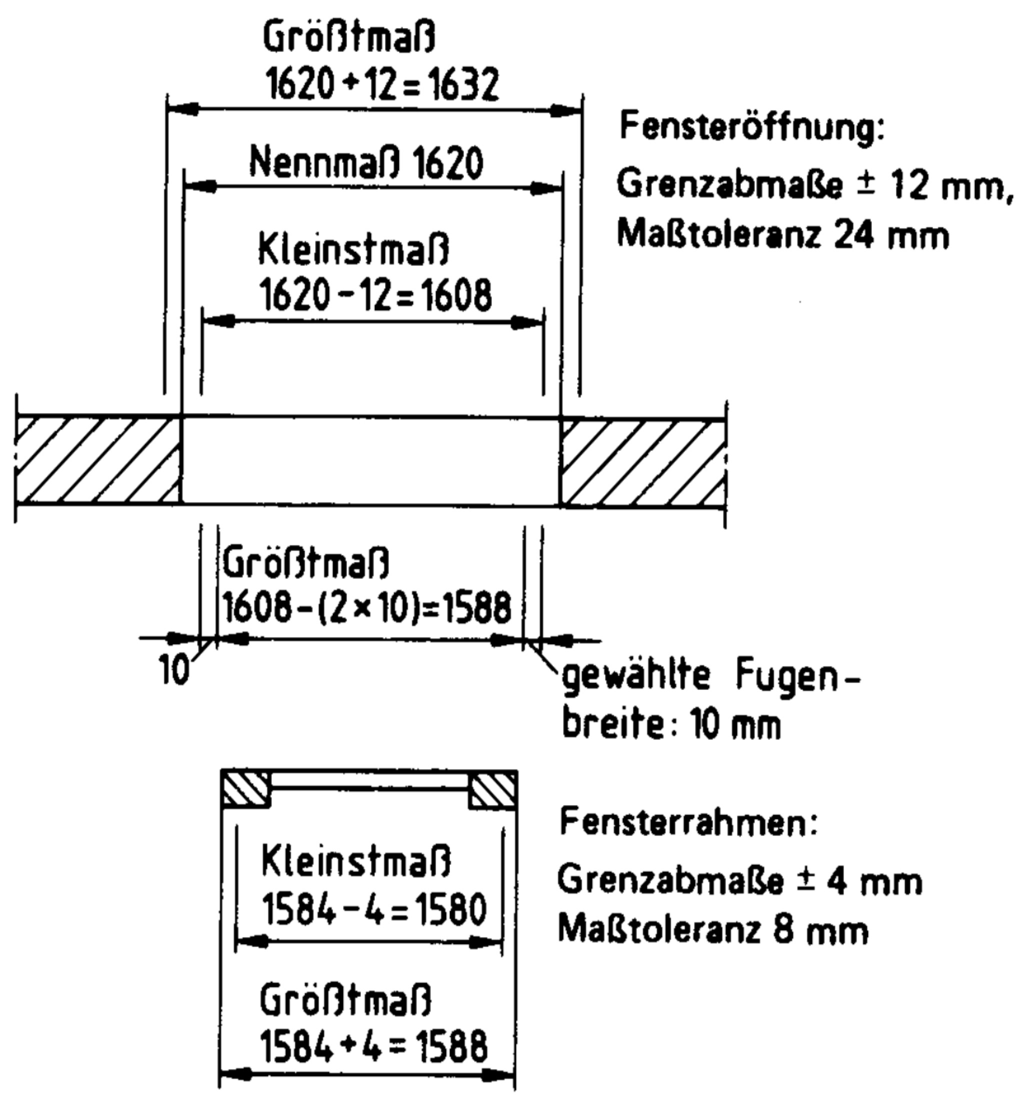
New Expressions and Quality Criteria

Klassische Fehlertheorie	**DIN 1319 Blatt 3 Januar 1992**	**Definitionen der Mathematischen Statistik bzw. Geodäsie**
Grober Fehler	Irrtum	Irrtum
Systematischer Fehler	Systematischer Fehler	Systematische Abweichung
Zufälliger Fehler	Zufälliger Fehler	Zufällige Abweichung
Mittelwert x	Mittelwert x	Mittelwert x bzw. μ
Mittlerer Fehler m	Standardabweichung s bzw. σ	Standardabweichung s bzw. σ Standardunsicherheit u_s
Innere Genauigkeit	Genauigkeit bei Wiederhol-Bedingungen	beide Bezeichnungen
Äussere Genauigkeit	Genauigkeit bei Vergleich-Bedingungen	beide Bezeichnungen
Fortpflanzungsgesetz für systematische Fehler	Lineare Fehlerfortpflanzung	Fortpflanzungsgesetz für systematischeAbweichungen
Quadrat des mittleren Fehlers	Quadrat der Standardabweichung	Varianz
Fehlerfortpflanzungsgesetz	Fehlerfortpflanzungsregel	Varianzfortpflanzungsgesetz
Grenzfehler G = 5 m	Messunsicherheit u	Messunsicherheit u Erweiterte M.
Zulässiger Fehler	Fehlergrenze	Fehlergrenze
Fehlerellipse	Konfidenzellipse	Konfidenzellipse

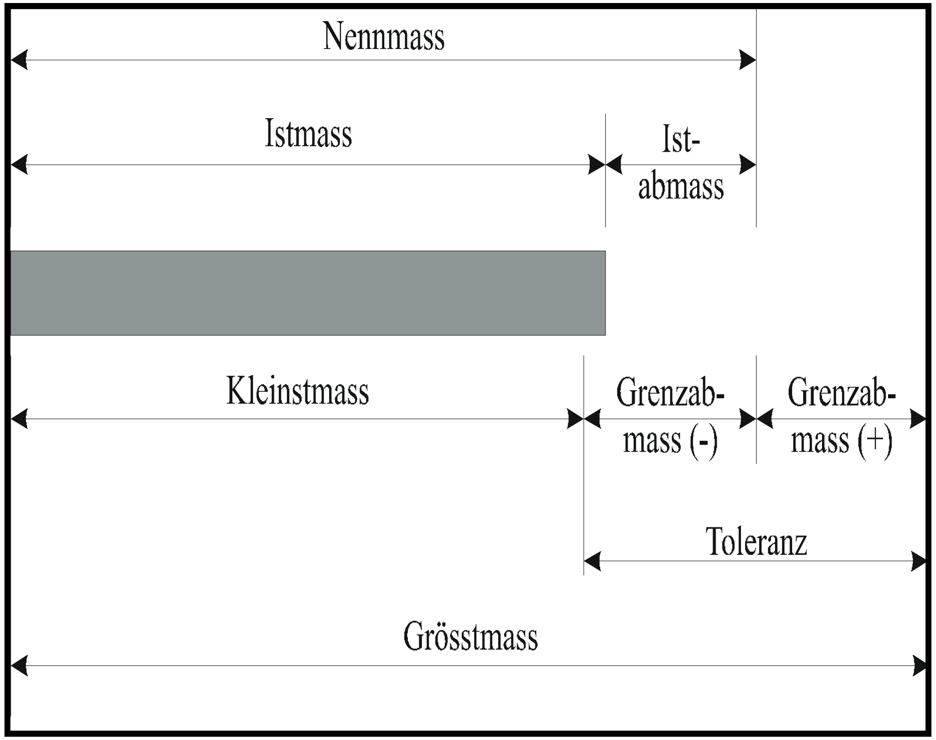
•Quality Requirements/Defintions of CE and ME

Tolerances

Tolerance propagation


Größtmaß
1620 + 12 = 1632
Nennmaß 1620
Kleinstmaß
1620 - 12 = 1608
Fensteröffnung:
Grenzabmaße ± 12 mm,
Maßtoleranz 24 mm
Größtmaß
1608 - (2 × 10) = 1588
10
gewählte Fugen-
breite: 10 mm
Kleinstmaß
1584 - 4 = 1580
Größtmaß
1584 + 4 = 1588
Fensterrahmen:
Grenzabmaße ± 4 mm
Maßtoleranz 8 mm

Toleranzen



Nennmass: Mass, das zur Kennzeichnung von Grösse, Gestalt und Lage eines Bauteils angegeben und in den Konstruktions- oder Bauplan eingetragen wird.

Istmass: Durch Messung festgestelltes Mass

Istabmas: Differenz zwischen Istmass und Nennmass

Grösstmass: Das grösste zulässige Mass

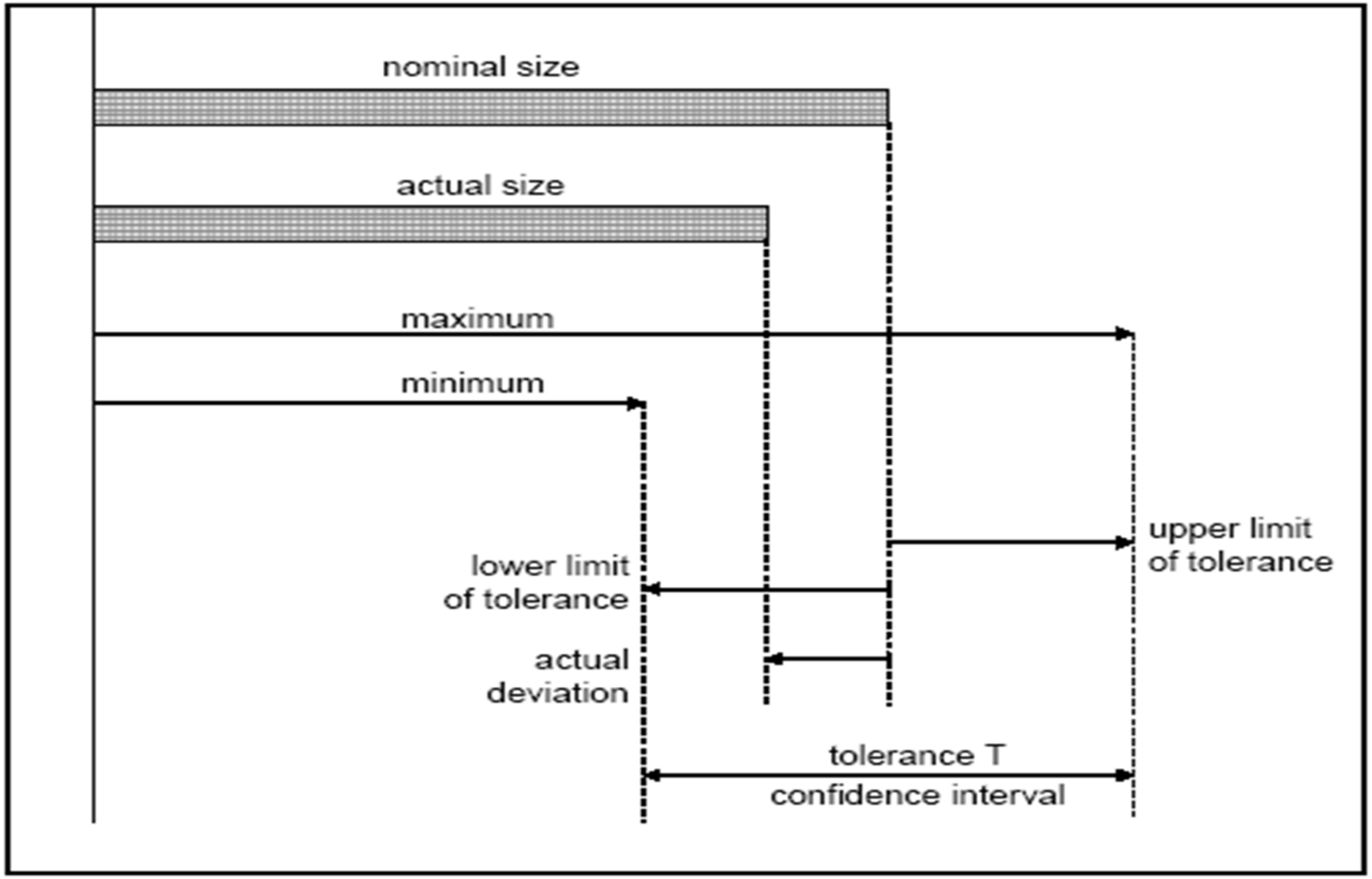
Kleinstmass: Das kleinste zulässige Mass

Grenzabmass: Differenz zwischen Grösst-mass und Nennmass oder Kleinstmass und Nennmass

Toleranz: Differenz zwischen Grösstmass und Kleinstmass

Tolerance (CE, ME)

Quality criteria in civil and machine engineering are tolerances.



$$T_g = \sqrt{T_1^2 + T_2^2 + \ \ldots \ + T_n^2}$$

quadratic Tolerance-chain (CE)

$$T_g = T_1 + T_2 + \ldots + T_n$$

Tolerance-chain (Mechanical Engineering)

Tolerance and Standard deviation

In general the tolerance T is composed of the components:

- T_p = production tolerance (Fertigungstoleranz)
- T_a = assembly tolerance (Montagetoleranz)
- T_s = surveying tolerance (Messtoleranz)

“Quadratic” Tolerance Propagation

$$T^2 = T_p^2 + T_a^2 + T_s^2$$

The relationship between surveying tolerance and tolerance is given in the following

$$T_S = T \cdot \sqrt{1-(1-p)^2} \; ;$$

where p denotes the probability of the surveying tolerance being off.

$$\sigma_S = \frac{T_S}{2 \cdot k} .$$

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Relation “Standard Deviation ←→ Tolerances

- If normal distribution is assumed and the significance level is chosen to 5 %, a common value for engineering tasks, the factor $k \approx 2$ is defined.

- A smaller significance level leads to a larger factor and therefore to a smaller standard deviation.

- as rule of thumb the portion p of the surveying tolerance of the whole tolerance is fixed to a third and significance level of 5 % or 0.3 % are chosen leading to a factor of $k = 2$ respectively $k = 3$. e.g. d = (17,282 +- 0.002)m (k=2)

- Thus the resulting ratio between tolerance and standard deviation is given by

  $\sigma_S \approx 0.2 \cdot T$ for $\alpha = 5\%$ and S $\sigma_S \approx 0.15 \cdot T$ for $\alpha = 0{,}3\%$.

- The exact relationship is defined in contracts between the civil engineer and surveyor and may refer to standards like DIN (1998), where e.g. a ratio of approximately 1:10 to 1:5 is defined.

Möhlenbrink et al 2006

http://www.geometh.ethz.ch/student/eg1/2006/01/Schwarz_DVW2004.pdf p.16

http://www.geometh.ethz.ch/student/eg1/

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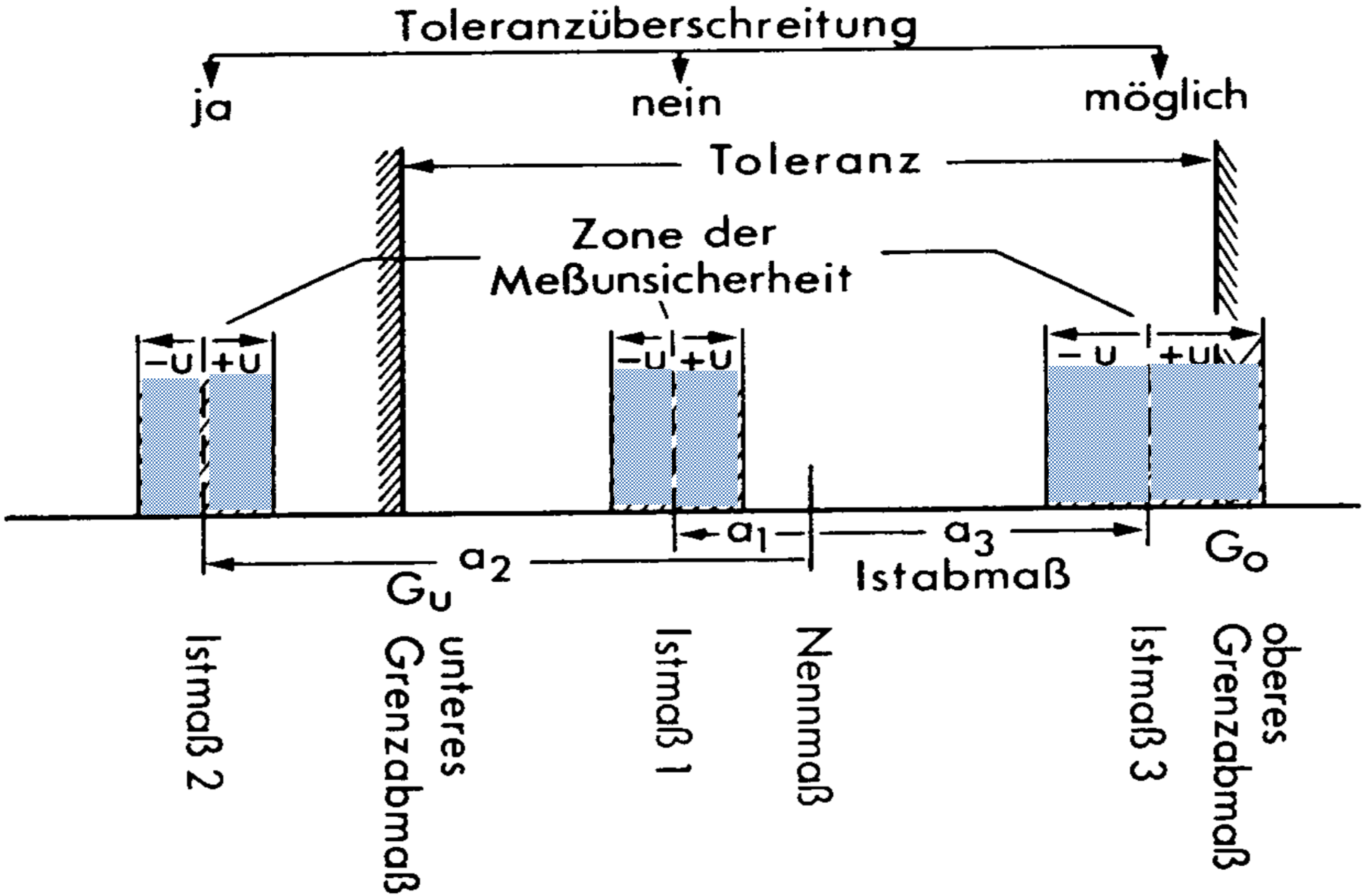
Uncertainty of Measurements

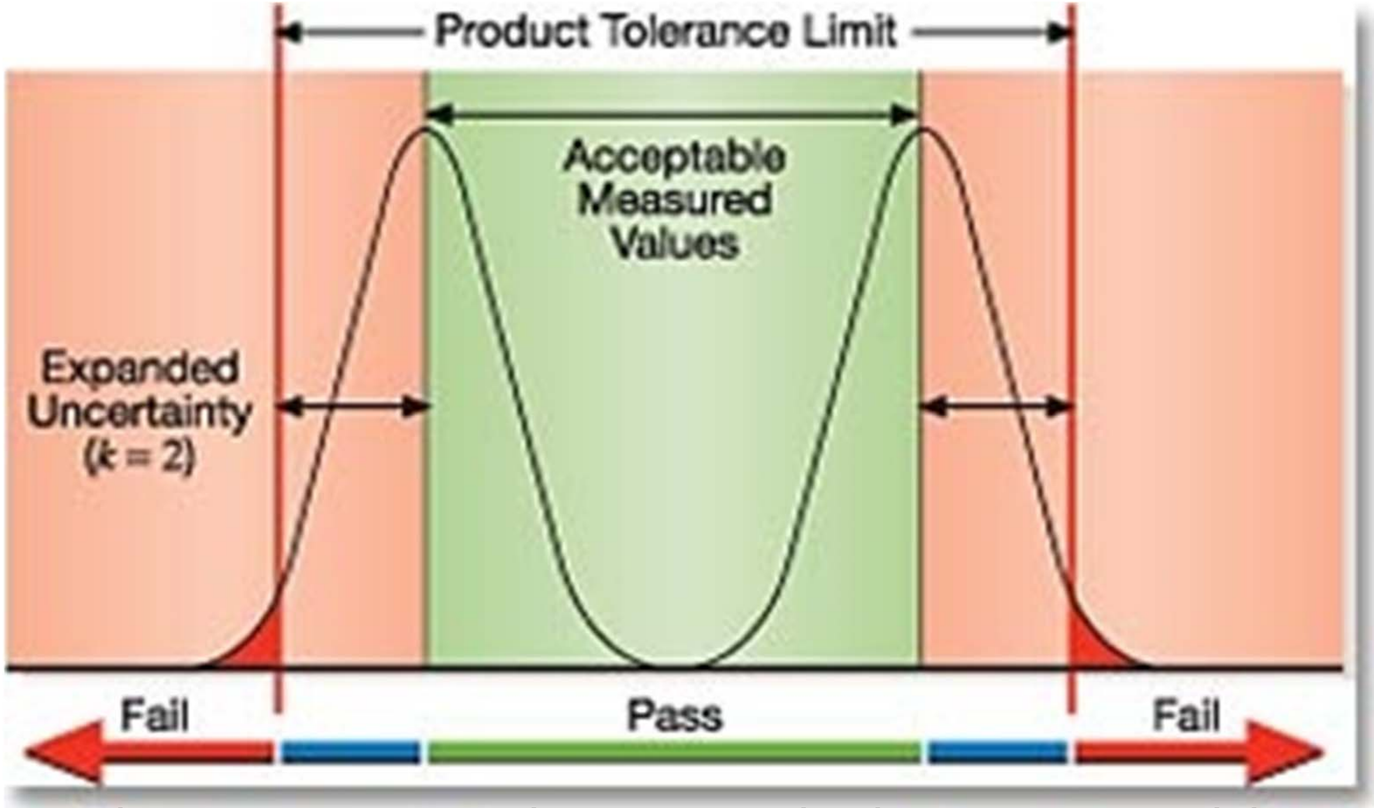
- http://physics.nist.gov/cuu/Uncertainty/basic.html

Checking Tolerances and „Uncertainty of Measurements“



Aus Witte
Schmidt

Expanded Uncertainty and Tolerance



For a product to pass a test, the measured value must exceed the tolerance and the expanded uncertainty (green area). The expanded uncertainty defines a confidence interval. Due to the confidence interval, products that are not acceptable will be taken as acceptable (solid red area) or indeterminate (blue).

http://oemagazine.com/fromTheMagazine/feb05/unce

Examples

Current Projects at Switzerland

- NEAT (project AlpTransit Gotthard) Gotthard Base Tunnel 57 Km , Lötschberg 37 Km, Ceneri, Zimmerberg, ...

  Zurich cross-city link (Durchmesserlinie Zürich incl. Weinbergtunnel)

- Falling rocks and landslides

  Randa, Falli Hölli, Heinzenberg, Cuolm da Vi, St. Moritz, Wäggital, Leventina, Campo, Lopper, Marmorea, Chapf, Eiger, Gurtnellen …

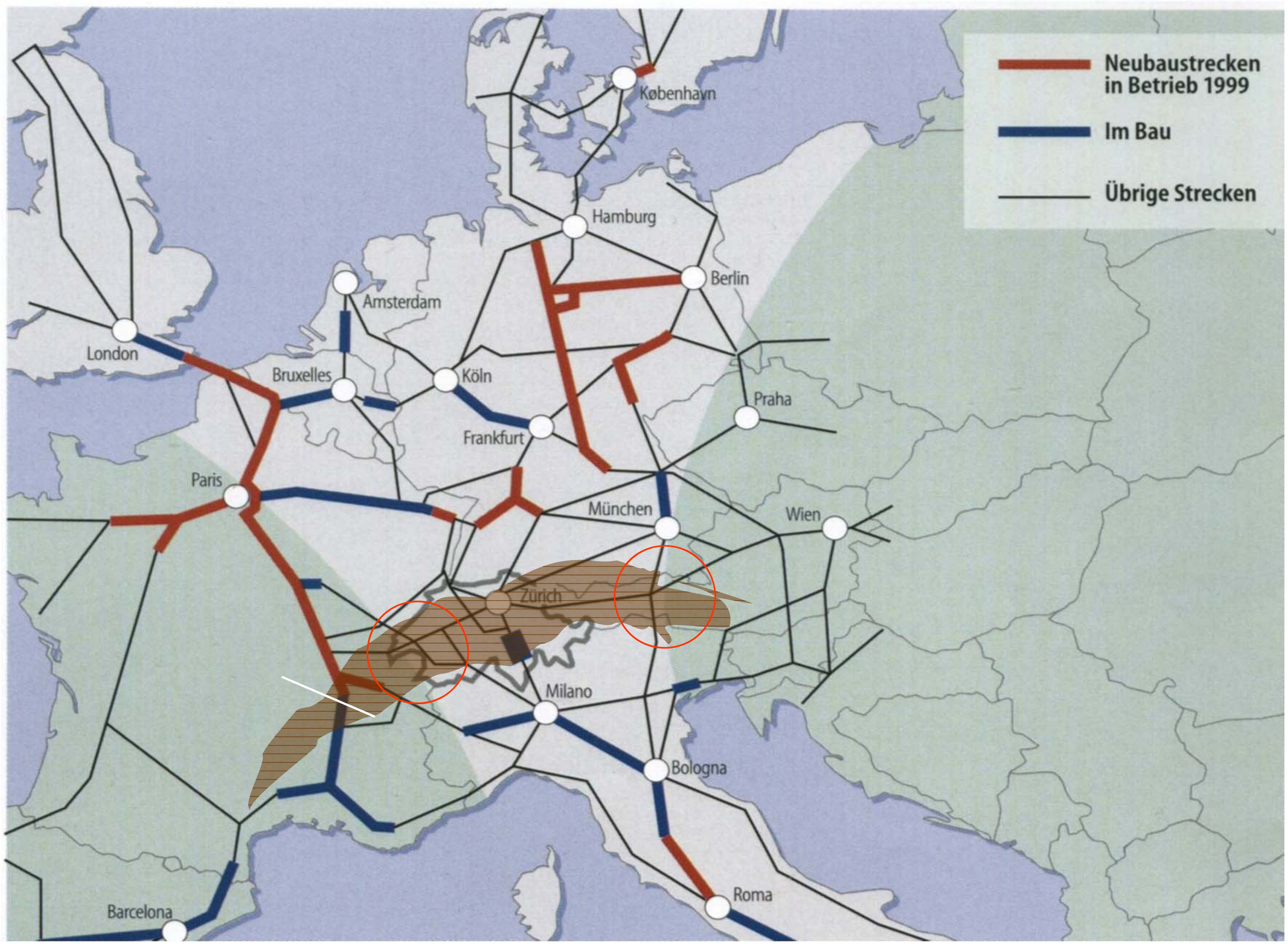
- Dam-Monitoring

  ca. 30 –40 Objects at Switzerland

- Accelerators

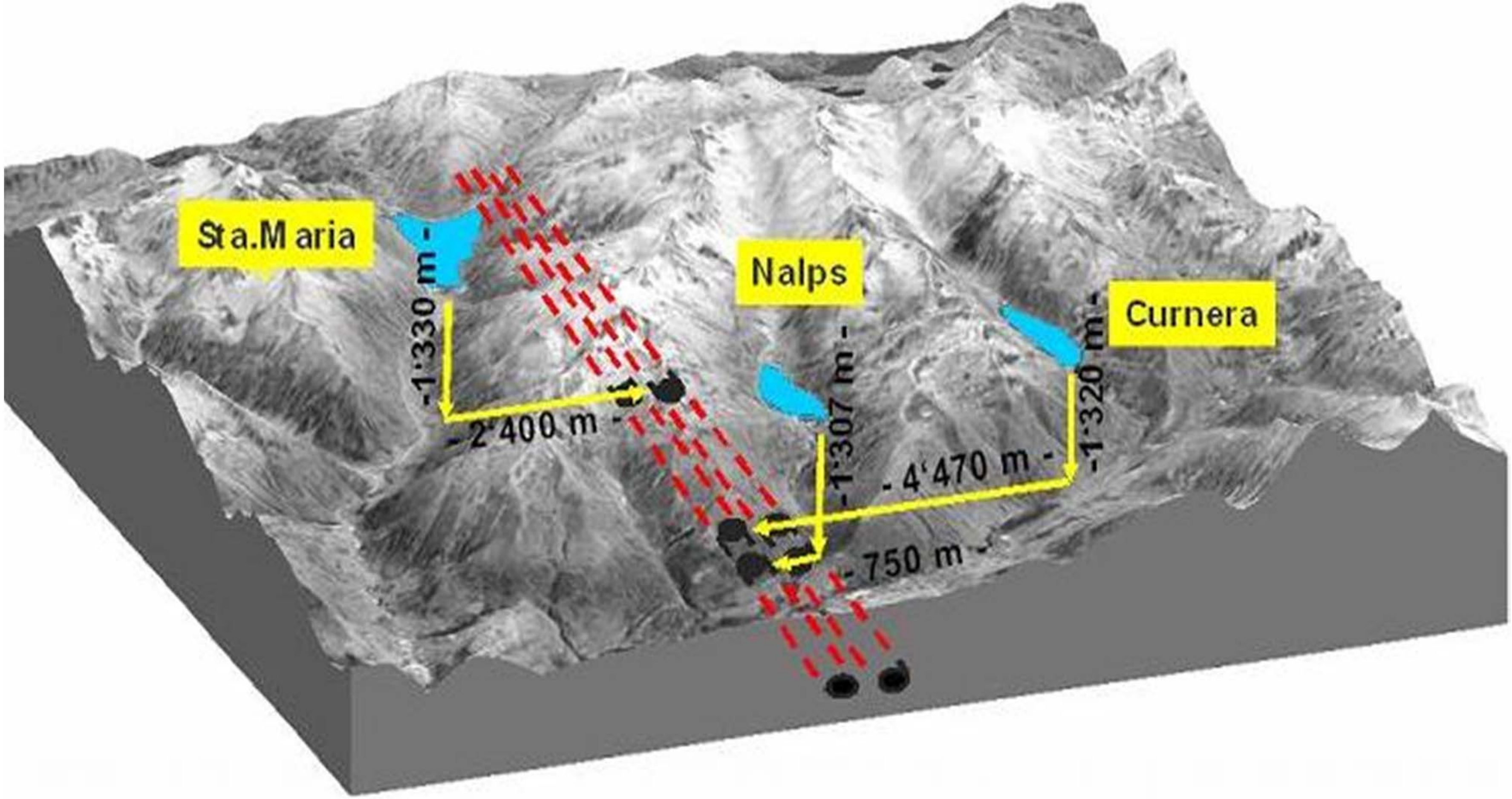
  CERN LHC, PSI (Neutron light source)

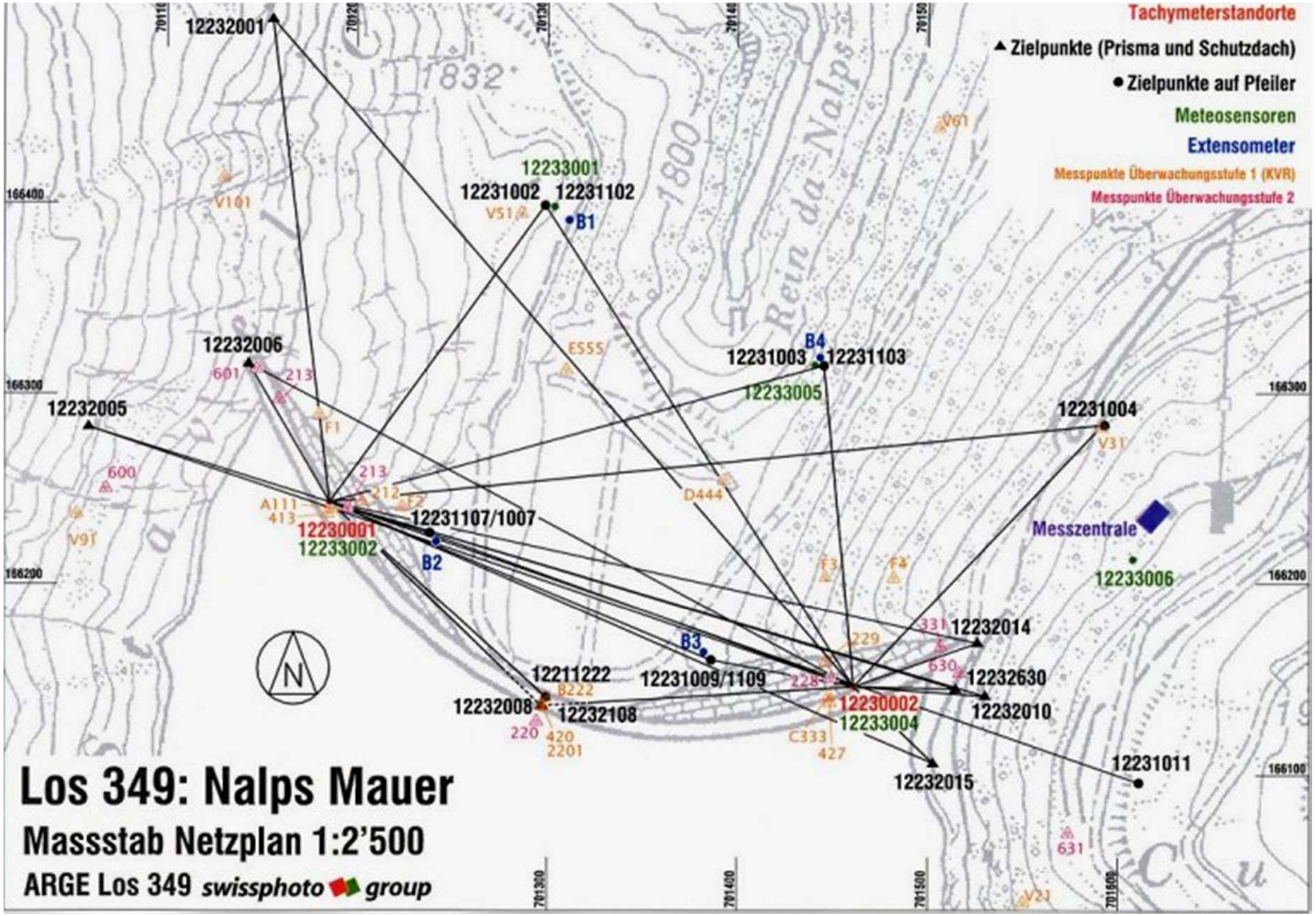
The European Railway Network




AlpTransit

Dams in the surrounding of the tunnel





Tachymeterstandorte
Zielpunkte (Prisma und Schutzdach)
Zielpunkte auf Pfeiler
Meteosensoren
Extensometer
Messpunkte Überwachungsstufe 1 (KVR)
Messpunkte Überwachungsstufe 2
12232001
12232006
12232005
12231002
12231102
12233001
B1
12231003
12231103
B4
12233005
12231004
12231107/1007
12230001
12233002
B2
B3
12231009/1109
12211222
12232008
12232108
12230002
12233004
12232014
12232630
12232010
12232015
12231011
Messzentrale
12233006
Rein da Nalps
Los 349: Nalps Mauer
Massstab Netzplan 1:2'500
ARGE Los 349 swissphoto group

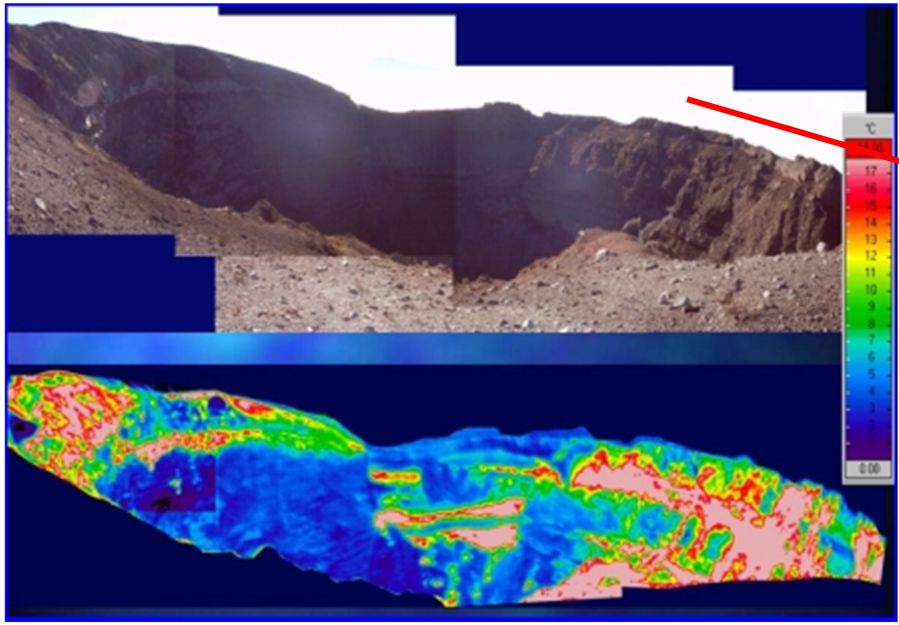
Total Stations installed on the Crest of the Dam

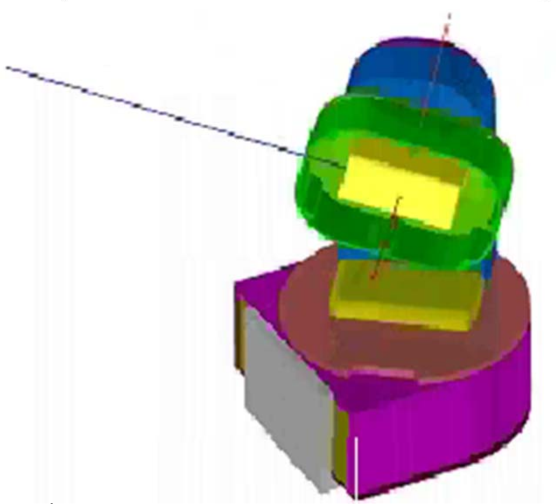
Photos: Swissphoto

Monitoring and Riskmanagement

Multisensor based Monitoring System for Disaster Prevention

MUMOSY





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KTI CTI

Worldwide Engineering projects

- Jütland Seeland; Denmark Sweden (Öresund) (finished)
- Eurotunnel (finished) , Bosporous Tunnel
- Elbetunnel (finished)
- Yangtse project (China)

- Planned Projects:

Brenner-Base Tunnel, Semmering Base Tunnel (2007–2011)

NEAT AlpTransit (under construction)

Gibraltarbridge

Messinabridge

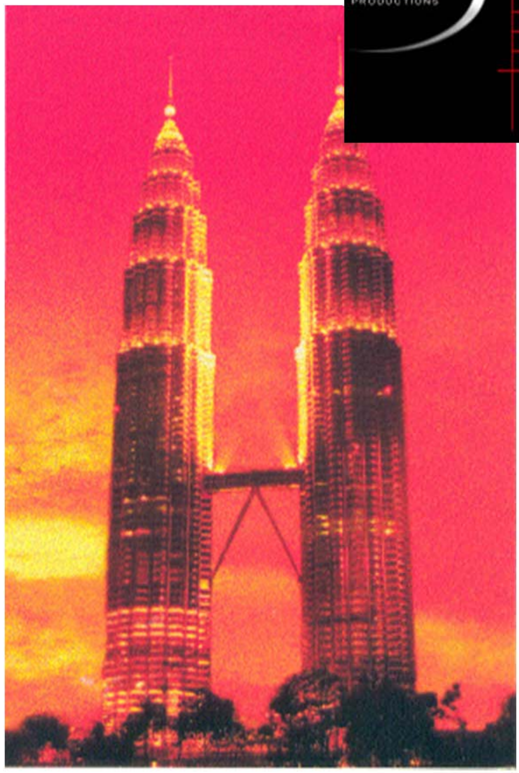
Swissmetro

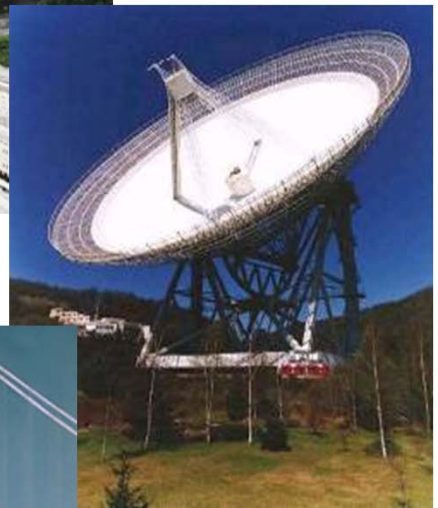
High Speed Trains (new track technologies)

Transrapid (D, China, Maglev (J), Swissmetro (CH))

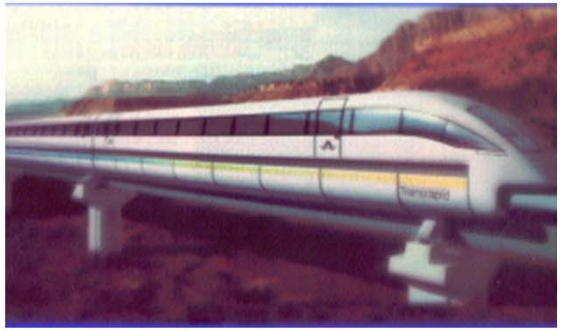
………….

Examples: Engineering Projects

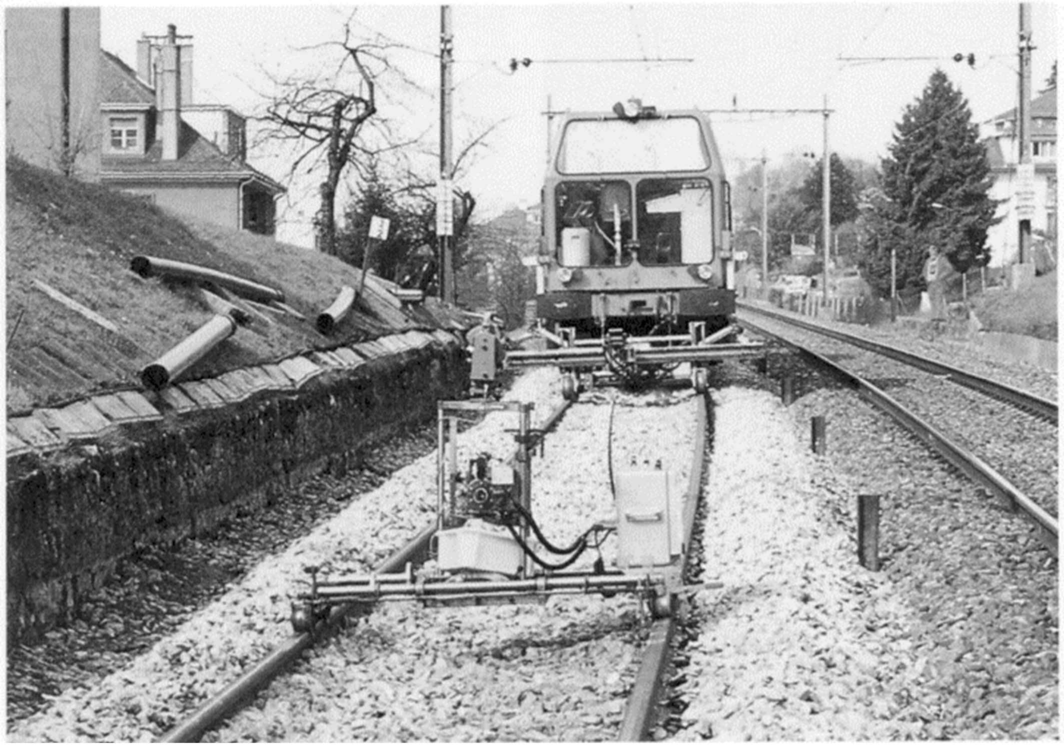




Trains:Transrapid,Swissmetro,Maglev



Railway-Geodesy

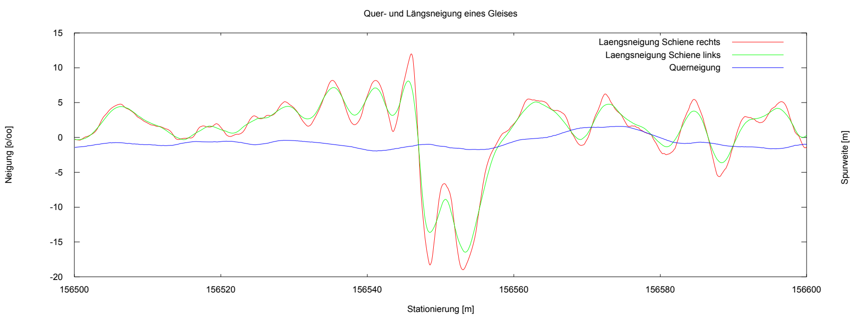


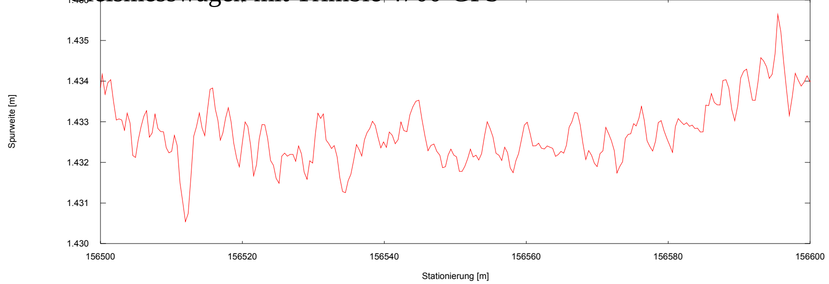
Kinnematic track surveying by means of a multi-sensor platform

The increasing use of modern high-speed trains requires increasing safety standards and, consequently, accurate railway tracks. Traditional methods for track surveying do not any longer satisfy economic aspects. For these reasons, HTA Burgdorf developed a track surveying platform in co-operation with terra vermessungen AG, Switzerland.

Tachymeter beim automatischen Verfolgen des Messwagens

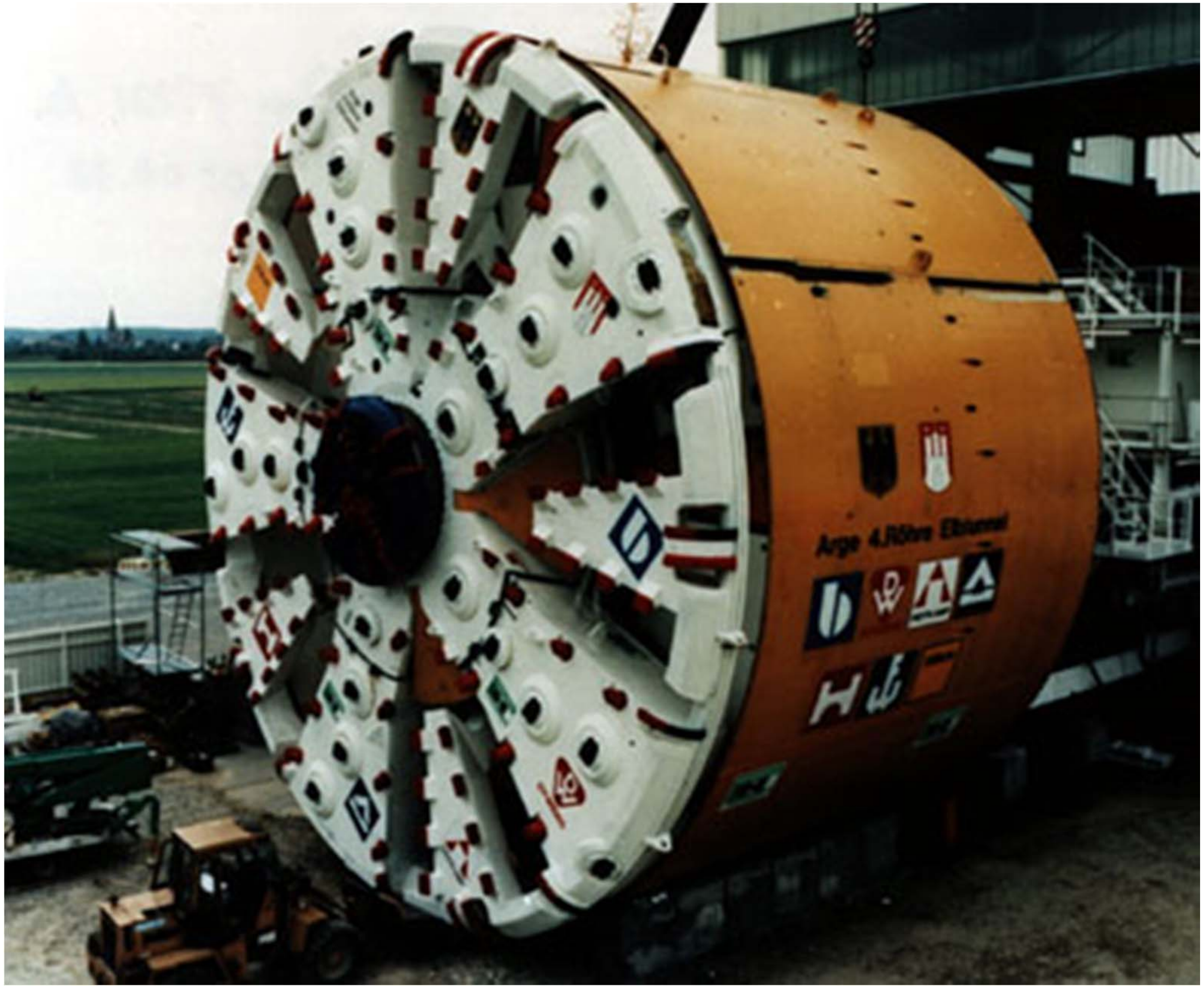
Gleismesswagen mit Trimble 4700-GPS






LEONHARD WEISS

TBM (Tunnel boring machine)



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Example: Deformation Measurements Cuolm da Vi (GR)

Example: Great Belt (Grosser Belt)

The Great Belt is 60 kilometers long and 16-32 km. wide. Bridge for rail and cars since 1997

Examples: Great Belt (1997) and Oeresund (2000)

Example: Tejo Bridge

Bridges

			[m]
Saint-Nazaire	F	1975	404
Barrios de Luna	E	1983	440
Skornsund	N	1992	530
Yang-Pu	China	1993	602
Normandie	F	1994	856
Tatara	JP	im Bau	890

			[m]
Brooklyn	USA	1883	486
Golden Gate	USA	1937	1281
Humber	GB	1981	1410
Grosser-Belt	DK	1998	1642
Akashi	JP	1998	1990
Messina	I	?	3300
Gibraltar	E	?	5000

Example: Bridge across the Aare

Example: Structural Monitoring of the Church in St. Moritz

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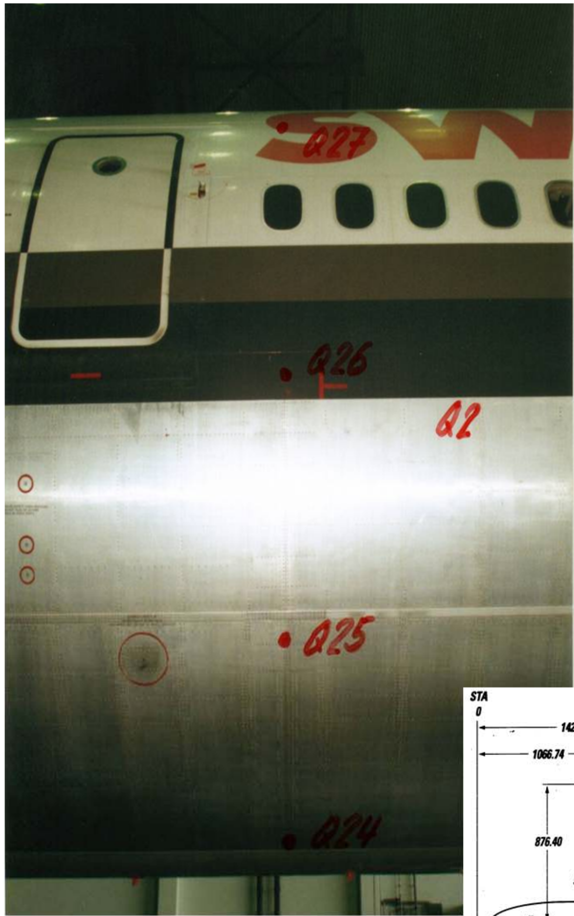
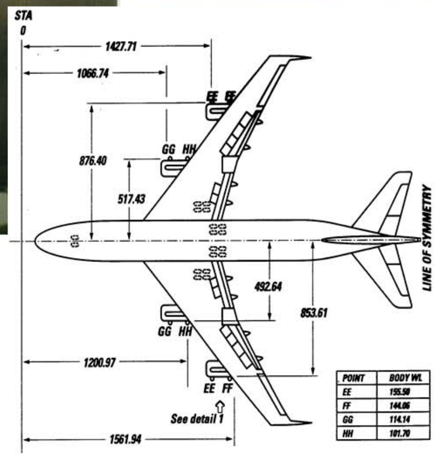
Industrial Metrology: Surveying of Aircrafts





POINT	BODY WL
EE	155.50
FF	144.06
GG	114.14
HH	101.70

Location of engine alignment points

Example: Science Laboratories (CERN, PSI, HERA;..)

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End