Methods for High Precision Deformation Analysis

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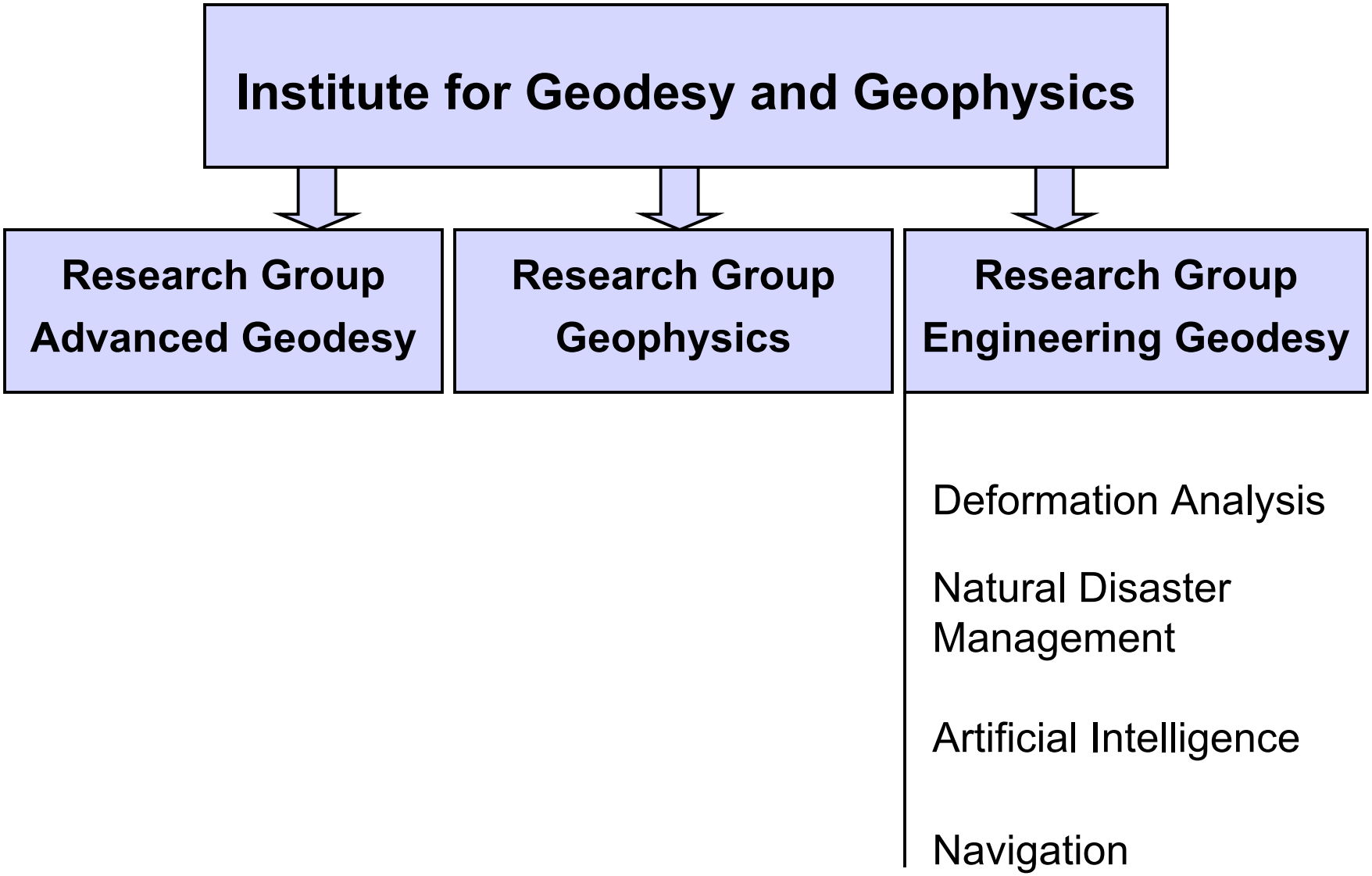
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Deformation Analysis
Natural Disaster Management
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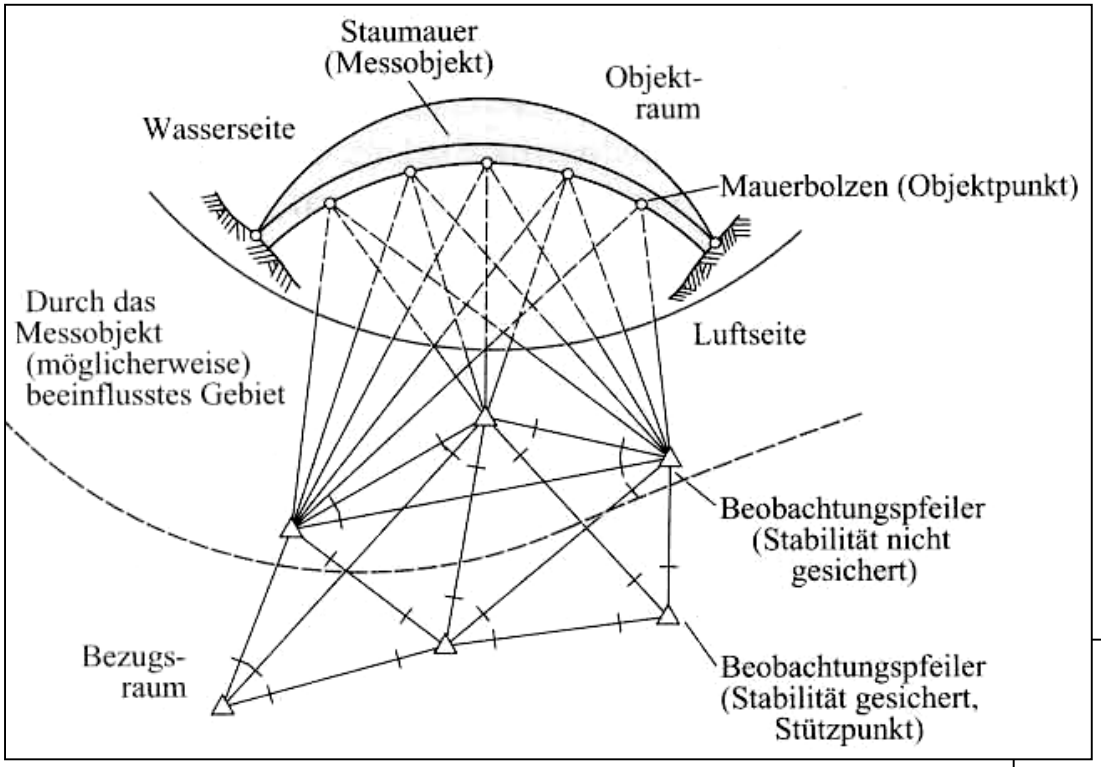
Deformation Analysis

- **Aims:** Monitoring / Modelling of rigid body movements and deformations of artificial and natural structures
- **Typical objects:** bridges, dams, tunnels, industry, etc.

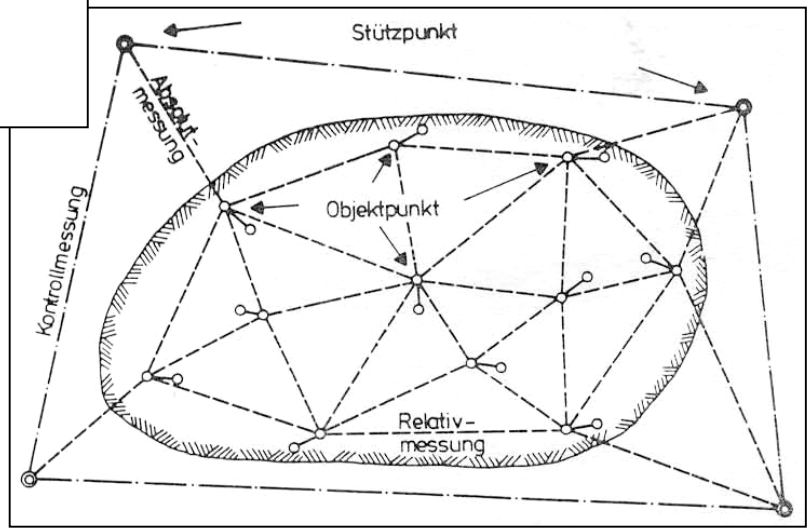
  => Local scale (range: sub-mm to km)

  => Local deformation networks with precise centering of prisms
- **Deformation range:** typical sub-mm to mm
- **Physical range:** Static or dynamic deformations
- **Influence quantities:** temperature, wind, tides, traffic, etc.
- **Observation periods:** < 1 sec up to years
- **Deformation periods:** < 1/100 sec up to months or years
- **Measurement frequency:** > 10^3 Hz up to 10^-8 Hz

Basic principle of a deformation network



Ref.: Welsch/Heunecke/Kuhlmann 2000



Ref.: Pelzer 1985

Sensors for deformation measurements (examples)

Outdoor and Indoor

Tacheometers

Precision:

Distance (1mm + 1ppm)

Angle (0,2 – 0,5 mgon)

Meas. frequency:

up to 0,2 Hz (Standard)

up to 10 Hz (Tracking)

Full-automatic

High inner accuracy

Precise Levelling

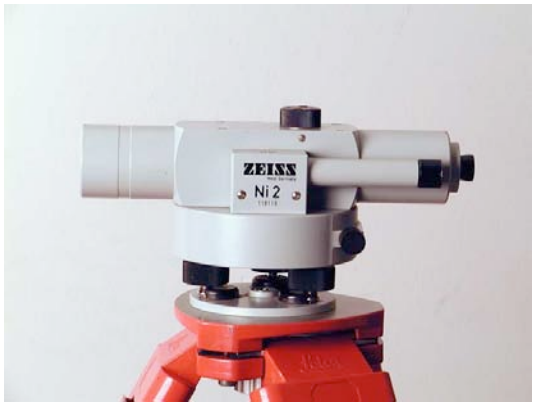
Precision:

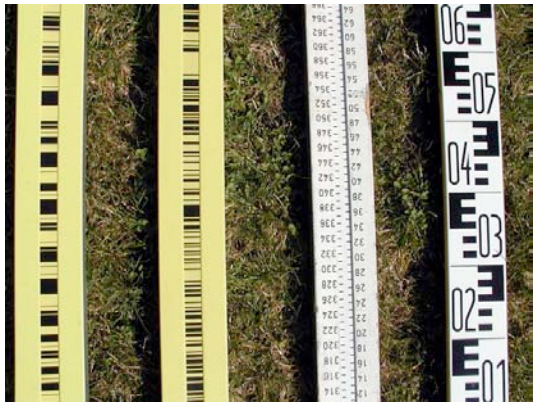
up to 0,3 mm / km levelling

Meas. frequency:

Periodical (days, weeks, ...)

Semi-automatic





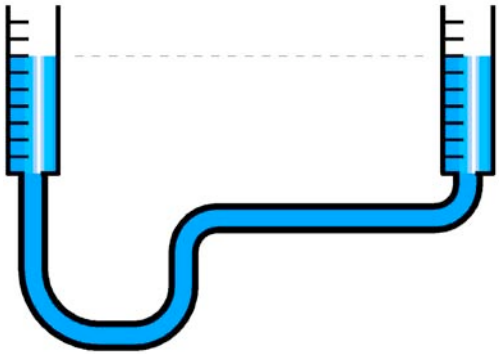
Hydrostatic Levelling

Precision:

up to 0,01 mm

Restricted measurement range (dm)

Full-automatic



Electronical levels

Precision:

up to 0,1 mgon => 1/100 mm per 10 m

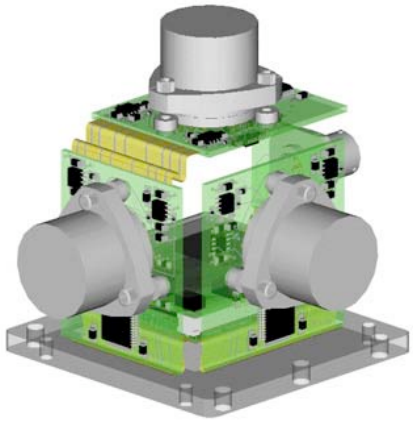
Meas. frequency:

> 100 Hz

Full-automatic

Restricted measurement range

Disturbances by accelerations



Strain gauge

Precision:

better 1 % of meas. range

Meas. frequency:

up to Mhz

Full-automatic

Restricted measurement range (< 1 mm)

Laser tracker

Precision:

up to 10 ppm between tracker and target (1/10 mm per 10 m, static)

Meas. frequency:

up to 1000 Hz

Full-automatic

Restricted measurement range (up to 40 m)

Interferometric (relative) measurements

Example for deformations in a building

Viennese theatre ‘Ronacher’ was founded in 1871

Since 1987 part of ‘Vereinigte Bühnen Wien’ (association of 3 theatres)

Serves for presentation of musicals

Theatre is a listed building

Increasing number of spectators requires a complete rehabilitation:

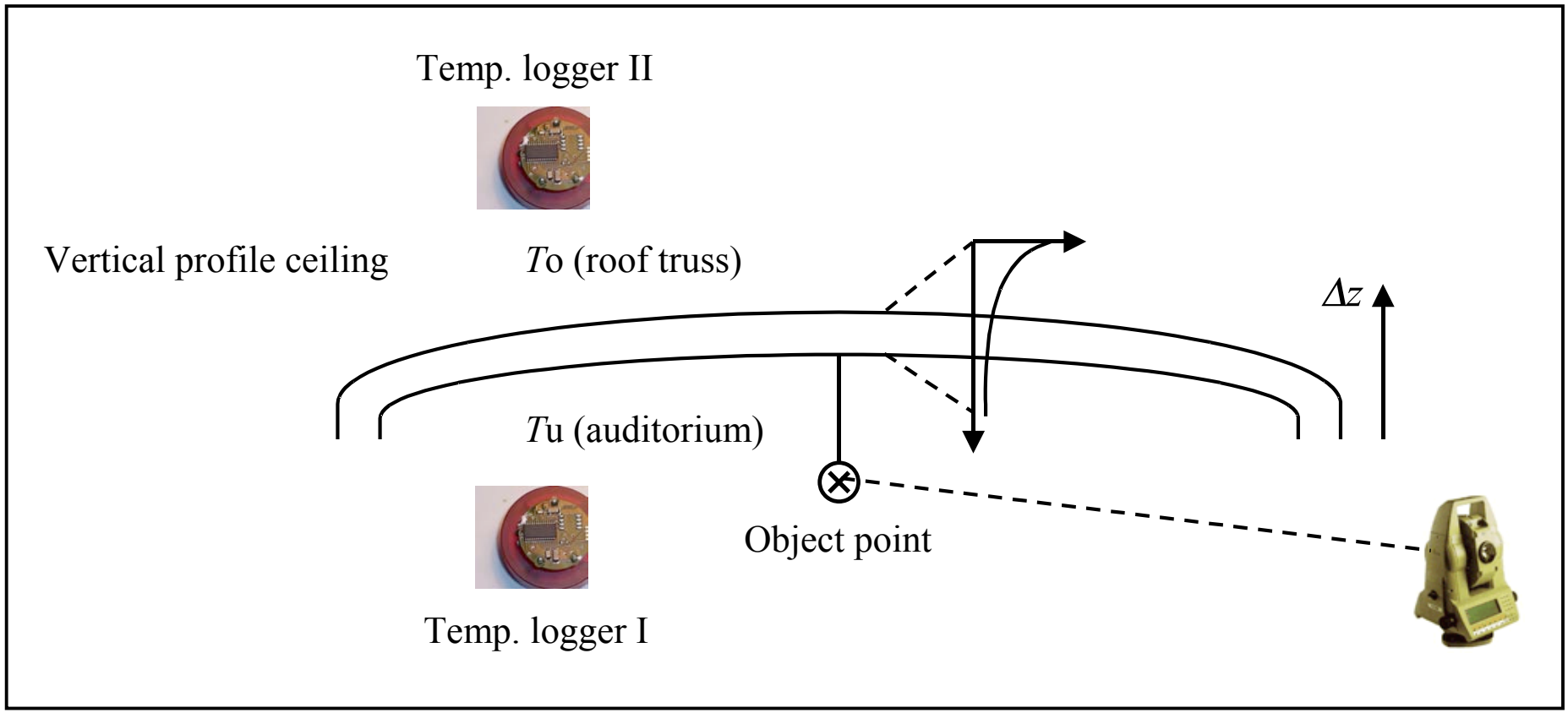
- Improvement of auditorium
- Extension stage and orchestra pit
- New rooms for practising and a cafeteria on the top of the building

=> massive reconstruction of the theatre ceiling required

Input:

First trigger: mechanical loads during construction process ; in most cases only imprecise info

Second trigger: thermal influences ; monitoring data available



Vertical displacements *dz* of O1 to O4
(Cut-out: May to Oct. 2006)

Deformation ranges:

Rigid body movements
up to 10 mm

Mechanical deformations
up to 1 mm

Thermal deformations
short-term: up to 0.4 mm
long-term: up to 3 mm