

Height Systems for 3D Cadastral

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Introduction

- Introduction
- Quality requirements for 3D-cadastrals
- Relative or absolute?
- Definition of height
- Determination of height
- Discussion and conclusions

Introduction

- 3D systems require a vertical component – it is typically assumed it is there and it is unambiguous
- Cadastres are designed to exist for centuries – movement of the earth must not affect the system
- No simple solutions for height e.g., physical vs. geometrical

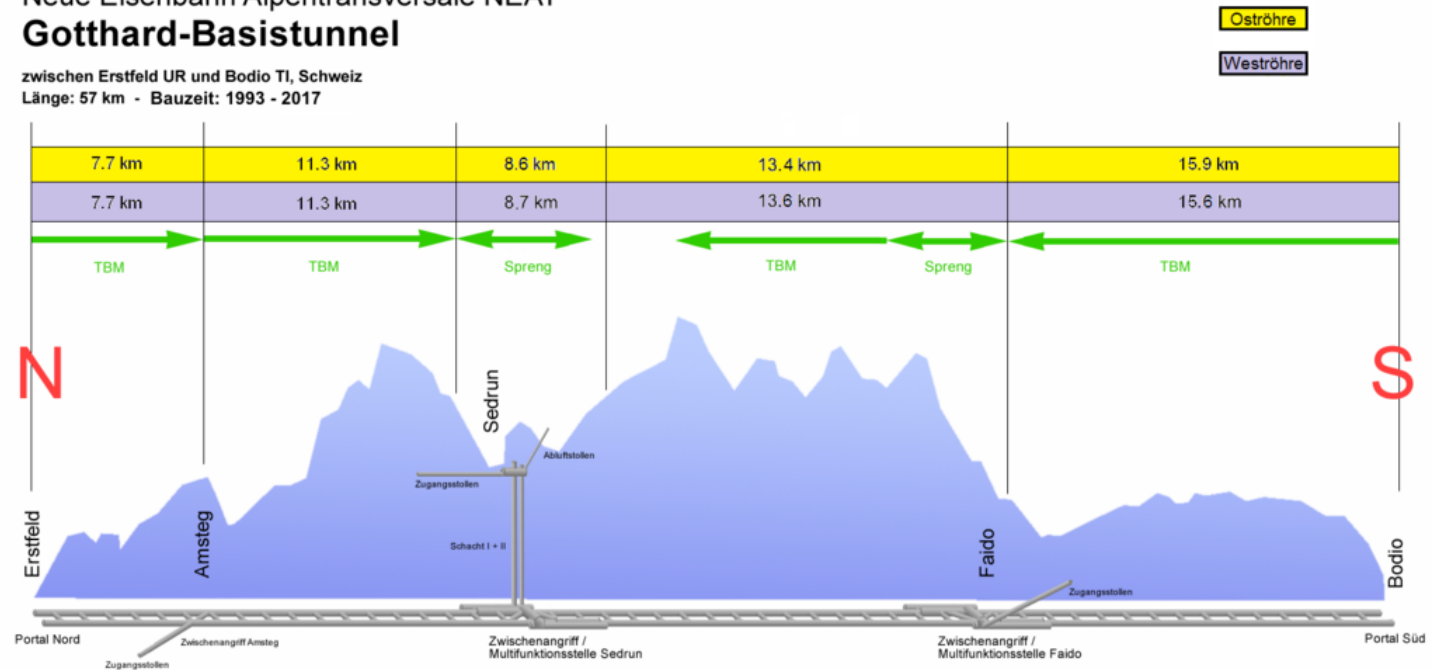
Quality Requirements (1)

Tunnel deep below: Knowledge of existence

Neue Eisenbahn Alpentransversale NEAT Gotthard-Basistunnel

zwischen Erstfeld UR und Bodio TI, Schweiz
Länge: 57 km - Bauzeit: 1993 - 2017

Stand: 13. Dezember 2009



Gotthard-Tunnel (Wikipedia)

Quality Requirements (2)

Tunnel near Surface: Construction work may damage tunnel

→ meter must be guaranteed

→ standard deviation of 16cm for $3\sigma = 0.5\text{m}$



Tunnel Losenstein (Hackl)

Quality Requirements (3)

Construction above public space

Clearances must be met

Lawyers do not consider quality of definition or measurement



FH Technikum Wien (Schwerlastforum)

Quality Requirements (4)

Ownership of apartment – border must lie within the ceiling

Ceiling thickness of ~30cm → Vertical accuracy of 5cm required

Otherwise boundary located a few cm above the floor ... carpet owned by neighbor?

Relative or Absolute

- **Absolute heights:** In relation to geoid or ellipsoid
What if the land itself is rising or falling?
e.g., Scandinavia
- **Relative heights:** In relation to surface
(e.g., 5m above the ground)
Ordering units possible: The apartment in the 3rd floor
But: Creative interpretation of law?

Definition of Height

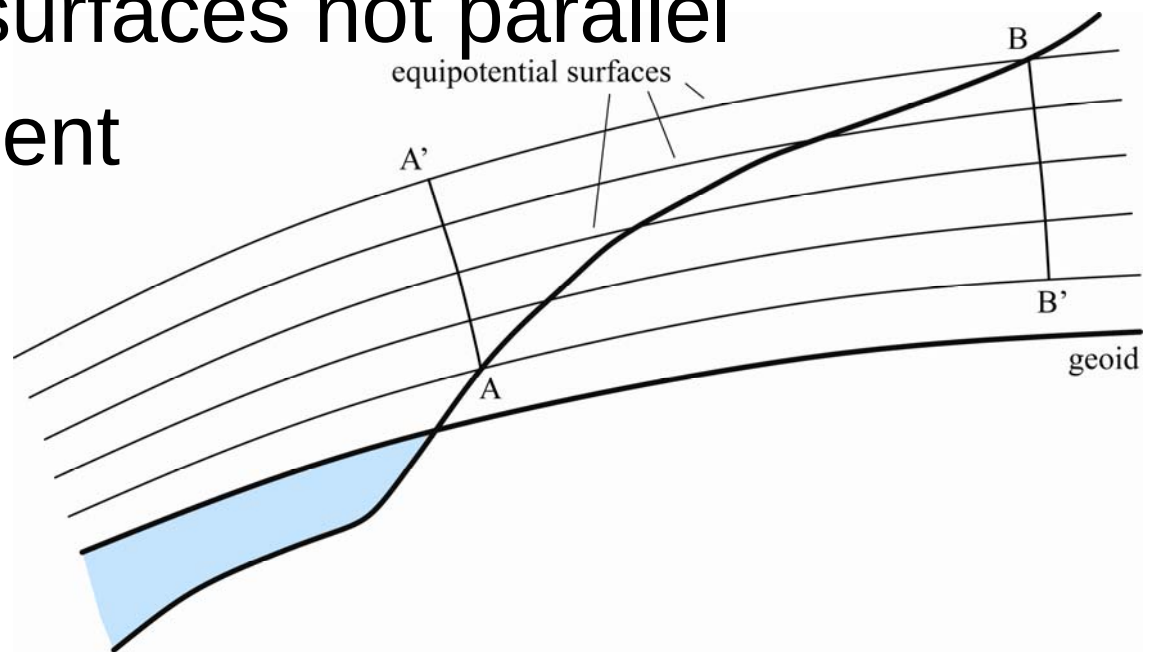
- **Physical definition:** Equipotential surface
- **Geometrical definition:** Length of a line (plumb line or surface normal)

Practical requirements:

- Easy to determine
- Independent of path
- Small corrections for observed values
- Free of hypothesis
- Physically meaningful
- Geometrically determined

Problem of Height Definition

- Plumb lines not straight
 - Plumb lines not parallel
 - Equipotential surfaces not parallel
- ➔ Not independent of path



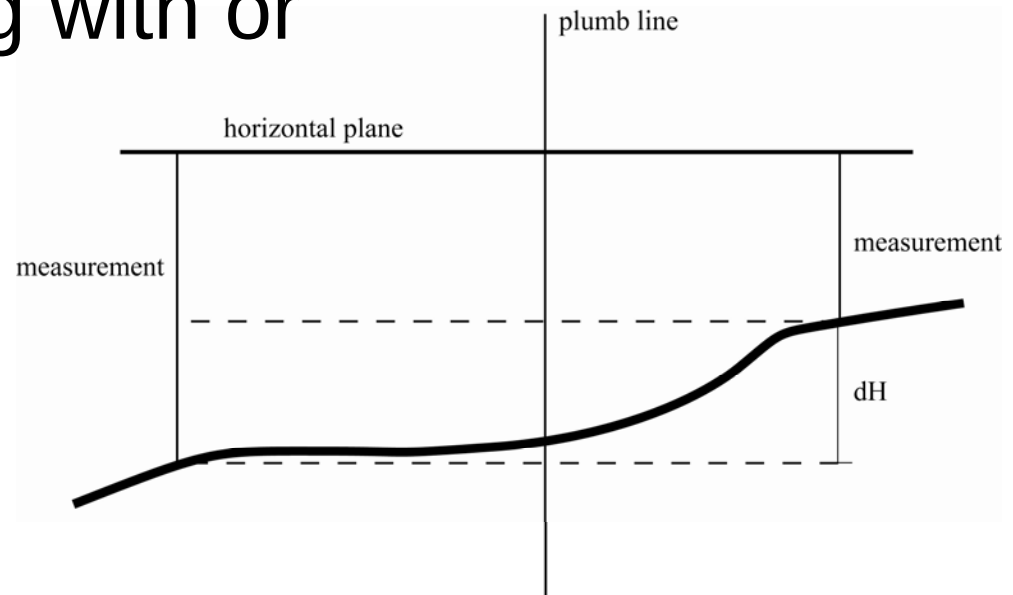
Height Systems

- **Geopotential height:** physically meaningful
- **Dynamic height:** Geopotential height divided by normal gravity
- **Orthometric height:** Geopotential height divided by average gravity in location
- **Normal height:** Distance in theoretical gravity field
- **Ellipsoidal height:** Length of surface normal of ellipsoid

Height Determination

Geometrical levelling with or
without gravity
observation

GPS for ellipsoidal
height – tunnels?



Conversion accuracy approx. 10cm

Discussion

- Varying quality demands
- Relative heights seems to be a practical solution but there are some problems
 - What if terrain changes?
 - Graphical representation may look strange if the terrain is flattened
- Absolute heights are problematic if there are vertical movements

Conclusions

- There is not THE BEST system
- A 3D cadastre may have to incorporate different systems depending on the objects – e.g., floor levels for ownership of apartment
- Answers may depend on the topology of the country (Netherlands vs. Peru)