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# RAILWAY GEODESY: THE BENEFITS OF USING A MULTI-DISCIPLINE APPROACH FOR THE ASSESSMENT OF TRACK ALIGNMENT DURING CONSTRUCTION

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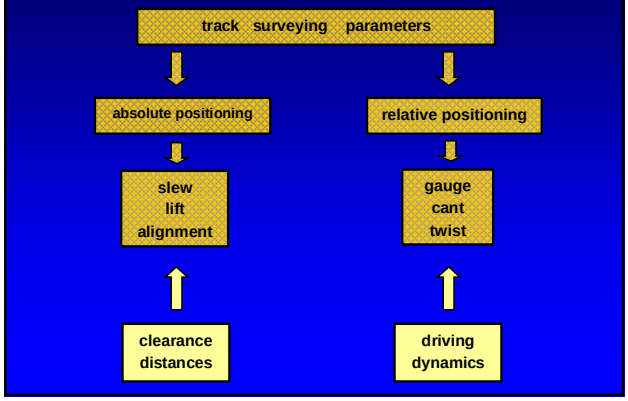
## Classification of track surveying parameters

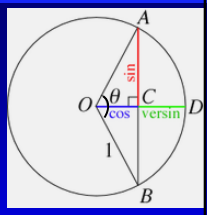



## Measures of track alignment

**definition:**

$$\text{versine}\left(\frac{\theta}{2}\right) = 1 - \cos\left(\frac{\theta}{2}\right)$$

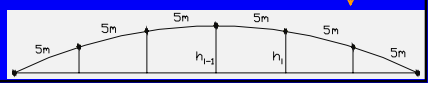
| straight line | arc of circle | clothoid |
|---|---|---|
| 0 | $R\left(1-\cos\left(\frac{S}{2R}\right)\right)$ | $\frac{A^2}{L}\left(1-\cos\left(\frac{SL}{2A^2}\right)\right)$ |




**specifications:**

$$\delta h = h_i^m - h_i^d$$

$$\delta\delta h_i = \left|\left(h_i^m - h_i^c\right) - \left(h_{i-1}^m - h_{i-1}^c\right)\right|$$




## Tolerance specifications for track surveying parameters

| | parameter | | high speed trains | LRT & tram |
|---|---|---|---|---|
| absolute | slew | | ± 10 mm | ± 20 - 30 mm |
| | lift | | ± 10 mm | ± 20 - 30 mm |
| | track alignment | δh | ± 3 mm | ± 4 mm / R>300m ↓ ± 10 mm / R<60m |
| | | δδh | ± 2 mm / 5 m, ± 10 mm / 150 m | ± 6 mm / 5 m |
| relative | track gauge | | -1 mm / +2 mm | -1 mm / +2mm |
| | cant | | ±2 mm | ±3 - 4 mm |

## The Athens light rail project

➢ **project details**

- 26 km of double track
- planning & construction time 30 m
- budget ~ 300 million euros

➢ **critical design values**

- min radius of horizontal curve: 25 m
- max longitudinal inclination: 6%
- max superelevation: 150 mm

## The Athens LRT project: construction stages

**Phase A ⇒ geodetic networks**

- GPS & precise leveling control network
- 28 stations (~1 km / <10 mm)
- 68 repères (~0,4 km / <2 mm)

**Phase B ⇒ rail laying on site**

- reference point establishment (35-50 m / ~0,4 mm)
- track laying & alignment GSF units

## The Athens LRT project: construction stages

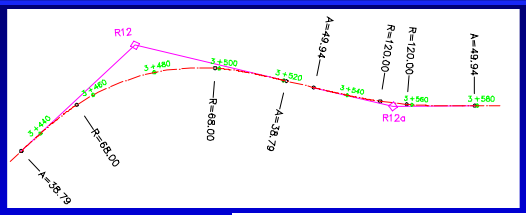
**Phase C ⇒ pre-concreting geodetic QC**
- rail marking & surveying
- track surveying parameter computation

**Phase D ⇒ concreting on the site**

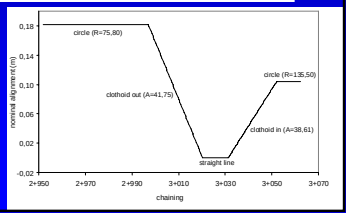
**Phase E ⇒ post-concreting geodetic QC**

**Phase F ⇒ run the line with a track surveying vehicle**
- GSF units removal
- run the line with a trv
- track surveying parameter computation

## The Athens LRT project: example data

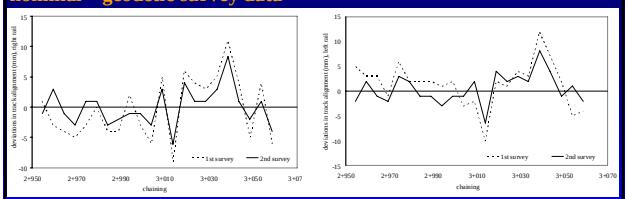



**nominal alignment** ⟶
- track length 120 m
- mixture of geometric elements
- small track radius

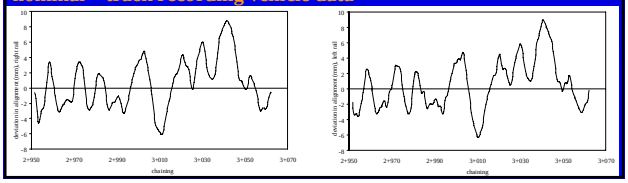



## The Athens LRT project: track alignment results

**nominal – geodetic survey data**

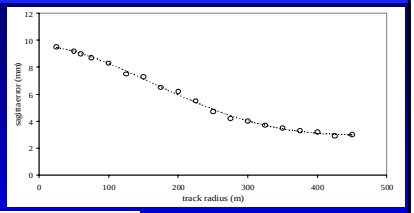


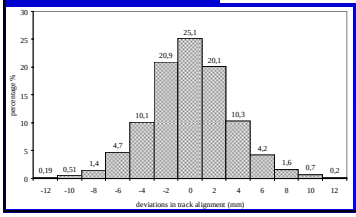

**nominal – track recording vehicle data**




## The Athens LRT project: track alignment statistics

**maximum deviations of track alignment vs. track radius**




**distribution of track alignment deviations**

## Precise track surveying system

➢ **absolute positioning**
- GPS/RTK
- tracking tacheometer
- odometer

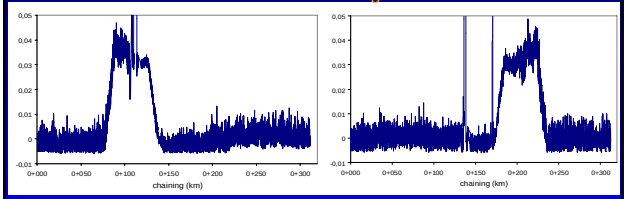
➢ **relative positioning**
- inclinometer
- gauge measuring system

➢ **platform vehicle**
- KRAB trolley
- accompanying sensors

## Precise track surveying system – preliminary results

**track alignment: tracking EDM data**

**- left rail** **- right rail**




**track alignment, left rail: track recording vehicle – tracking EDM**