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SLR Tracking of GNSS Constellations

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ACCURATE GEOID UNDULATION DETERMINATION ALONG A 100 km LONG RAILWAY TRAVERSE IN CENTRAL GREECE: PRELIMINARY RESULTS AND VALIDATION

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Key objectives and working principle

diploma thesis key objectives

- to setup, test and validate a multi-sensor system for kinematic surveying applications
- to perform a two-way survey of a railway line (100 km) in order to extract rail track axis geometry
- to compute the geoid separation profile along the railway traverse and το attempt a cross-validation against GGMs

working principle

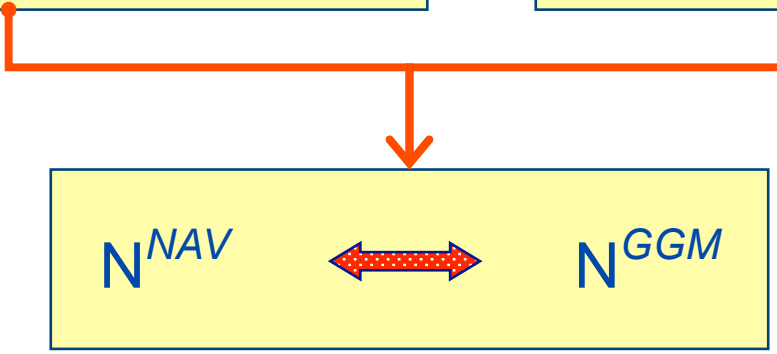
$N^{NAV} = h - H$

H : orthometric heights (*from as-built plans*)

h : ellipsoidal heights (*kinematic survey*)

N^{GGM}

(EGM96 & EGM08)



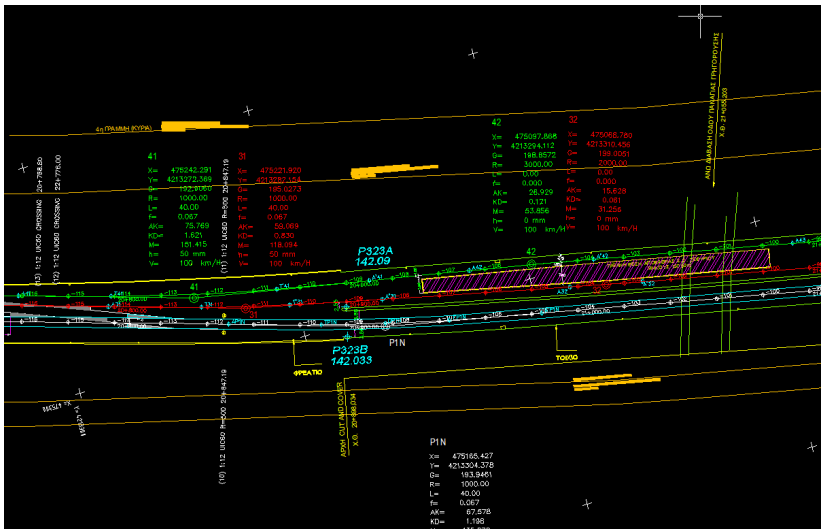
Orthometric heights computation

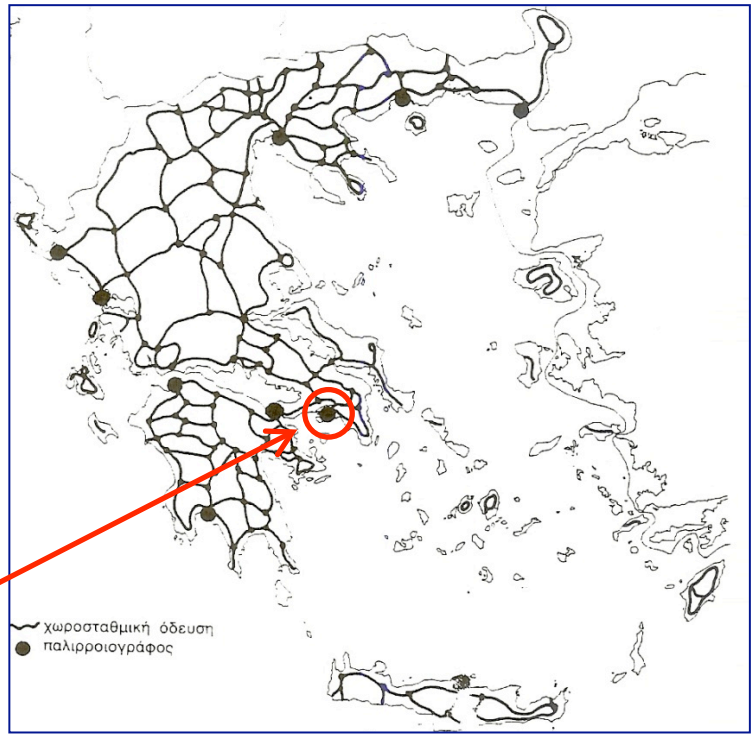
Hellenic Vertical Datum (HVD)

- the official height system is Helmert orthometric heights
- “precise heights” are provided by the adjustment of the 1st and 2nd order leveling networks
- the reference surface of the HVD is given by the MSL (1933-1978) at the port of Pireaus

orthometric heights of the railway traverse

- along the railway track orthometric heights are provided at 20 m intervals
- observed heights refer to the top of the lower rail track
- the railway track was surveyed after construction by spirit leveling techniques in loops closed traverses

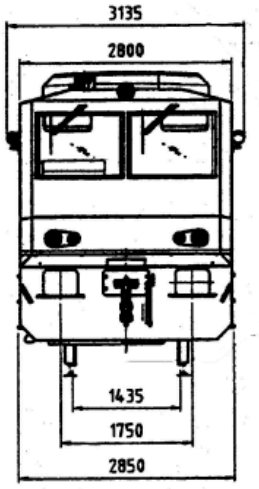


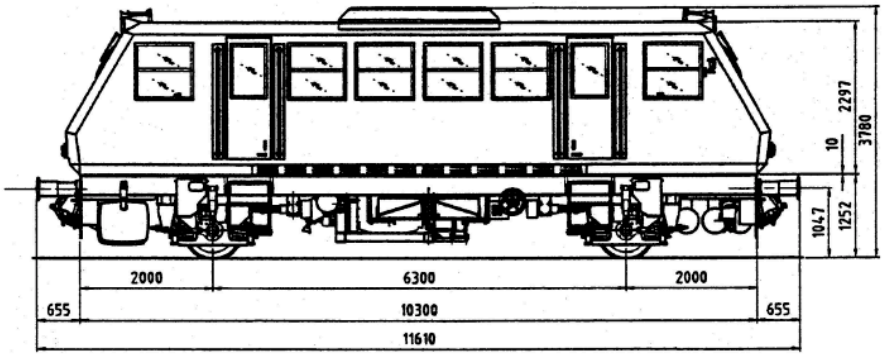


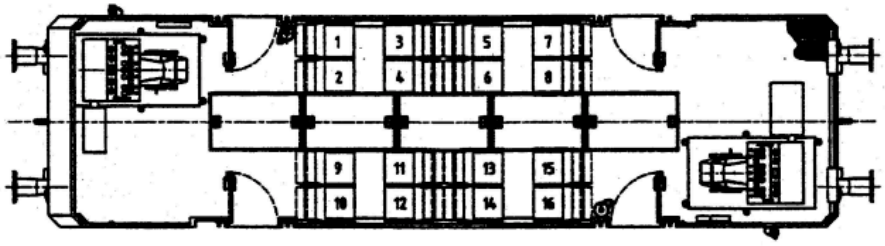
Multi-sensor kinematic surveying system: recording vehicle

rail track recording vehicle

- railway diesel coach provided by the Hellenic Railways Organization
- dimensions (11.5 × 3 × 4) m
- max operating speed 100 km/h

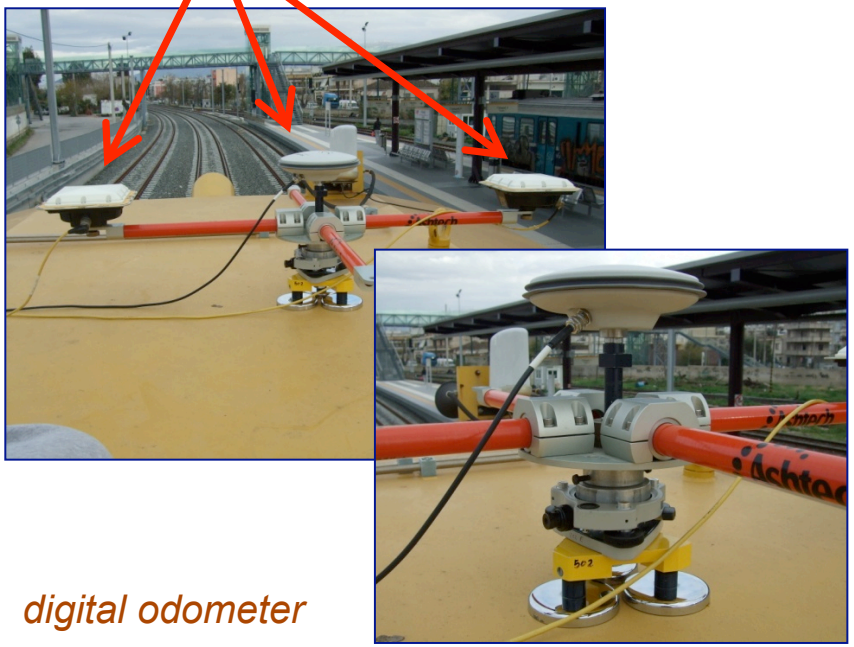




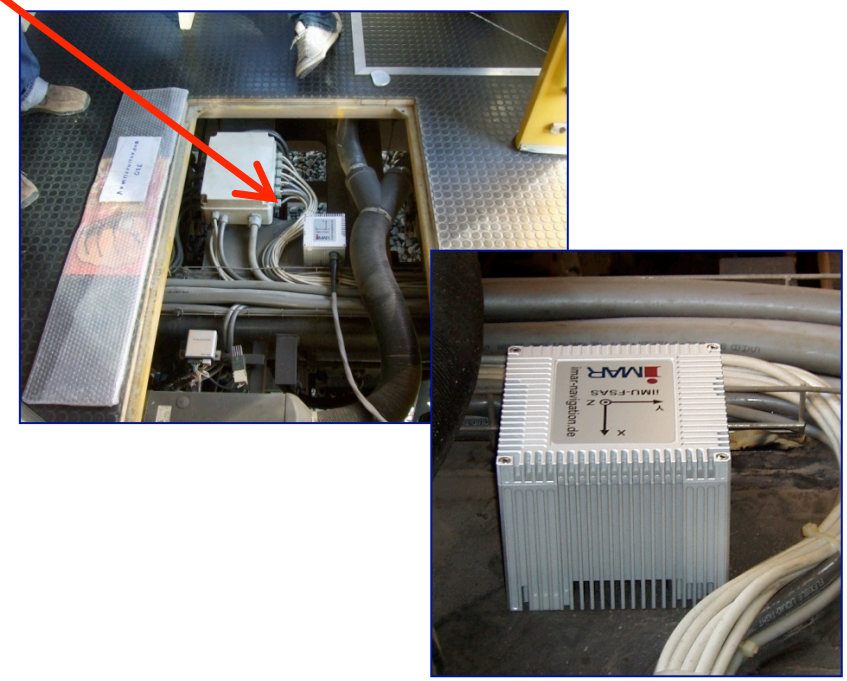


Multi-sensor kinematic surveying system: setting up of sensors

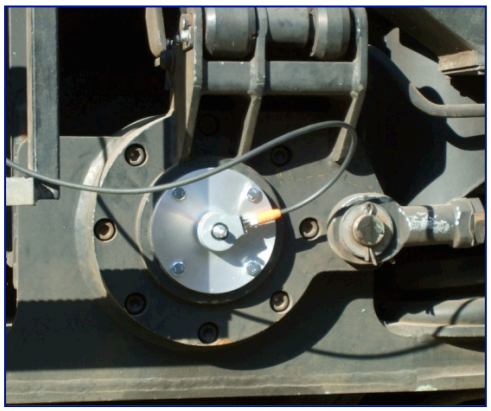
GNSS receivers



inertial unit

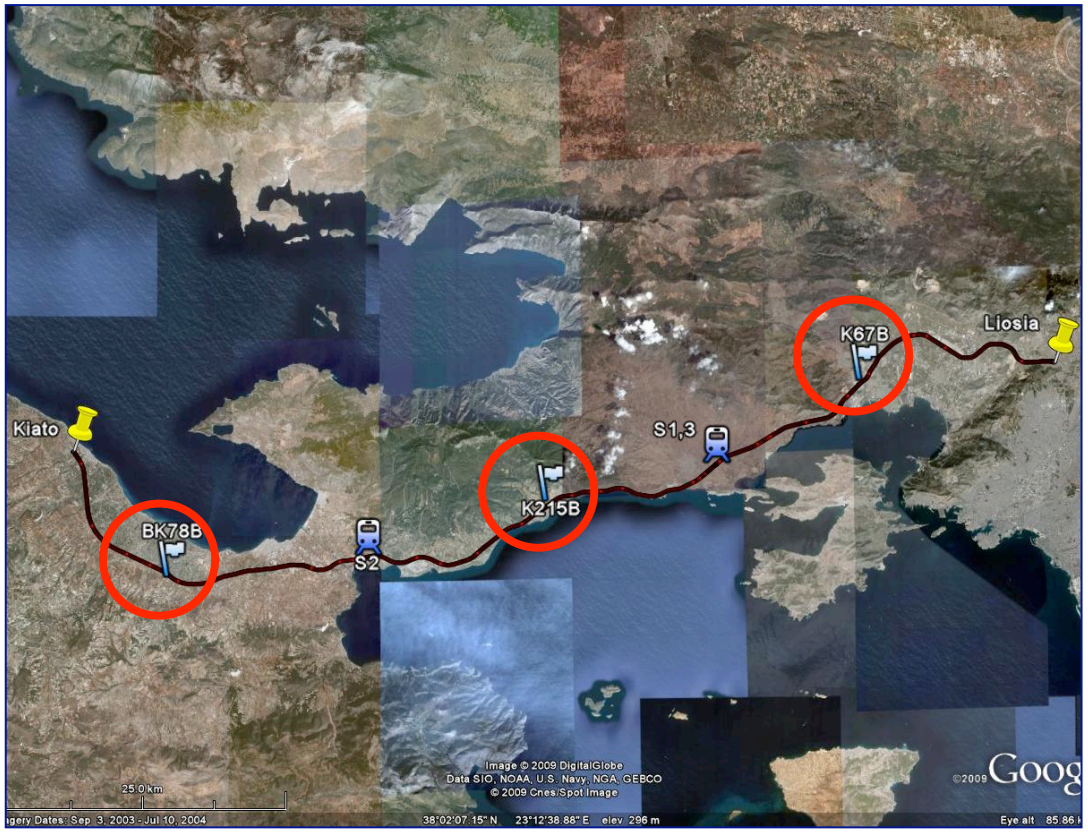


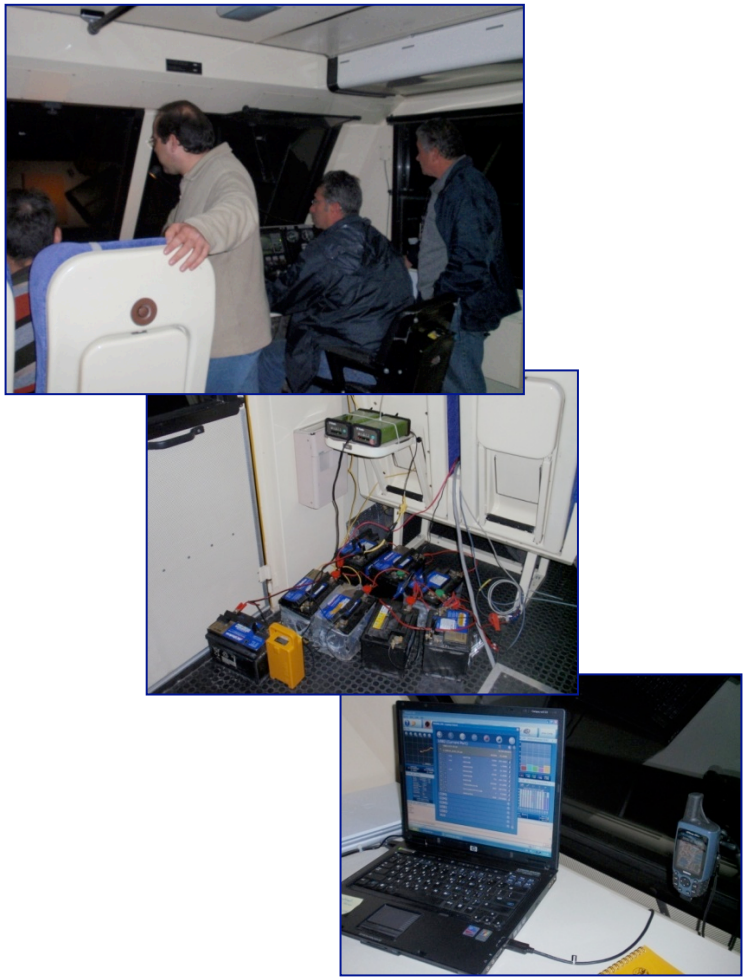
digital odometer installation



Multi-sensor kinematic surveying : data acquisition

- two way survey at maximum running speed 90 km/h
- three GNSS receivers were set up along the travel path (baseline length <15 km)
- survey accomplished night time to ensure continuous recording
- five tunnels (max. length 2.5 km)





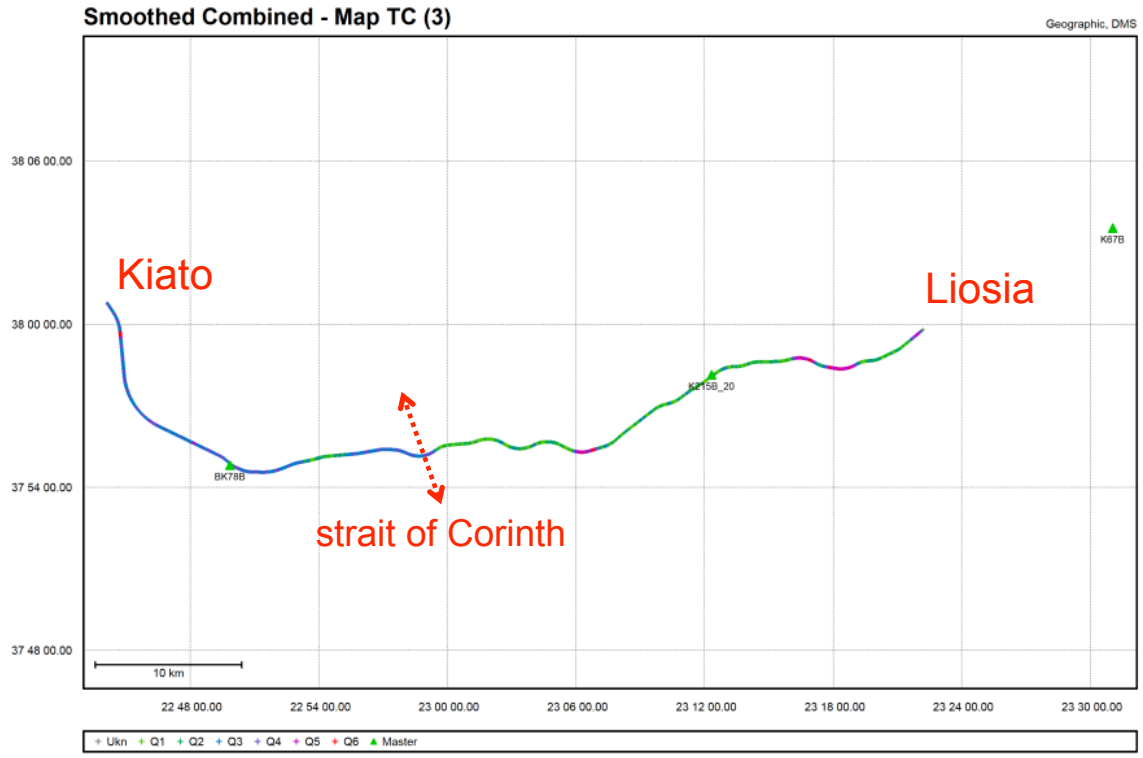
Multi-sensor kinematic surveying : data processing

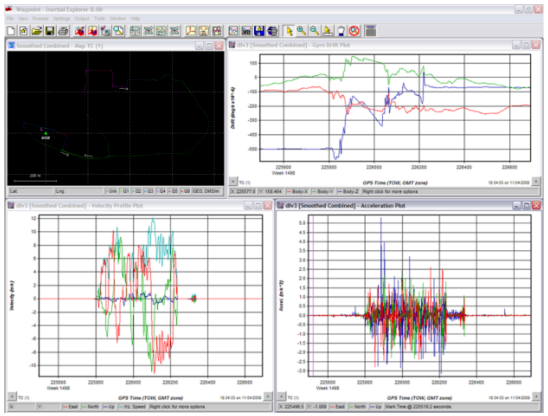
input data

- multi-sensor (GNSS / INS / DMI) raw data
- raw GNSS data at reference stations
- reference stations coordinates
- relative location of sensors (lever-arms)
- recording vehicle wheel dimensions

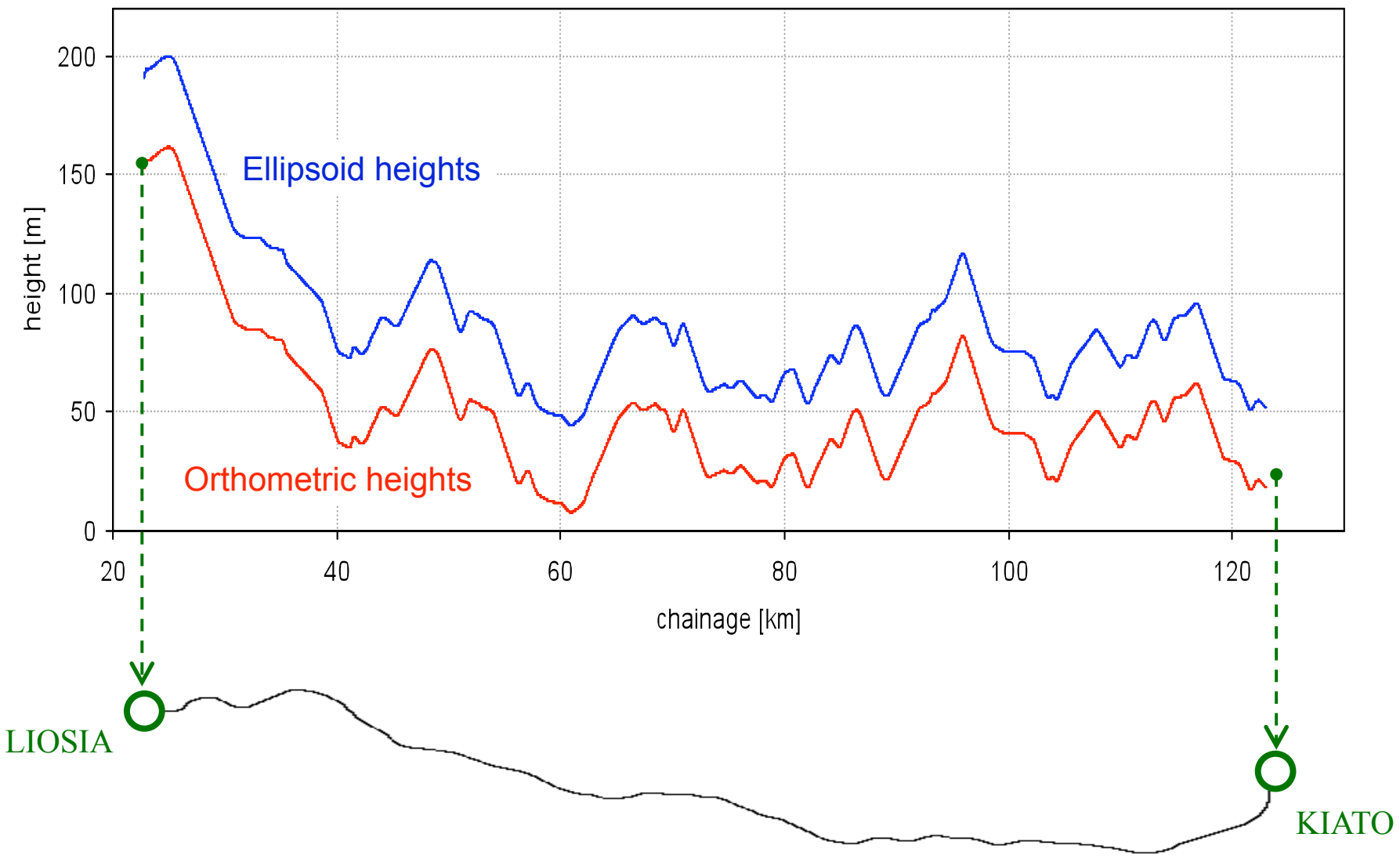
output data

- rail track axis coordinates (φ, λ, h) in WGS84
- recording vehicle kinematics (velocity, acceleration) and quality measures

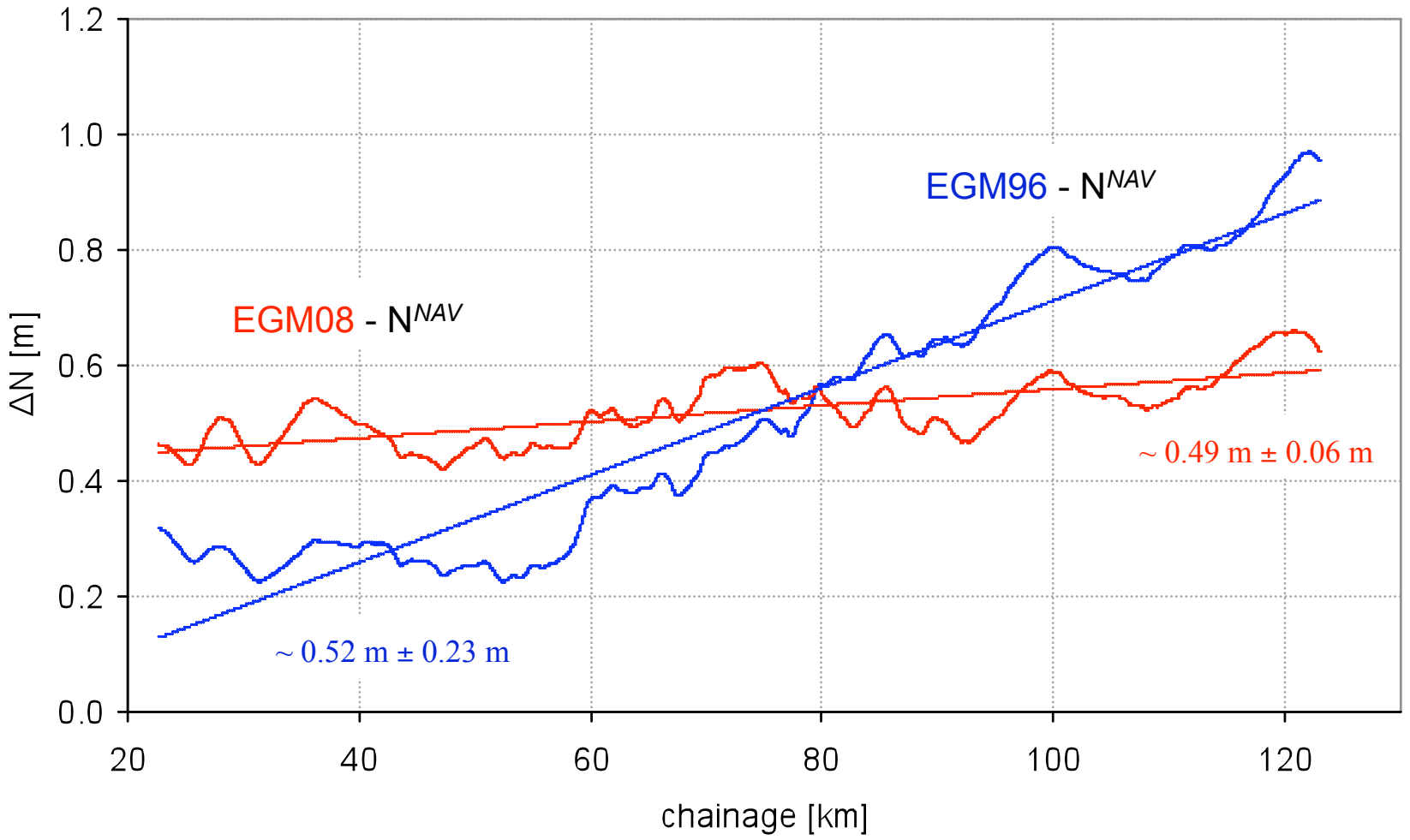




Longitudinal sections (orthometric & ellipsoid heights)



Evaluation of GGMs (EGM96, EGM08)



Summary and conclusions

- experimentally derived *geoid separation* along a 100 km railway traverse in Central Greece
- a cross-comparison is attempted against GGMs
- *orthometric heights* along the railway track at 20 m intervals (as-built plans)
- *ellipsoid heights* compute using a multi-sensor kinematic surveying system

- comparison of the observed N (h - H) against modeled N (GGMs) reveal:
  1. a good agreement in the geoid separation slope
  2. a bias suggesting an offset between the equipotential surface adopted by the GGMs and the HVD
  3. the superiority (improved statistical fit) of EGM08 over EGM96 for the test area
- the results obtained in this study reinforce the conclusions of recent studies for Greece (*Kotsakis et al, 2008*)