



## **Refinement of Geoid in Saudi Arabia using GNSS/Benchmark data with EGM1996 and EGM2008**

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Most control surveys conducted for practical purposes nowadays are established using Global Navigation Satellite Systems (GNSS). The reference datum for GNSS is WGS84 where heights are referred to a theoretical "mathematical" ellipsoid, not to real-life terrain or geopotential surface. Hence, in order to reference GNSS-derived heights to terrain, the geoid-ellipsoid separation must be known to be used in the famous equation of  $h = H + N$ . Two models for this separation have been implemented using GNSS/Benchmark data: EGM1996 and the recently-released EGM2008.

Vertical reference network of Saudi Arabia, established in early 1970's as first order vertical control network by spirit leveling based on tidal gauges along the Red Sea and Arabian Gulf, is analyzed for determination of GNSS/Benchmark geoid countrywide. The analysis is based on existing and newly-created benchmarks where there are no benchmarks or the geoid is thought to be steep.

Thin plate surface fitting applying least squares collocation and surface fitting applying Kriging algorithm were carried out to derive the conversion surface throughout Saudi Arabia by using ellipsoidal heights and orthometric heights of benchmarks, hence geoid heights were calculated. These geoid heights (N) were differenced twice, with EGM1996 and EGM2008 heights, to acquire two different sets of  $\Delta N$ : [ $\Delta N = N - N_{EGM} = h - H - N_{EGM}$ ].

The accuracy analysis is based on comparisons of the one case of geoid heights (N) and the two cases of residuals ( $\Delta N$ ). The RMS of surfaces determined by N fitting and by  $\Delta N$  fittings were found in dm level for both algorithms, but an improvement of about 2 dm was noticed with using EGM2008 as compared to EGM1996. These results indicate that refinement of spherical harmonic geopotential model with GNSS/Benchmark data and in reference to latest EGM2008 has given practically acceptable values to be used to devise orthometric heights for the surveying applications of the Ministry of Municipal and Rural Affairs; the exclusively mandated governmental agency to produce big-scale maps for 220 cities in Saudi Arabia.