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ACCURACY ASSESSMENT OF HEIGHT DETERMINATION USING CONVENTIONAL GEODETIC METHODS AND GNSS TECHNOLOGY: A CASE STUDY OF THE REȘIȚA PERMANENT STATION

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Introduction

Accurate height determination is essential for geodetic reference networks, topographical surveying, cadastral applications, and geospatial monitoring. Although GNSS technology provides precise three-dimensional positioning, the determination of elevations in national height systems requires reliable measurement and verification procedures. This study evaluates the accuracy and consistency of height determination methods applied to the permanent GNSS station Reșița (RESI), Caraș-Severin County, Romania. The research combines precision geometric leveling, short-distance trigonometric leveling, and static GNSS observations to investigate the agreement between independent height determinations. Particular attention is given to height transfer through the TM1 and TM2 control benchmarks, measurement consistency, and the relationship between satellite-derived coordinates and the Black Sea 1975 national height system.

Material and method

The study was conducted at the Reșița permanent GNSS station (RESI), using precision geometric leveling, short-distance trigonometric leveling, and static GNSS observations. Height transfer was performed from a national leveling benchmark to two control points, TM1 and TM2, using a Leica Sprinter 250M digital level. Trigonometric observations were carried out with a Leica TCR 1203 total station to determine the elevation of the rooftop GNSS antenna. Static GNSS measurements were performed using JAVAD Triumph-1 receivers, with a 10-second recording interval and a 15° elevation mask. The observations were processed in Trimble Business Center, and the resulting coordinates were expressed in ETRS89 and transformed into the national Stereographic 1970 system. Independent height determinations were compared to assess measurement consistency and identify altimetric discrepancies.

Result and discussions

The study was conducted at the Reșița permanent GNSS station (RESI), using precision geometric leveling, short-distance trigonometric leveling, and static GNSS observations. Elevations were transferred from a national leveling benchmark to two control points, TM1 and TM2, using a Leica Sprinter 250M digital level. A Leica TCR 1203 total station was used to determine the rooftop antenna elevation through independent trigonometric observations. Static GNSS measurements were performed with JAVAD Triumph-1 receivers, using a 10-second recording interval, a 15° elevation mask, and approximately 1.5-hour observation sessions. GNSS data were processed using Trimble Business Center, while TransDAT was applied for coordinate transformation. The resulting height determinations were compared to evaluate measurement consistency, altimetric differences, and the reliability of the geodetic network.

The analysis of the geodetic documentation highlights the integration of precision geometric leveling, trigonometric leveling, and static GNSS observations for determining the elevation of the Reșița permanent station (RESI).

The reference benchmark and the height transfer through the control points TM1 and TM2 are illustrated in Figures 1 and 2. The GNSS network configuration supported the positioning of the control points, with estimated horizontal accuracies of 5–9 mm and vertical accuracy indicators of 21–22 mm (Fig. 3).

Two independent height determinations yielded 256.201 m and 256.238 m, resulting in a difference of 37 mm (Fig. 4). The final adopted elevation was 256.220 m in the Black Sea 1975 height system. The observed discrepancy highlights the importance of independent measurements and additional verification when high altimetric accuracy is required.

The integration of these complementary surveying methods provides a consistent framework for evaluating elevation differences and improving the reliability of geodetic reference networks.



Fig. 1 – Reference levelling benchmark (RNG)

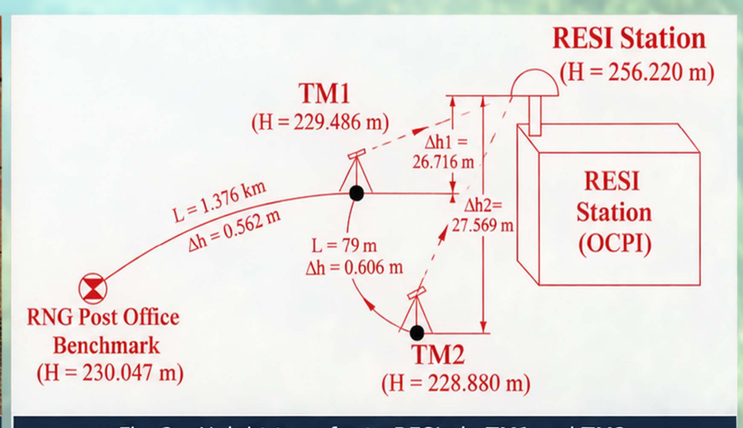


Fig. 2 – Height transfer to RESI via TM1 and TM2

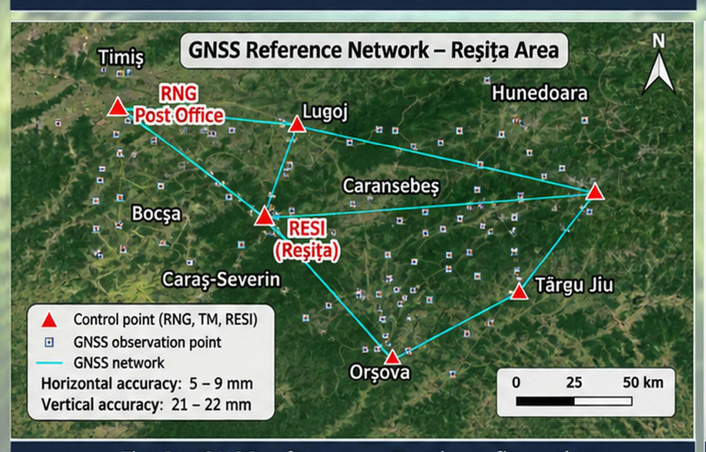


Fig. 3 – GNSS reference network configuration

No.	County	Levelling section (geometric levelling, high precision)	Distance [km]	Measured height difference Δh [m]	Determined elevation in Black Sea 1975 H [m]
1	Caraș-Severin	RNG Post Office Benchmark – Reșița	-	-	230.047
2		TM1	-	-0.562	229.485
3		RESI GNSS Station	-	+26.716	256.201
4		TM1	-	-	229.485
5		TM2	-	-0.606	228.879
6		RESI GNSS Station	-	+27.359	256.238
Adopted elevation H_{RESI}					256.220

Fig. 4 – Comparison of height determinations

Conclusions

The study highlights the importance of combining precision geometric leveling, short-distance trigonometric leveling, and static GNSS observations for accurate height determination at permanent geodetic stations. The two independent determinations of the Reșița permanent station (RESI) resulted in elevations of 256.201 m and 256.238 m, with a difference of 37 mm. The results demonstrate that integrating conventional geodetic methods with GNSS technology supports reliable geodetic reference networks, while independent measurements remain essential for assessing altimetric consistency.

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