Experimental study of real time multi-constellation PPP, applied to SIRGAS GNSS stations in Uruguay

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INTRODUCTION

Uruguay's REGNA-ROU GNSS network, integrated into SIRGAS-CON, provides a high-density, multi-constellation framework for a growing community of real-time users. The advent of Galileo High Accuracy Service (HAS) represents a paradigm shift, offering the first free, global PPP corrections. This service enables surveyors to achieve high-accuracy positioning in the field without local base stations. In this study, PPP is applied to Uruguayan SIRGAS stations (Fig.1) to rigorously evaluate the method's stability and performance using high-precision reference coordinates.

OBJECTIVES

- Evaluate the performance (convergence, stability, accuracy) of Real-Time PPP in Uruguay.
- Analyze PPP accuracy and convergence for SIRGAS stations using the Galileo HAS-IDD correction stream.
- Perform real-time test with multi-constellation receivers, to determine the viability of Galileo HAS as an alternative to traditional RTK methods in the region.
- Evaluate the positional quality of different receivers, with emphasis on low-cost ones.

METHODS

- The BNC (BKG NTRIP Client) software was utilized for PPP processing, incorporating Galileo HAS-IDD corrections.
- Processing parameters were defined according to the standard BNC configuration examples (PPPGalHAS.bnc).
- Field tests were conducted using GNSS receivers tracking the Galileo E6 signal in space (HAS SIS).
- PPP coordinates were compared against high-precision references derived from long-period static sessions via the NRCAN-PPP service.

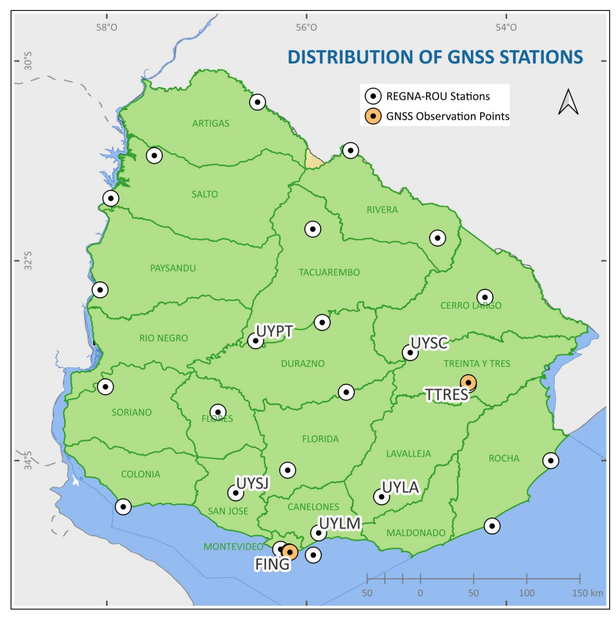

Fig 1: Location of the REGNA-ROU selected stations (multi-constellation) and receiver test.

SIRGAS PPP MONITORING (GALILEO HAS)

REGNA-ROU stations were continuously monitored from 2025/12 to 2026/05. Daily time series revealed **inconsistencies and instantaneous jumps** (offsets). Generally, these events did not occur simultaneously across all stations (Fig. 2)

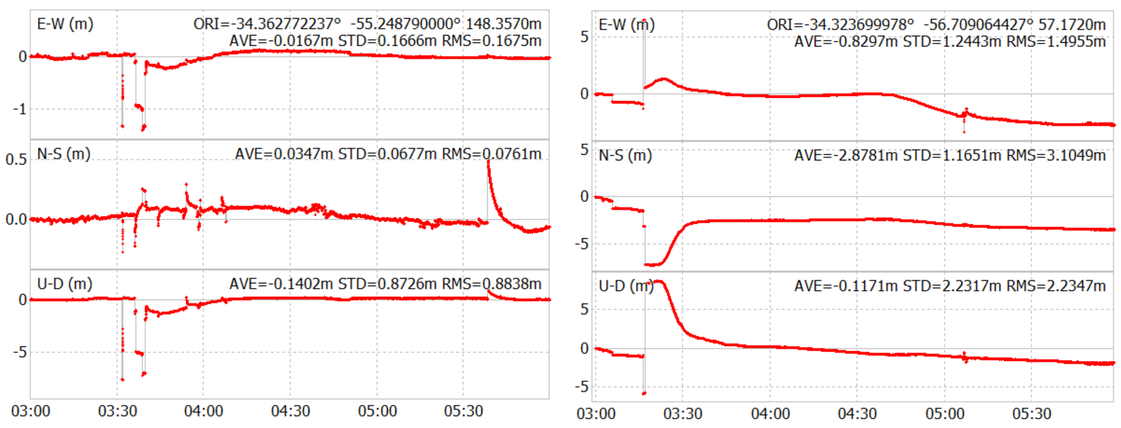

Fig 2: PPP -HAS Plot to UYLA (left) and UYSJ (right) at 2026-05-02 (BNC Software).

Figure 3 compares **3-day simultaneous performance** between four Uruguayan stations and global references (WTZL, LPGS, MGUE) to ensure independence of results.

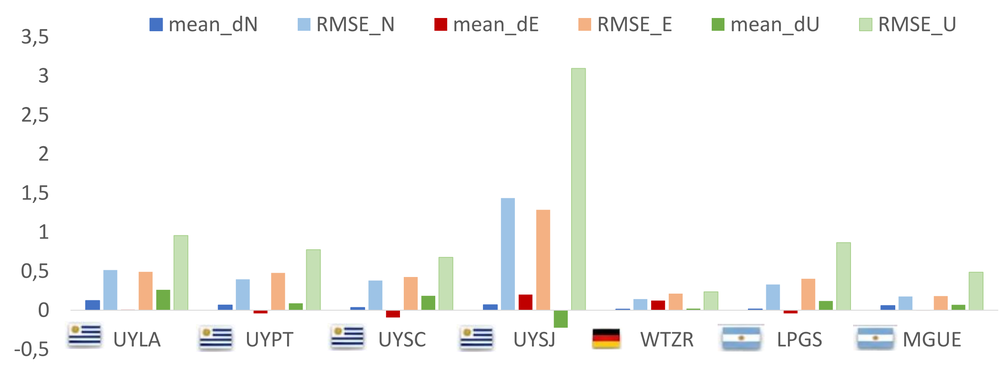

Fig 3: Statistical error for PPP-Has (BNC Software) at different stations.

The **IGS03 real-time corrections** were analyzed simultaneously for comparison. The results demonstrated superior consistency and a significantly **lower occurrence of jumps** compared to the HAS-IDD service (Figure 4).

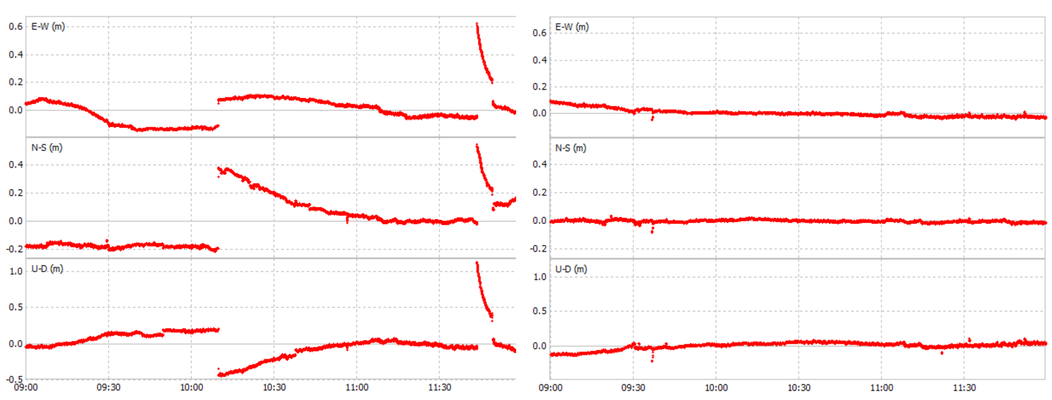

Fig 4: Galileo HAS (left) vs IGS03 (right) corrections, PPP estimation at UYLA, 2026-05-09

MULTI-GNSS RECEIVER TESTS

Field trials showed consistent performance across all hardware. Low-cost receivers (Fig. 5) achieved equally satisfactory results, with an average 20-minute convergence to reach horizontal accuracy < 20 cm and vertical < 50 cm relative to NRCAN-PPP.

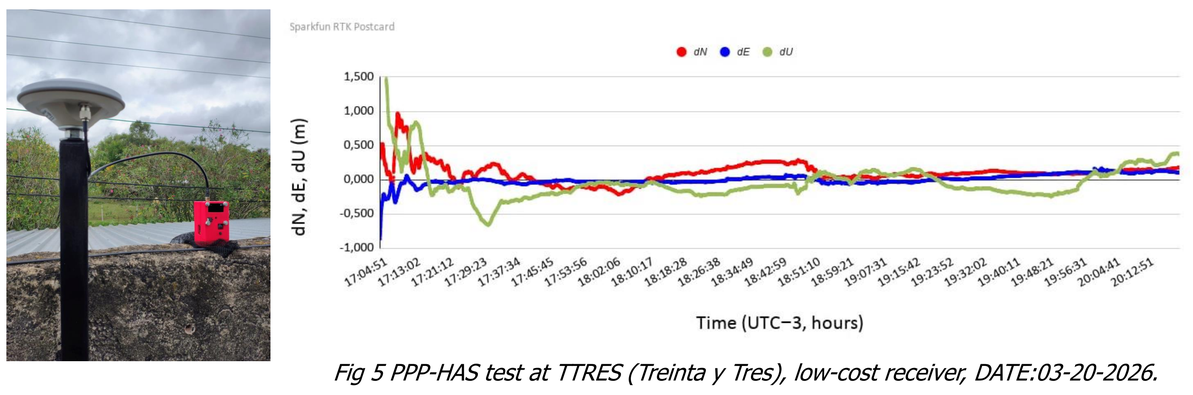

Fig 5 PPP-HAS test at TTRES (Treinta y Tres), low-cost receiver, DATE:03-20-2026.

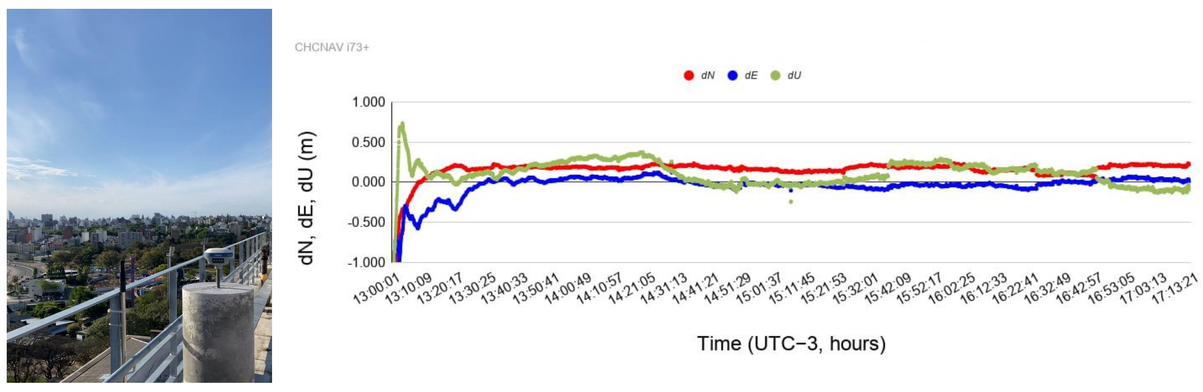

Fig 6: PPP-HAS test at FING (Montevideo), receiver CHCi73+, DATE:04-24-2026.

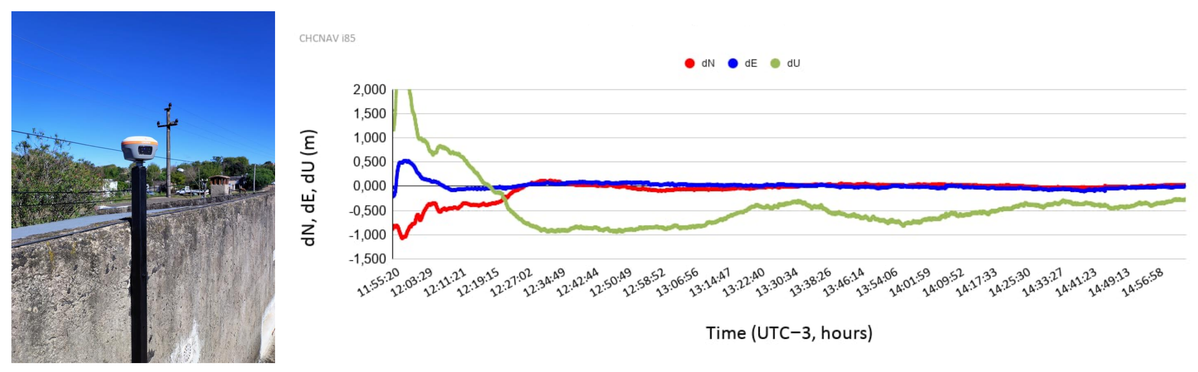

Fig 7 PPP-HAS test at TTRES (Treinta y Tres), receiver CHCi85 DATE:04-24-2026.

Table 1 summarizes the formal errors obtained with different receivers, corresponding to surveys carried out between December 2025 and March 2026.

	bias_NE	RMS_NE	bias Up	RMS_Up
Sparkfun	0,117	0,122	0,124	0,225
CHCi73	0,166	0,177	-0,215	0,248
CHCi85	0,119	0,143	0,353	0,422

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CONCLUSIONS

- The presence of non-simultaneous jumps confirms that these instabilities are likely due to local inconsistencies or specific processing issues. These events currently prevent full reliability in real-time PPP estimation for high-precision tasks.
- When compared to the IGS03 stream, Galileo HAS currently exhibited lower consistency and a higher frequency of convergence resets.
- Despite current limitations, the method demonstrates decimetric-level viability for field applications without local differential infrastructure
- For PPP to become a definitive alternative to RTK in professional surveying, further optimization in accuracy and stability is essential.

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