

GNSS Data Robustness and Resilience: The Recife Multi-GNSS Experimental Nucleus for Autonomous Assessment of PNT Service Performance, Integrity and Continuity



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INTRODUCTION

Global Navigation Satellite Systems (GNSS) constitute critical infrastructure for scientific, technological and operational applications, including Positioning, Navigation and Timing (PNT), high-precision geodesy, atmospheric monitoring and essential services.

The growing dependence on GNSS highlights the need for resilient and interoperable monitoring solutions, particularly in low-latitude regions, where ionospheric and tropospheric variability may degrade positioning accuracy and affect PNT service integrity and continuity.

In this context, the Recife Metropolitan Region, since August 2025, brings together, within a reduced geographic radius, three permanent GNSS infrastructures with complementary technical functions, establishing a unique framework for experimental multi-GNSS monitoring in Brazil.

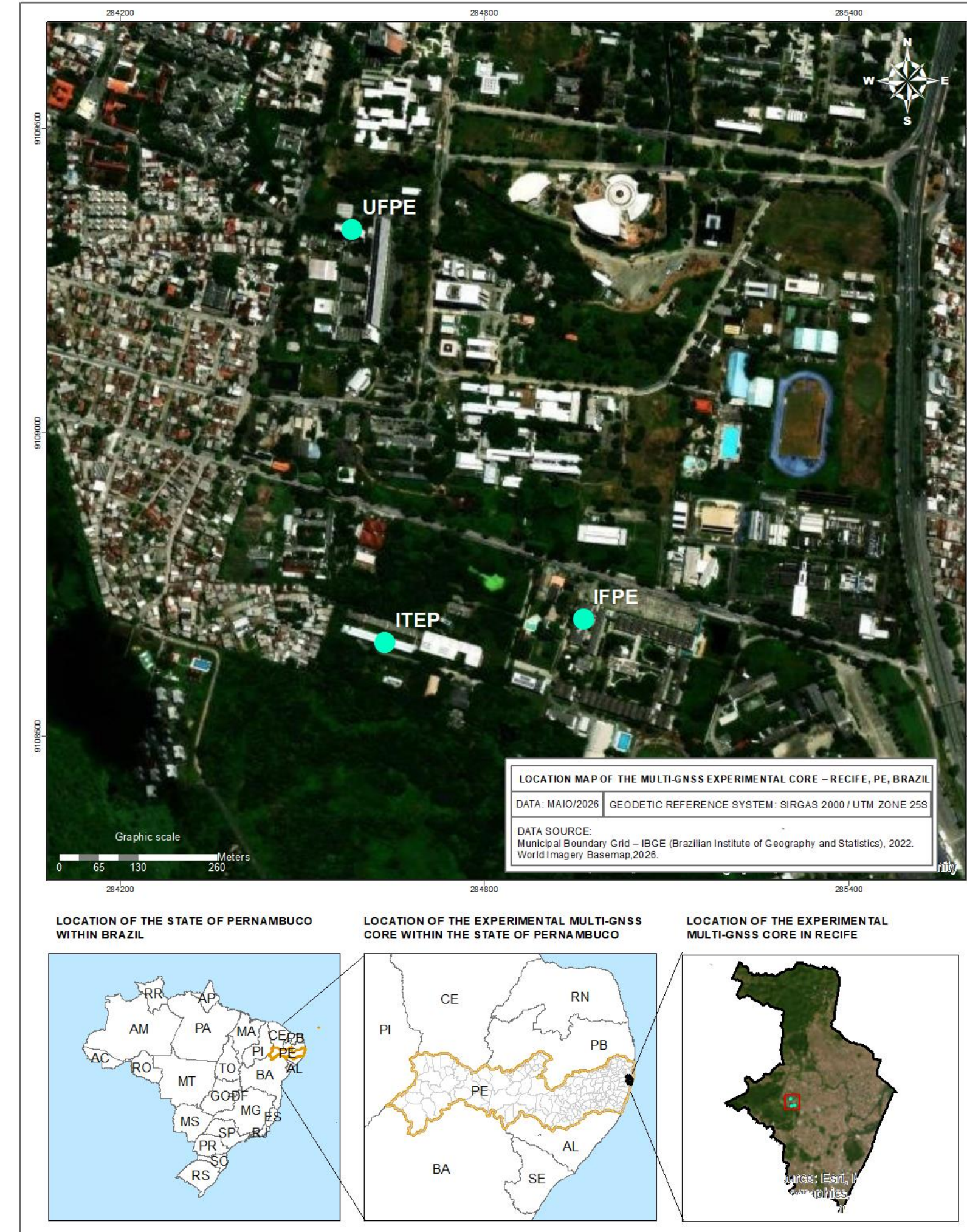
The coexistence of these infrastructures establishes a framework for continuous multi-GNSS monitoring, cross-validation of positioning and timing solutions, and autonomous assessment of PNT service performance, integrity, continuity and resilience under real operational conditions.

OBJECTIVE

To present the experimental multi-GNSS framework established in the Recife Metropolitan Region as an integrated infrastructure for continuous monitoring, cross-validation and autonomous assessment of PNT service performance, integrity, continuity and resilience under low-latitude operational conditions.

METHODS

The experimental framework is based on the integration of three complementary GNSS infrastructures located within the Recife Metropolitan Region, enabling continuous monitoring, cross-validation of positioning and timing solutions, and autonomous assessment of PNT service performance under low-latitude operational conditions.



ITEP – GLONASS Ground Segment



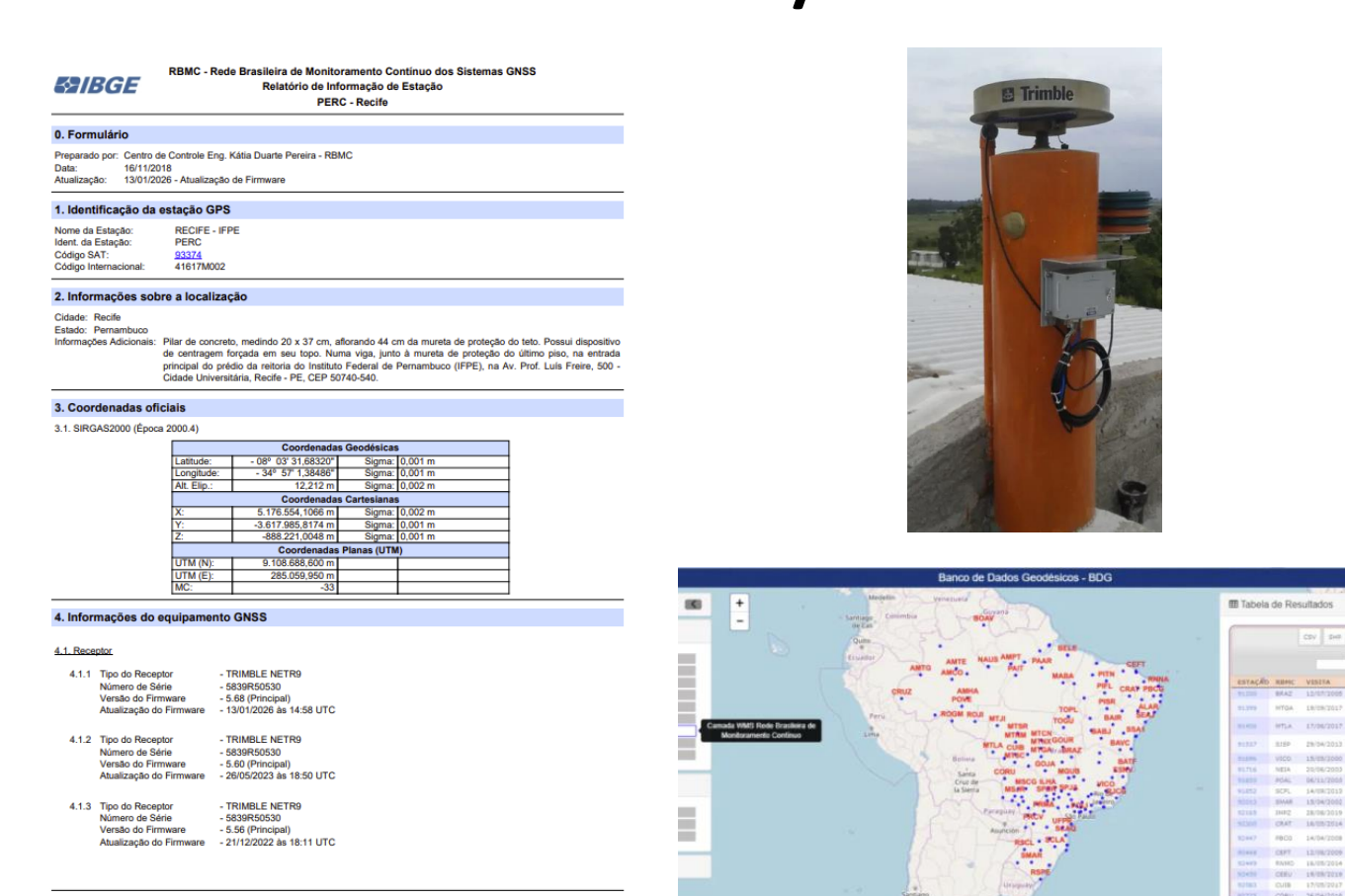
- infrastructure since 2016;
- Historical archive of GNSS observations and operational records;
- Ongoing implementation of real-time GNSS data access
- Planned modernization toward OMS/SSI-S architecture and future multi-constellation capabilities.

UFPE – i-LITPEG / LAGEO



- Continuous ionospheric and atmospheric GNSS monitoring;
- Space weather and low-latitude environmental studies;
- Vertical land motion analysis using GNSS observations;
- Scientific cooperation within the INCT GNSS NavAer framework coordinated by UNESP.

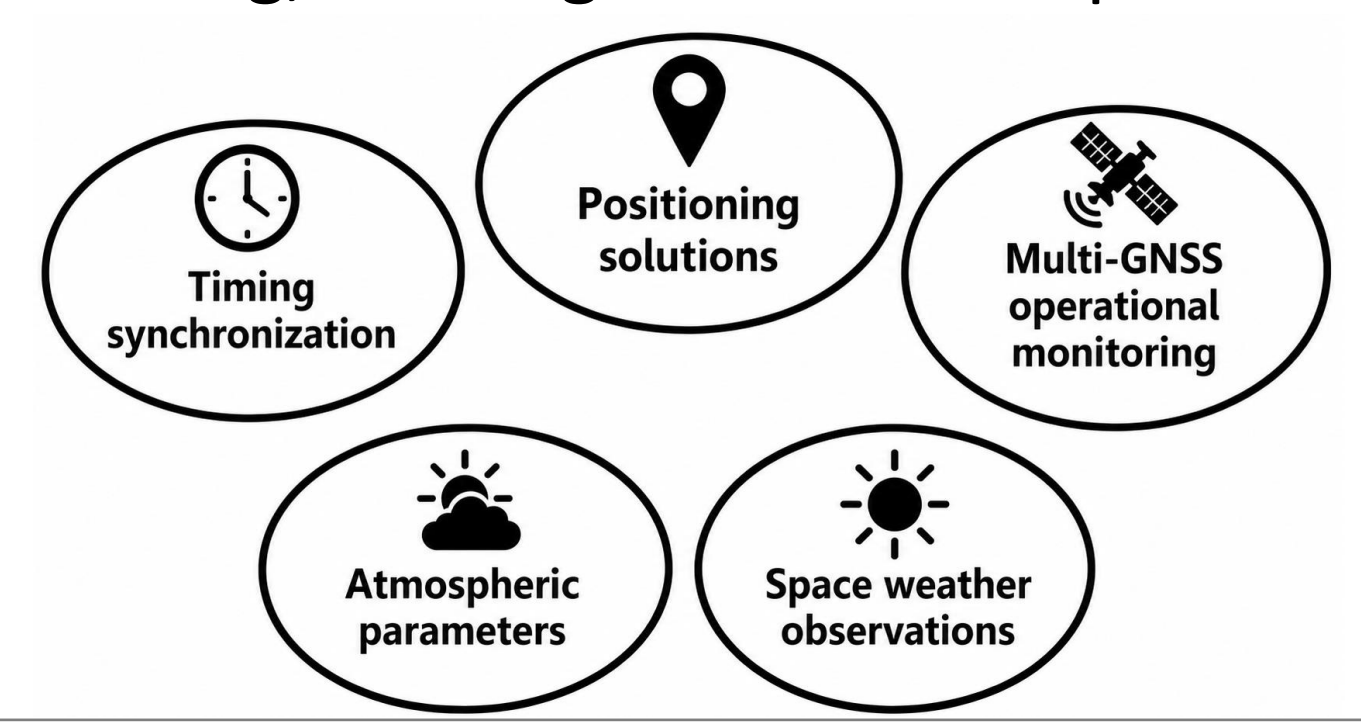
IFPE – RBMC/IBGE



- Permanent geodetic reference station integrated into RBMC/IBGE;
- SIRGAS2000 reference infrastructure for geodetic applications;
- Positional validation and geodetic quality control support;
- Continuous GNSS observations for spatial reference stability monitoring.

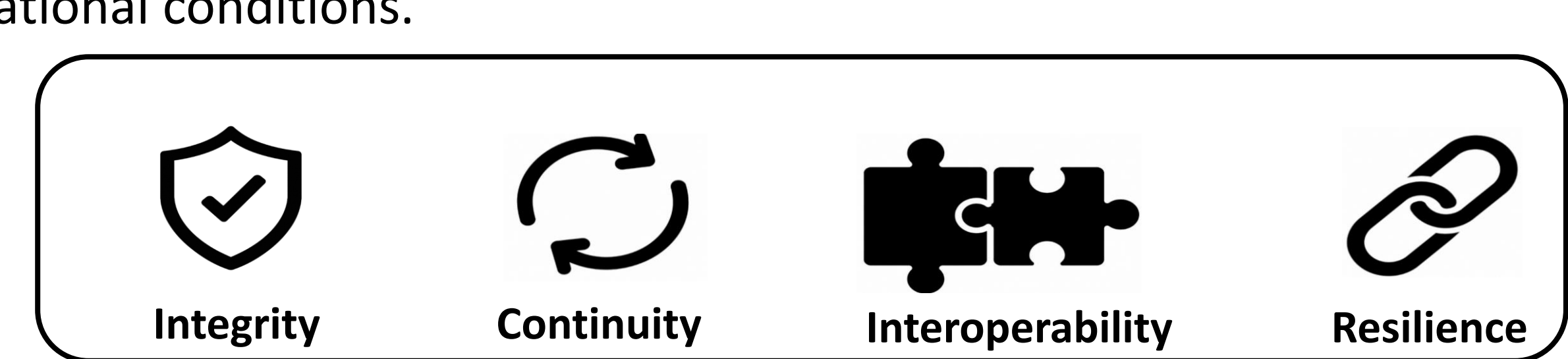
INTEGRATED MULTI-GNSS FRAMEWORK

Integrated observations from complementary GNSS infrastructures enable continuous cross-validation of positioning, timing and atmospheric parameters under real operational conditions.



AUTONOMOUS PNT SERVICE ASSESSMENT

The integrated framework supports autonomous evaluation of PNT service integrity, continuity, interoperability and resilience under low-latitude operational conditions.



RESULTS / EXPECTED CONTRIBUTIONS

- Continuous low-latitude multi-GNSS monitoring under real operational conditions
- Autonomous assessment of PNT service integrity, continuity and resilience
- Cross-validation between positioning, timing and atmospheric observations
- Integration of complementary geodetic, operational and atmospheric GNSS infrastructures
- Support for independent GNSS performance evaluation strategies
- Potential replicable framework for resilient multi-GNSS infrastructures in Brazil

CONCLUSIONS

The Recife experimental multi-GNSS framework demonstrates the potential of integrating complementary GNSS infrastructures for autonomous and resilient assessment of PNT service performance under low-latitude operational conditions.

The ongoing modernization of the ITEP GLONASS ground segment, including real-time data access implementation and future expansion toward OMS/SSI-S architecture with multi-constellation tracking and atomic-clock time reference capabilities, may further strengthen independent GNSS monitoring, interoperability and continuous validation strategies in Brazil.

**ABSTRACT
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