Power Matters.

Coherent Network Primary Reference Time Clocks (cnPRTC) Concept and Technology

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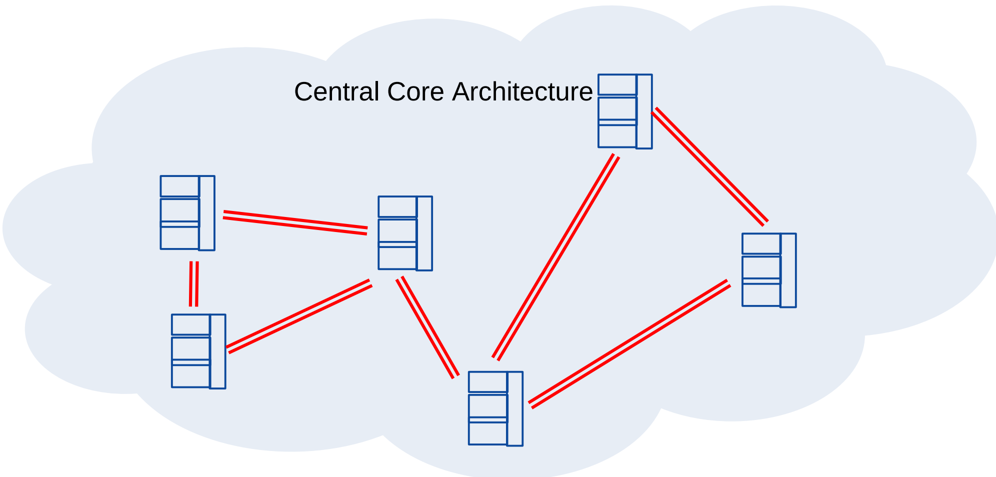
Coherent Network PRTC Overview

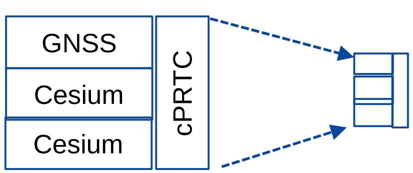


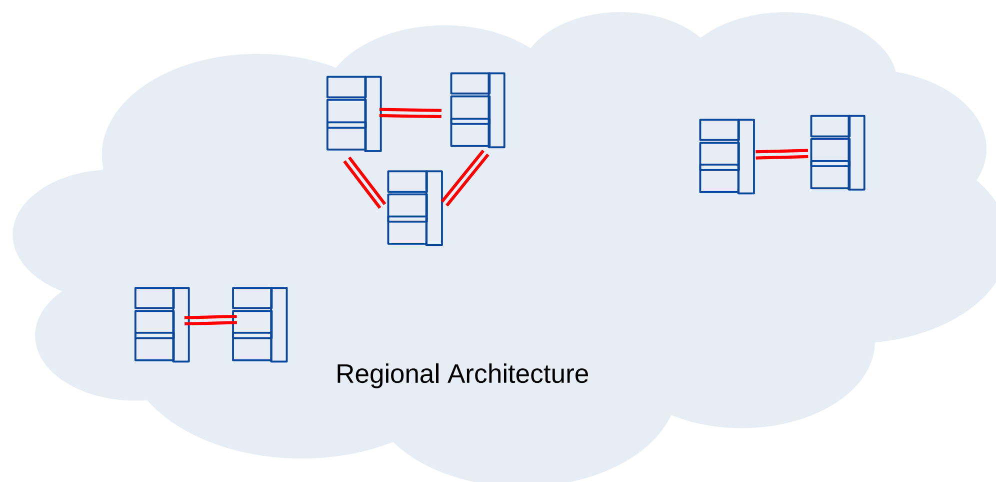
Primary Objectives

• Reliability: Immune from local jamming or outages

•Autonomy: Cesium Ensemble Sustained Timescale (definition of second) GNSS connect non-critical.

•Coherency: 30ns coordination assures overall PRTC budget





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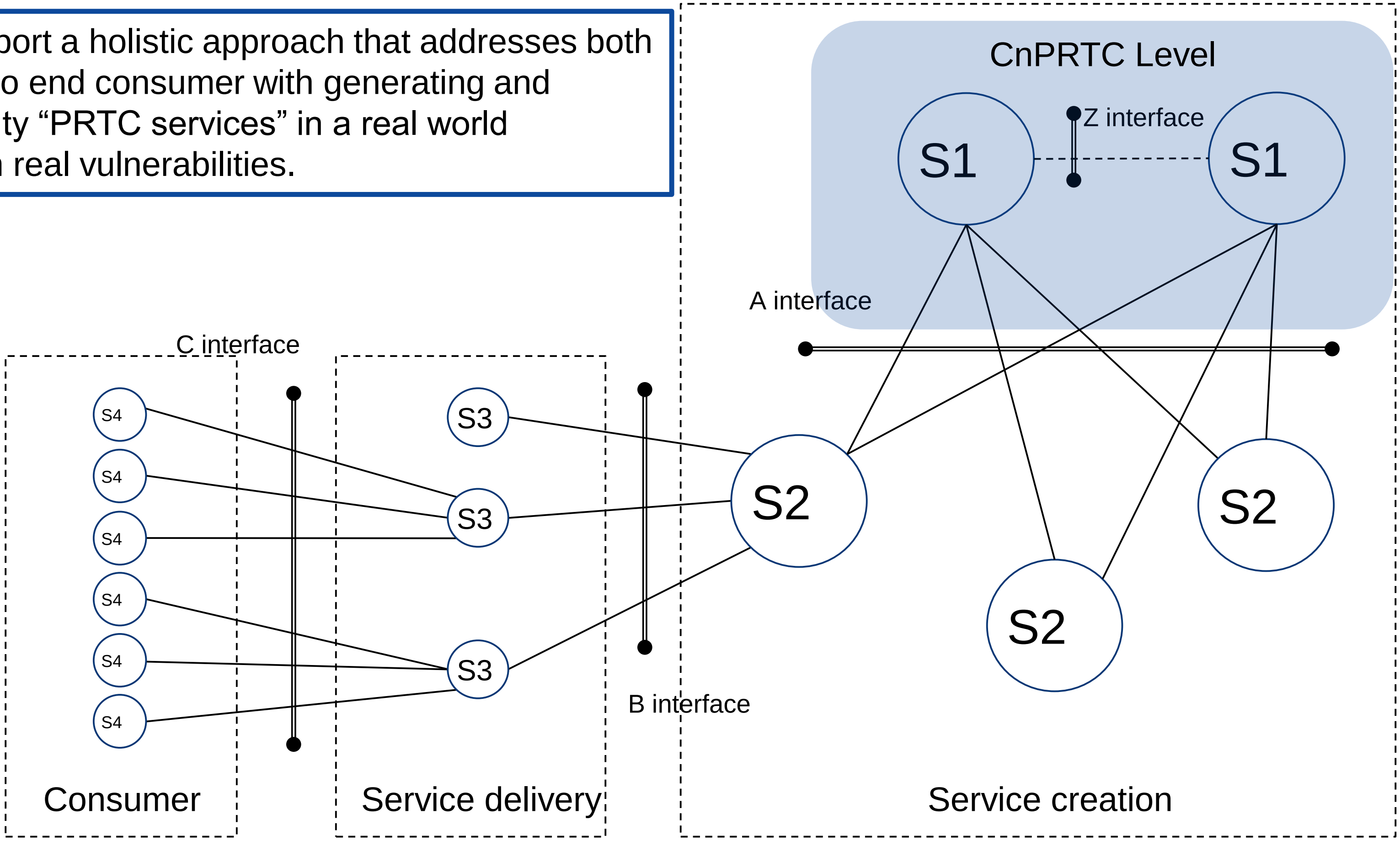
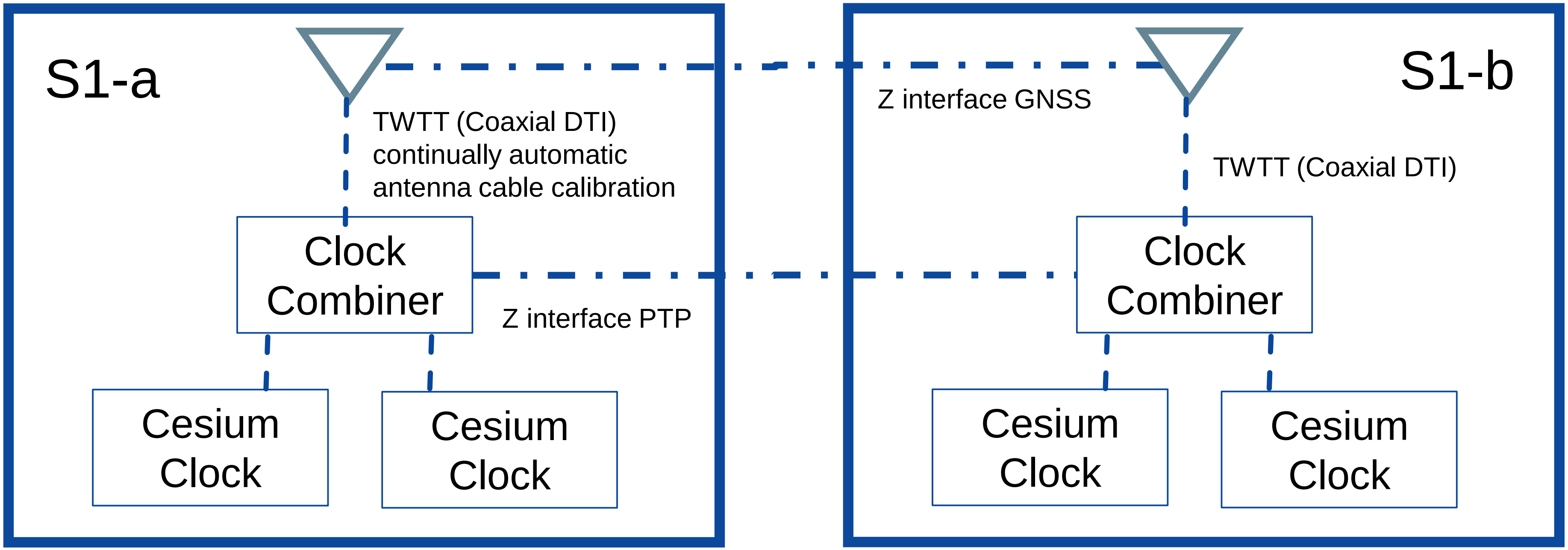
Coherent Time/Frequency Functional Architecture

Architecture support a holistic approach that addresses both service delivery to end consumer with generating and maintaining quality “PRTC services” in a real world environment with real vulnerabilities.



S1: Coherent cnPRTC level– Ensembling timing source, Perpetual Coherent Time Traceability
S2: Hierarchical PRTC level– Redundant Traceable A interfaces from S1 extend service creation from core.
S3: Sync delivery – delivers sync source to clients (PTP and associated path aware standards plus frequency sync e.g. Sync E)
S4: Sync edge/client – consumes the services

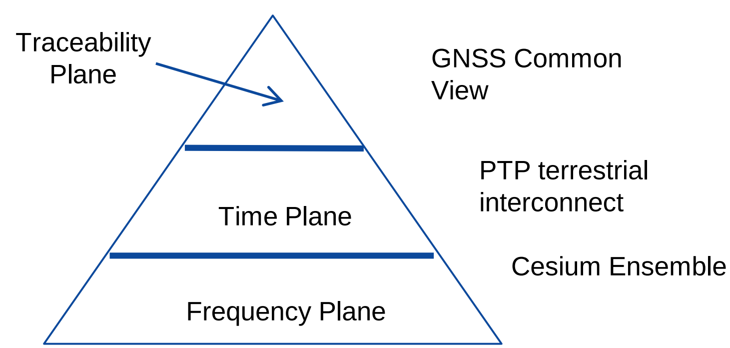
Coherent CnPRTC Service Creation Level



Current Clock Combiner supports patented enhanced clock control ensembling algorithm to generate **robust local timescale** supporting to the PRTCe requirements

Evolution of algorithm is planned to support network coherent operation as precision PTP network interconnect is deployed.

Note: Z interface (between S1 locations) consists of a PTP terrestrial interconnect and a GNSS common view interconnect

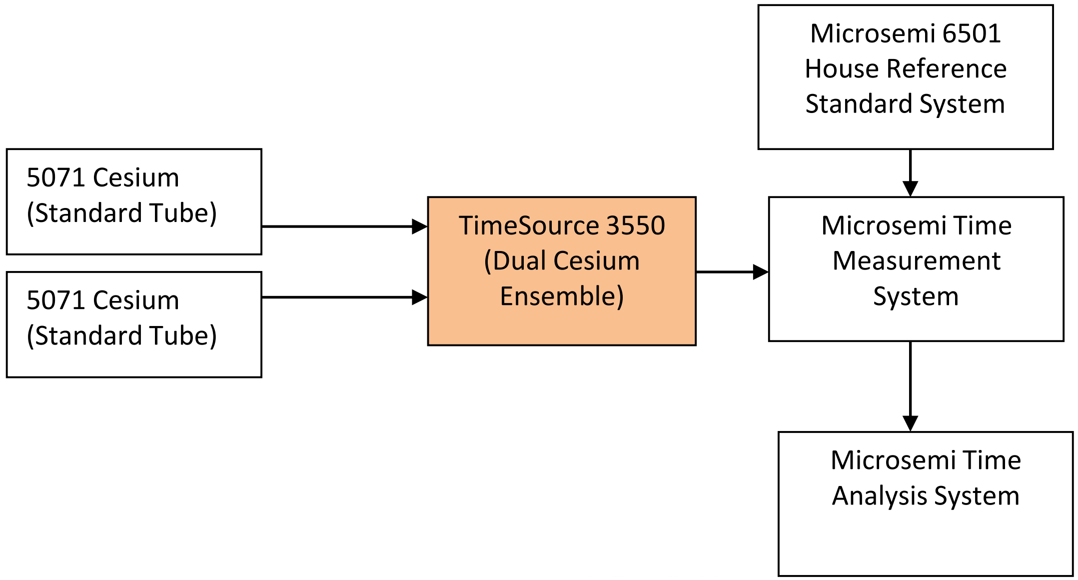


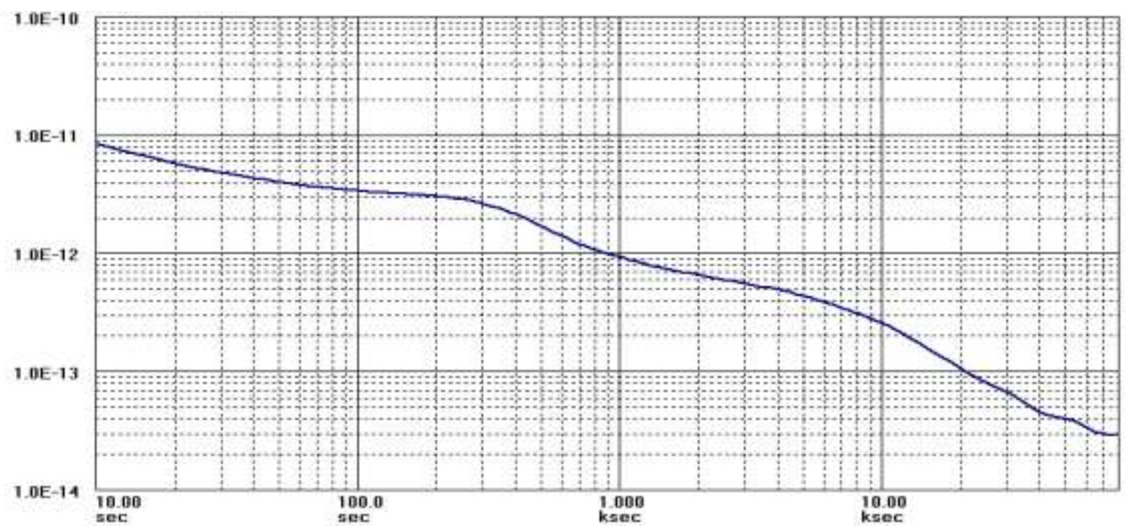
Local Timescale Generation

Baseline Performance Dual Cesium Timescale Ensemble

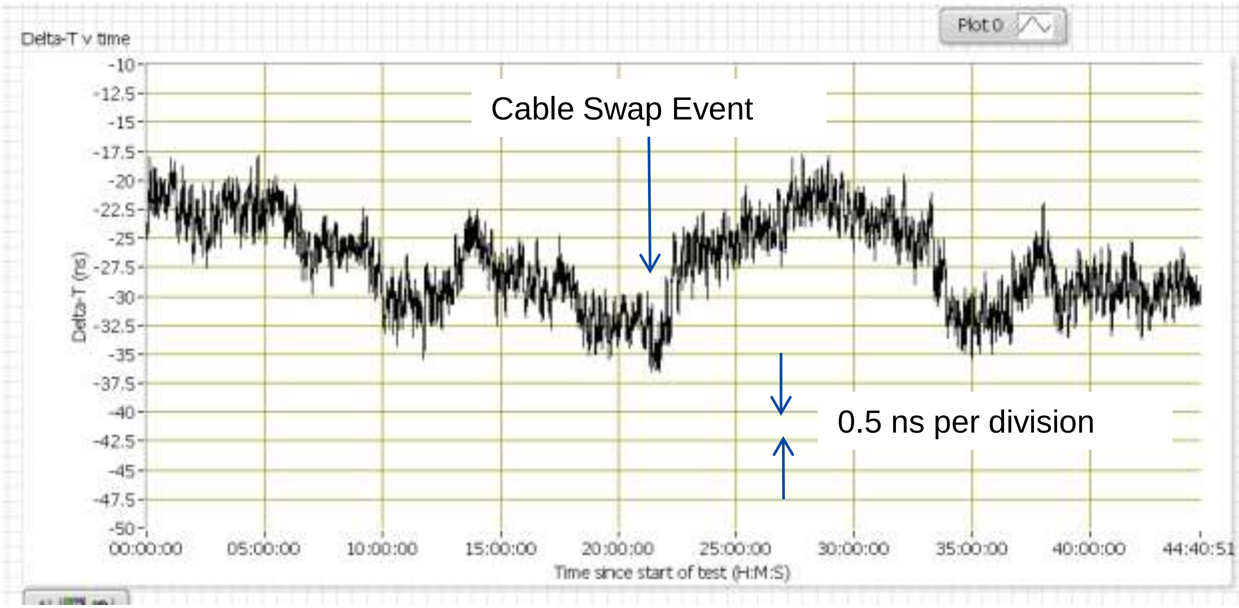
- Test Configuration is as shown.
- The Clock Combiner algorithm is operational in the TimeSource 3550 system
- The internal laser driven Rubidium is disciplined based on the combined performance of both external Cesium clocks.

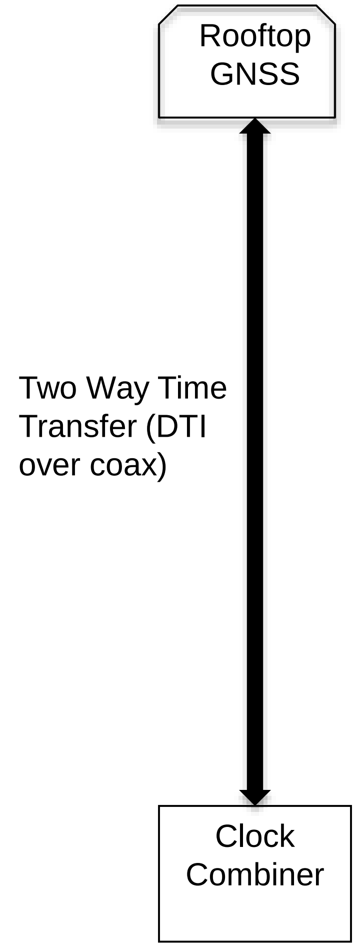
The testing interval result shown over a 4.5 day test. The test result shows a stability noise floor at the 3e-14 level consistent with an ensemble of two standard performance 5071 cesium standards.





TWTT Continual Automatic Antenna Cable Delay Calibration

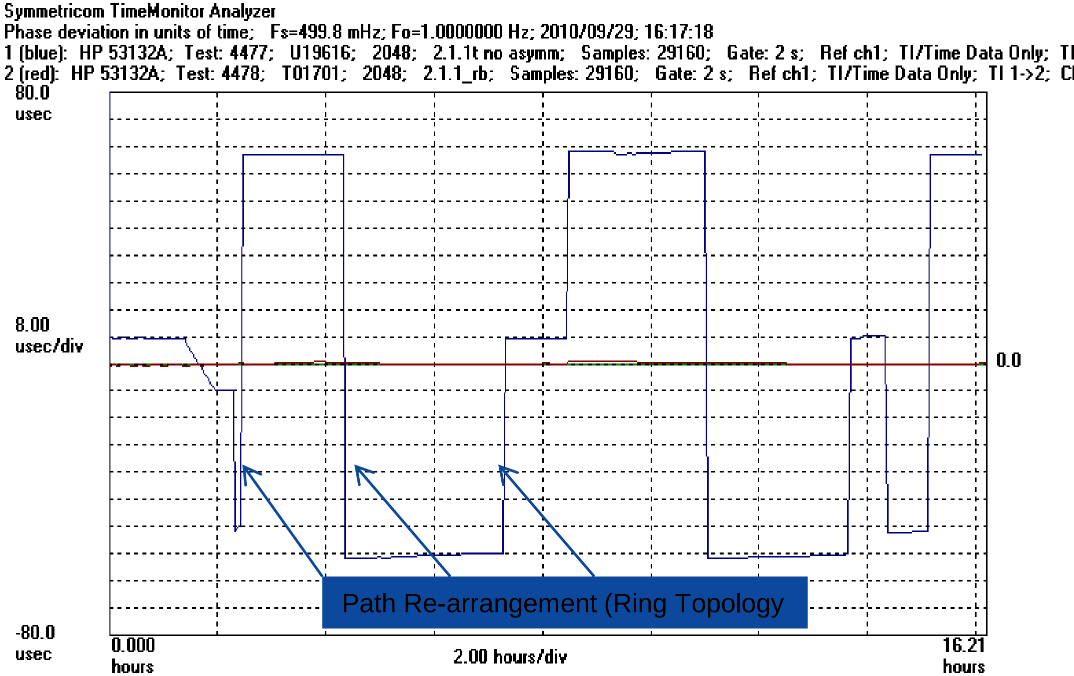




Cable Delay Bias Mitigation Test Results (200ft and 700ft cable swap)

Z interface combined strength of PTP and GNSS

- **Asymmetry Correction Algorithm supplies external correction factor defined in 1588 standard.**
- **Algorithm learns asymmetries to prevent in-accurate time output**
- **Addressed both PTP and GNSS potential vulnerabilities**



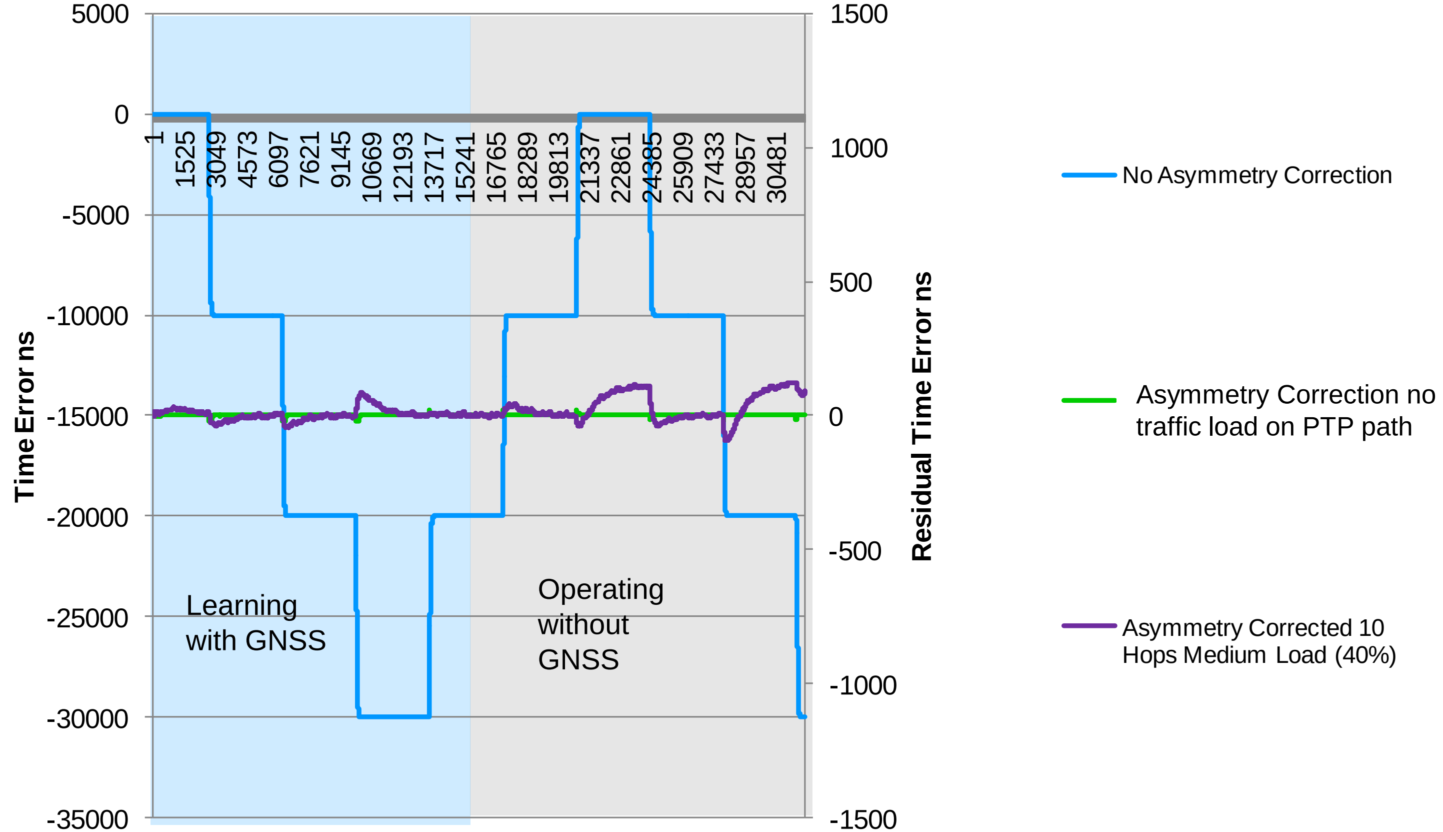
Path Signature			Asymmetry Bias (ns)
Round Trip Delay	Observed Bias	Secondary Path Parameters	
Path Signature A			AAA.A
Path Signature B			BBB.B
Path Signature C			CCC.C

Performance on Customer Network test environment:

BLUE: PPS Performance without Asymmetry correction.

RED: PPS Performance with Asymmetry correction.

Automatic Path Delay Compensation Learning Behavior



Summary

- CnPRTC addresses operating a phase/time service in a real-world environment with vulnerabilities such as GNSS jamming.

- CnPRTC complements local PRTC distribution.

- CnPRTC leverages the strengths of both GNSS and PTP