# Maintaining Precise Time for Power System Applications in the Event of Wide-Area Loss of GPS


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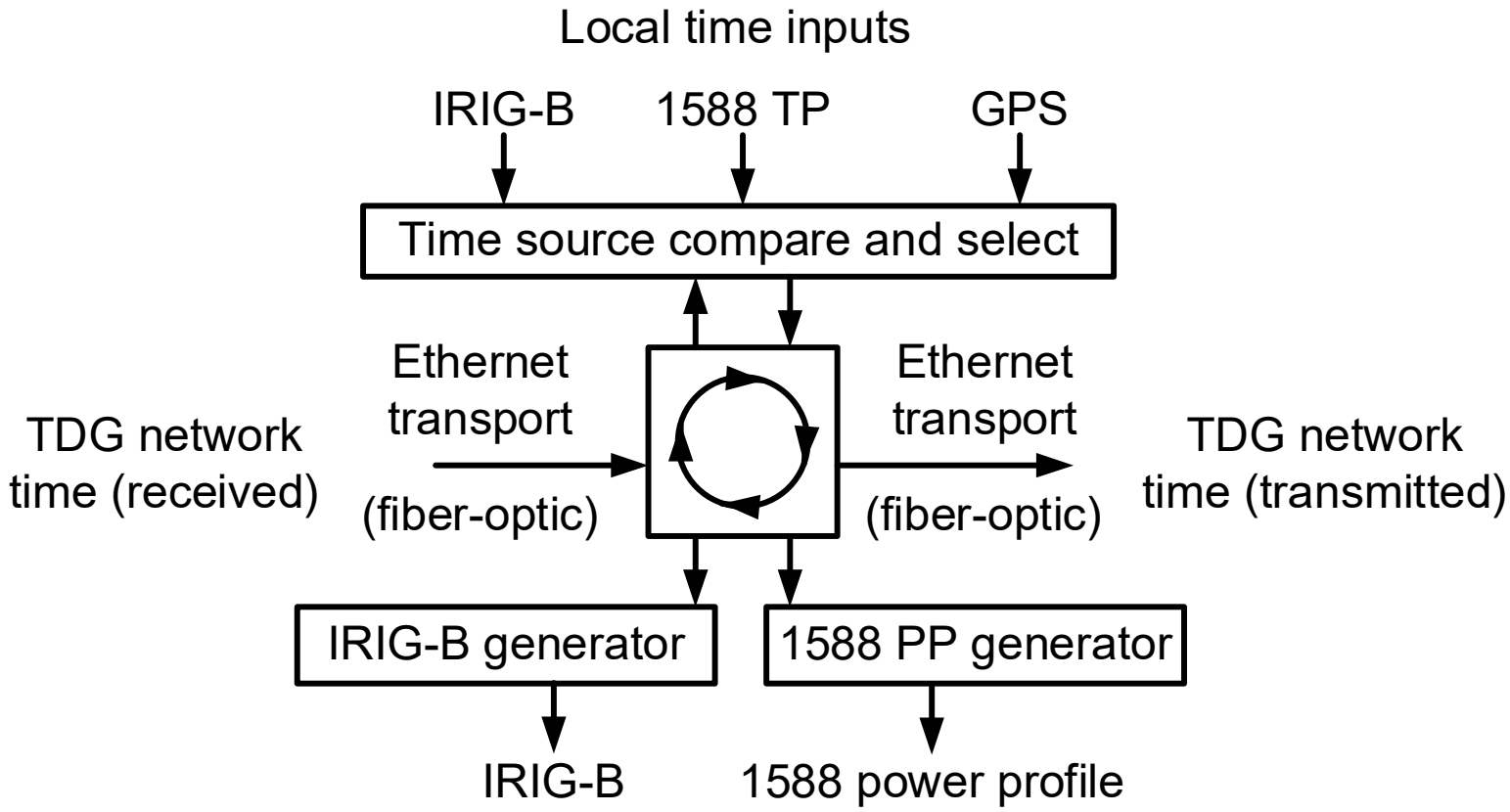
# Topic introduction

- Critical infrastructures need precise timing
- Paradigm shift prevents complete reliance on satellite sources, allowing packet networks to assist
- This solution iteration uses PRTC that provides **high-accuracy** time during GPS outages
- Next solution iteration uses ePRTC to provide **best-in-class accuracy** time during GPS outages

# Time distribution gateways

- Input time
  - Satellite-based GPS or IRIG-B
  - PSN-based via 1588 TP
- Output time
  - IRIG-B
  - PTP PP



# Concept Validation

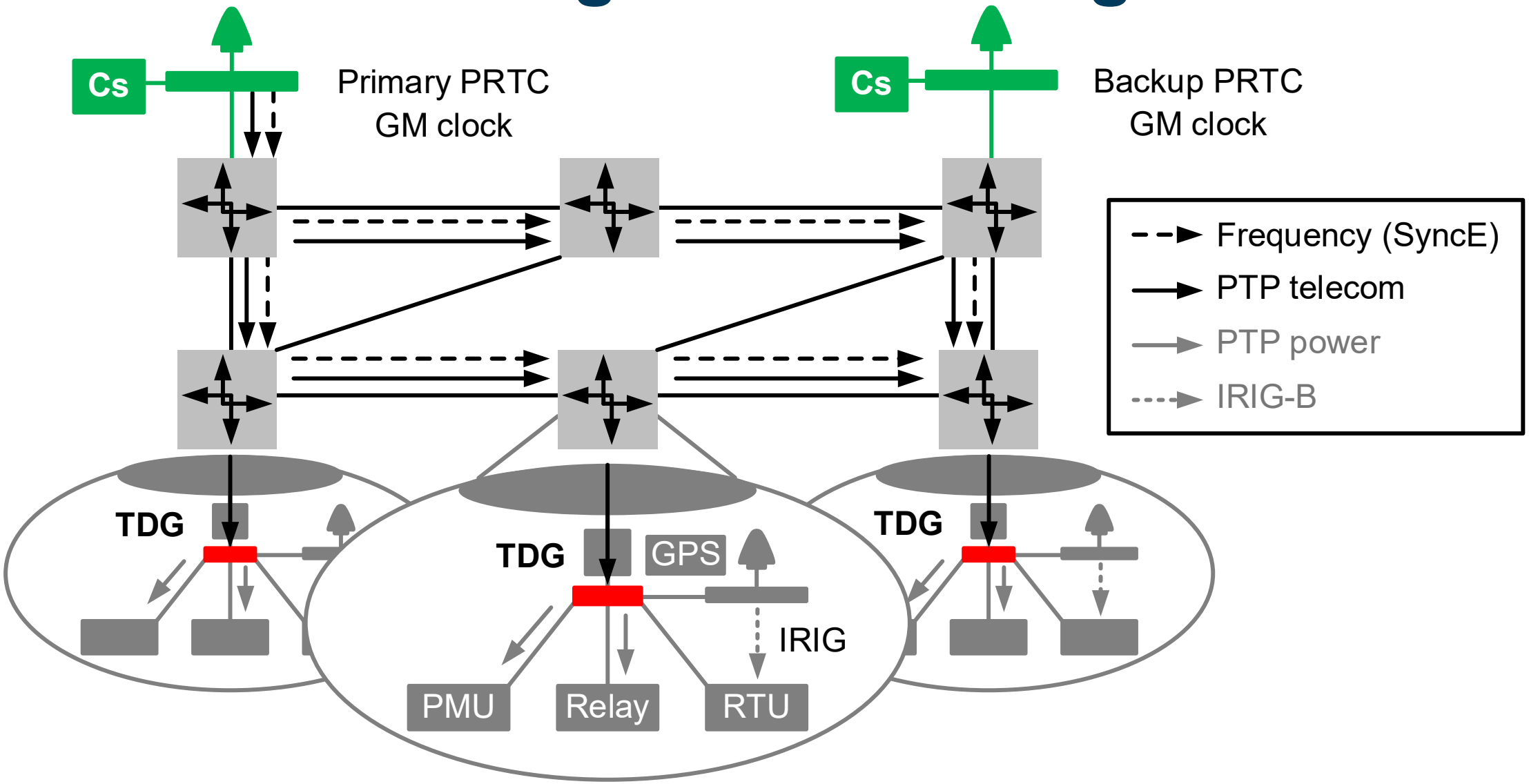
# Performance comparison

- **PRC** – ITU-T G.811
- **PRTC** – 100 nanoseconds to UTC with GPS
- **PRTC** holdover
  - 200 nanoseconds for 1 day with internal rubidium oscillator
  - Better accuracy achieved with cesium-assisted PRC
- **ePRC** – ITU-T G.811.1
- **ePRTC** – 30 nanoseconds to UTC with GPS
- **ePRTC** holdover
  - 100 nanoseconds for 14 days
  - Better accuracy achieved with modern cesium ePRCs

# Solution – cesium-backed PRTC plus TDG

- Incorporates PRTC plus TDG technologies
  - Better holdover performance for PTP in the **WAN**
  - Better accuracy and performance for PTP in the **LAN**
- Is proven to work well on 14-day loss of GPS

# Centralized timing network design w/ PRTC



# Here is what we needed

- Ideally, we needed a high-accuracy time reference better than the system under testing
- What we had was a system of equal performance (due to budget and equipment constraints)

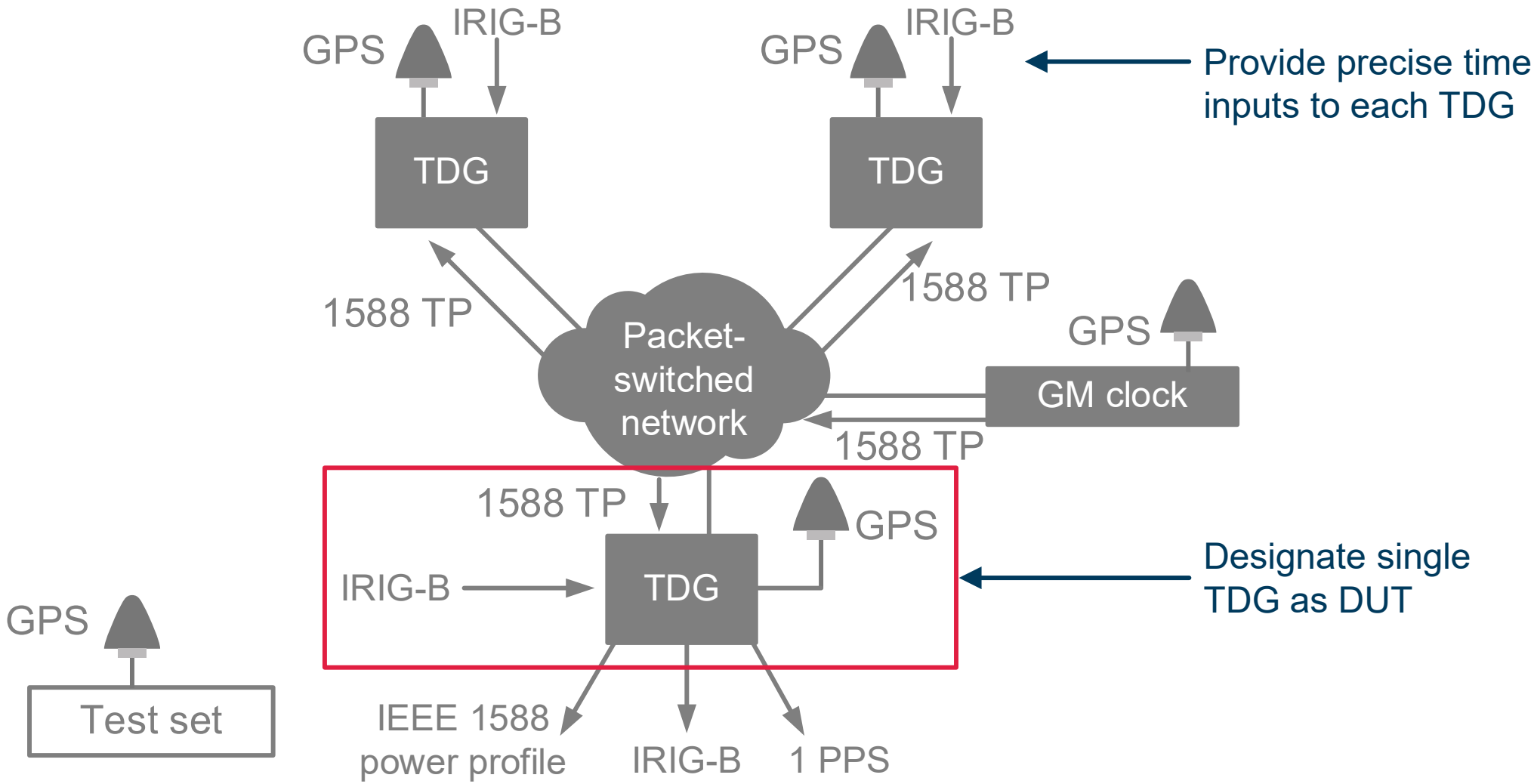
# Here is what we had

- GPS
- PRC (cesium clock that complied to ITU-T G.811 specifications)
- PRTC and ePRTC (hardware, software, license, and configuration in place to enable PRTC and ePRTC functions)

# Test setup – equipment and test set

- 2 PRTCs
  - 1 PRTC under testing
  - 1 PRTC-calibrated test set
- PSN transport for PTP TP with 3 simulated sites
- TDGs at 3 simulated sites
- PTP test set to log time error for more than 14 days

# Topology


GPS
IRIG-B
TDG
GPS
IRIG-B
TDG
Provide precise time inputs to each TDG
1588 TP
1588 TP
Packet-switched network
GPS
GM clock
1588 TP
1588 TP
GPS
IRIG-B
TDG
Designate single TDG as DUT
GPS
Test set
IEEE 1588 power profile
IRIG-B
1 PPS

# Scenarios

## Baseline test cases

Time error measurements at

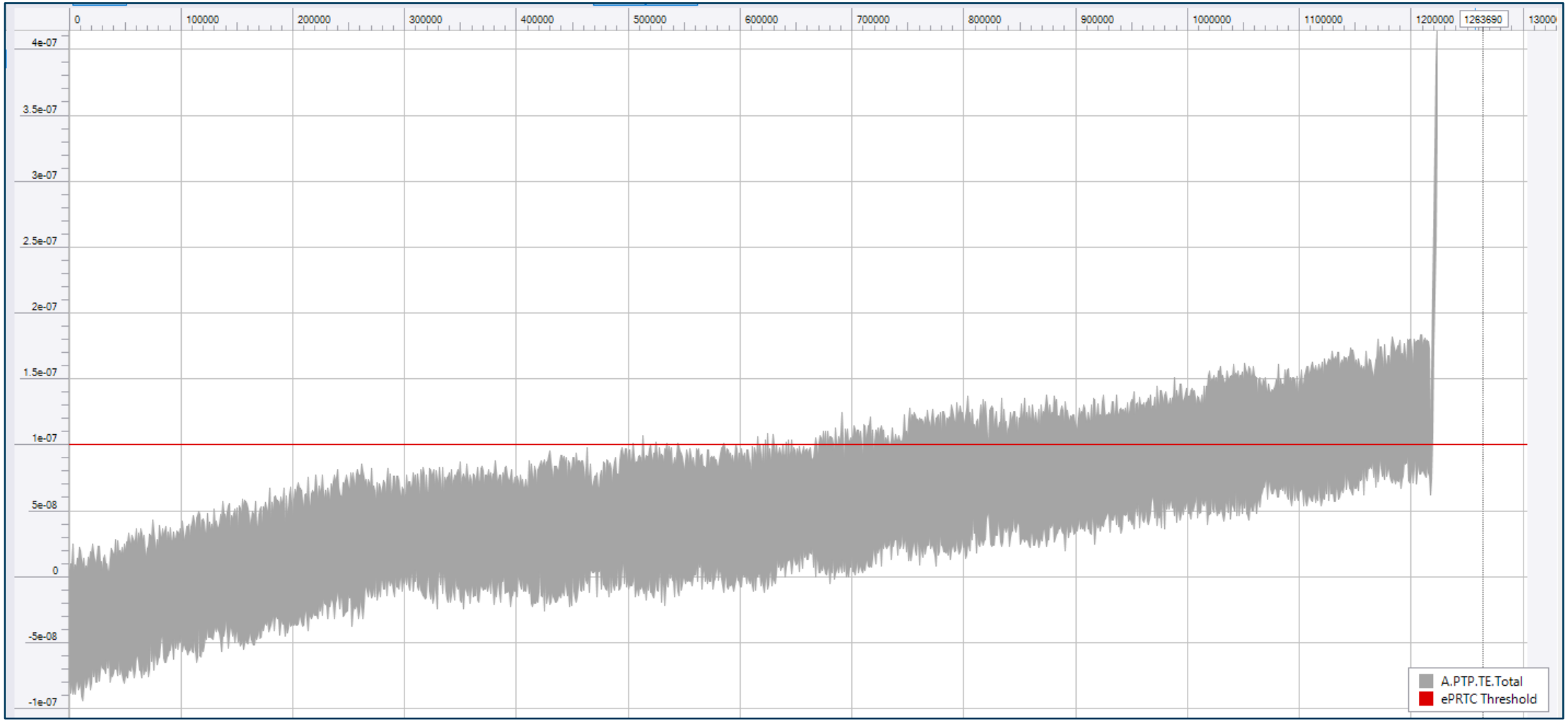
- GM clock (calibrate PTP test set)
- PSN transport device at Sites 1, 2, and 3
- TDG at Site 3 – DUT

## Negative test cases

Remove GPS antenna and qualify TE at TDG

1. PRTC plus cesium holdover
2. PRTC plus cesium recovery

# PRTC plus cesium holdover over 14 days



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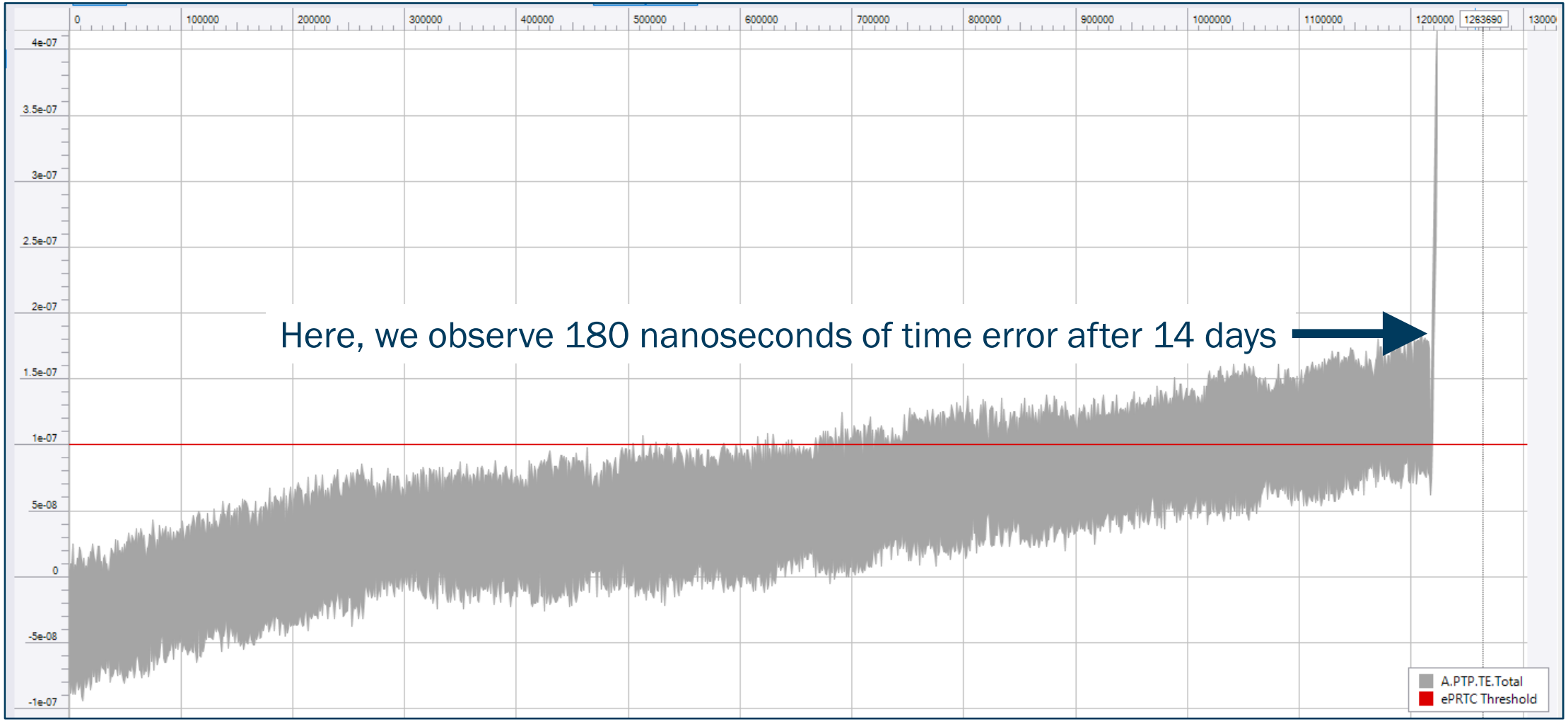
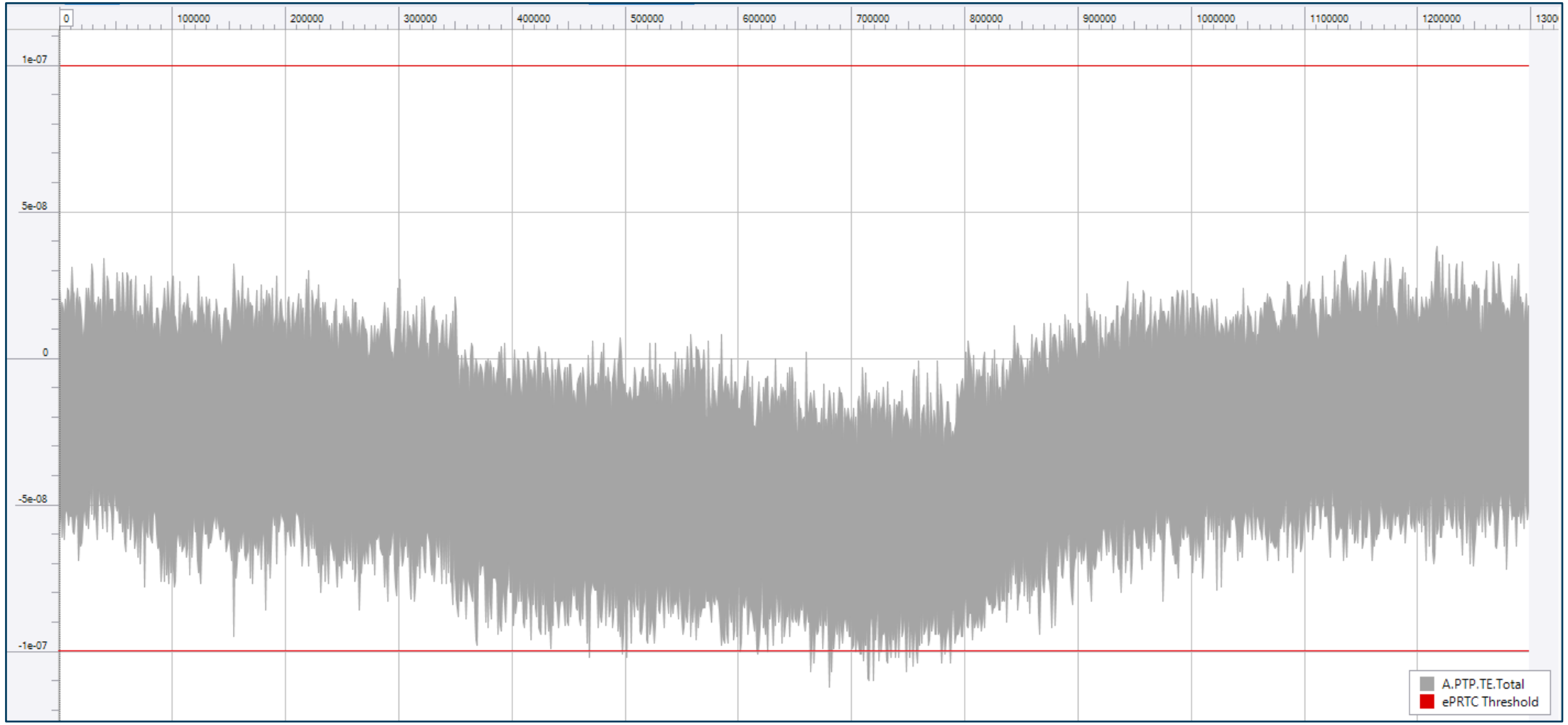


# Results – PRTC without GPS and with GPS



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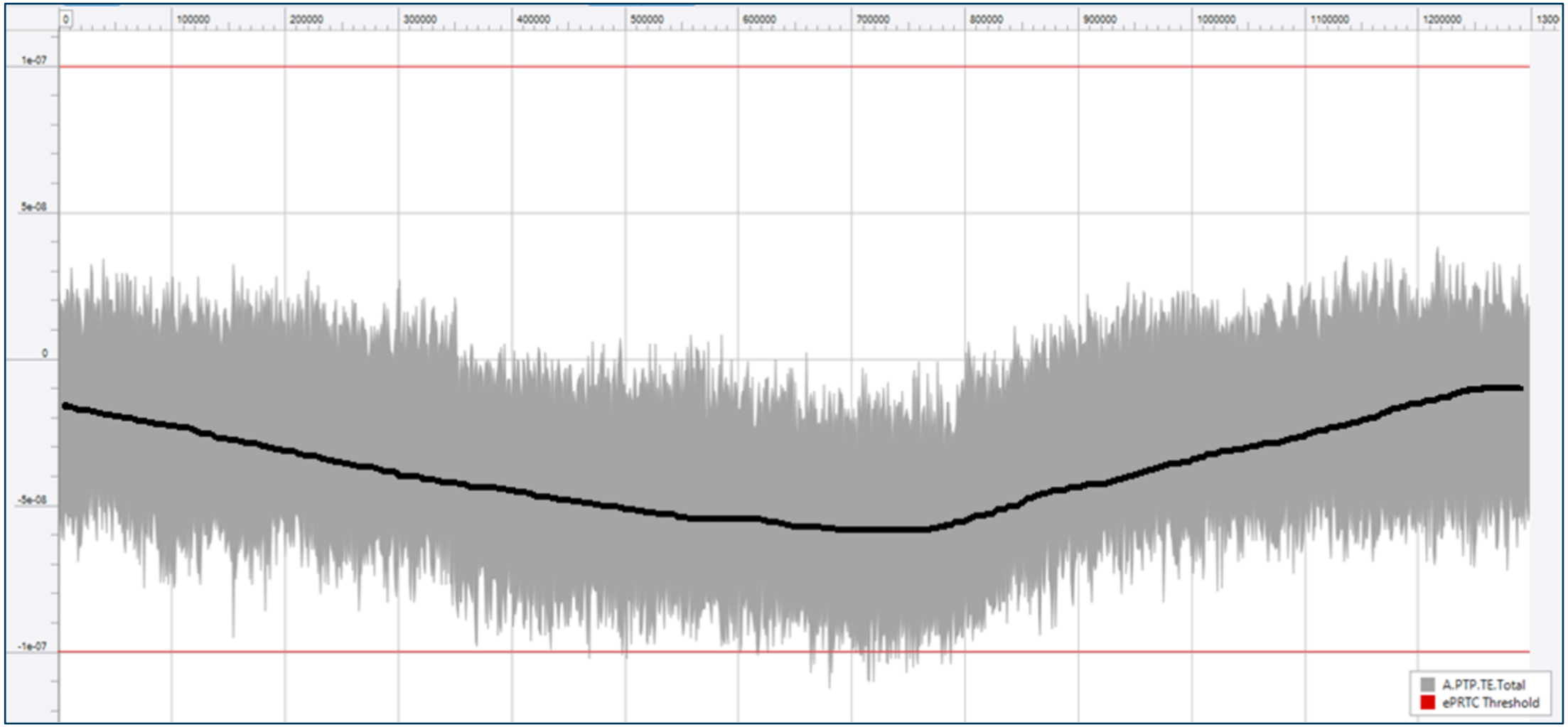

# Lessons learned

- Budget appropriately
- Know your cable specifications
- Ensure 3 weeks of full GPS lock – ensure logs are clean with no bumps in the night

# Conclusion

- PRTC plus cesium solution performance was validated
- TDG proved that hybrid approach of satellite- and PSN-based time sources can help mitigate disruption and protect critical infrastructure

# Thank you


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