ePRC+ Optical Cesium – Behond the limits

WSTS March 30,31 & April 1 , Online

Claude Besse, PLM Time & Frequency

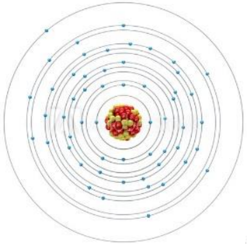
Optical and magnetic cesium

Lifetime

Optical cesium is improving utilization of Cs atoms, leading to longer lifetime

Performance

Optical cesium achieves superior performance



Reliability

Both cesium clock technologies apply proven, highly-reliable components

Production

Midterm advantages for optical cesium due to synergies with photonic assembly technologies

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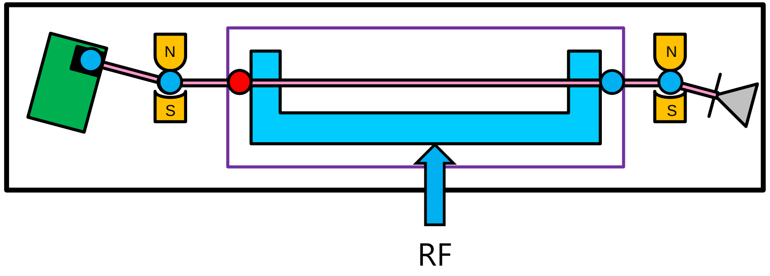
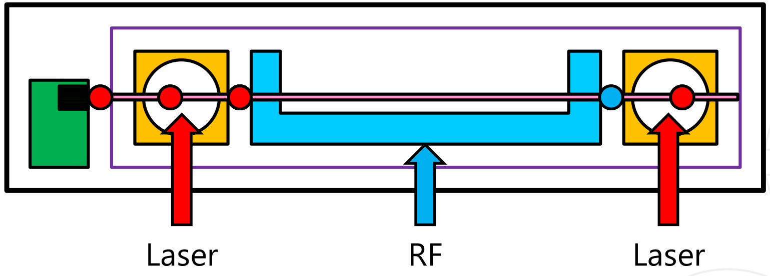
Cesium atomic clock, Magnetic compared to Optical





Magnetic deflection technology for ePRC

Weak flux

- Strong **velocity selection** (bent)
- Magnetic deflection (**atoms kicked off**)

Typical performances:

- **3^{E}-11 $\tau^{-1/2}$**
- 8 years

Stringent alignment (bent beam)

Optical pumping technology for ePRC+

High flux (x100)

- **No velocity selection** (straight)
- Optical pumping (**atoms reused**)

Typical performances:

- **3^{E}-12 $\tau^{-1/2}$**
- 10 years

Relaxed alignment (straight beam)

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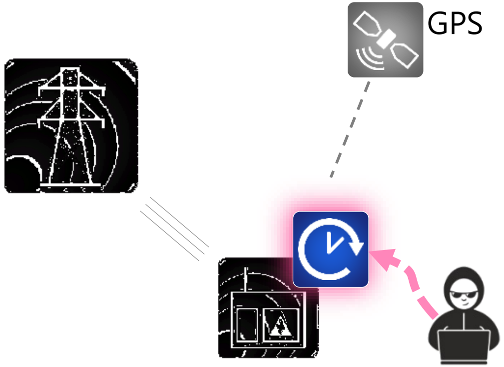
Atomic clocks for resilient critical infrastructures

Problem

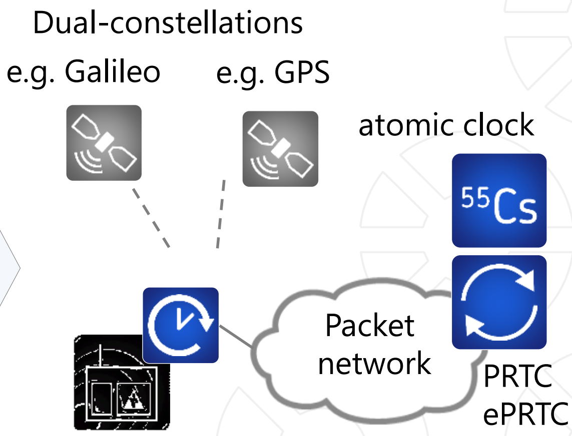


Jamming and spoofing create risk for business continuity in power networks

Governmental response

Executive order on strengthening national resilience through responsible use of positioning, navigation, and timing services.
February 2020

Solution



Redundancy and terrestrial sync delivery from atomic clock providing highly stable timing signal

Highly stable atomic clocks are subject of national interest

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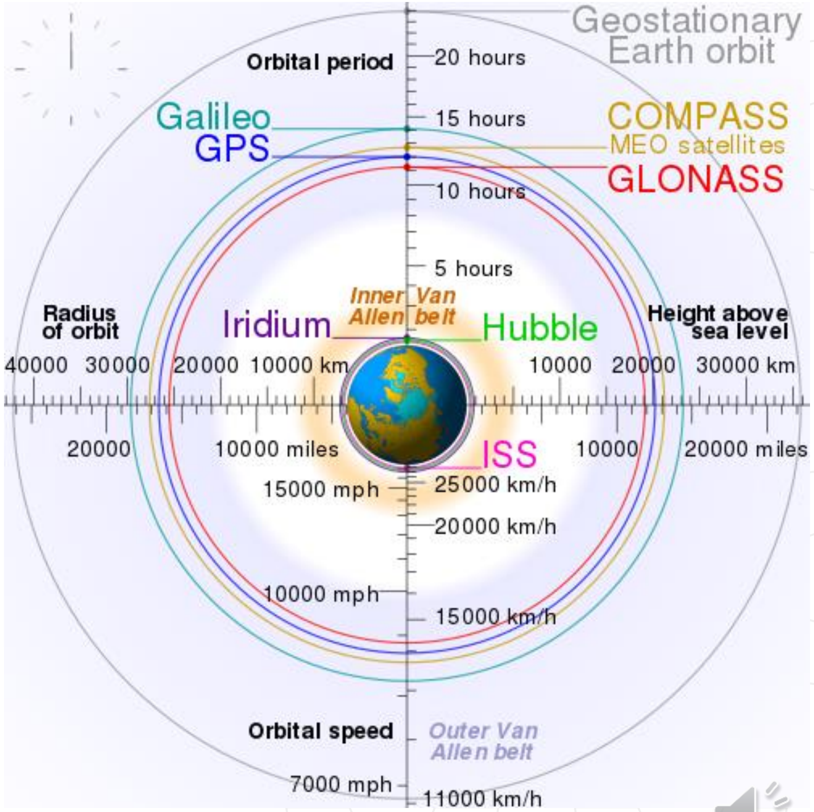
GNSS Vulnerability

- Maintains high accurate UTC
- Free for everyone but not everywhere
- Critical infrastructure will not Scale with ever increasing amount of GNSS Antennas
- Vulnerable source
  - Interferences
  - Intentional (Jamming), Unintentional
  - Multipath, Spoofing, GNSS Outages
  - Atmosphere (Solar Activities)
  - Indoor & Outdoor (Urban Canyons)



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Markets

Telecommunication network reference

- Telecom operators, accurate phase sync for 5G (ePRTC)

Critical infrastructure

- Power utilities , railways, transport, airports

Enterprise / Data-centers (ICPs) / Finance

- Synchronization of distributed databases
- High-frequency trading

Defense

- Precise timing for security applications
- Highly accurate localization

Optical Cesium as GNSS backup and for higher stability as well as better holdover

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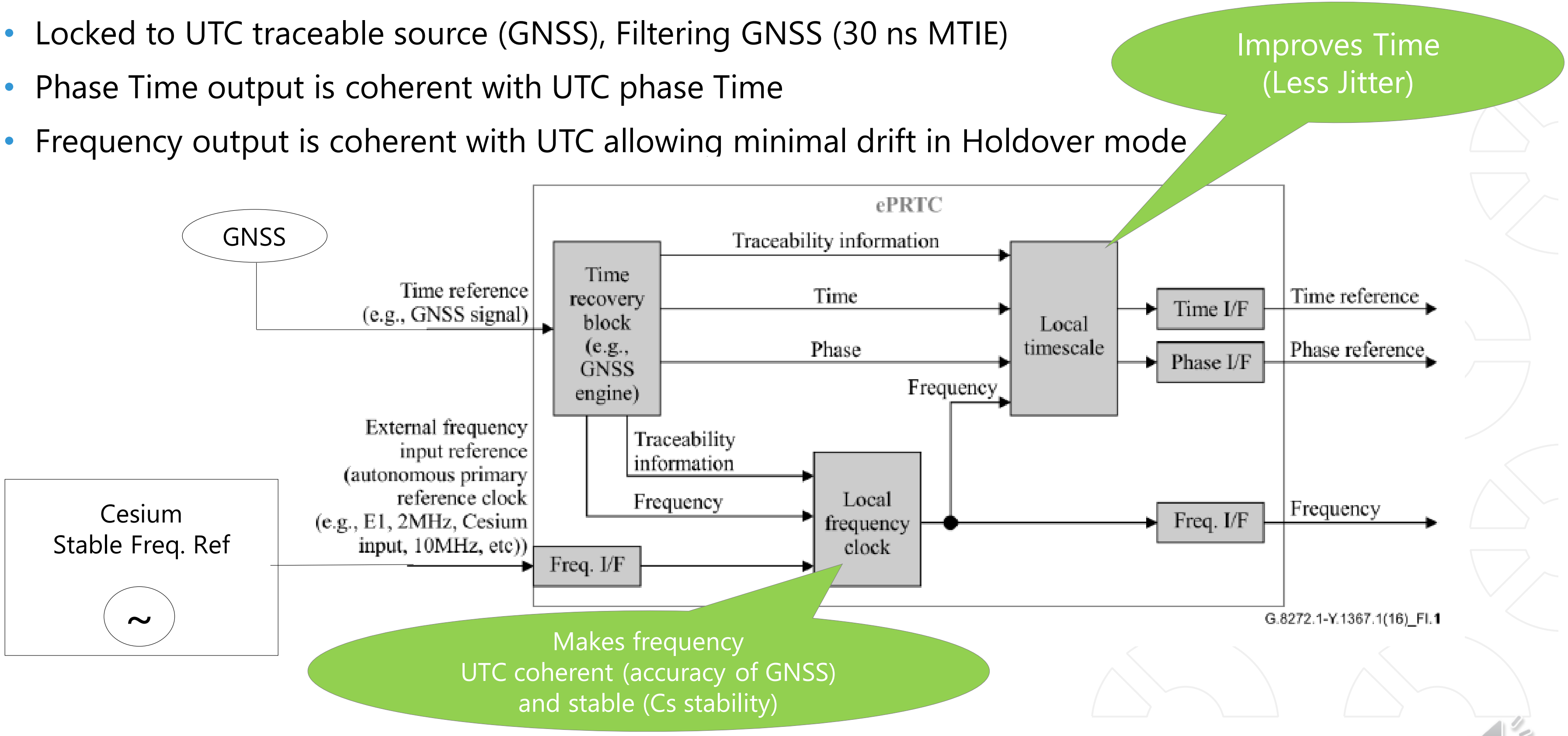
ePRTC logical implementation model

- Locked to UTC traceable source (GNSS), Filtering GNSS (30 ns MTIE)
- Phase Time output is coherent with UTC phase Time
- Frequency output is coherent with UTC allowing minimal drift in Holdover mode



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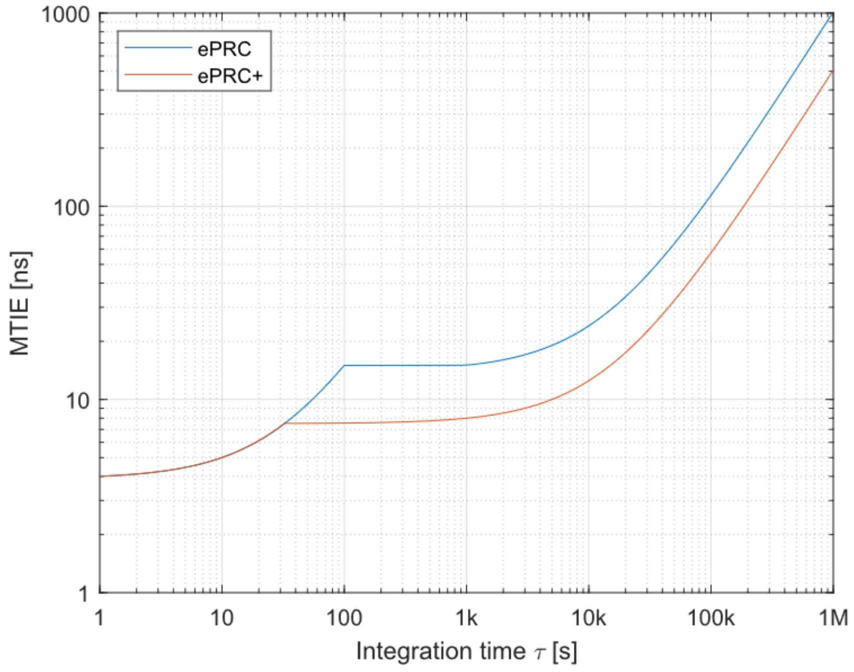
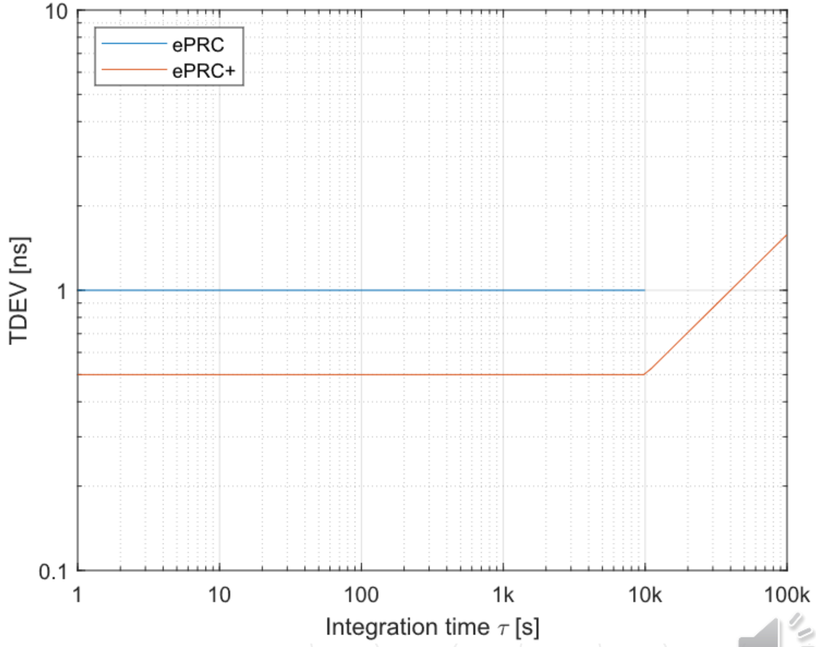
Suggestion for ePRC + improvement

Optical Cesium outperform the G.811.1 ePRC spec (MTIE & TDEV)

MTIE



TDEV



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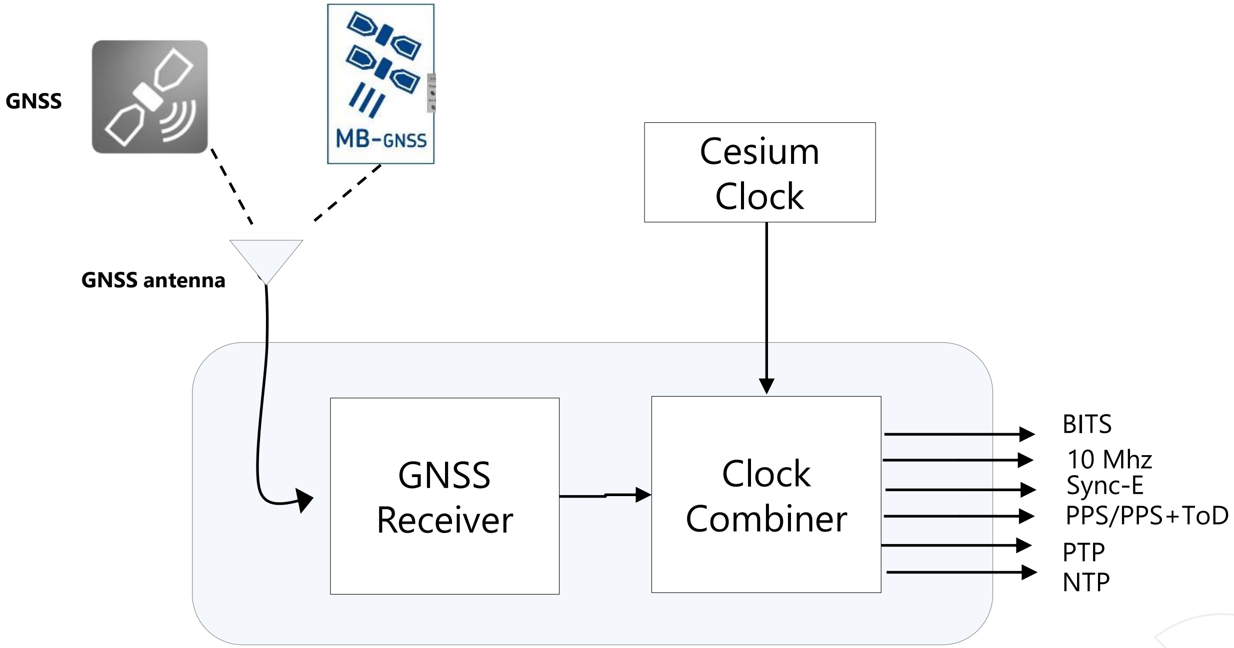
Typical implementation (single channel)
Cesium as a backup to any GNSS event



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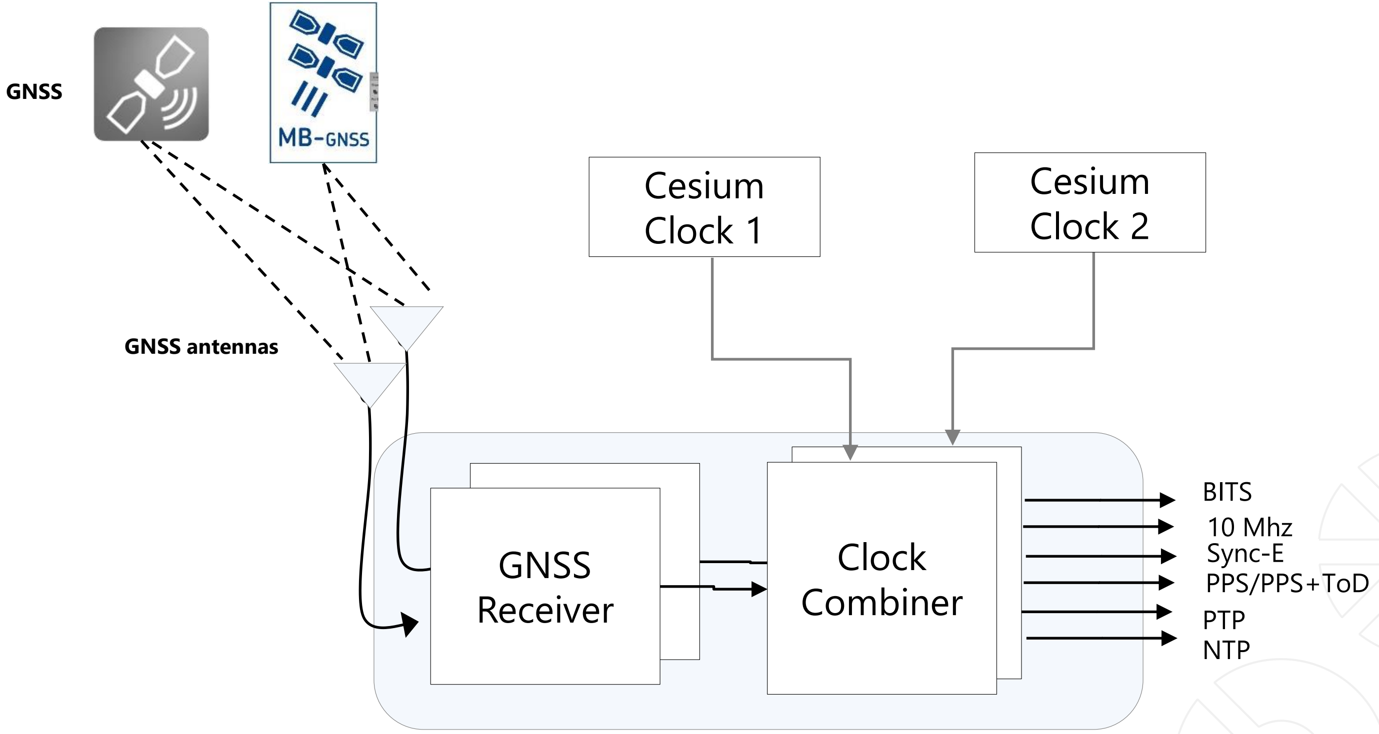
Typical implementation (1+1)
Cesium as a backup to any GNSS event



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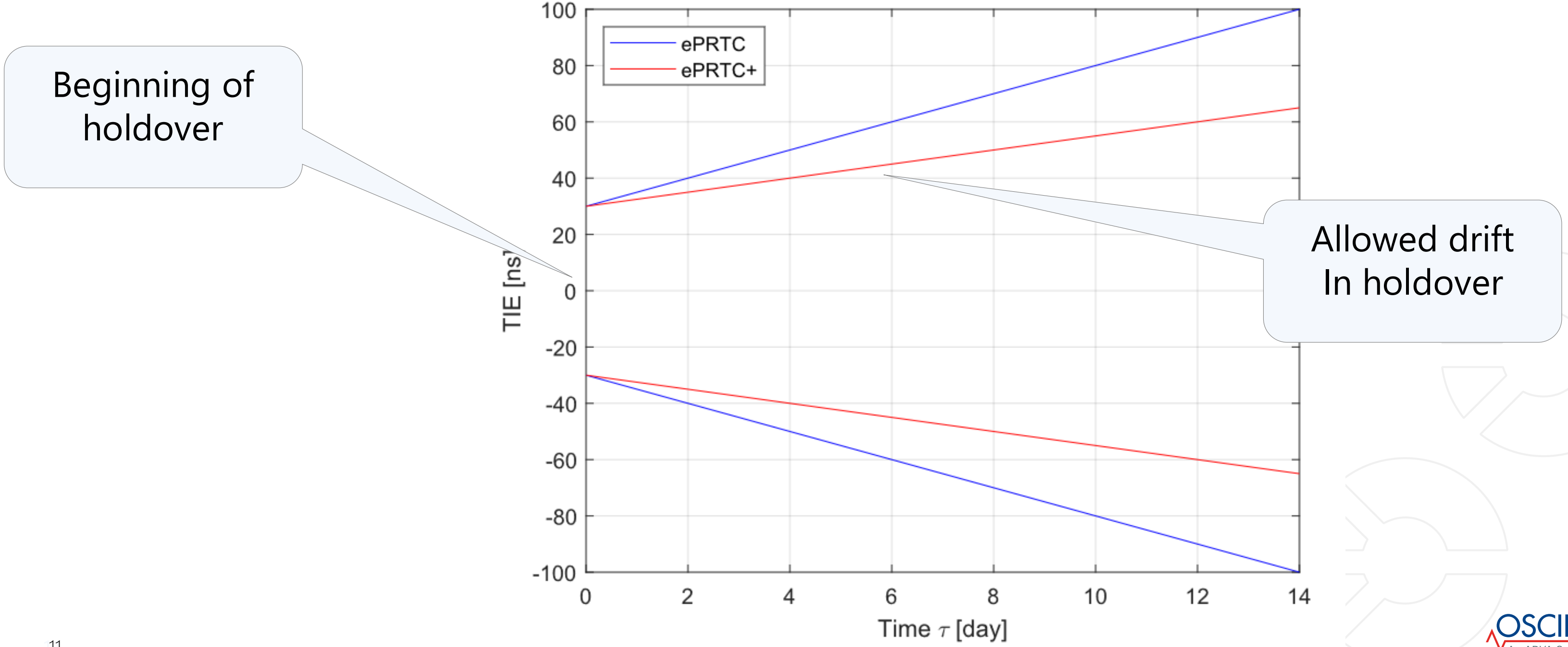
Optical Cesium ePRC+ for ePRTC+

When our Optical Cesium is used with OSA ePRTC it provides improved holdover (OSA ePRTC+ holdover)

Will not drift more then 35nsec in 14 days!



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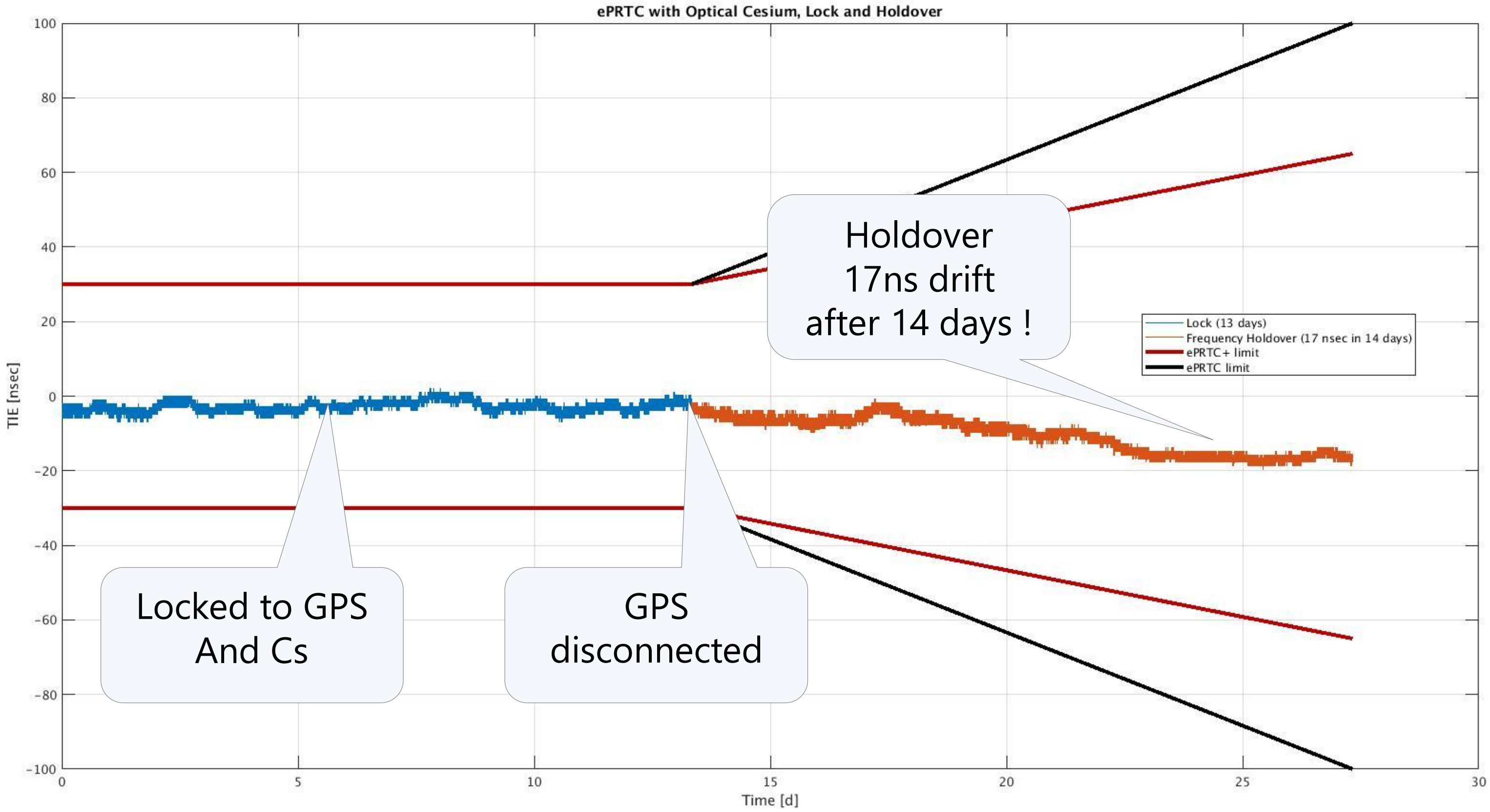
Optical Cesium ePRC+ in ePRTC – Holdover test result A



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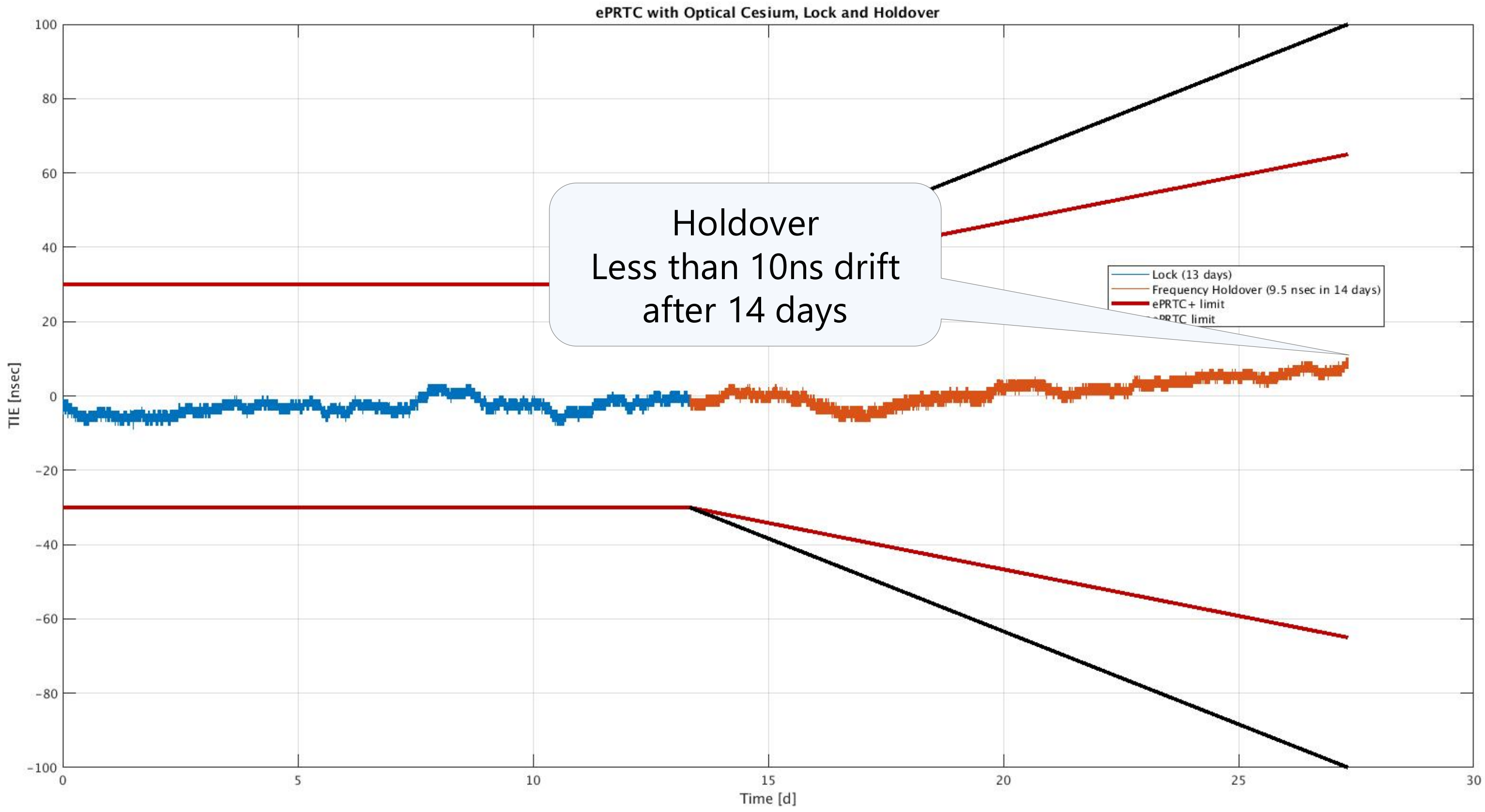
Optical Cesium ePRC+ in ePRTC – Holdover test result B



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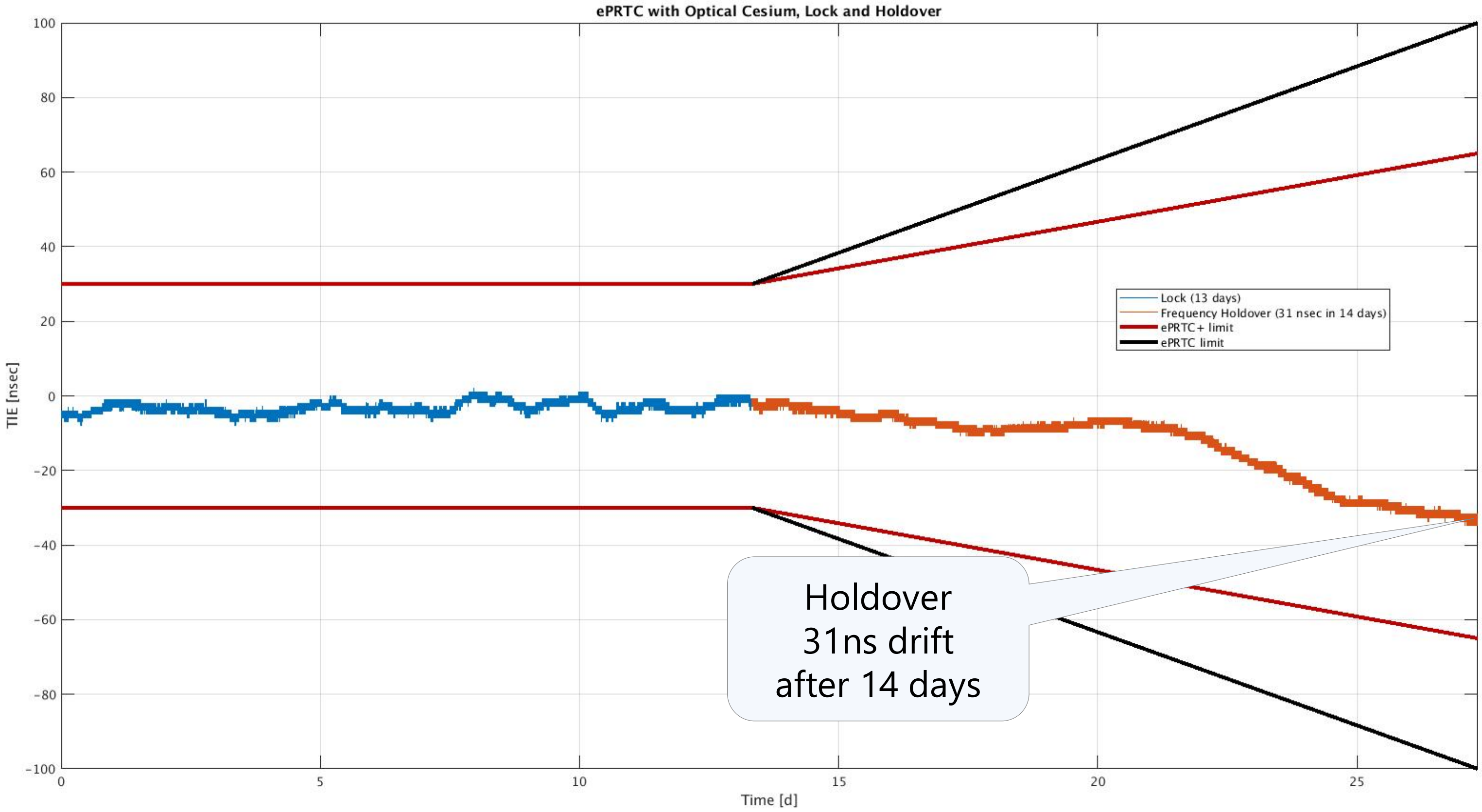
Optical Cesium ePRC+ in ePRTC – Holdover test result C



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Key takeaways

- Optical cesium provides better stability and longer lifetime (no compromise between lifetime and performance)
- Essential solution for backup to GNSS with mobile networks, power utilities, defense among others
- Optimized ePRTC+ performance in combined use with our GNSS receivers
- Common and unique remote management

A major innovation in atomic cesium technology

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