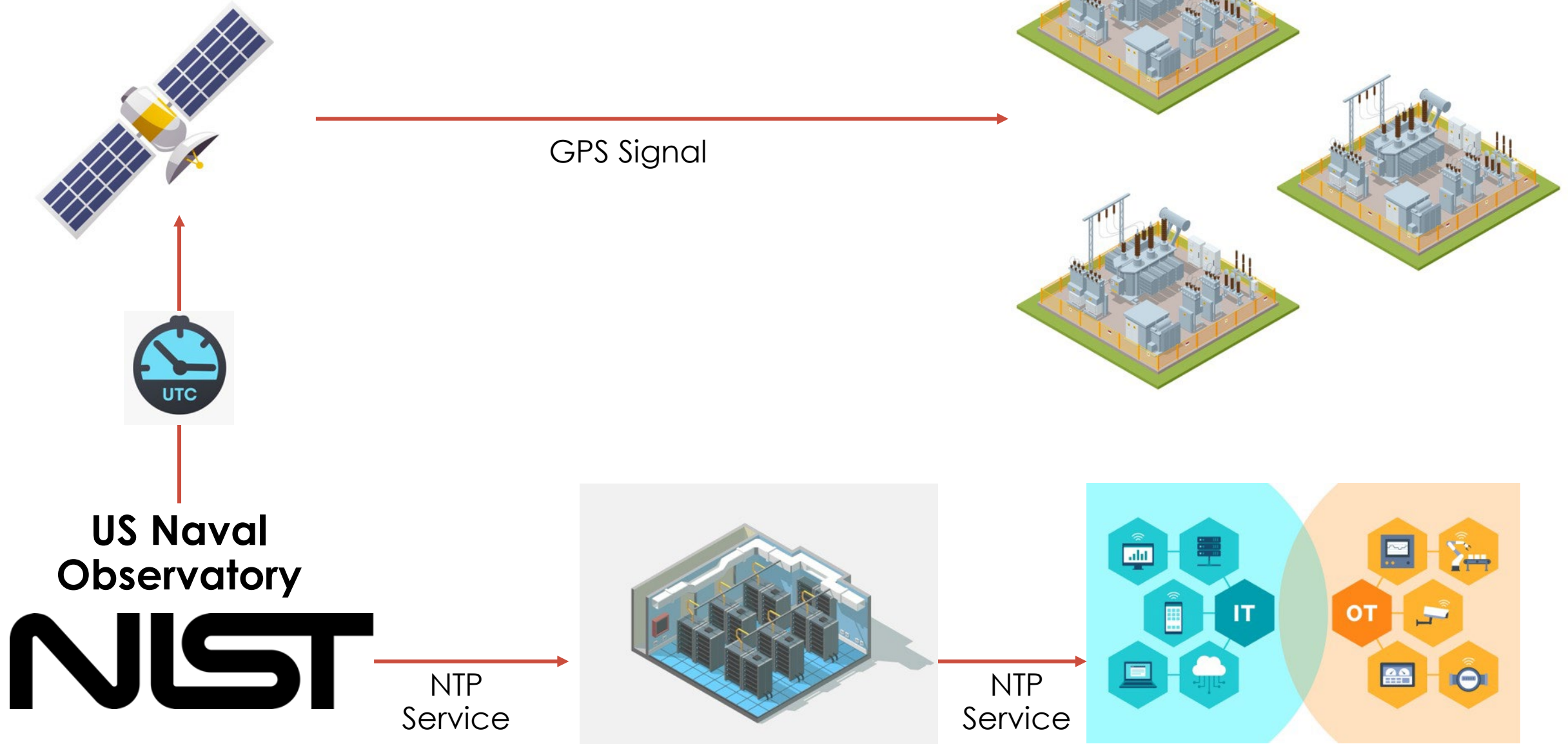# Novel Grid-Specific Approaches to Synchronization and Time Distribution

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Sponsored by the US Department of Energy,
Office of Electricity

Basic Concept - Today

GPS Signal

UTC

US Naval Observatory

NLST

NTP Service

NTP Service

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Risk and Vulnerabilities

Proliferation of GPS and NTP on the Grid

- Tens of thousands of devices on the grid require microsecond or better synchronization
  - PMUs
  - Substations
  - SCADA
  - Control Centers
  - Data Centers

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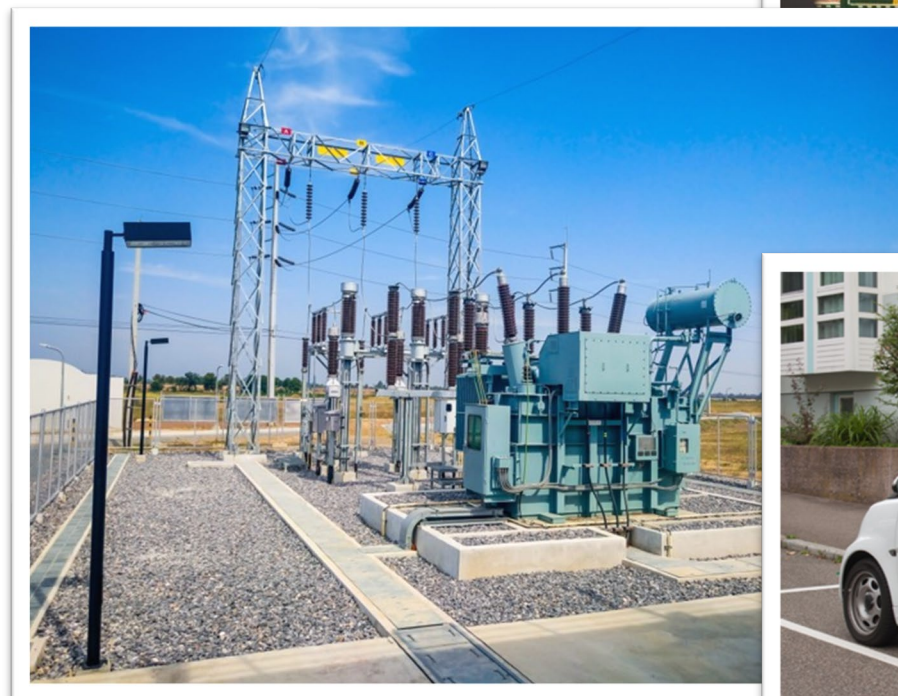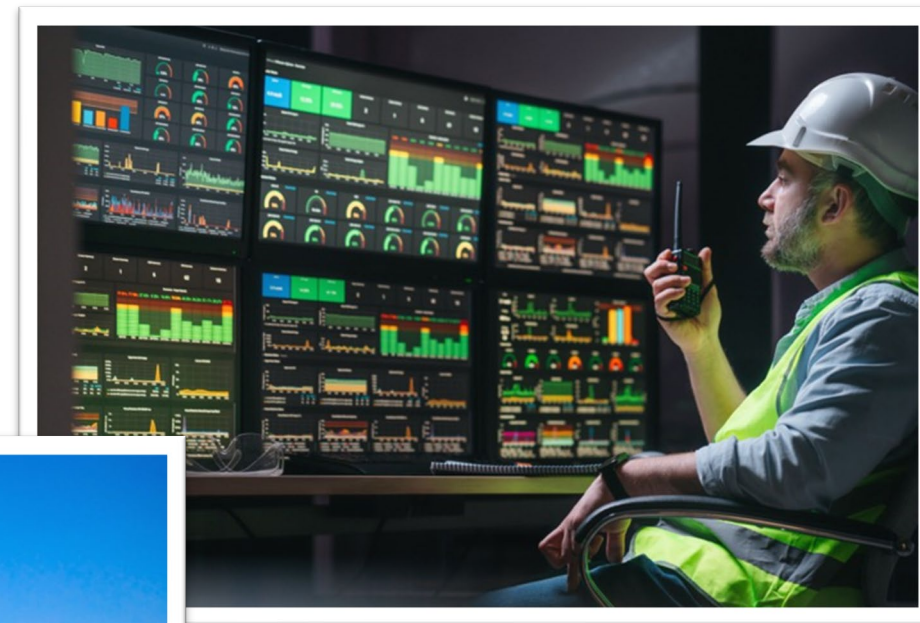
Developing Wide-Area Time Synchronization Solutions to Augment GPS for US Critical Infrastructure

National Security & Modernization Imperative

- GPS is an amazing capability but is vulnerable to spoofing and other cyber threats

- Executive Order 13905 (2020): National Resilience through PNT

- PTP timing necessary for a smart grid

One-of-a-Kind Testbed with Dozens of Commercial Partners

- Leveraging COTS capabilities to evaluate against strict accuracy & cyber requirements of the grid

- Partnerships to improve, refine, and adapt OEM capabilities

R&D and T&E of Novel Timing Architectures for the Grid

- Developing nanosecond-scale secure timing solutions

- Testing across a variety of terrestrial and space-based comms links

- Evaluating integrations with existing utility equipment baselines

Established Capacity for Transition to Utilities

- CAST collaborates with PMAs and utilities to demonstrate and implement new synchronization capabilities

- Team is documenting best practices for sharing with and supporting utilities

CAST — Center for Alternative — Synchronization and Timing

ORNL Timing & Synchronization Test-Bed: Industry-Leading Technologies and Nationwide Partnerships
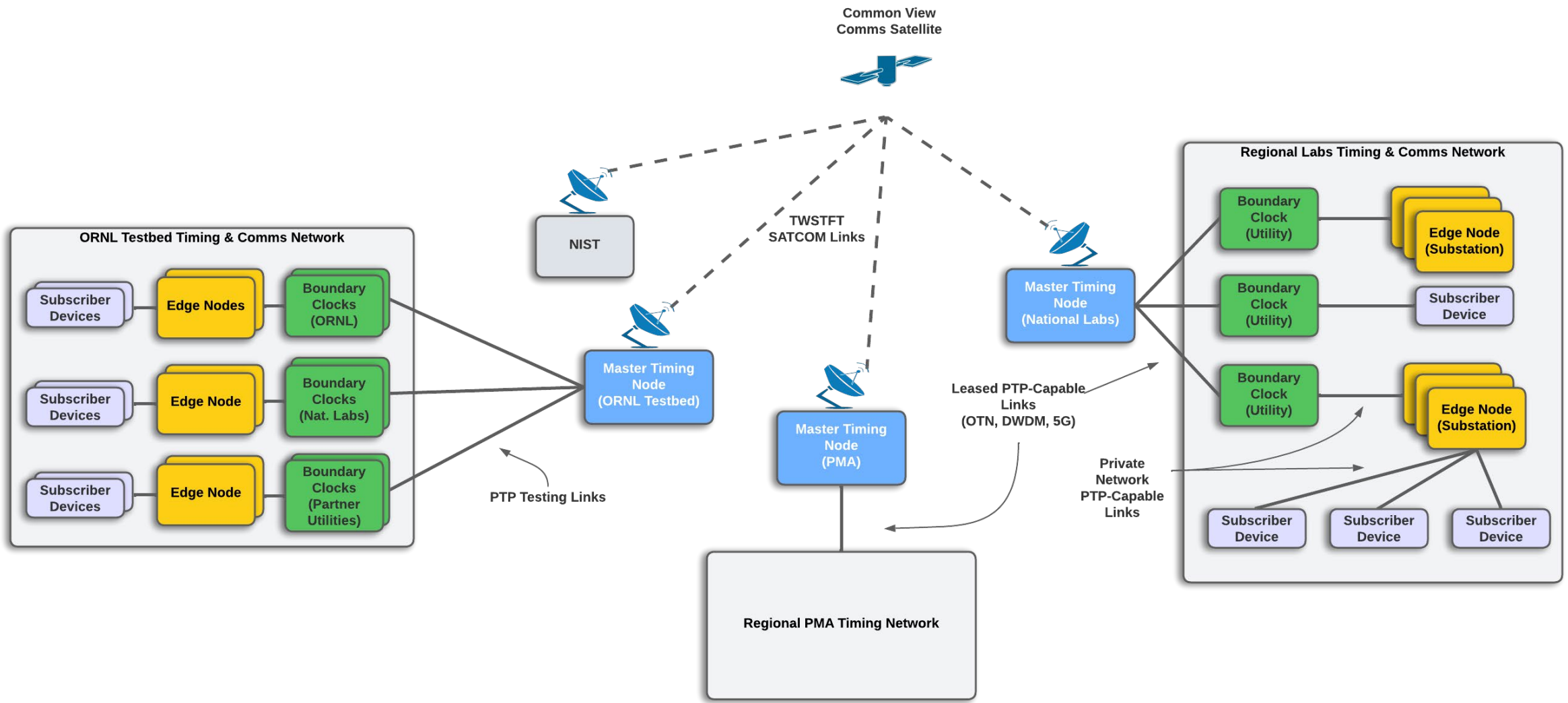
One-of-a-Kind Technology Baseline

- Multiple **atomic clocks**
  - One optical cesium clocks
  - Two magnetic cesium clock
  - Two rubidium clocks

- **Cyber** accredited, industry leading firewall and signal **encryption**

- Multiple **communications networks** integrated to the lab
  - Dark fiber
  - DWDM
  - Carrier Ethernet
  - OTN
  - DOE ESNet
  - Cellular/5G
  - Dedicated SATCOM Satellite Internet

Industry and Lab Partnerships for Testing and Development

- Hardware
  - Adtran/Oscilloquartz
  - Microchip
  - Palo Alto
  - Juniper
  - Arista
  - Nokia
  - Orolia

- Communications
  - ESNet
  - AT&T, Verizon
  - InMarSat
  - SES Government

- R&D and Testing
  - Idaho National Lab
  - Sandia National Lab
  - Savannah River National Lab
  - National Institute of Standards of Technology (NIST)
  - Electric Power Board (EPB) of Chattanooga
  - Public Service Company of New Mexico (PNM)
  - Dominion Energy
  - Western Area Power Administration (WAPA)

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Tomorrow - Multi-Tier Timing Architecture for Resilient PNT

Timing Nodes and Pathways

Stratum 0 – UTC

- USNO – GPS
- NIST – NTP

Stratum 1 – Master Clock

- Cesium Reference
- Disciplined Oscillator
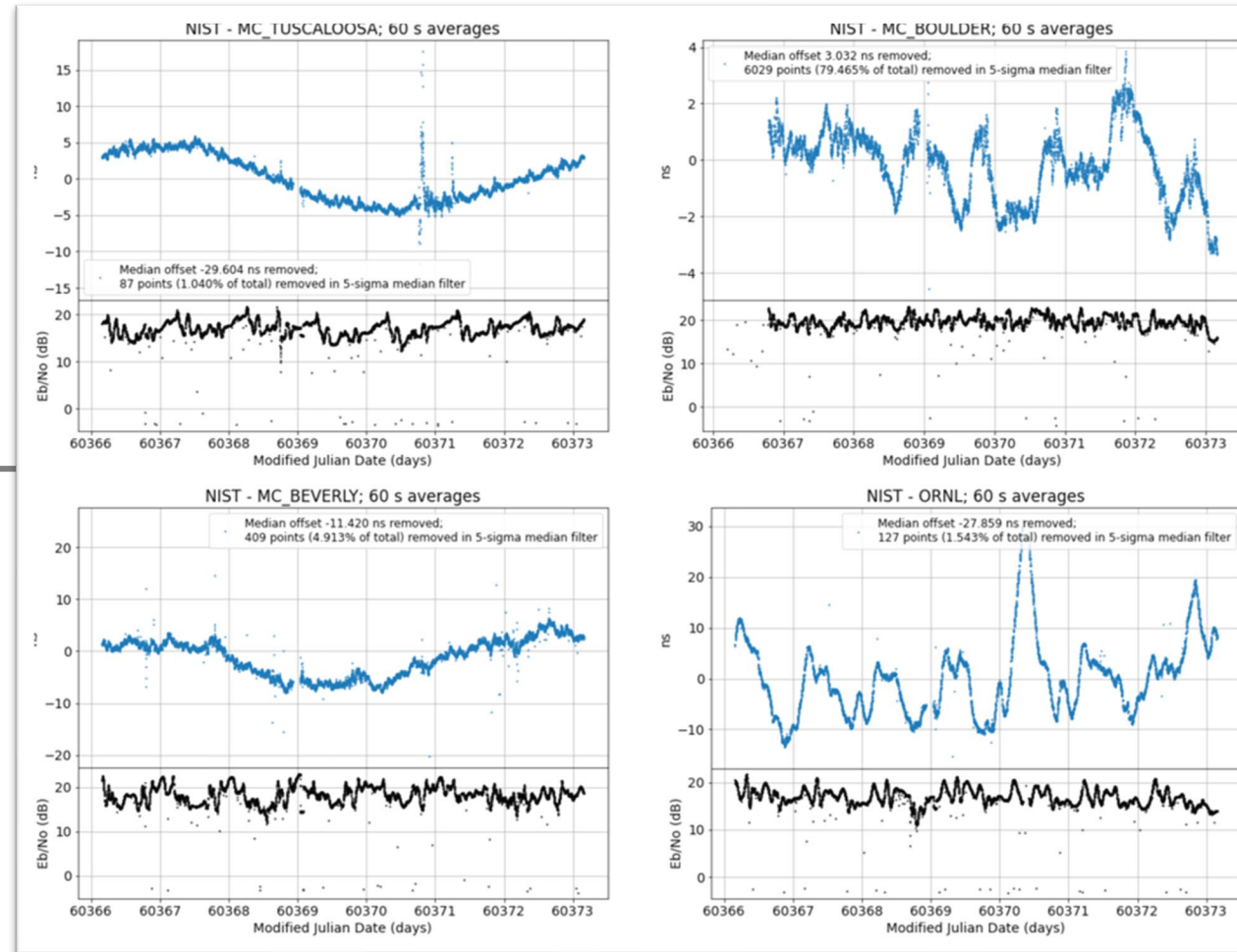
Investigating novel methods for time transfer from authoritative sources
- Collaboration with NIST
- TWSTT as a service
- Future investigations of LEO offerings

Stratum 3 – Boundary Clock

Disciplined Oscillator

Timing Nodes and Pathways

Stratum 0 – UTC

- USNO – GPS
- NIST – NTP

Benchmarking commercial master clock systems for power grid accuracy, precision, and holdover performance
- Collaboration with Oscilloquartz and Microchip
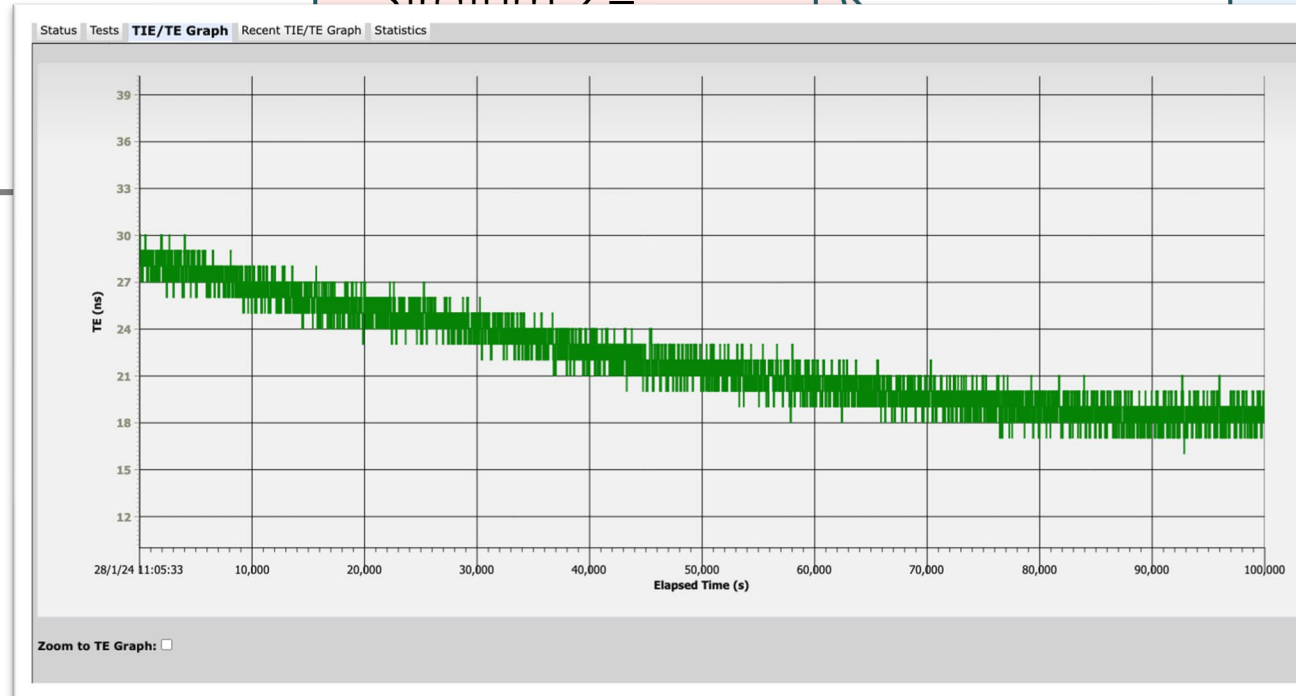- 14-day, 30-day, indefinite ePRTC holdover tests

Stratum 1 – Master Clock

- Cesium Reference
- Disciplined Oscillator

Stratum 2 –

Stratum 3 – Boundary Clock

Disciplined Oscillator

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Timing Nodes and Pathways

Stratum 0 – UTC

- USNO – GPS
- NIST – NTP

Evaluating performance of different network mediums for time delivery and synchronization
- DOE ESNet for Federal entities
- Dark fiber, OTN, DWDM, SONET/SDH, Commercial/Carrier Ethernet, MPLS
- Precision Time Protocol (IEEE 1588-2008/2019), Network Time Protocol
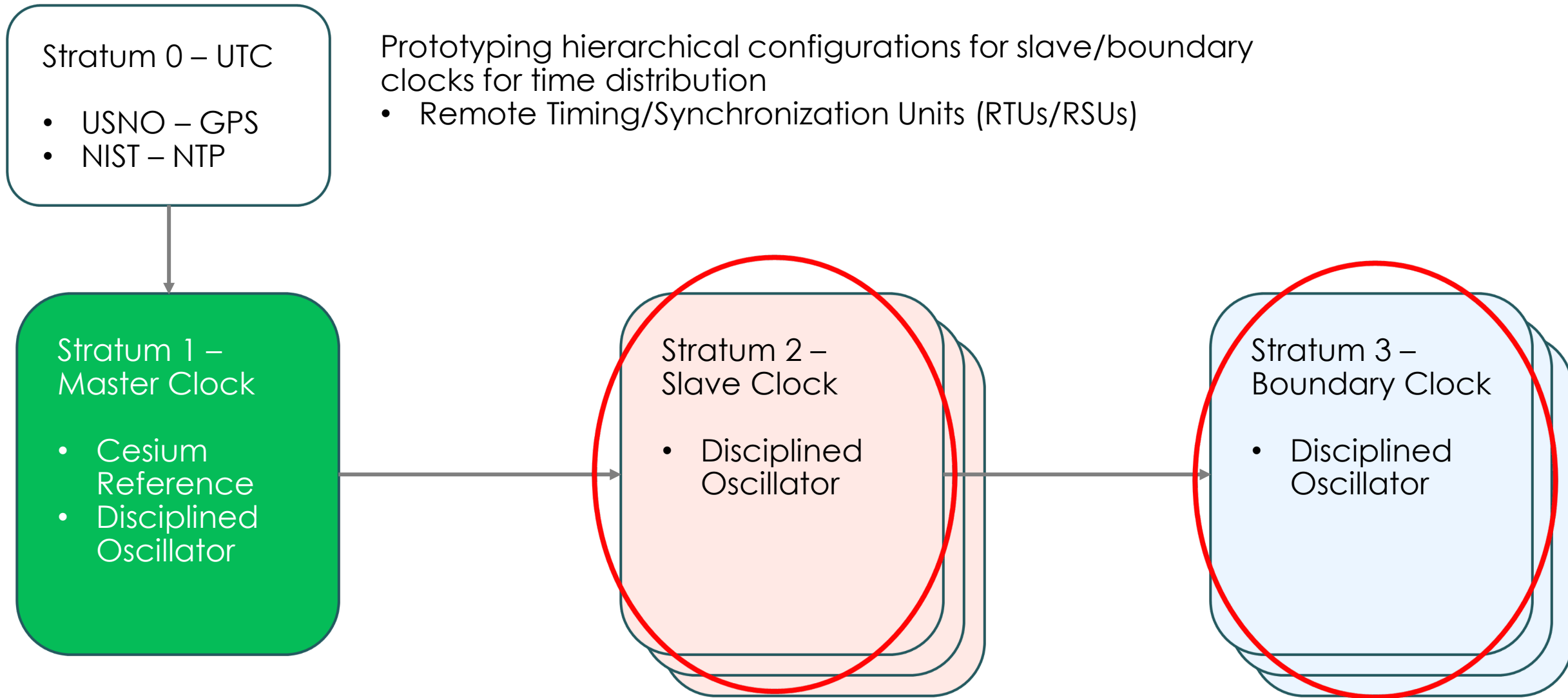
Stratum 1 – Master Clock

- Cesium Reference
- Disciplined Oscillator
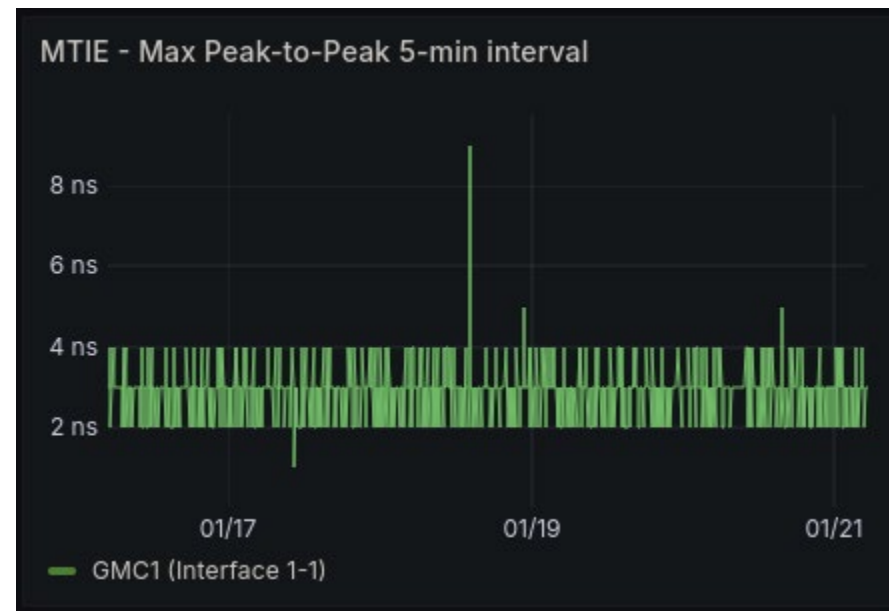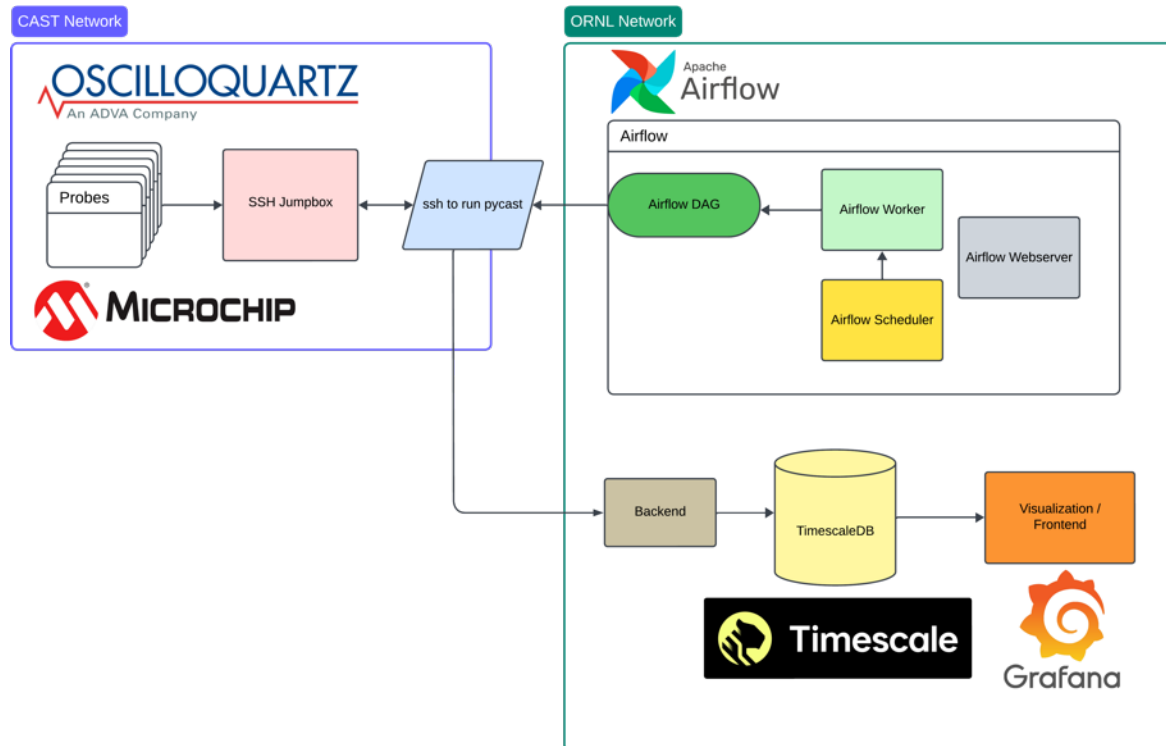
Stratum 2 – Slave Clock

- Disciplined Oscillator

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Timing Nodes and Pathways

Stratum 0 – UTC

- USNO – GPS
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Prototyping hierarchical configurations for slave/boundary clocks for time distribution
- Remote Timing/Synchronization Units (RTUs/RSUs)

Stratum 1 – Master Clock

- Cesium Reference
- Disciplined Oscillator

Stratum 2 – Slave Clock

- Disciplined Oscillator

Stratum 3 – Boundary Clock

- Disciplined Oscillator

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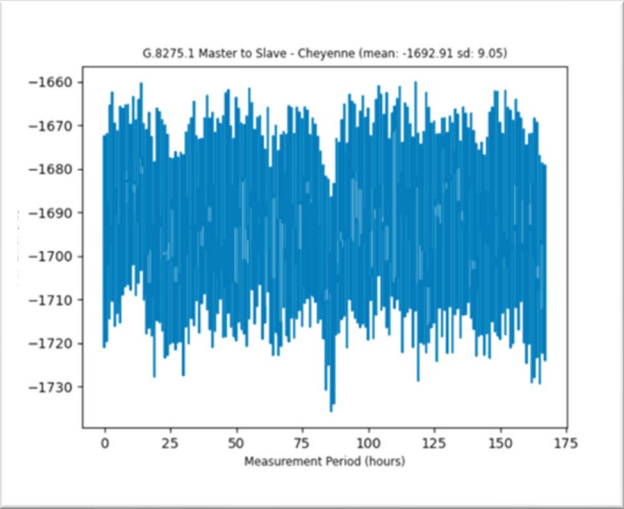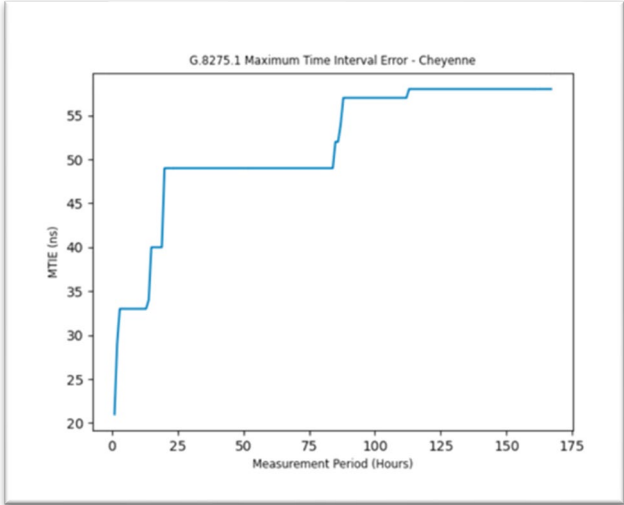
Monitoring

Developing a real-time monitoring and analytics platform for automated data collection, visualization, and anomaly detection

CAST Web Page

https://cast.ornl.gov

THANK YOU

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