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Complementary Timing in a Transmission Utility Environment

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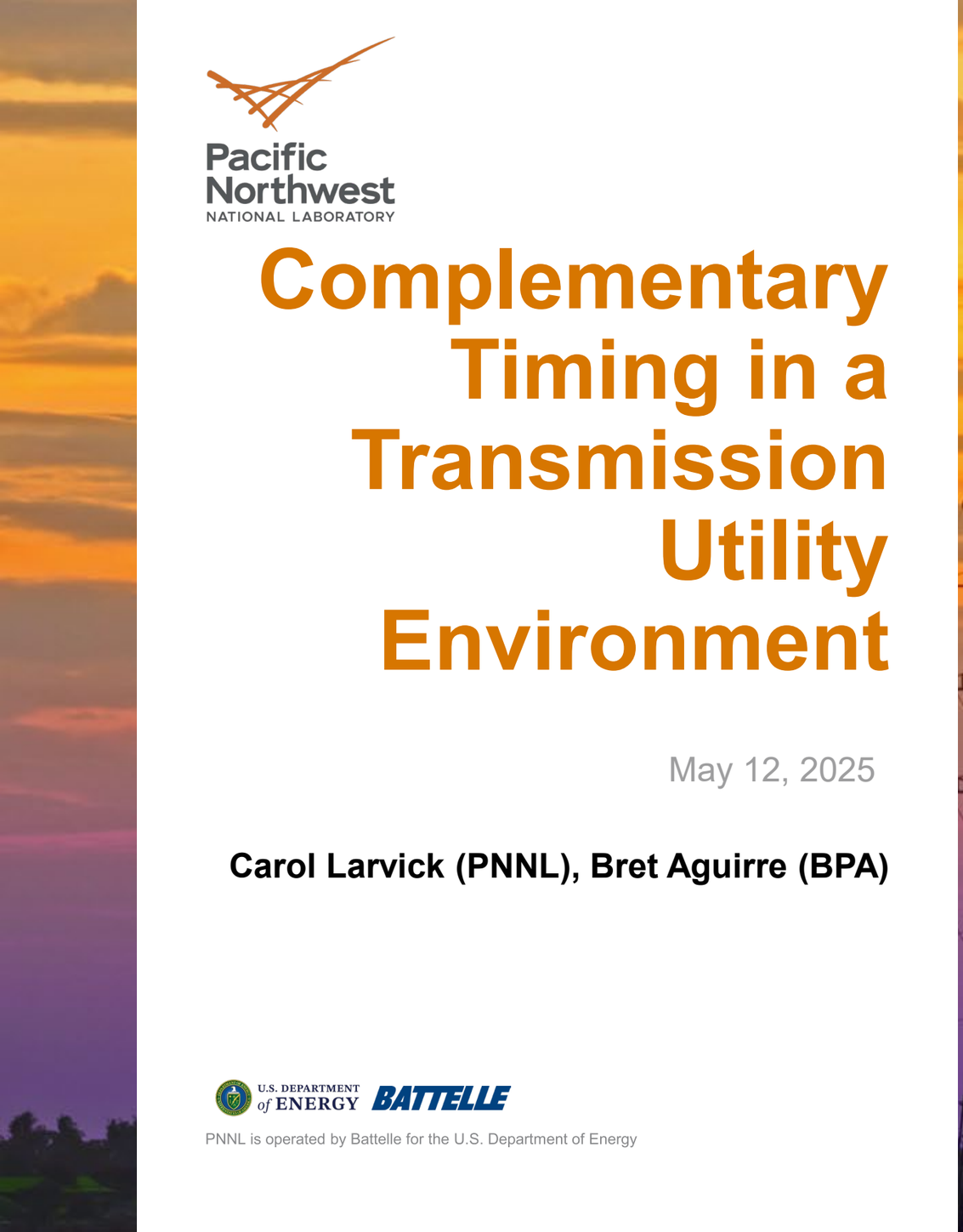

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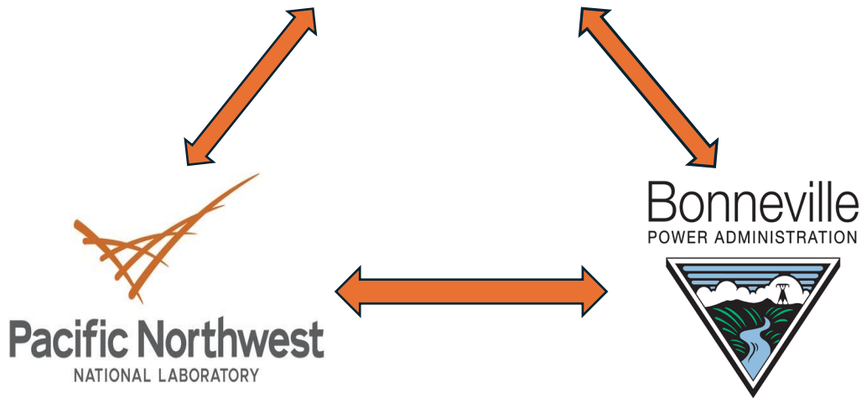
What to Expect Today

U.S. DEPARTMENT of ENERGY | Grid Deployment Office



Agenda

- Introductions
- Significance of testing
- GPS and the Bulk Electric System (BES)
- BPA's approach and goals
- Results
- Next steps

Who are we?

- Sponsor – DOE Grid Deployment Office (GDO)
- National Lab – Pacific Northwest National Laboratory
- Power Marketing Administration – Bonneville Power Administration
  - ✓ Transmission – 15,000 circuit miles
  - ✓ Substations – 250+

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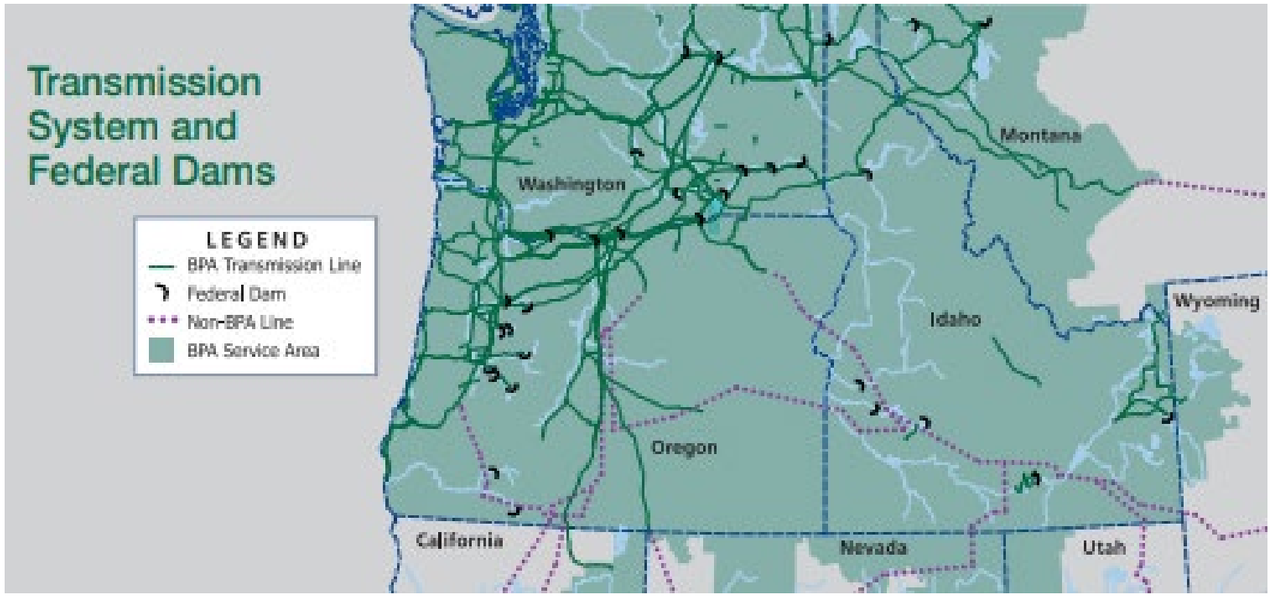
BLUF: Why is this Significant?

- BPA transmission system
  - Service Area = 300,000 square miles in PNW
- BPA owns and operates a large private utility communications system
  - Challenging terrain; long paths

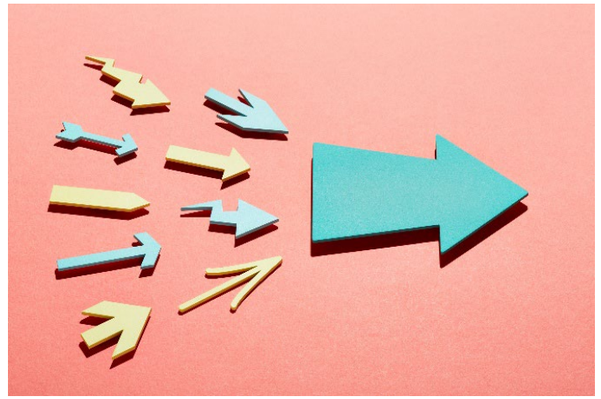
- Use “every tool in the belt” to carry grid traffic
  - Multiple media, technologies, and manufacturers interoperate in many combinations
  - Same equipment models as field locations (Substations / radio stations)
- “Real-world” communications impairments
  - Congestion, delay, QoS checks
- Provides a baseline for medium-scale field testing →Phase 3



Drivers for Testing

- BES dependence on GPS timing
  - Control and protection
  - Disturbance analysis
  - Fault location
  - Synchrophasors
- Disruption – Natural/man-made; intentional or not
- Additional drivers for change
  - Federal government – Strengthening national resilience by:
    - ✓ Engaging with critical infrastructure owners / operators
    - ✓ Fostering a deliberate, risk-informed use of PNT
  - Internal driver – Cybersecurity plan

- BPA's 2-prong approach to reduce dependence on GPS
  - Complementary sources
  - **Optimizing source distribution**
    - ✓ High reliability and high accuracy



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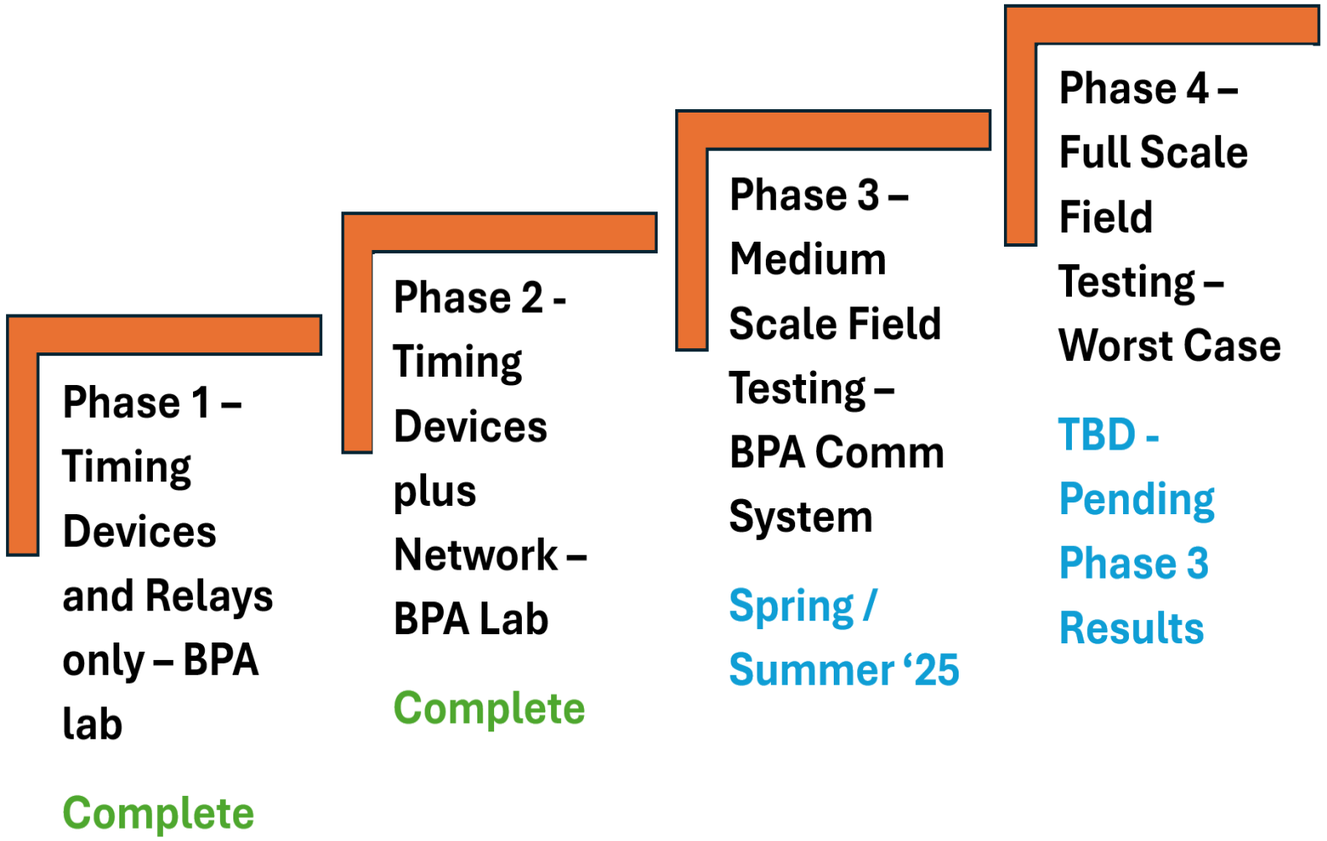
Multi-phase approach, increasing complexity

Optimizing Source Distribution

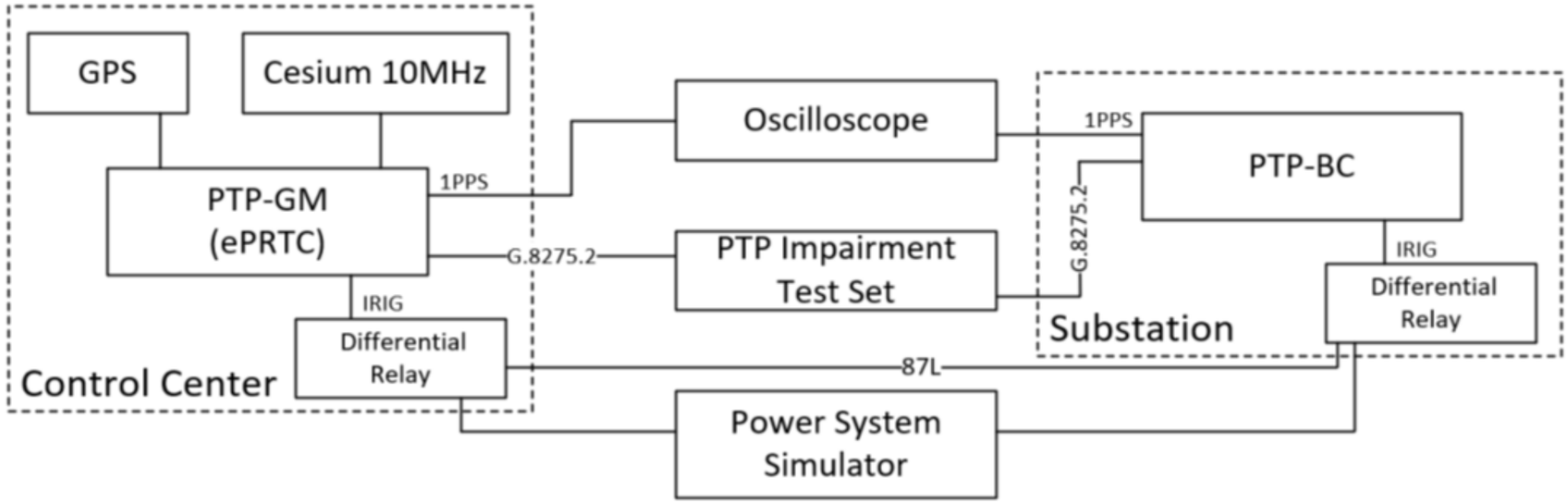
Goals

- Determine **best method for distributing precise time-of-day (ToD)** over BPA's utility communications system **with an accuracy of ±1 µs**
- Demonstrate **detection and alarming**



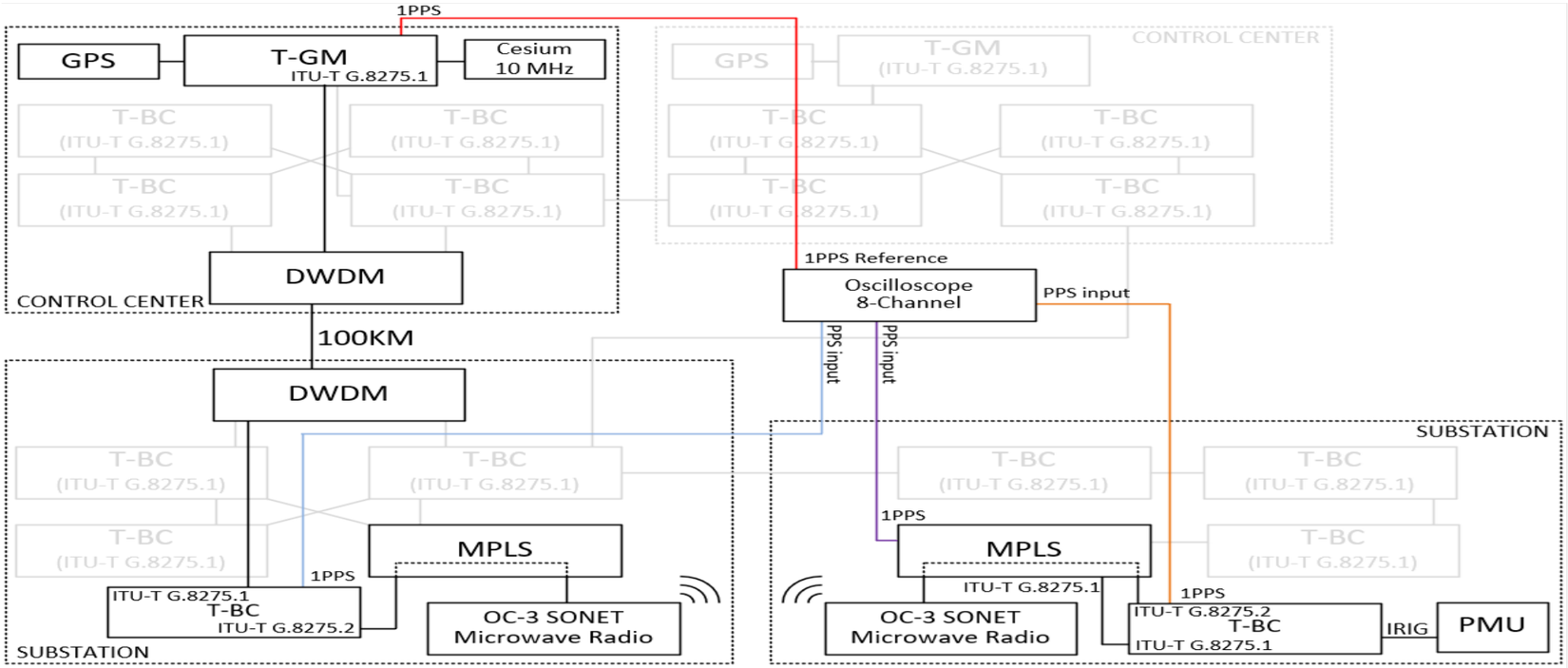
Phase 1 (Hardware) Testing and Results

- Arrangement – No network; Controlled lab environment
  - Fully monitored; Impairment capability
  - GPS disciplined by cesium clock to form PTP Grandmaster clock (IEEE 1588)
- Goals met?
  - ✓ BPA timing requirements (TOD ±1 µs) – Achieved
  - ✓ Detection and alarming of time errors – Achieved



Phase 2 (Hardware + Network) Testing and Results

- Arrangement – Network elements and timing hardware in lab environment
- Multiple combinations of:
  - Media – 100 km fiber run (including DWDM) plus microwave radio hop
  - Technology - legacy SONET, MPLS, Ethernet
  - Manufacturers - Interoperability



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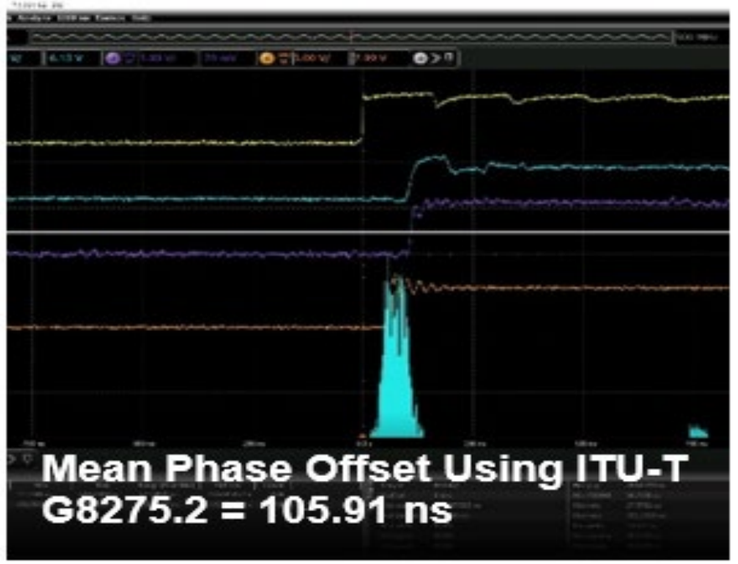
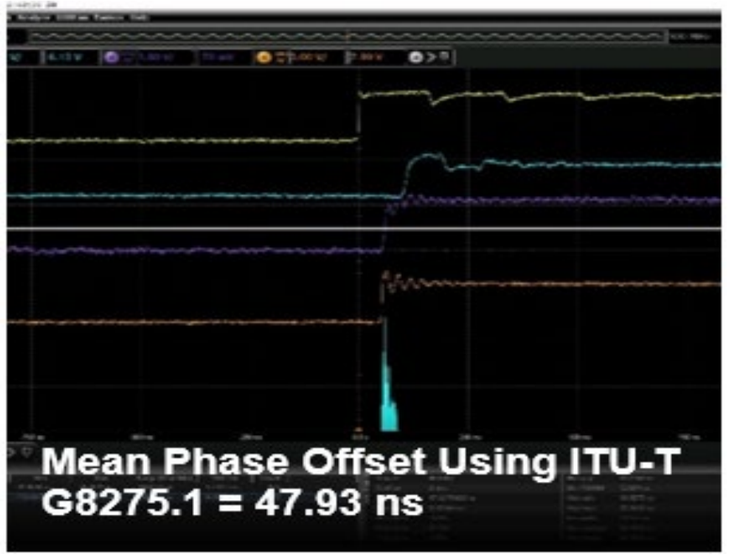
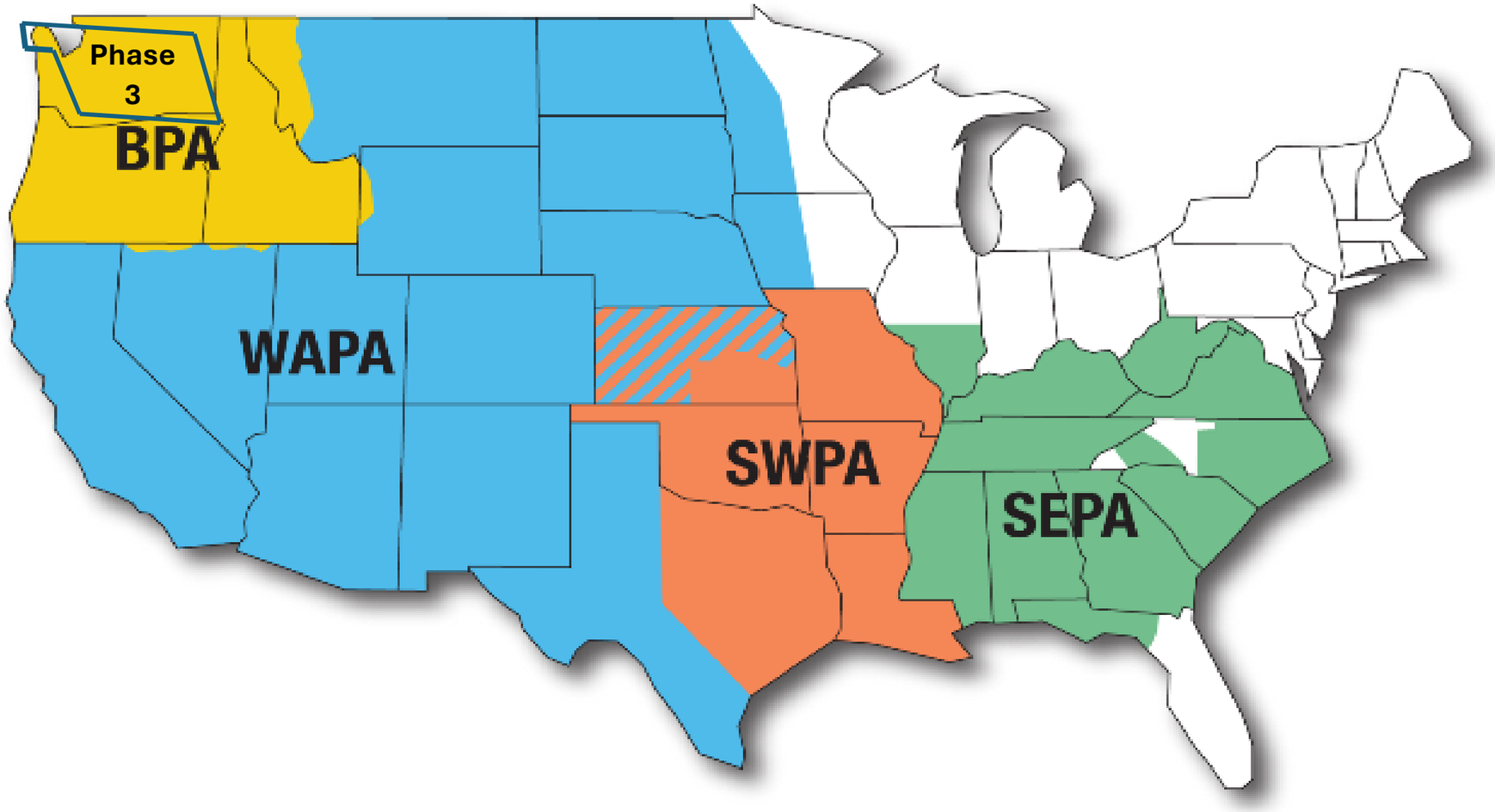
Phase 2 - Key Points and Sample Data

- **ITU-T G.8275.1** (full timing support) **significantly outperformed ITU-T G.8275.2** (partial timing support) in all test instances
- Standard Deviation:
  - ITU-T G.8275.2 = 165.70 ns
  - ITU-T G.8275.1 = 5.78 ns
- Goals met?
  - ✓ BPA timing requirements (TOD ±1 µs) – Achieved
  - ✓ Detection and alarming of time errors – Achieved

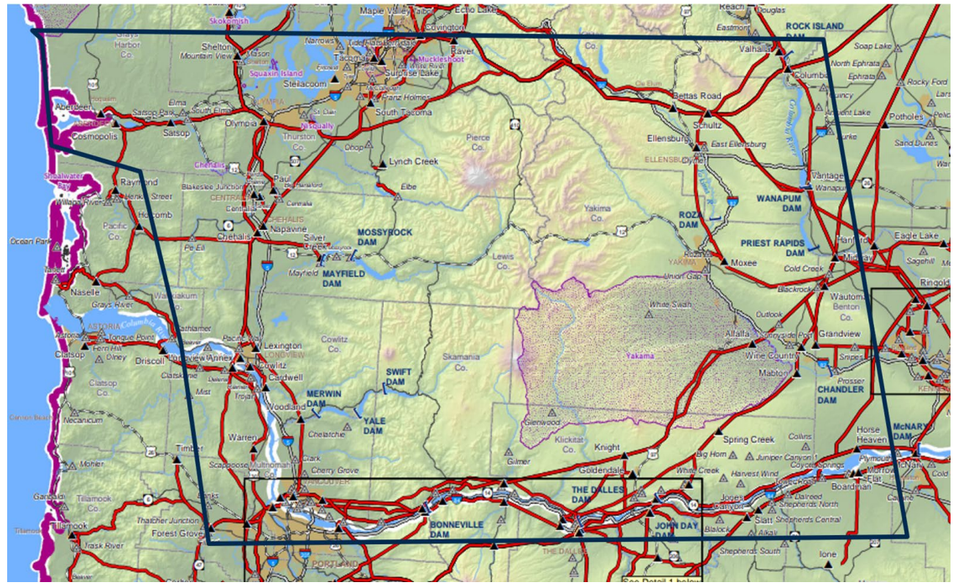




Power Marketing Administrations – Service areas



Next Steps – Phase 3 and Phase 4



Phase 3 Test Region

- Phase 3 Field Testing – Underway
  - Aligned with system-wide upgrade of telecom system – MPLS
  - Geographically diverse locations plus multiple generations of equipment and media
  - Test-unit line differential relays with multiple timing sources at multiple sites
  - Existing PMU device will be switched from normal GPS-derived time to PTP-derived time
    - ✓ Data will be logged and evaluated against a comparable live PMU at the same site
- Phase 4 (TBD by outcome of Phase 3)
  - Larger scale than Phase 3 with most difficult communications segments
  - Resolve Phase 3 anomalies as needed

Questions?

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Thank you