Time Synchronization Alternatives for the Electric Power System

Achievement: PMUs need access to reliable Coordinated Universal Time (UTC) to allow synchrophasor applications to time-align the voltage and current time series data for analysis and coordinated activity over a wide geographical area. Most of the PMUs in North America acquire timing data from GPS. Since GPS signals are weak, they are inherently vulnerable to both human-caused and natural disruptions. This report identified alternative means for high precision (better than 1 microsecond uncertainty) distributed time.

Significance and Impact:
The results of this workshop illustrate the need for alternatives to existing GPS timing systems as well as backup systems and many of the challenges that need to be addressed to develop and implement alternatives. Some of the overarching themes that emerged include the following: (A) While a number of potential alternative exist, they will require further infrastructure, research and concerted investment to implement and demonstrate their potential to replace, supplement, back up, or fill gaps in existing GPS systems. (B) Potential alternatives may need to be combined in ensembles to fill gaps, create the needed redundancies, and supplement GPS-based timing. (C) Future alternatives to GPS will need to have the same or better levels of accuracy, resilience, security, trustworthiness, and availability to supplant existing systems; a diversity of timing distribution systems may be needed (e.g., terrestrial, communication-based, wireless, etc.). (D) Dependency on space-based systems is currently strong due to their perceived reliability; there is limited awareness of the possible adverse impacts of timing failure events in such systems (and few backups exist). (E) Developing and using existing alternatives and new technologies, and integrating these with legacy systems will require standards and use cases to enable new technology, architectures, and interoperability among systems. (F) Better understanding of attack and failure threat modes is needed to estimate and demonstrate the true consequences of timing failures in systems based entirely on GPS.

Research Details:
Findings from the workshop cover desired future characteristics and targets for time distribution alternatives; challenges and barriers to adoption of time distribution alternatives; and priority R&D areas for time distribution alternatives. Note that when 'source' is referenced it refers to the clock at the beginning of the distribution system, while the GPS system is the distribution system. Potential alternative technologies to GPS and GPS backup systems were also discussed. Exhibit E-1 provides a high-level summary of the results in all categories.

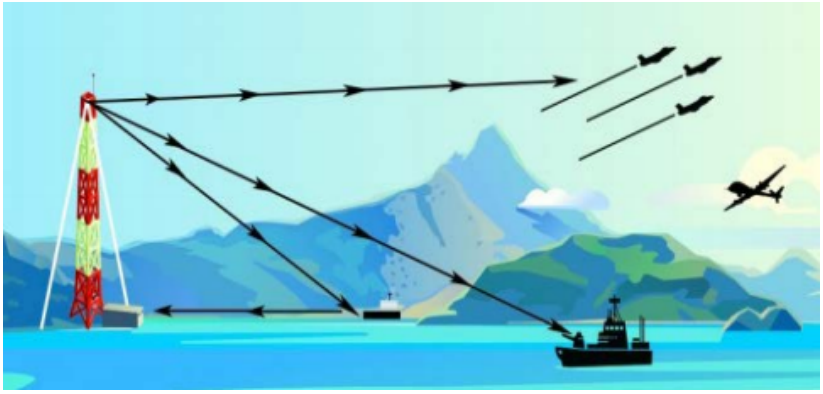

Figure 1. Enhanced Loran or eLoran is one of the alternatives discussed in the report. eLoran uses modern technology and low frequency radio signals from fixed land-based radio beacons to determine position. It meets the accuracy, availability, integrity and continuity performance requirements for maritime harbor entrance and approach maneuvers, aviation non-precision instrument approaches, land-mobile vehicle navigation and location-based services.

- Alternative Technologies. Information was presented on the capabilities of Enhanced WWBV, eLoran, Wide Area Precision Time Protocols (PTP) and various GPS backups and enhancements. All have some potential for supplementing GPS, filling gaps, or providing redundancy in the future.
- Future Characteristics. Minimal infrastructure, diverse time distribution systems, interoperability, and spoof/jamming/failure resistant, redundancy, precision and resiliency were identified as desirable traits.
- Future Targets. Affordability ($500 range for users), greater accuracy (less than 10 µs to 100 µs for distribution), quantified error/performance (1 µs accuracy), no discontinuities, high uptime and integrity (99.99 %), and long time between failures (10 000 years) were identified as primary targets.
- Challenges and Barriers. Existing and future solutions face a number of technical challenges. These include the lack of standards for performance and communication and a use case-driven architecture; inadequate capabilities to detect failures/attacks and awareness of the impacts of failures; infrastructure issues such as the development of timing networks, wireless propagation delays, and optimization of

data/timing for convergence; breaking the existing dependency on space-based timing systems; and optimizing combinations of timing systems (e.g., wired, wireless, clocks).

- Priority Research Areas. As shown in Exhibit E-1, the research priorities address the major challenges identified. R&D efforts needed range from development of standards, use cases and architecture to development of timing networks and other infrastructure. Test beds and demonstrations were identified throughout as necessary for new technology and infrastructure development as well as understanding system needs to help inform standards and architecture.

Sponsor/Facility: This work was a collaboration between ORNL, other laboratories, industry and academia. ORNL involvement was sponsored by the US Department of Energy Office of Electricity Delivery.

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Publication: Chris Kelley, Joan Pellegrino and Emmanuel Taylor (eds.). *"Time Distribution Alternatives for the Smart Grid Workshop Report"*. **Technical Report NIST.SP.1500-12.** National Institute of Standards and Technology, Gaithersburg, MD, USA, 20899. 33 pp. 2017. URL: https://doi.org/10.6028/NIST.SP.1500-12S.