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eLoran signal to support NASPI timing requirements

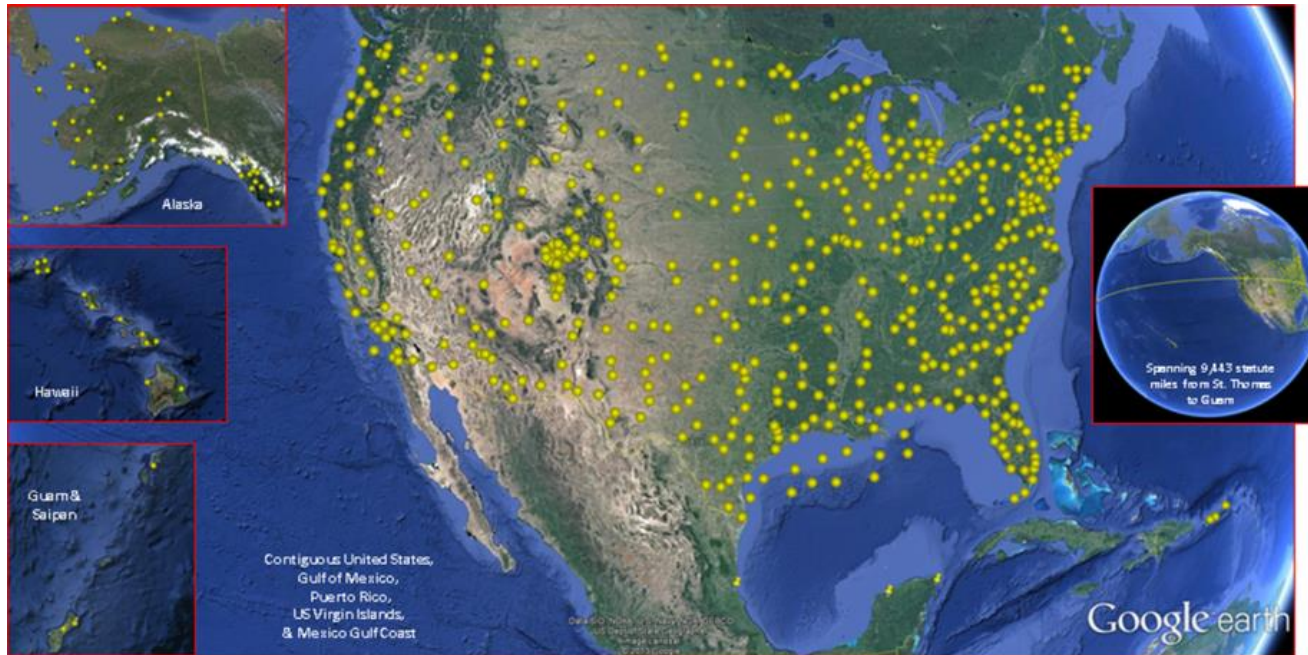
21 October 2016

URSANA.V INC. & HARRIS CORPORATION

- A Need for Precise Timing for Surveillance Systems
- eLoran for Precise Timing In Synchronphasor Applications

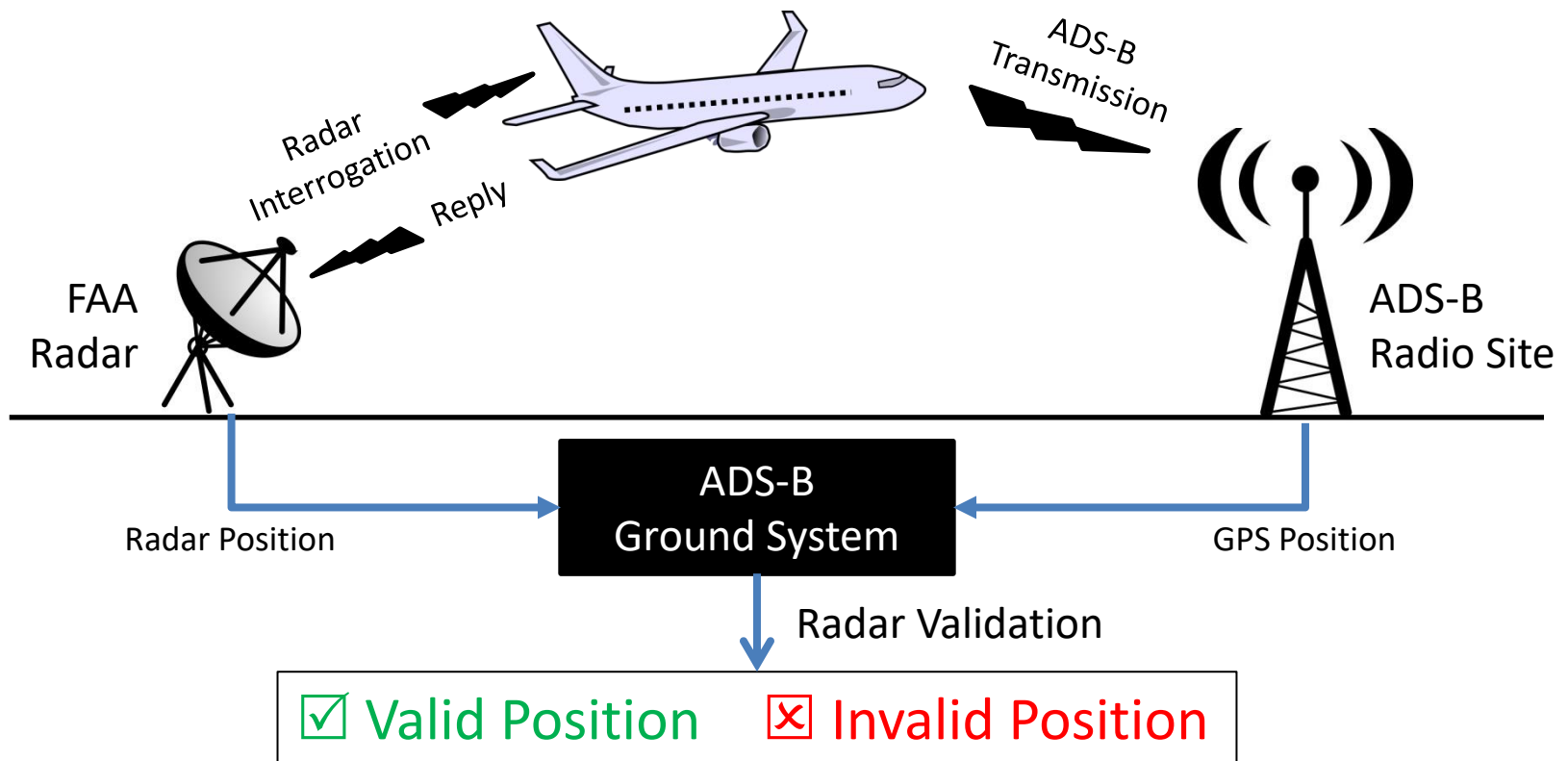
A NEED FOR PRECISE TIMING FOR SURVEILLANCE SYSTEMS

- Harris operates and maintains the Automatic Dependent Surveillance Broadcast (ADS-B) system, which provides aircraft position data to the FAA for Air Traffic Control (ATC)

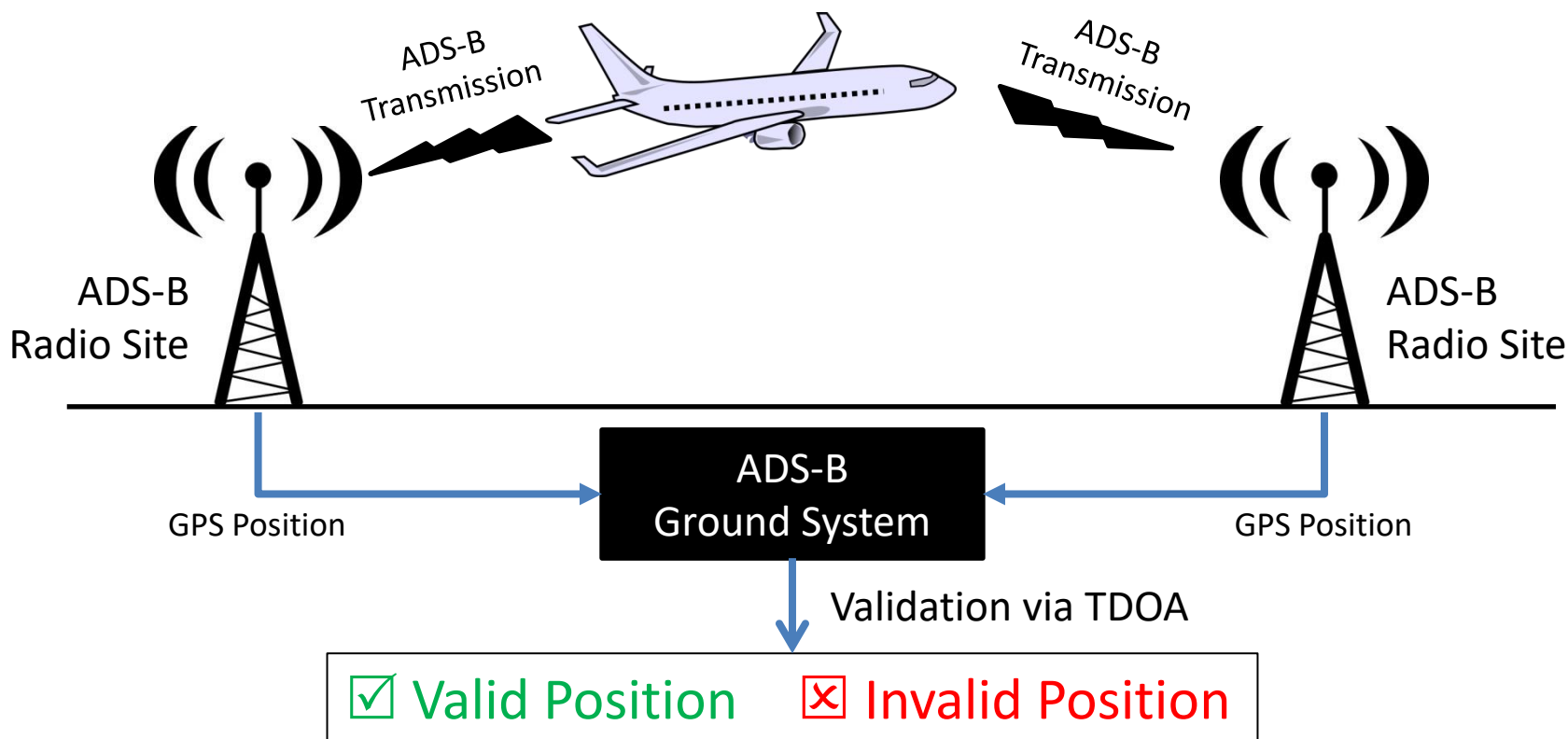


- The ADS-B system is comprised of a nationwide terrestrial network of 650+ radio sites that receive transmissions from aircraft with their GPS-reported position information
 - This ADS-B sensor distribution is analogous to a large synchrophasor network

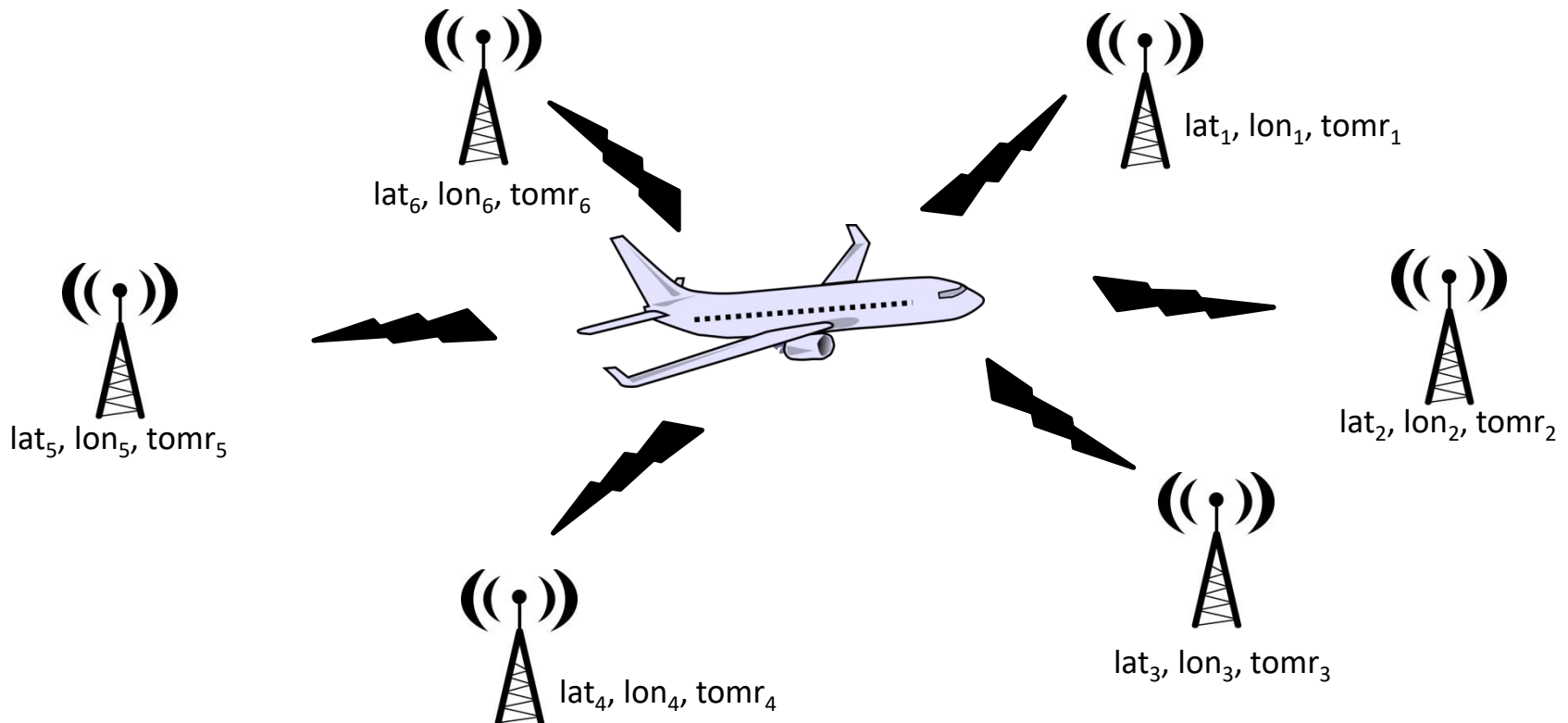
- The ADS-B Ground System validates the GPS-reported positions broadcast by the aircraft with data from FAA radars to ensure the aircraft are where they claim to be



- All ADS-B radio sites are equipped with GPS receivers so that they can accurately timestamp the reception of transmissions from aircraft
- In the absence of radar, validation of aircraft position can be achieved via Time Difference Of Arrival (TDOA) within some acceptable tolerance



- A sufficiently dense network of radio sites allows for independent determination of the aircraft position (called Wide Area Multilateration or WAM), but relative timing among all radios must be **very** precise (± 30 ns)



- ADS-B radio sites currently use GPS for timing, but GPS can be vulnerable to RF interference (both intentional and unintentional)
 - A shared problem for ADS-B and synchrophasors
- High-precision atomic clocks can maintain timing for limited periods of timing in the event of GPS failures, but these devices are **very** expensive
- As an alternative to expensive atomic clocks, Harris began investigating the use of alternative timing capabilities
- An ideal timing solution would be
 - Accurate (synchronized to UTC)
 - Precise (stable to within ± 30 ns)
 - Cost effective (much cheaper than atomic clocks)
 - Robust to failures of GPS
- Our research determined that eLoran was the only mature technology able to satisfy these criteria
- The establishment of a national eLoran timing service will provide a robust complement to GPS timing for surveillance systems and potentially for synchrophasors

ELORAN FOR PRECISE TIMING IN SYNCHROPHASOR APPLICATIONS

GPS / GNSS *Vulnerabilities*

- ✓ Antenna needs clear view of the sky
- ✓ Performance Degradation
 - ✓ Natural
 - ✓ Human
- ✓ Spectrum Competition
- ✓ Radio Frequency Interference
- ✓ System Anomalies & Failures
- ✓ Jamming
- ✓ Spoofing & Counterfeit Signals
- ✓ Proliferation of Satellite Systems
- ✓ Satellite Launch Problems
- ✓ Ground Segment Problems

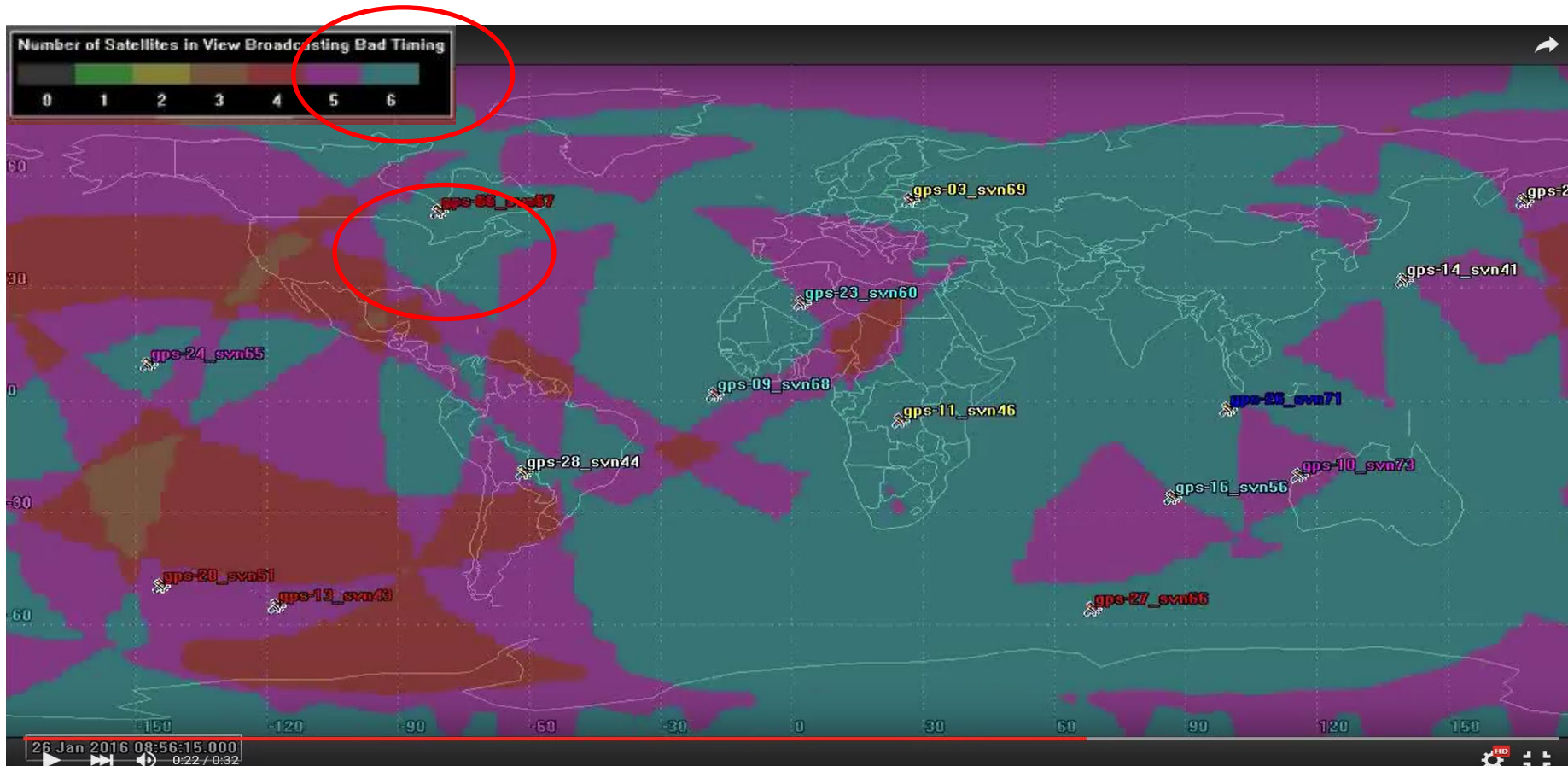
Of the 16 Critical Infrastructure / Key Resource sectors in the U.S., 15 use GPS for **timing**.

GPS **timing** is deemed **essential** for 11 of the sectors.

Source: U.S. DHS

The Need For A Resilient Timing and UTC Service in Synchrophasor Applications

January 26, 2016 2:49 to 8:10 AM 13.7 microseconds timing error.
Contaminated an additional 15 satellites.

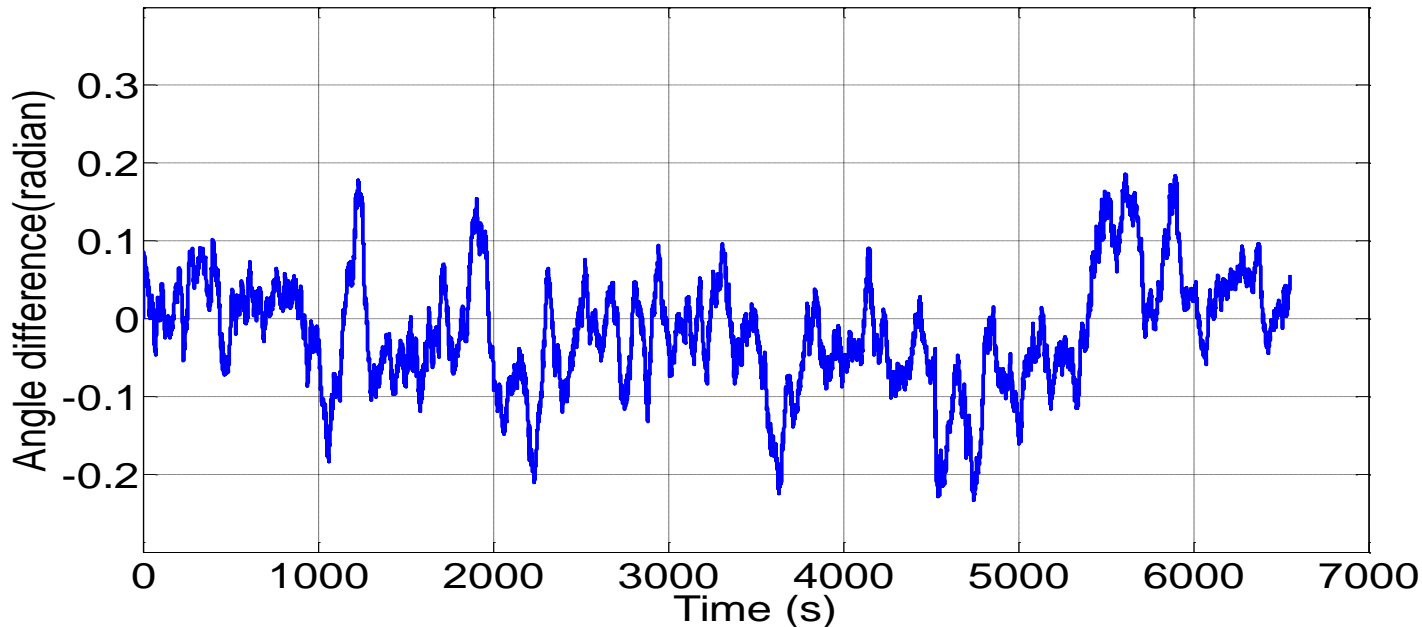


GPS SVN 23 Timing Anomaly Video: <https://www.youtube.com/watch?v=ZjnK8GmSvnc>

- **Time spoofing of Synchrophasors has been demonstrated in:**
- **Evaluation of the Vulnerability of Phasor Measurement Units to GPS Spoofing Attacks**, Daniel P. Shepard and Todd E. Humphreys
The University of Texas at Austin Aaron A. Fansler
Northrop Grumman Information Systems
- **Smart Grid Use of GPS Time: Protecting Synchrophasor Timestamps**, Kevin M. Skey and Dr. Michael L. Cohen *The Mitre Corporation*
- **Timing vulnerabilities are even more pressing as grid control becomes more automated**

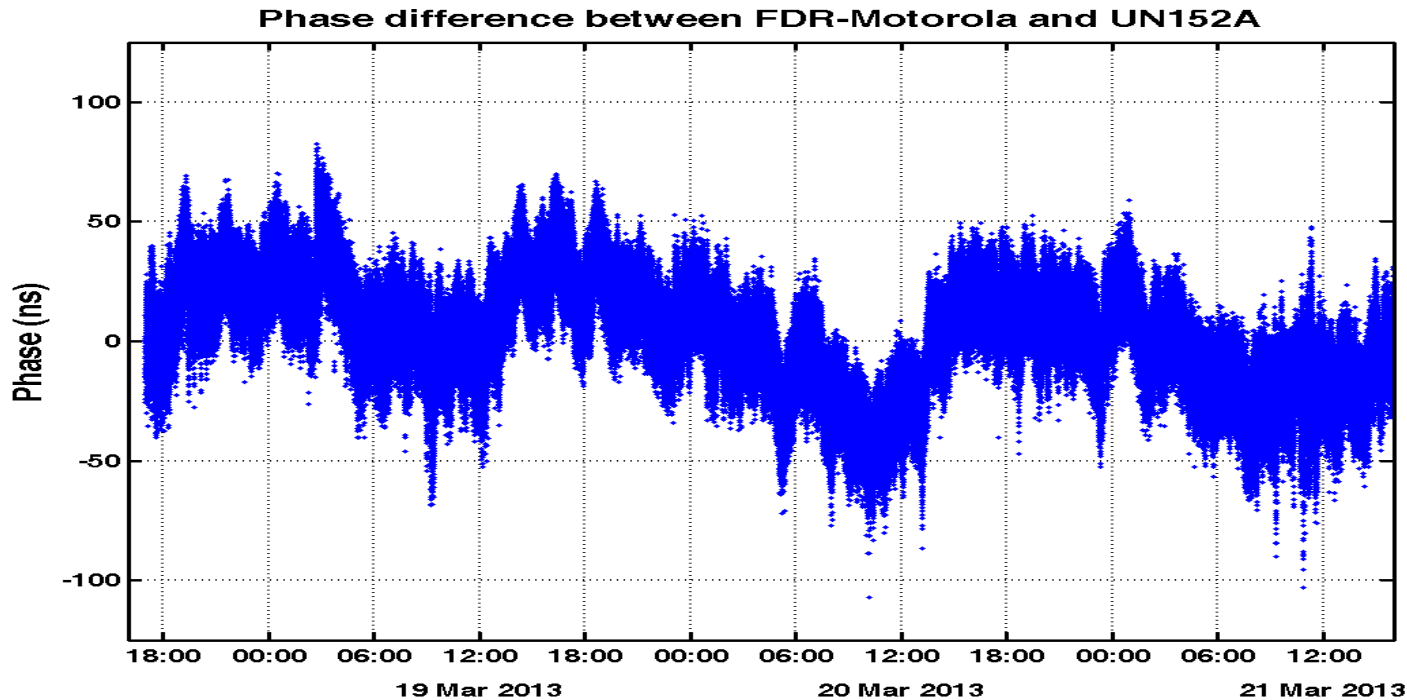
eLoran has been demonstrated to be a good alternative source of time in PMU applications

Angle difference between GPS-FDR and eLoran-FDR



Proof of Concept conducted in conjunction with University of Tennessee at Knoxville. Distance from eLoran Transmitter was approximately 320 miles

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FDR (Motorola GPS) vs. UN152A (eLoran)
Proof of Concept conducted in conjunction with University of Tennessee at Knoxville. Distance from eLoran Transmitter was approximately 320 miles

- **We will be performing further measurements and investigations at VELCO substations in coordination with ISO-NE this fall**
- **Field Tests at substations in the New England and/or Virginia areas are currently under discussion**
- **With an initial four transmitting stations, eLoran can provide a stable, resilient and complimentary timing, frequency, and data service over the Lower 48 United States**

- ✓ eLoran **is** a stable, wide area source of PNT for redundancy and resiliency in grid applications.
- ✓ It works in many locations where GPS is not available. It works when GPS may be untrustworthy.
- ✓ **Without** differential corrections, eLoran is capable of meeting 2014 FRP timing user requirements of +/- 1 microsecond over very wide areas.
- ✓ **With** the application of differential corrections, eLoran is capable of meeting the needs of higher accuracy timing users of +/- 100 nanoseconds over a local area.
- ✓ eLoran transmitters and receivers are available now in commercial packaging and can be quickly integrated into existing timing products.

Contact Us for Collaborative Efforts!

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