



# Clock Models, Metrics, and Testing

Reid McGaughey  
Cisco Systems

**Technical Track**

[www.odva.org](http://www.odva.org)



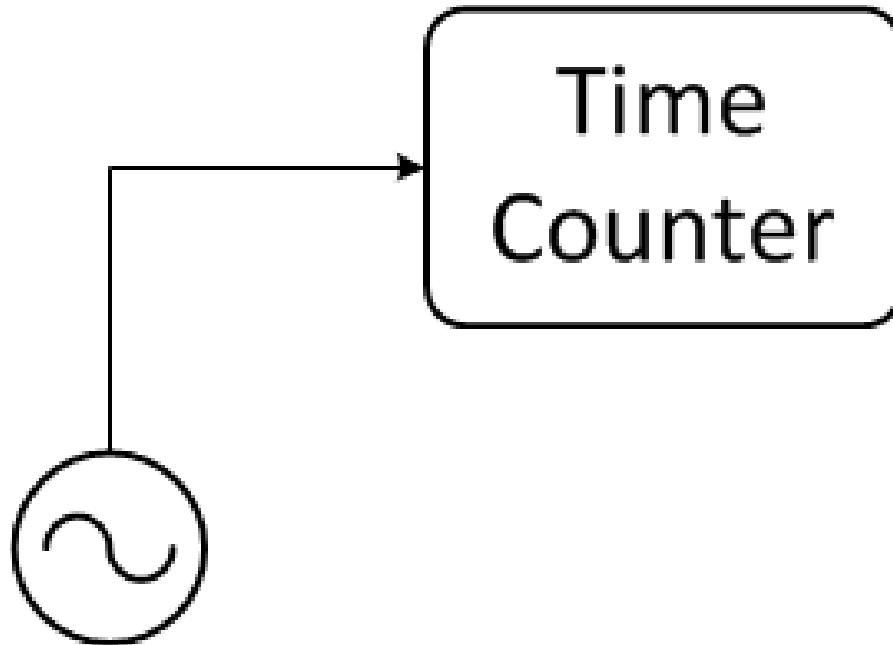
# Models

**Technical Track**

[www.odva.org](http://www.odva.org)

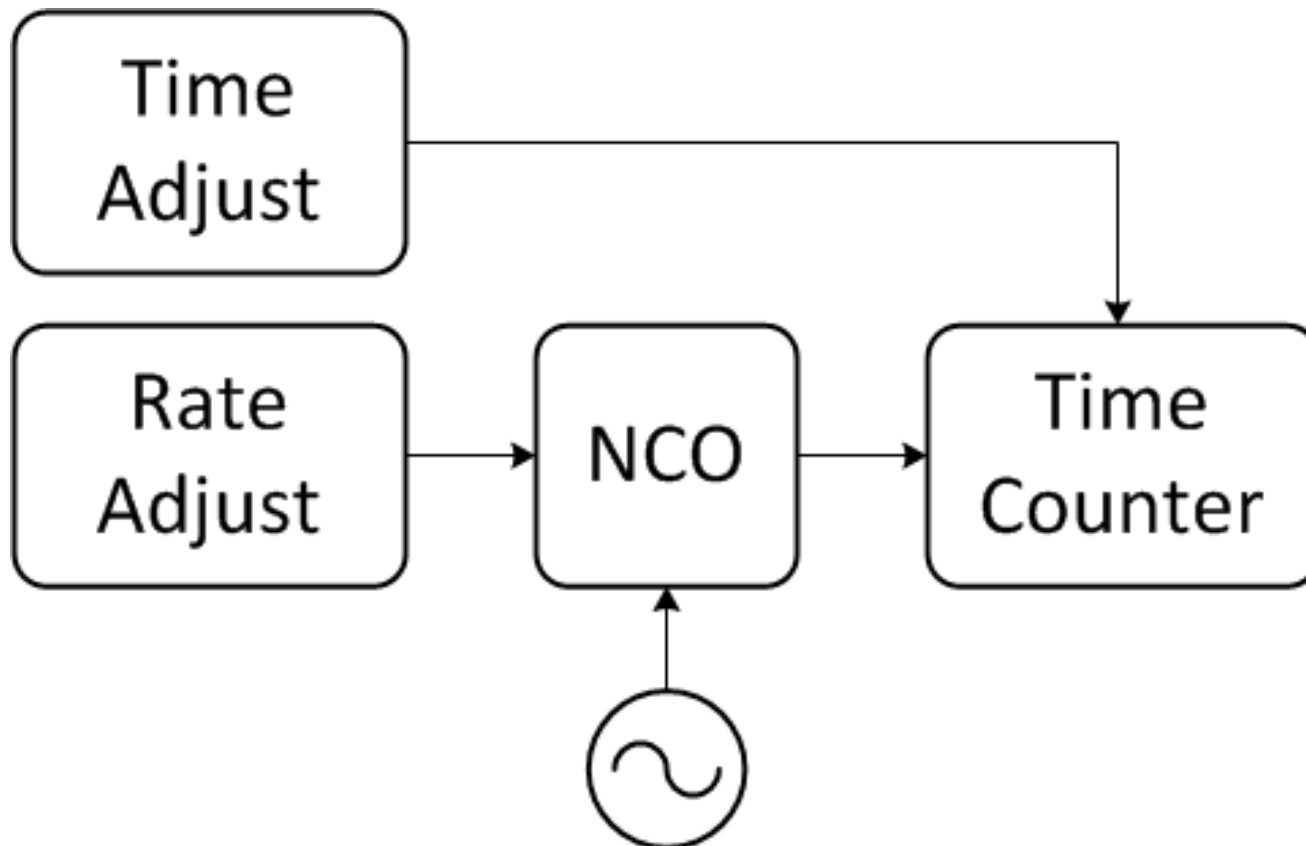
## Build a Clock (simplest model)

- ▶ Just a counter integrating an oscillator's edges.
- ▶ Oscillator quality is everything.



## Build a Clock (with rate and time adjust)

- ▶ Actuators control time and rate



## Clock Equations

- ▶ Time Equations

$$time = time_0 + rate_0 * t + 0.5 * drift * t^2$$

$$rate = rate_0 + drift * t$$

- ▶ Time comes Rate and Drift

- ▶ Rate and Drift come from the oscillator.

## Clock vs. Motion

### ▶ Time Equations

$$time = time_0 + rate_0 * t + 0.5 * drift * t^2$$

$$rate = rate_0 + drift * t$$

### ▶ 1-D Position Equations

$$x = x_0 + v_0 * t + 0.5 * a * t^2$$

$$v = v_0 + a * t$$

### ▶ Motion Actuates through Force, Time actuates through rate.



# Measurement and Metrics

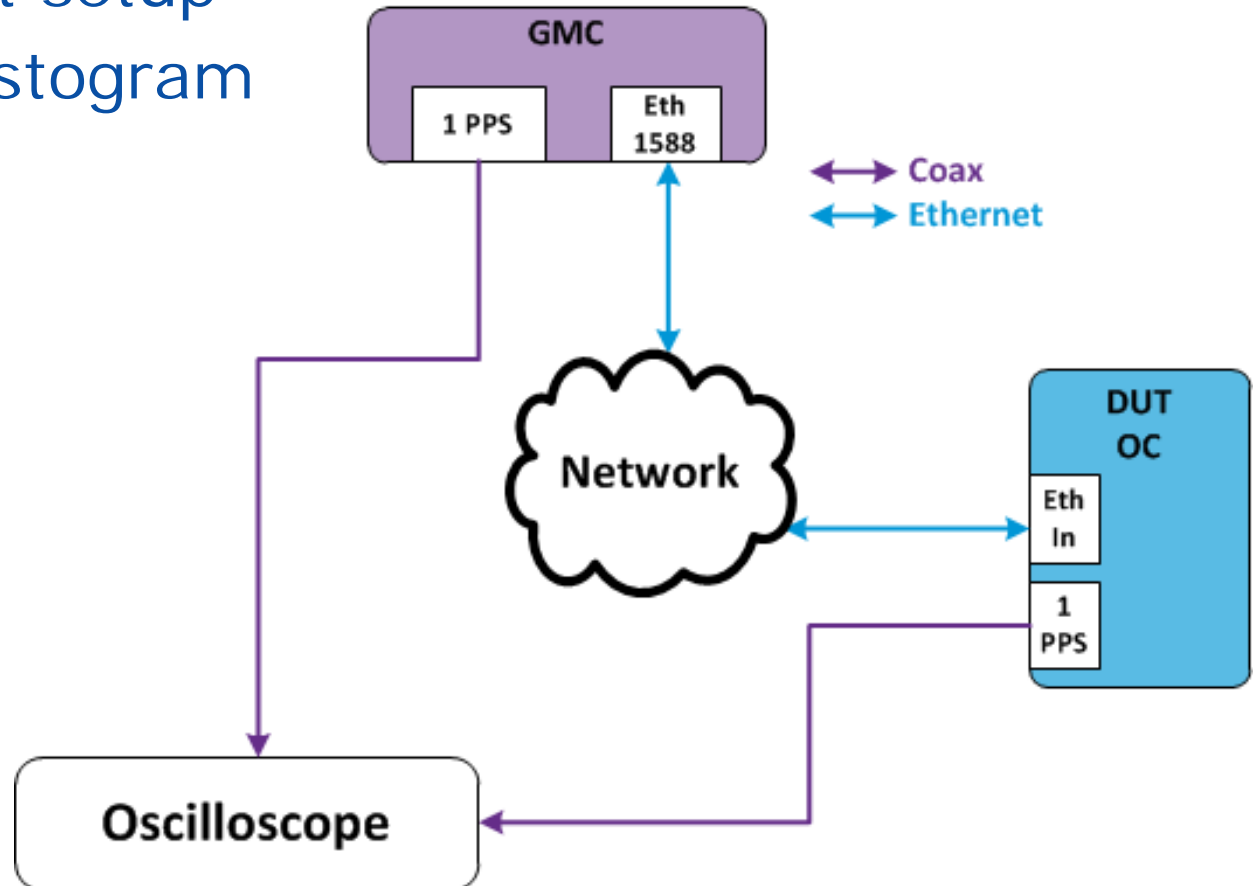
Technical Track

[www.odva.org](http://www.odva.org)

# Metrics and Testing

## 1 PPS + Oscilloscope

- ▶ Simplest test setup
- ▶ Creates a Histogram

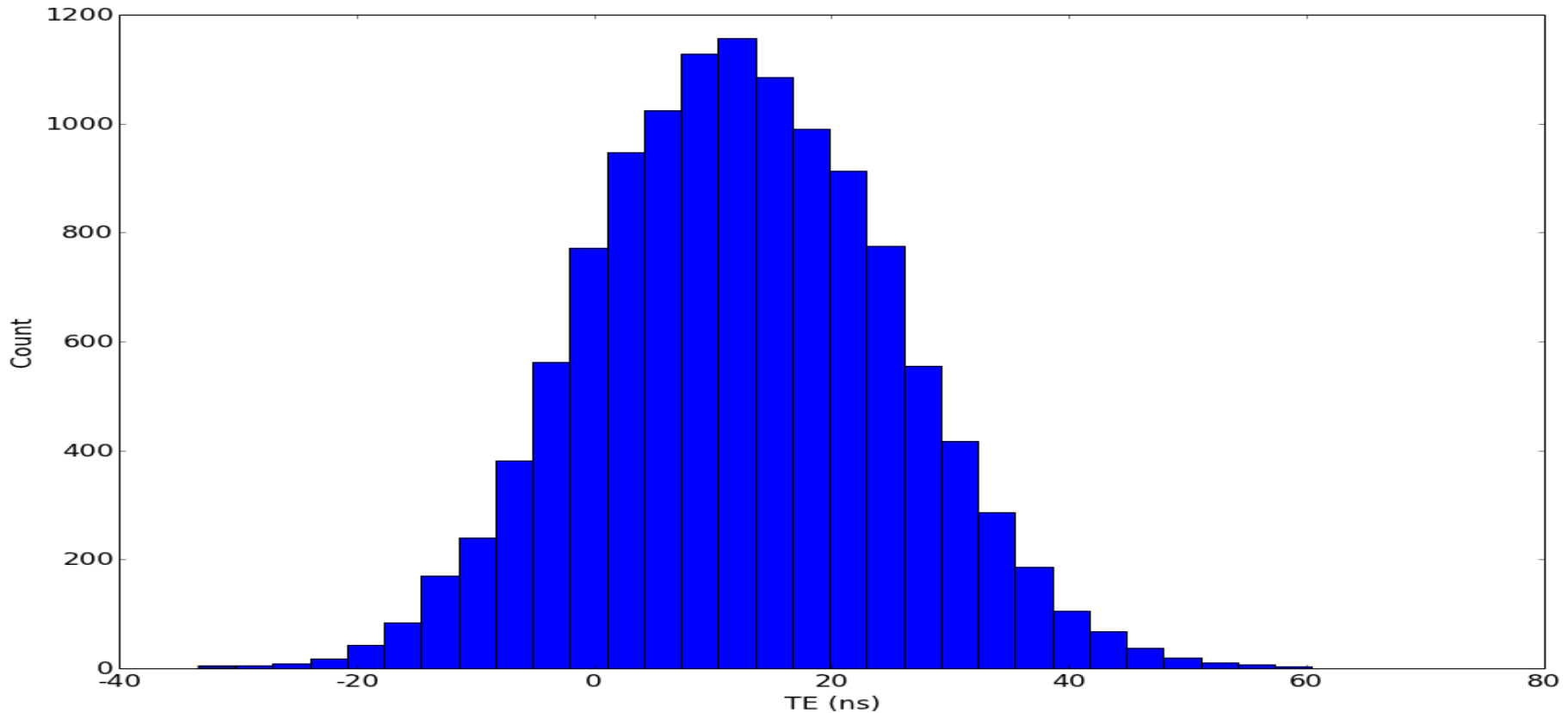




# Metrics and Testing

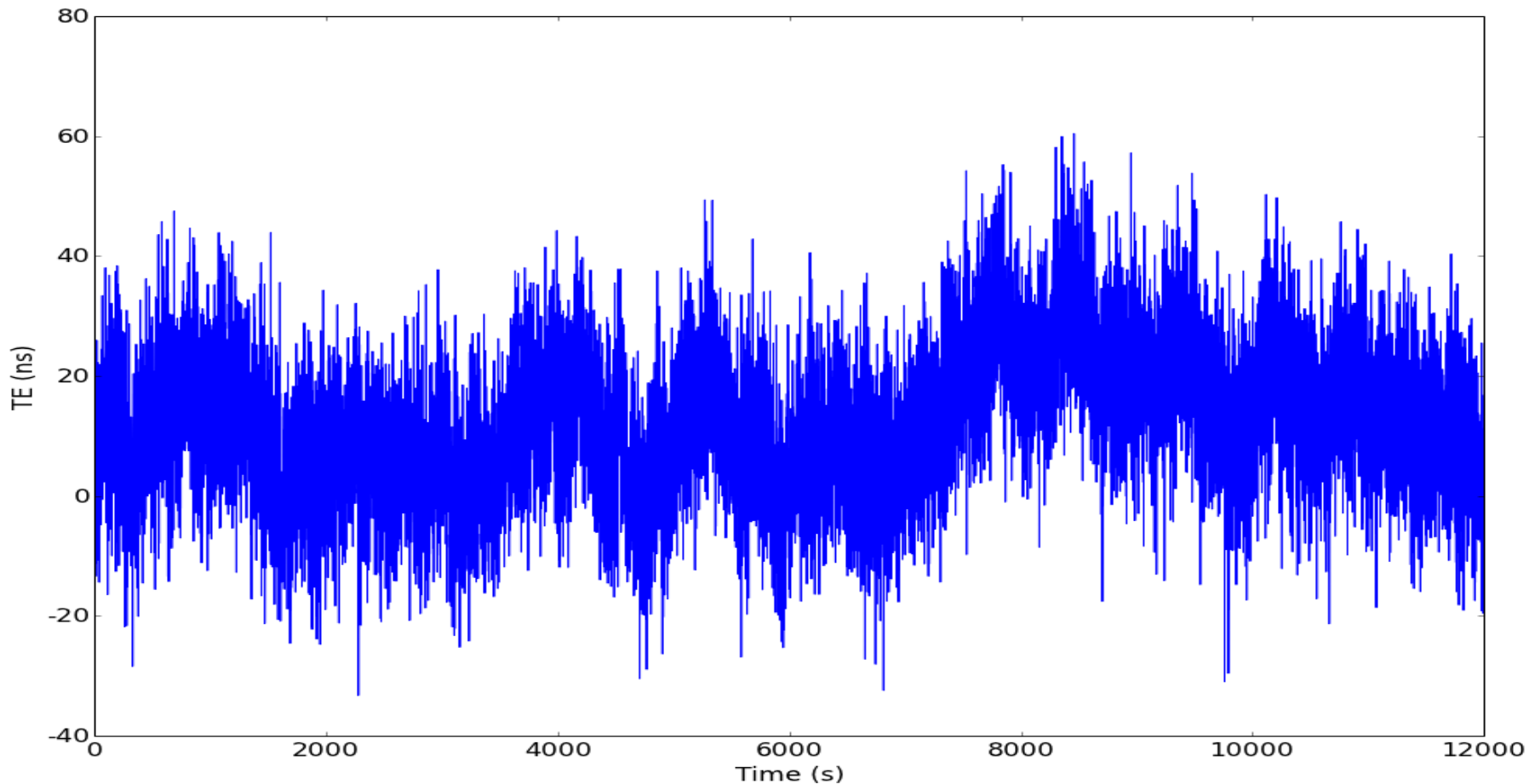
## Histogram

- ▶ Tried and true
- ▶ Know mean, variance, peak-to-peak, and etc.



## Time Error Series

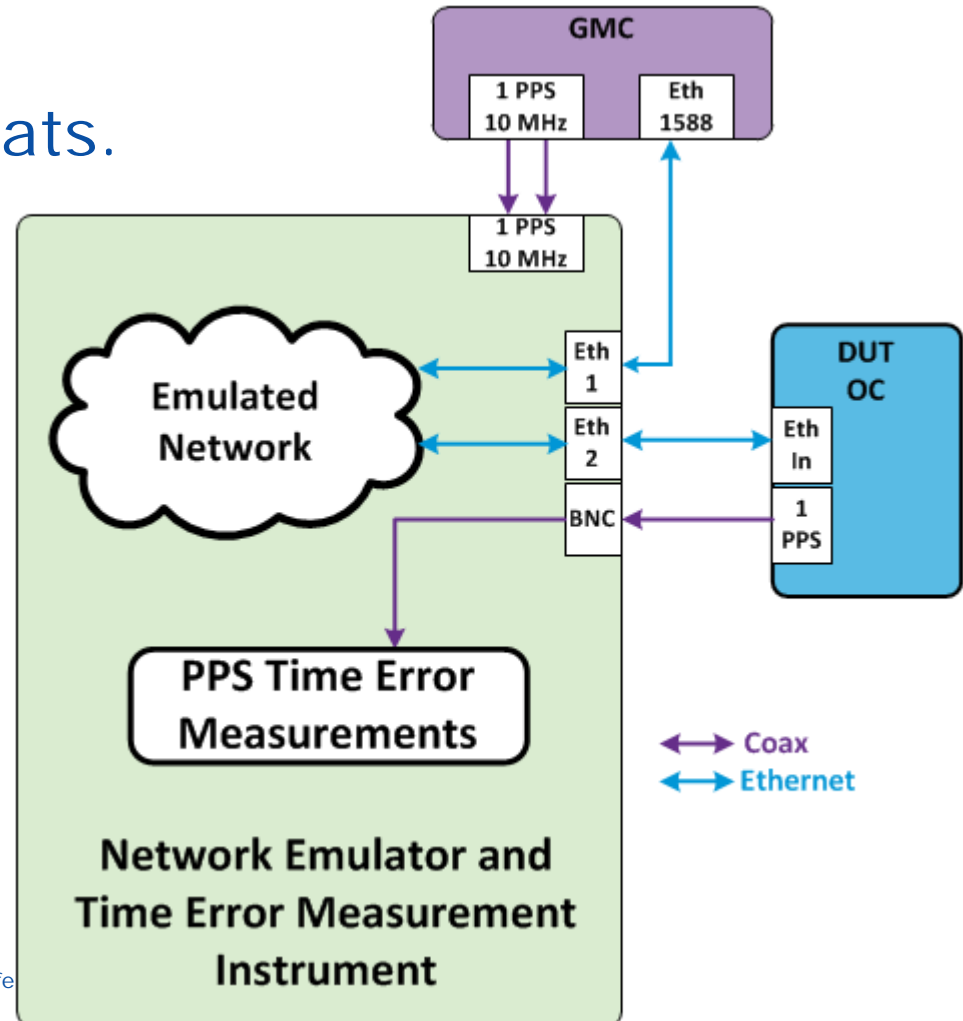
- ▶ Clock noise is not AWGN



# Metrics and Testing

## Dedicated PTP Equipment

- ▶ Impair and Measure.
- ▶ Sophisticated clock stats.
- ▶ Unit Test.



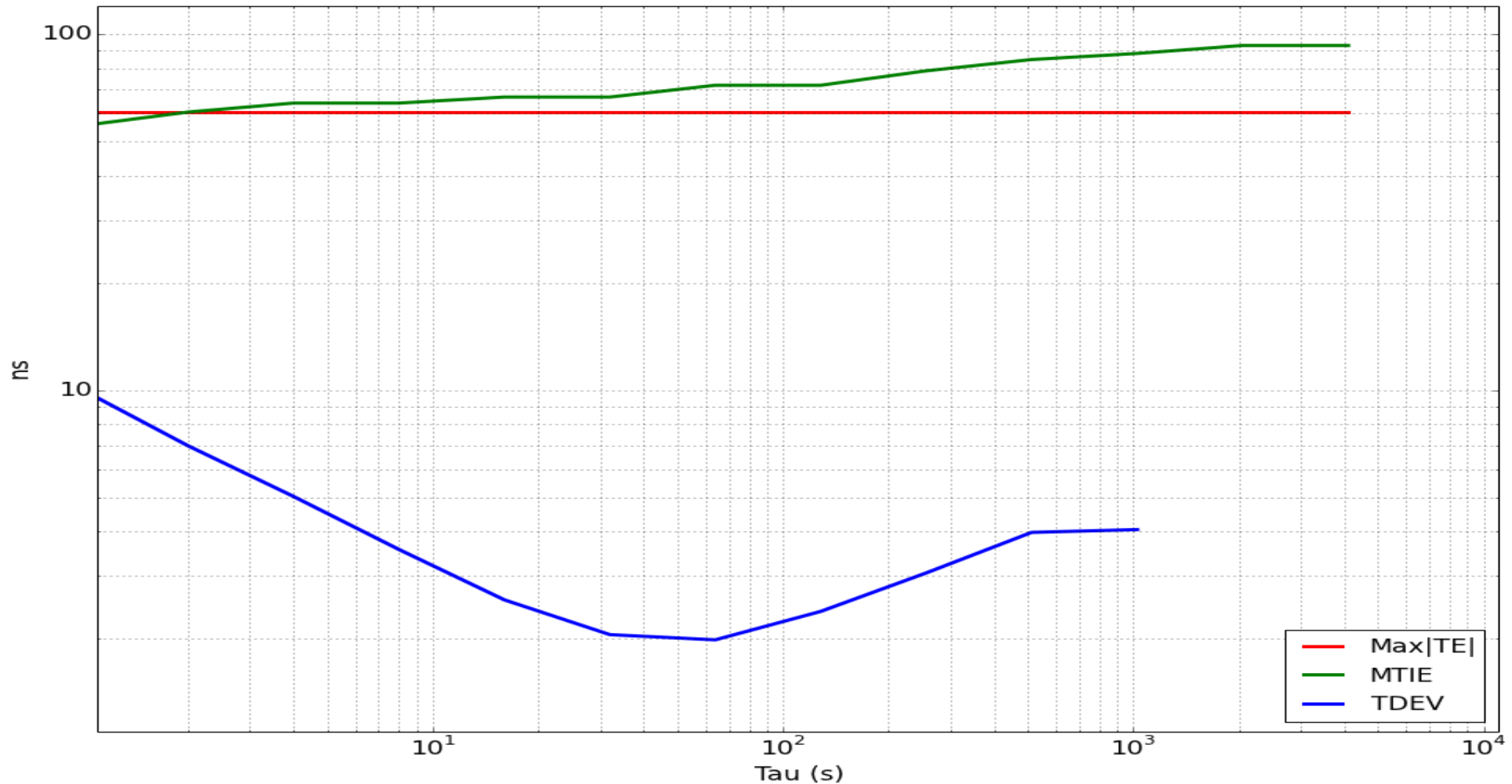
# Metrics and Testing

## Clock Statistics

- ▶ Maximum Absolute Time Error ( $\text{Max}|TE|$ )
  - Shows the largest measured time error.
- ▶ Time Deviation (TDEV)
  - The Standard Deviation and a Fourier analysis combined.
  - Shows the clock's stability over a given range of time.
- ▶ Maximum Time Interval Error (MTIE)
  - Shows the maximum rate of change for a given range of time.

## Clock Metric Plot

▶ Clock noise is not AWGN



# Conclusions

- ▶ Oscillator Quality
- ▶ Unit testing of clocks, or control traffic.
- ▶ For those who need it, sophisticated clock metrics provide more insight.



**Q/A**

**Technical Track**

[www.odva.org](http://www.odva.org)