



Single Regulation Signal Modeling and Analysis

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Regulation Market Design Senior Task Force
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Balancing Interchange

< ACE >



Frequency Error

Ideal

- Clearly state the operational need
- Sellers should offer to meet the need
- The market should select the cheapest way to meet the need

Degradation

- The operational need is indirectly expressed
- Sellers offer independent of operational value
- The market rewards behavior misaligned from the need

- 1) **Discussing the Status Quo:** Reg-A & Reg-D Signal

- 2) **Define the Metrics:** What Makes a Signal Good or Bad?

- 3) **Examine Trade Offs:** Single Signal vs. Reg-A / Reg-D

WHAT

Signal 1

Regulation D



WHO

Batteries

Hydro

WHY

Faster Response

Signal 2

Regulation A



CT's

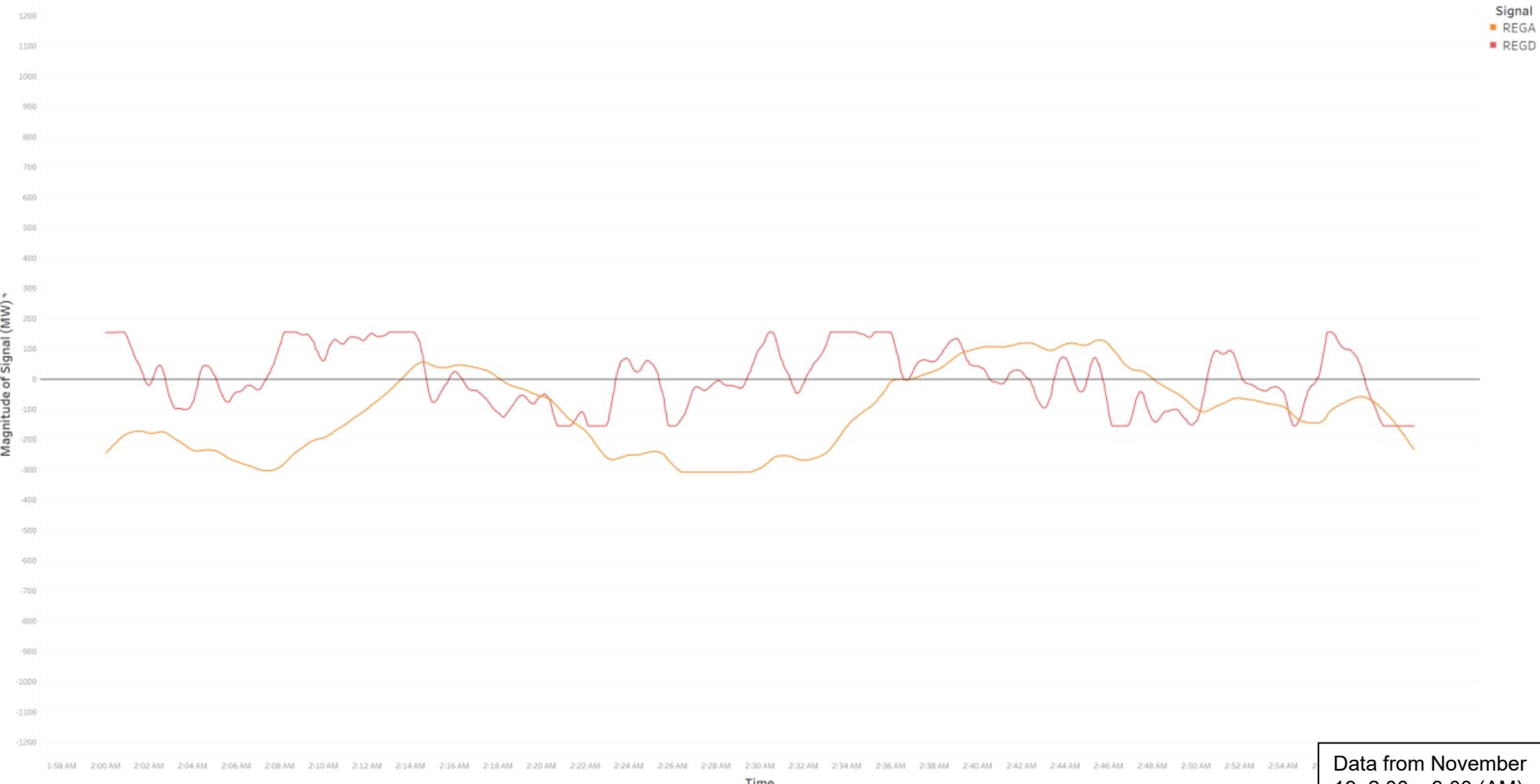
Steam

Hydro

Slower Response

Dual Signal (Current)

Signal
 ■ REGA
 ■ REGD

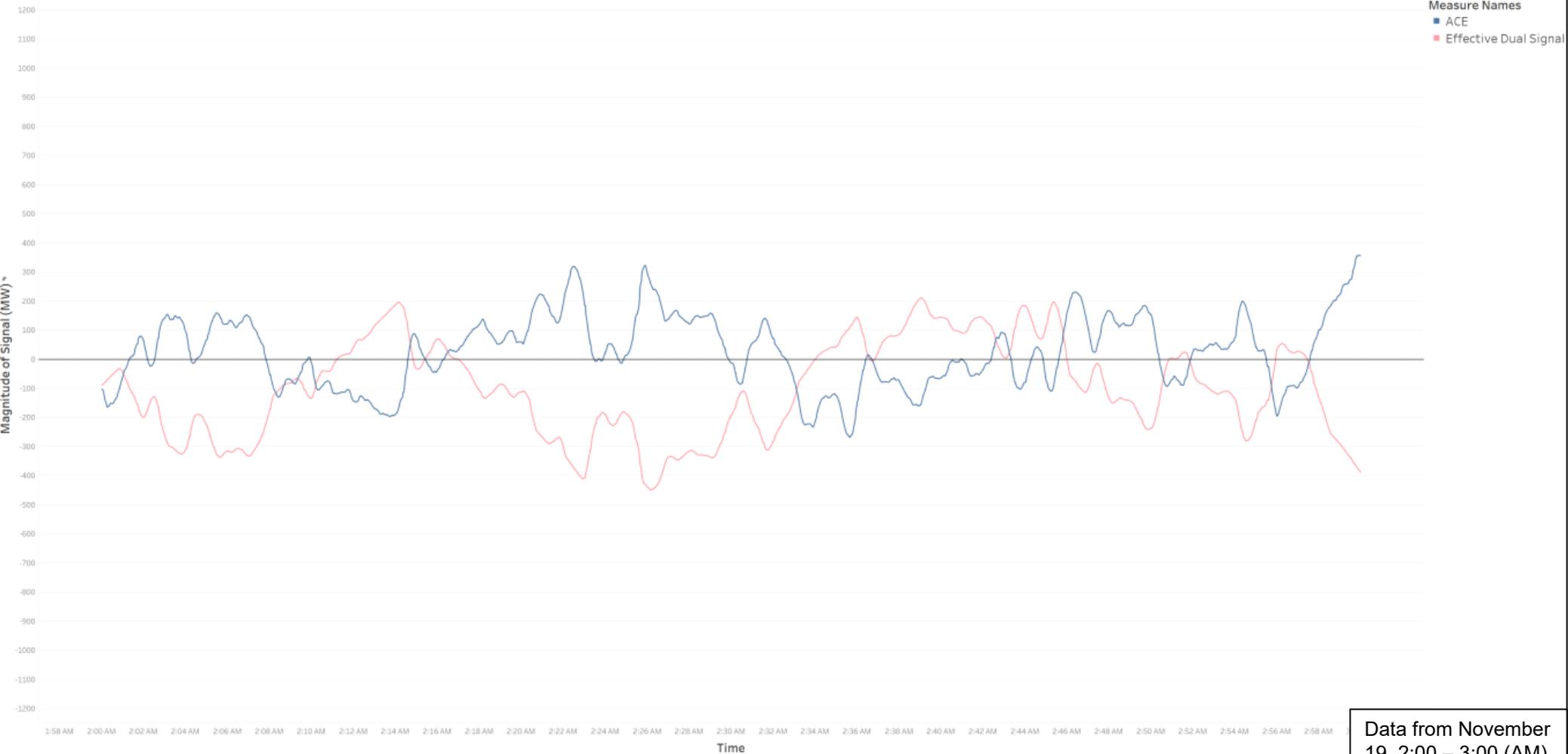


Data from November 19, 2:00 – 3:00 (AM)

- Signals sent concurrently
- Signals respond to ACE, not frequency
- What do they effectively do?

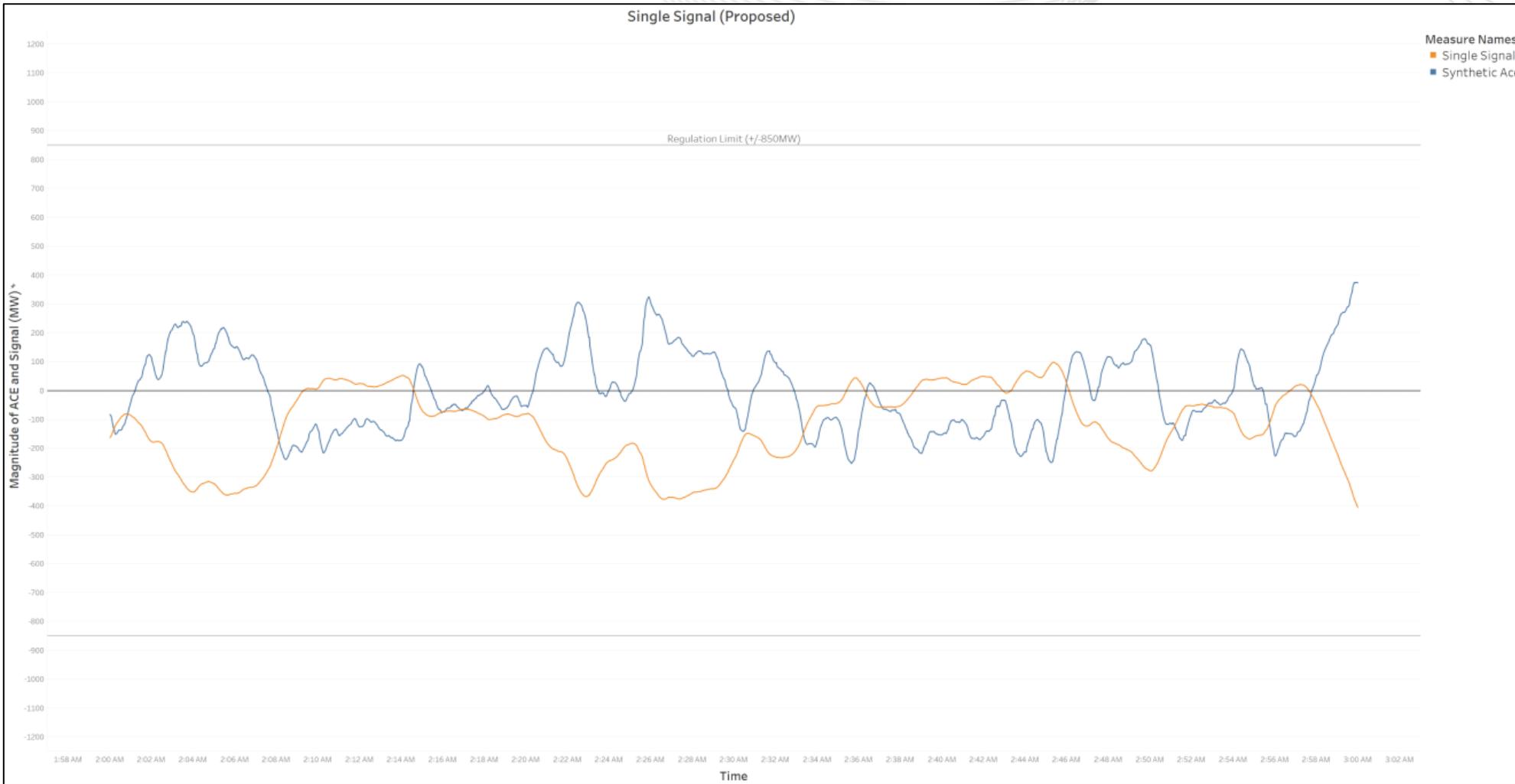
Effective Dual Signal (Current)

Measure Names
■ ACE
■ Effective Dual Signal



Data from November 19, 2:00 – 3:00 (AM)

The trends of ACE and Effective Dual Signal for Time Selector. Color shows details about ACE and Effective Dual Signal. The data is filtered on Time1, which excludes 12/30/1999 7:31:06 AM.



Data from November 19, 2:00 – 3:00 (AM)

What Makes a Signal Good or Bad?

- 1) Volatility: Can Generators Follow our Signal?
- 2) How Well Does Signal Regulate ACE?
- 3) How Well Does Signal Regulate Extreme ACE Events?

1) Volatility



- **Metric 1: What is our Signal Mileage?**



- The absolute value of a signal's movement
- Normalized per unit of regulation assignment

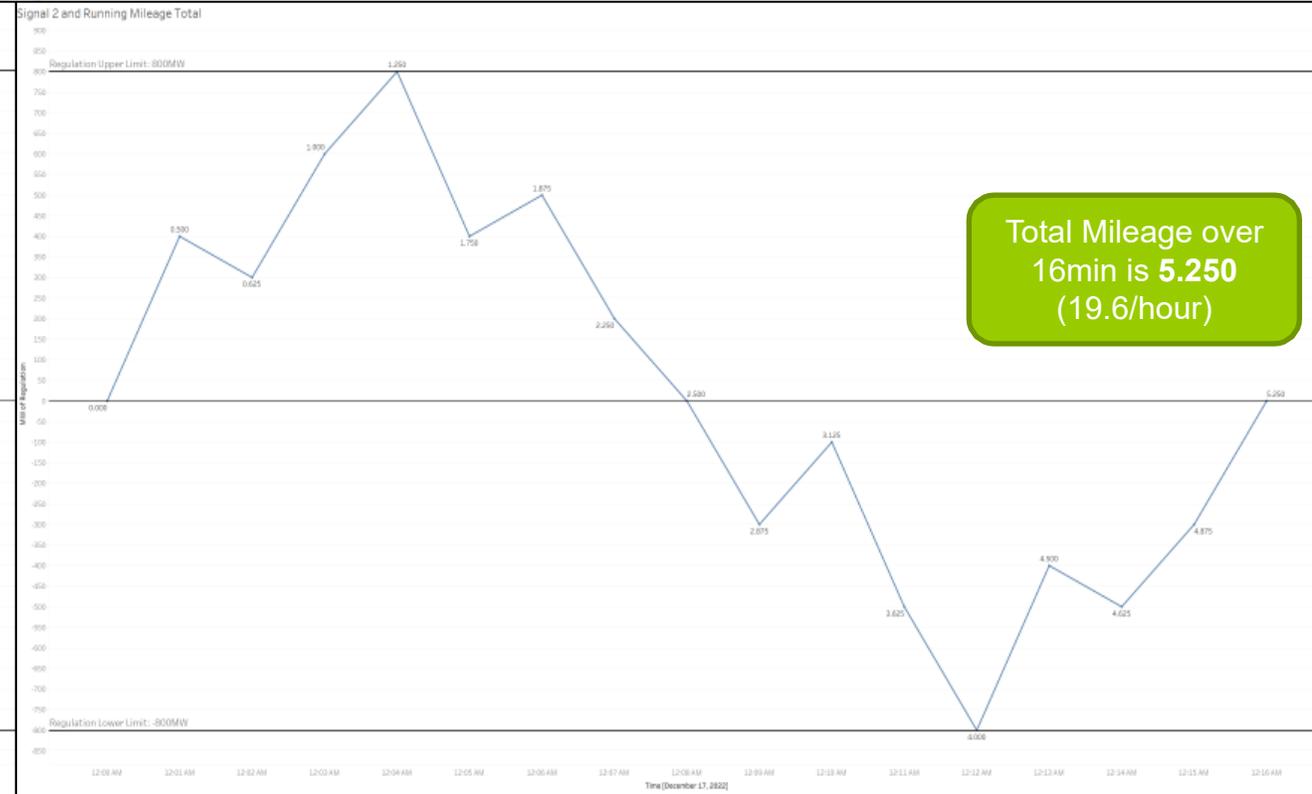
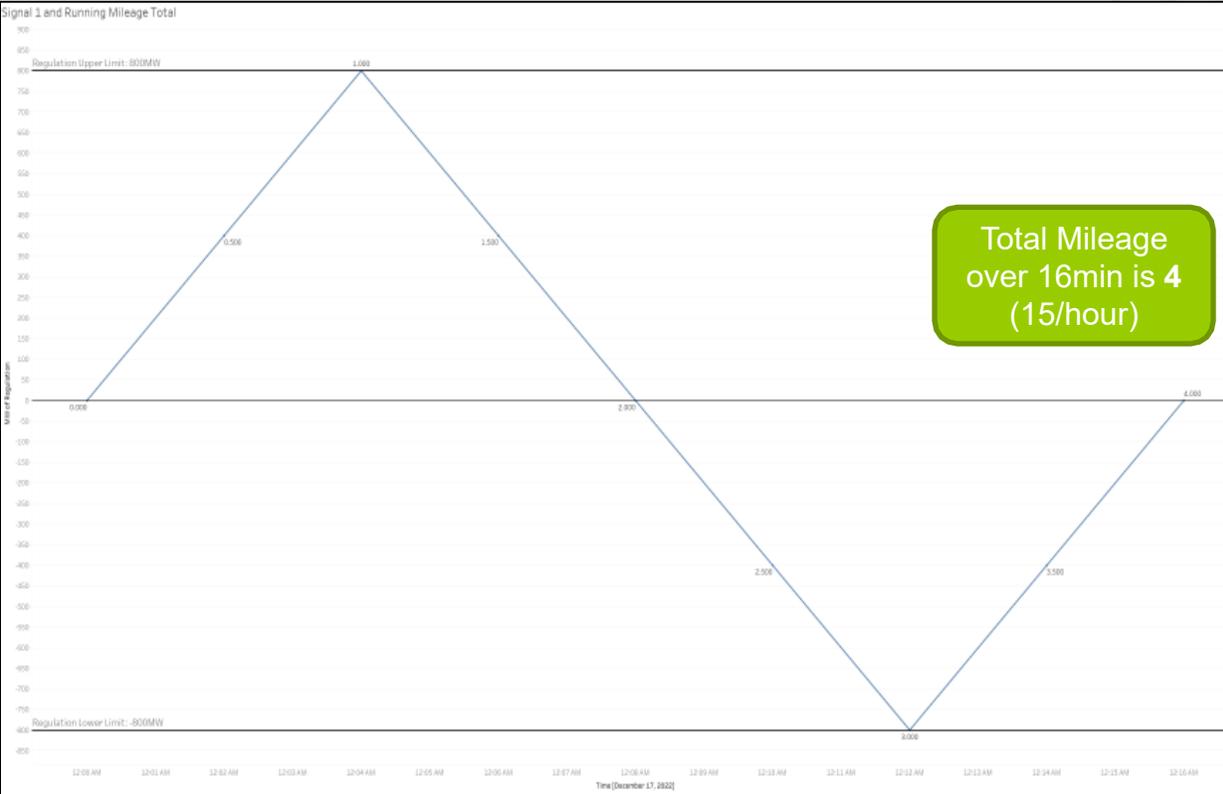


Why is Volatility Important?

Less volatile signals are easier for generators to follow.

Lower ramp rate required from fleet. **Control ACE with as little volatility as possible**

Signal 2 has higher mileage, or “volatility”. Signal 2 is harder to follow and requires greater ramp rates.



2) How Well Does a Signal Regulate ACE? Average Over Time

- The goal of regulation is to control ACE
- In an ideal world, $ACE = 0$
- **Metric 2: How close is our average ACE to 0?**

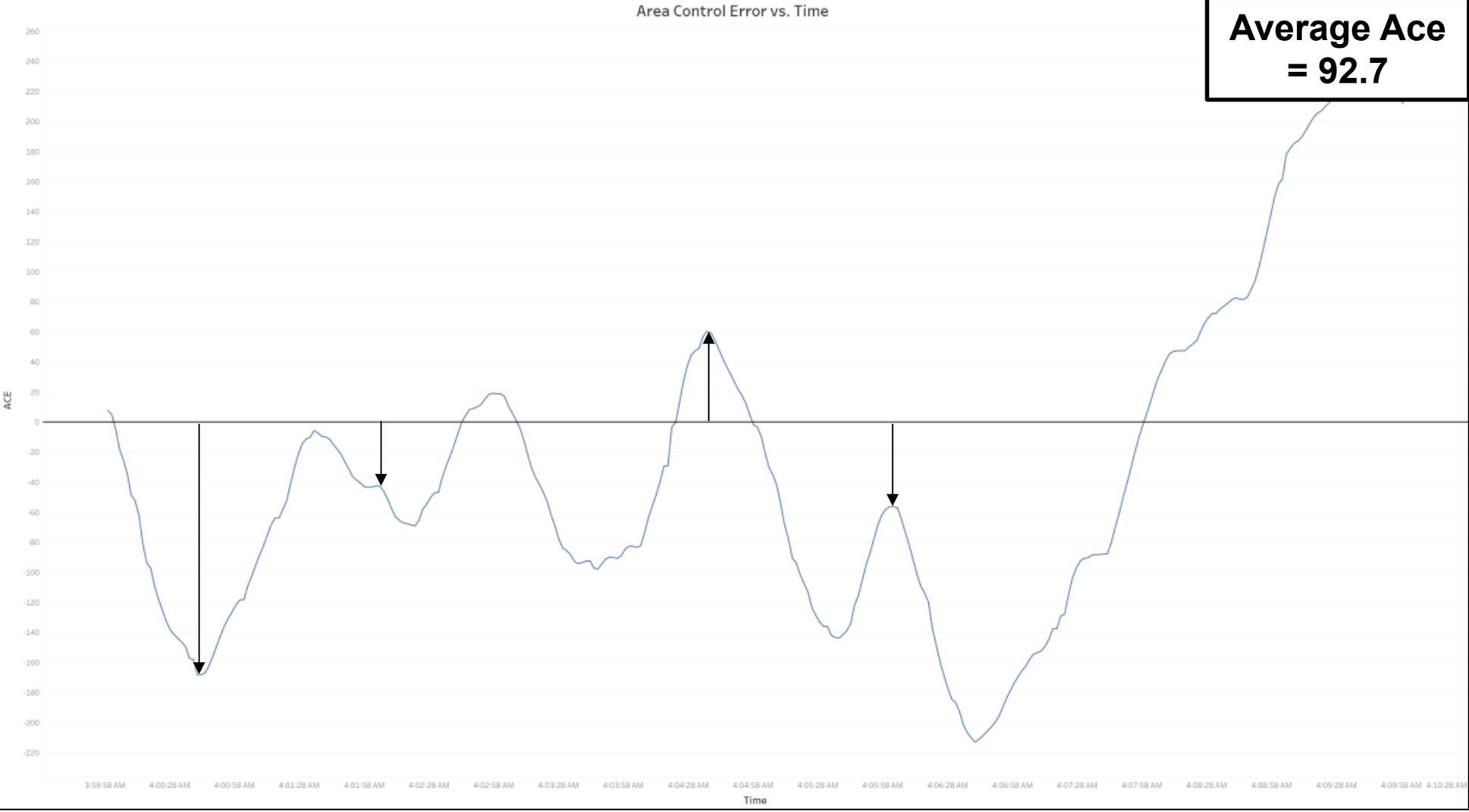


2) How Well Does a Signal Regulate ACE? Average Over Time

Defining Metrics

Area Control Error vs. Time

**Average Ace
= 92.7**



- On average, our ACE is 92.7 from 0 for this length of time
- Peaks may be higher or lower than 92.7, it is an average

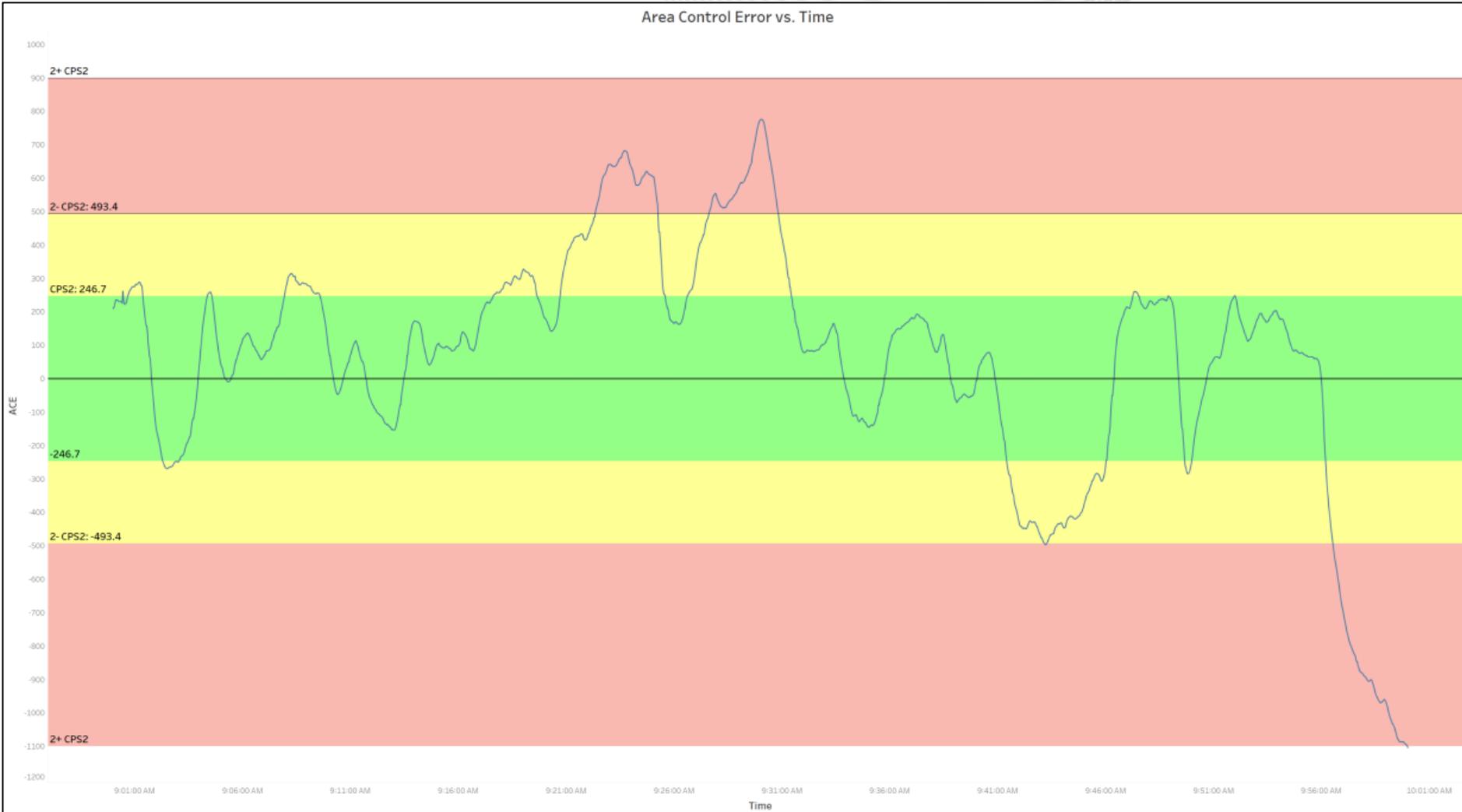
3) ACE Regulation: CPS2 Scores

- Extreme ACE values are dangerous, we want to avoid them
- Less extreme ACE values are good, we don't care as much if ACE is close to 0
- **Metric 3: How much time does ACE spend in each CPS2 bucket?**

3) ACE Regulation: CPS2 Scores

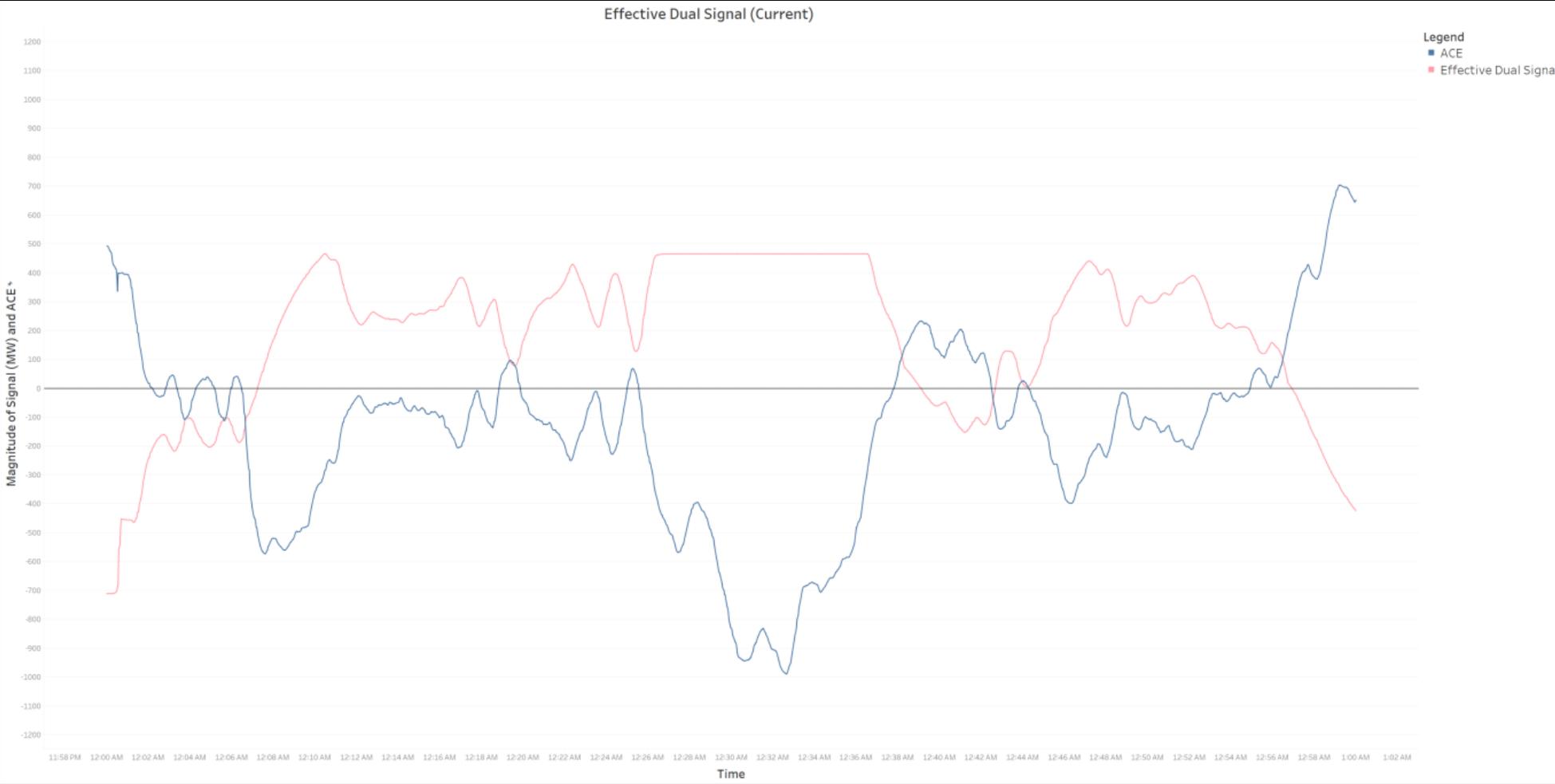
Defining Metrics

- Want ACE to spend as much time in the **GREEN** as possible
- As little time in the **RED** as possible. Any ACE over +/- 493.4 is red

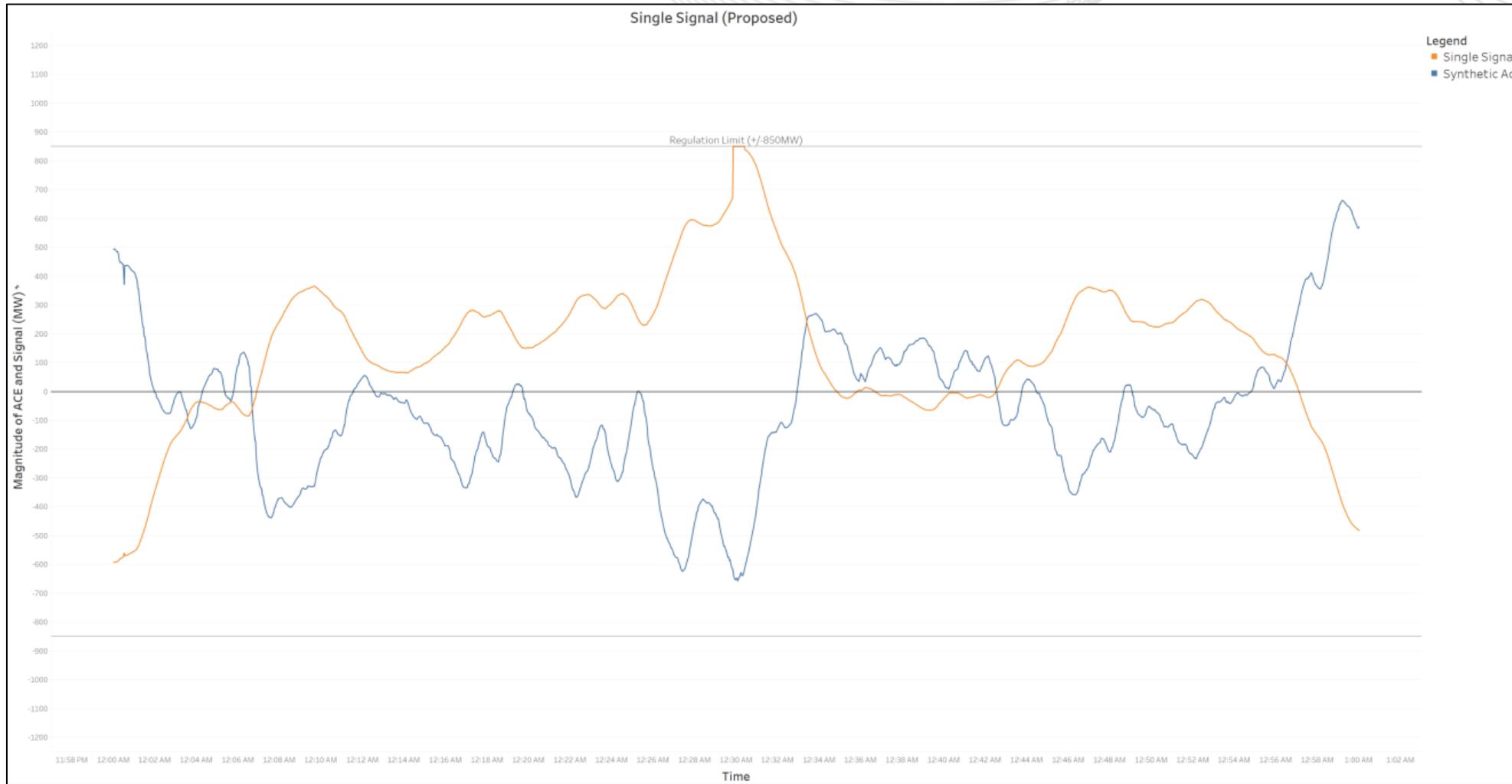


Examining Trade-Offs

- Look at real historical ACE data, and the respective regulation data, for 12-12-2022
- Look at models of ACE and single signal regulation data, for 12-12-2022
- Examine metrics for both, discuss trade-offs

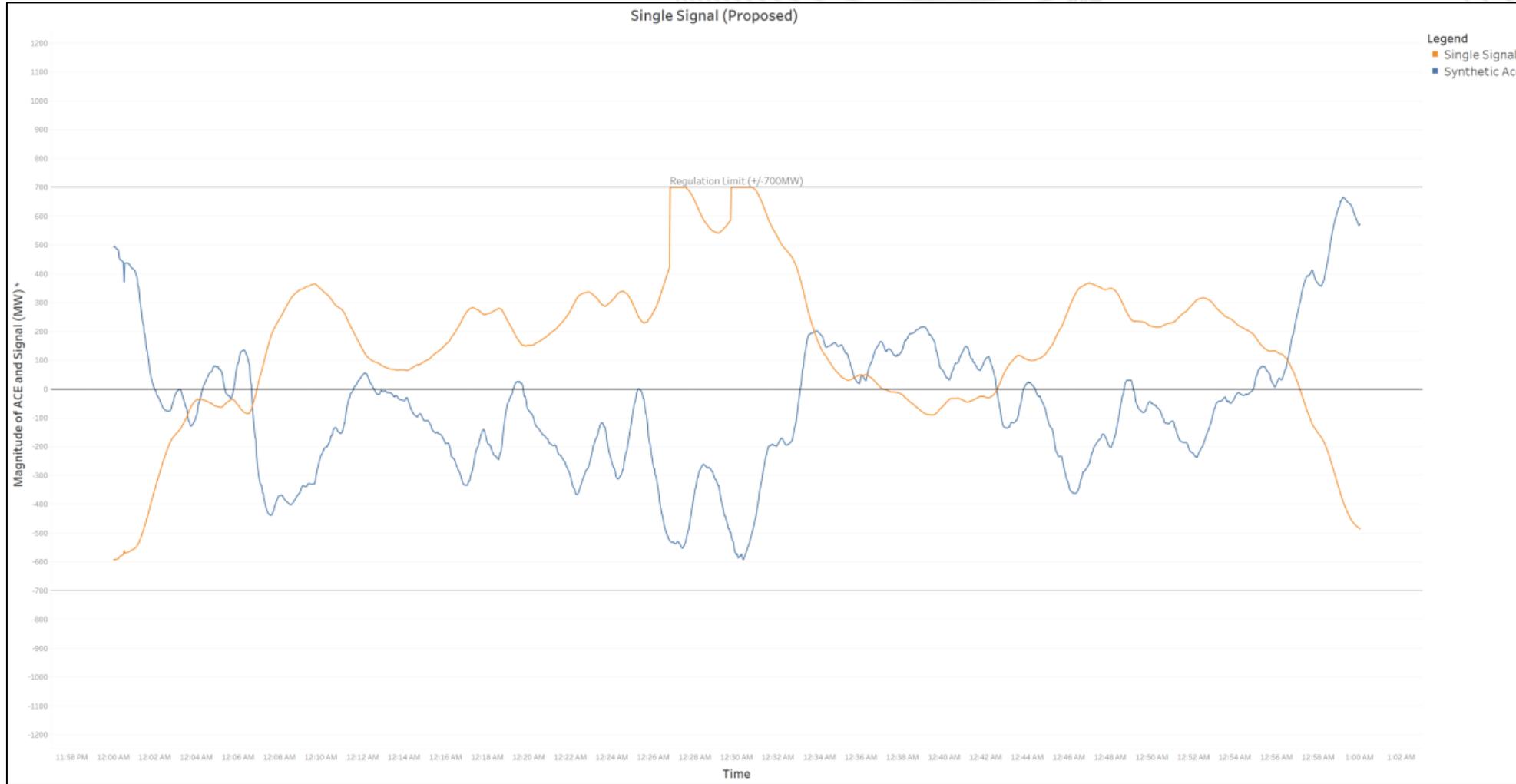


- This graph shows very volatile ACE data on 12-22 morning
- REG D Mileage is extremely high, which keeps REG A mileage low
- Signal has trouble handling volatility, ACE hits -1000, not enough regulation (pegs at ~470)

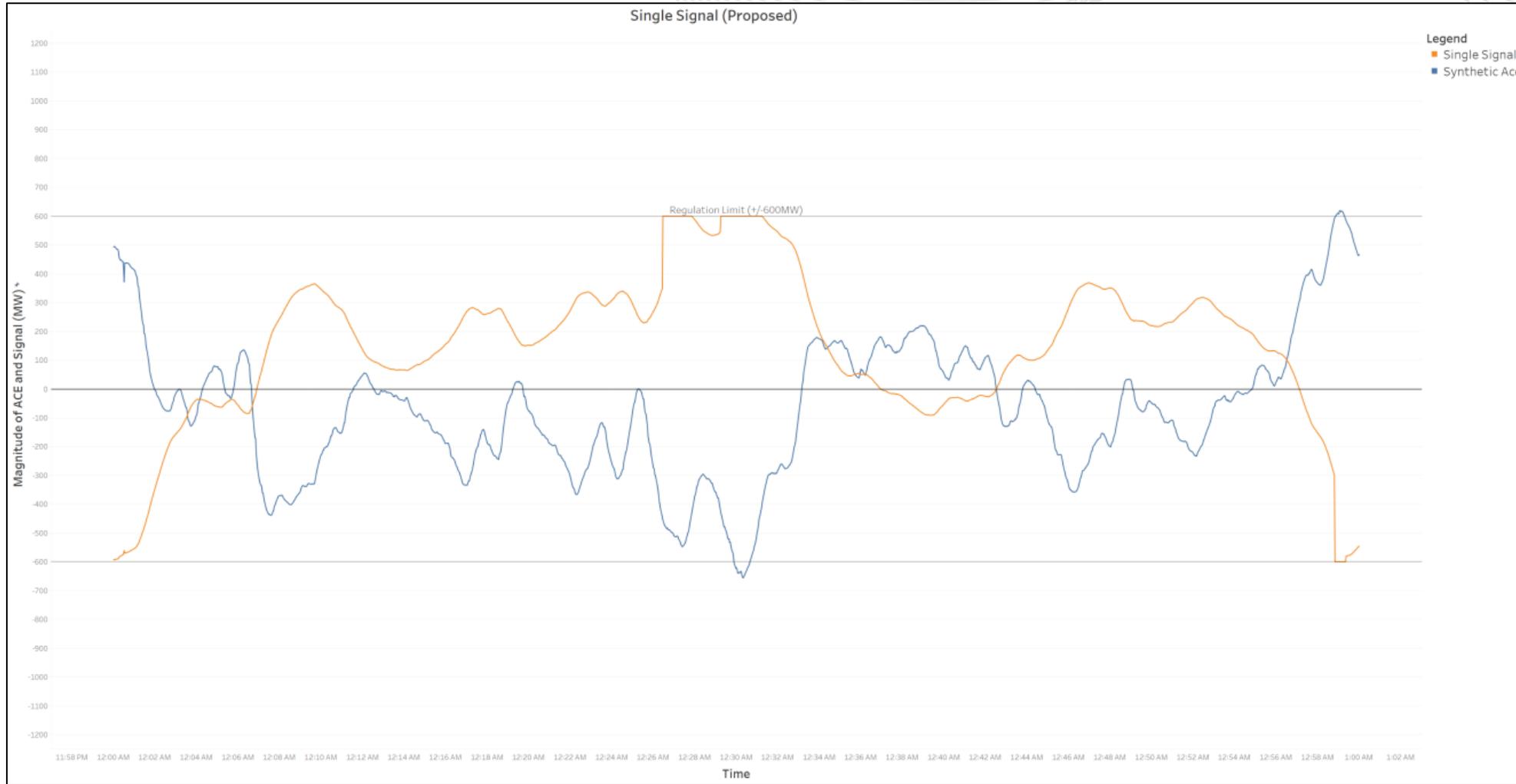


- This graph presents a model of a single signal
- It also shows a model of how ACE responded to the single signal
- No need for any high mileage signal to control ACE
- What if we don't have 850MW of regulation?

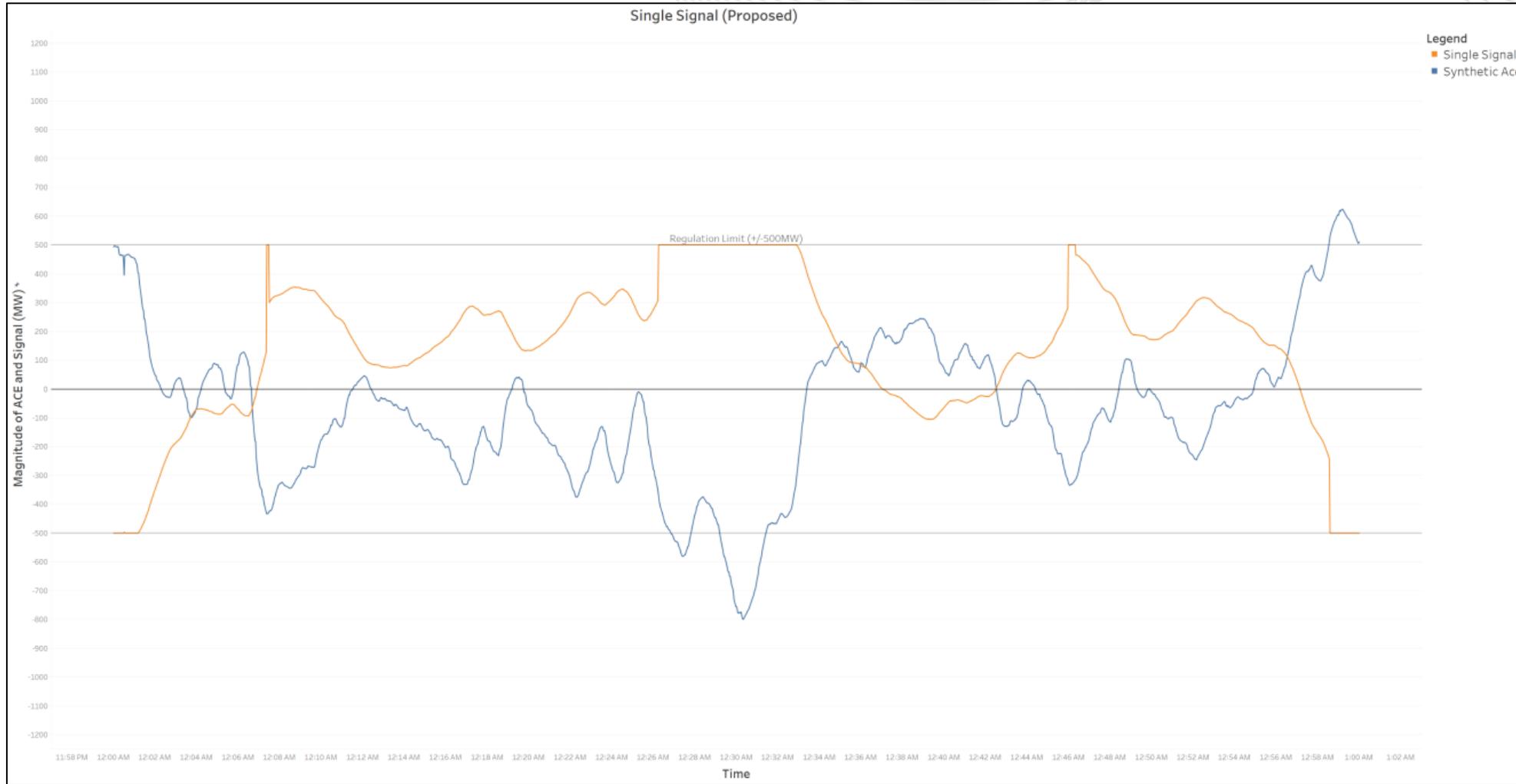
Single Signal (Proposed)



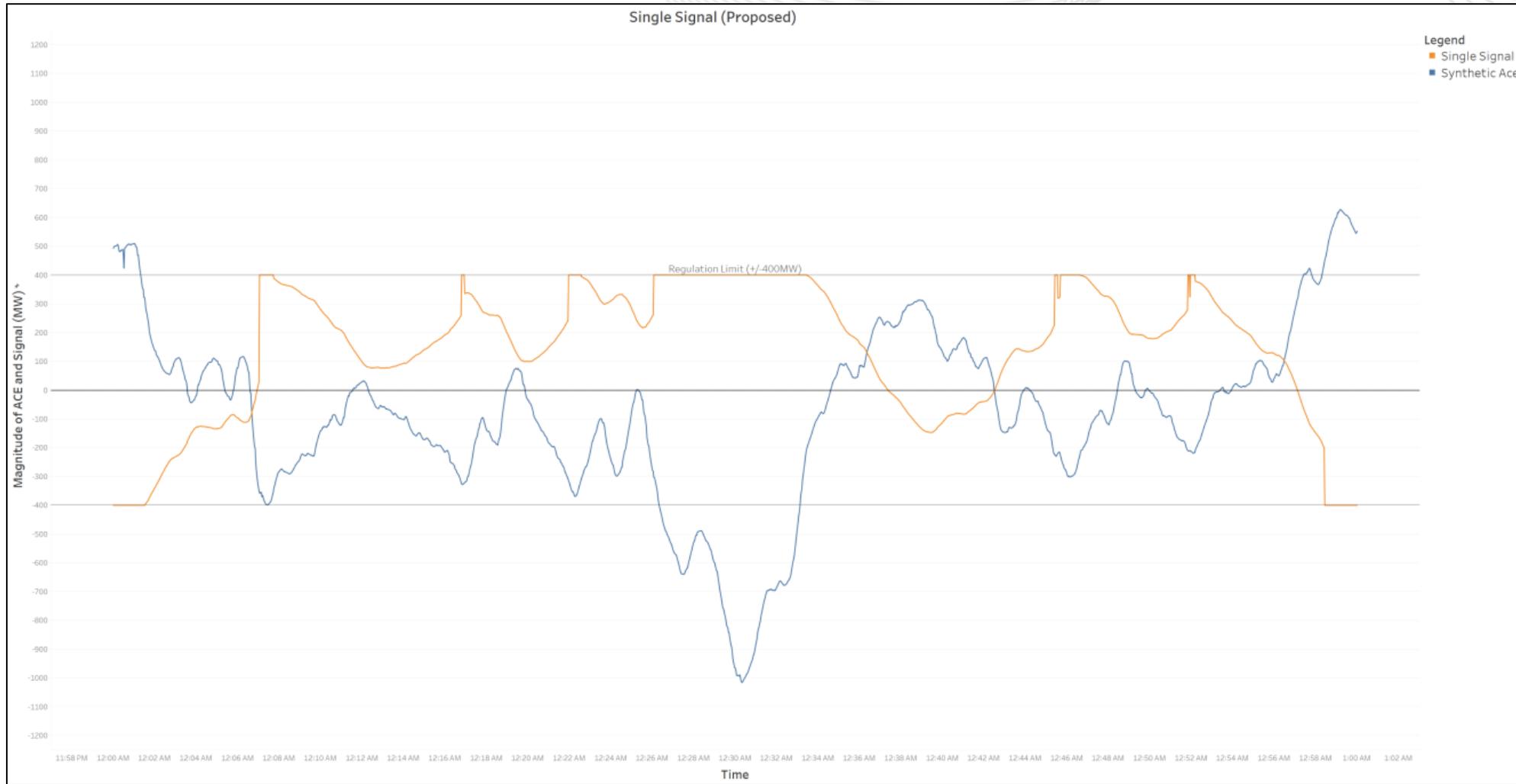
Single Signal (Proposed)



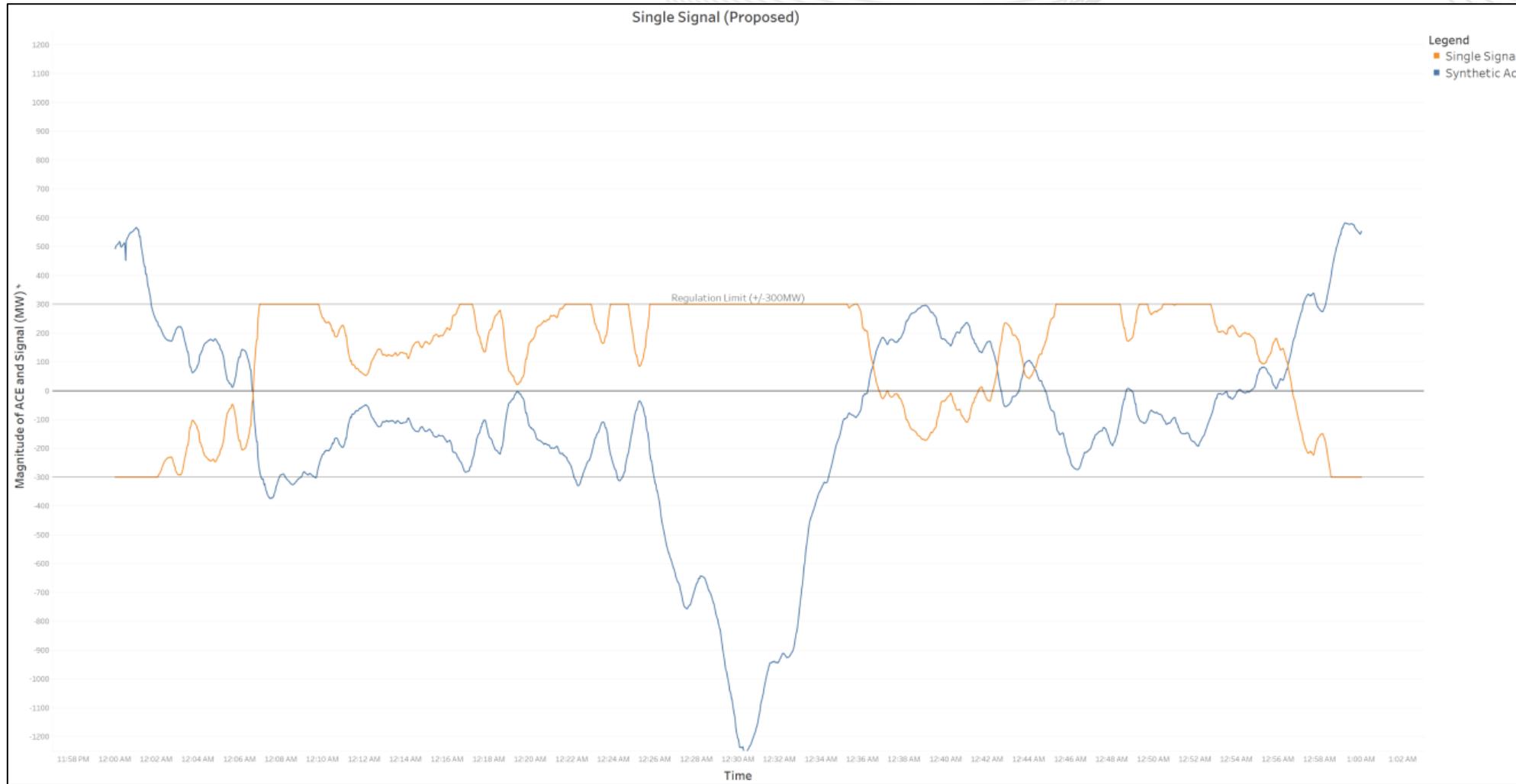
Single Signal (Proposed)



Single Signal (Proposed)



Single Signal (Proposed)





Metrics for Status Quo and Single Signal Variations: 12-22-2022

Trade Offs

SIGNAL	MILEAGE/HR	AVERAGE ACE	CPS2	2- CPS2	2 + CPS2
STATUS QUO ~470MW	6.32 REGA 29.69 REGD	190.3	71.99%	21.47%	6.54%
850MW	5.97	177.75	74.31%	22.92%	2.77%
700MW	7.69	176.10	74.84%	22.65%	2.50%
600MW	8.96	176.50	74.76%	22.77%	2.56%
500MW	9.01	176.59	74.67%	22.76%	2.57%
400MW	11.4	212.57	67.28%	24.80%	7.912%
300MW	11.33	290.12	52.65%	29.70%	17.65%

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**PROTECT THE
POWER GRID
THINK BEFORE
YOU CLICK!**

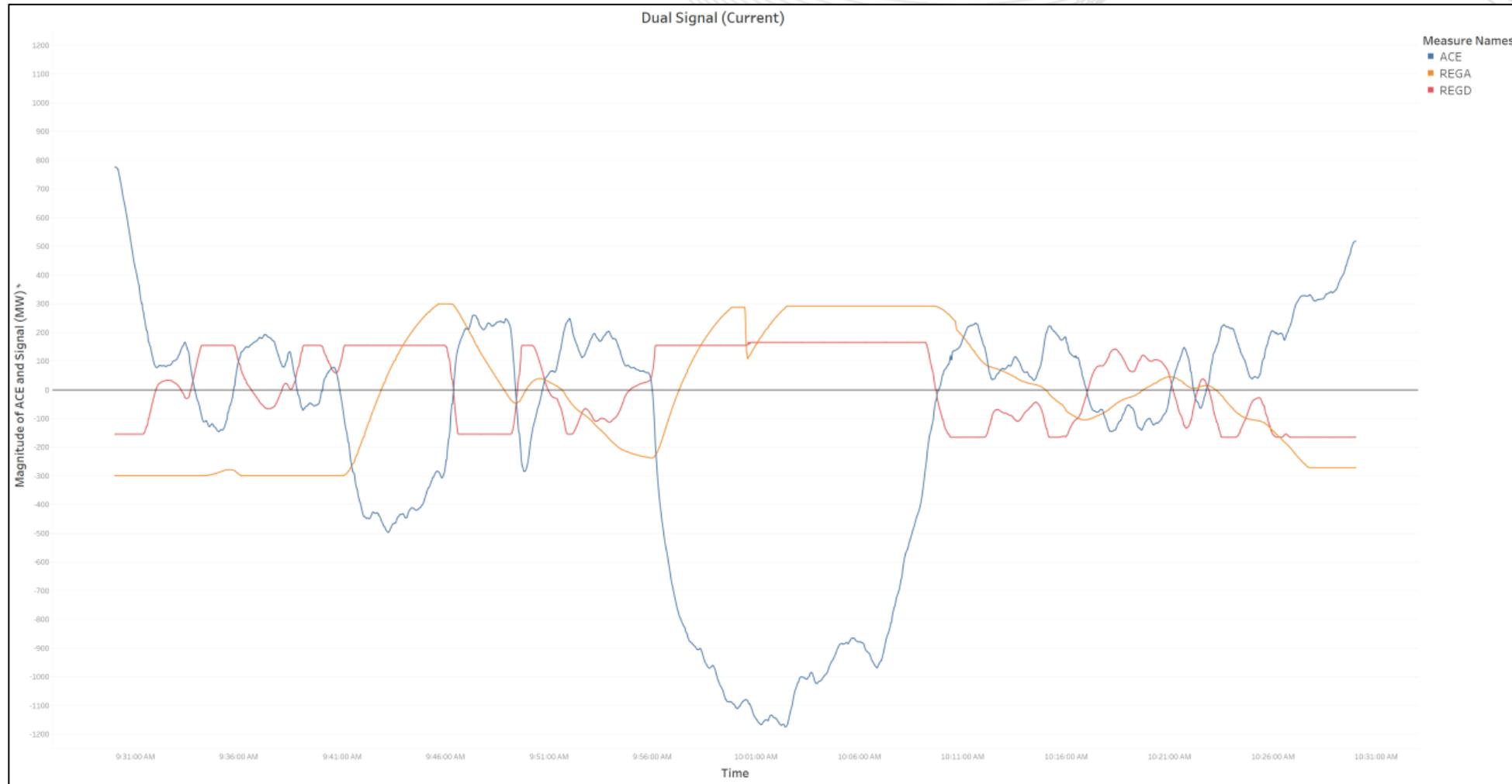


Be alert to
malicious
phishing emails.

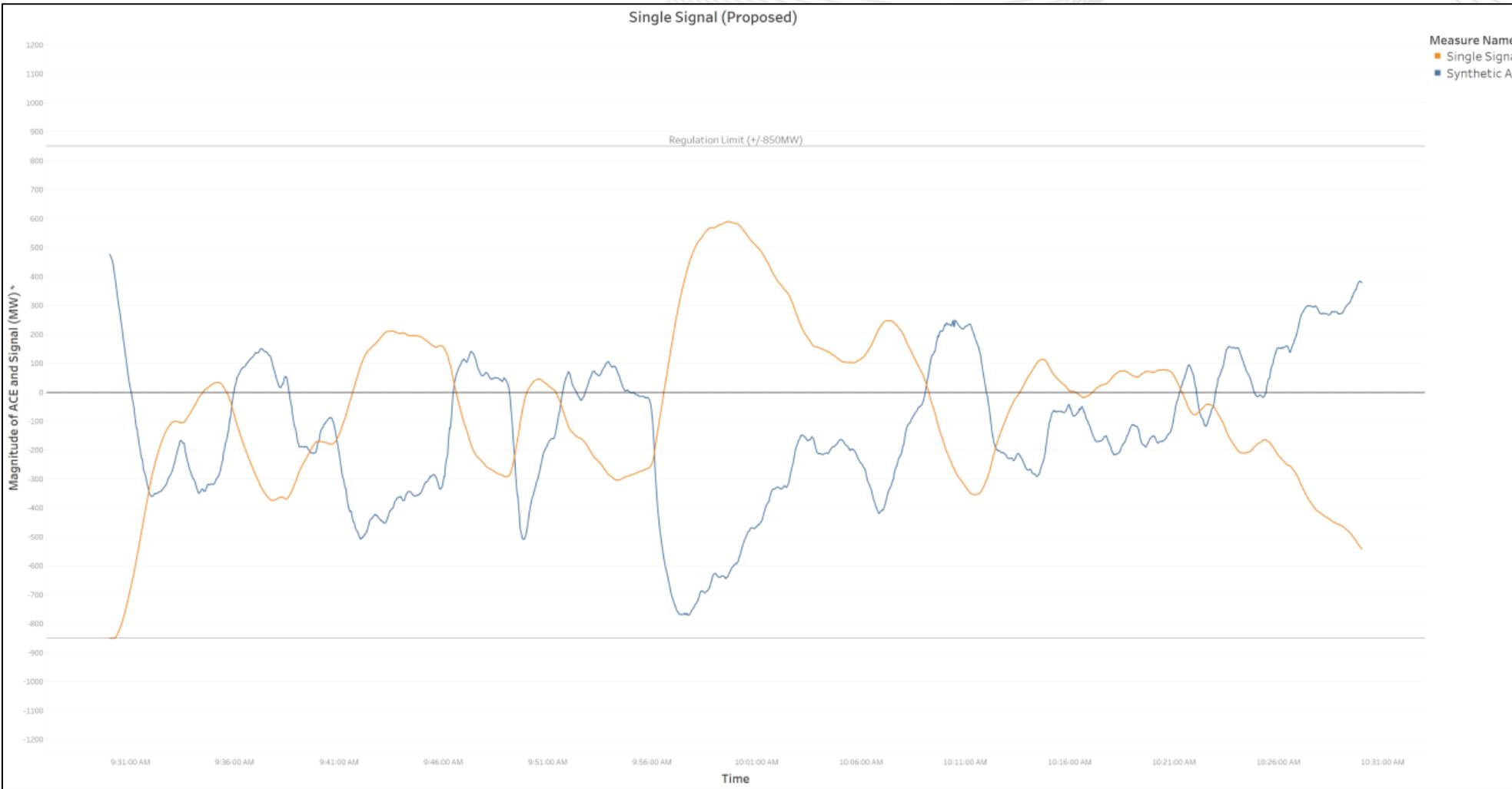
Report suspicious email activity to PJM.
(610) 666-2244 / it_ops_ctr_shift@pjm.com



Dual Signal (Current)



Data from November
19, 9:30 – 10:30 (AM)



Data from November 19, 9:30 – 10:30 (AM)