

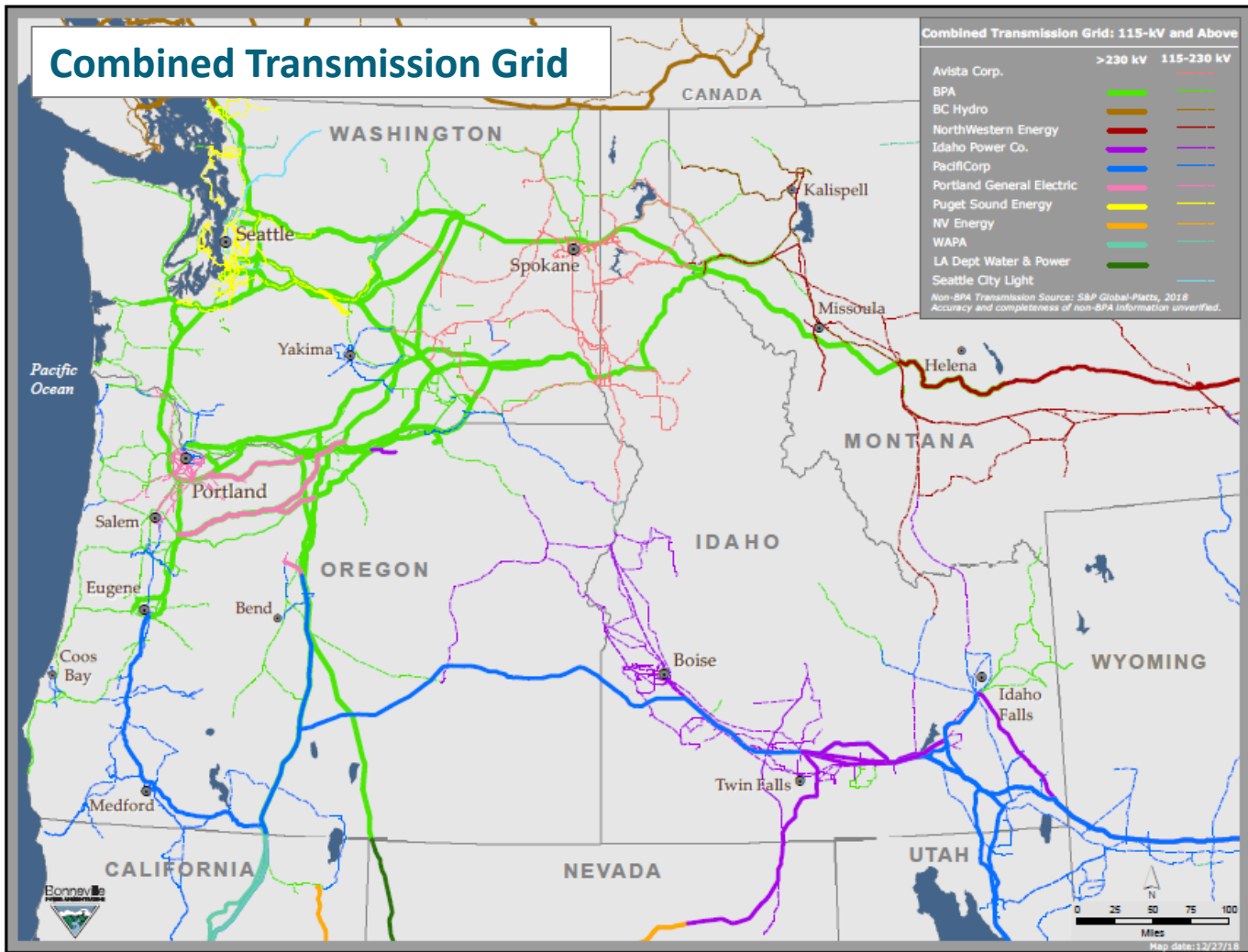


BPA Use of Synchrophasors in the Control Room

Daniel Goodrich

Kliff Hopson





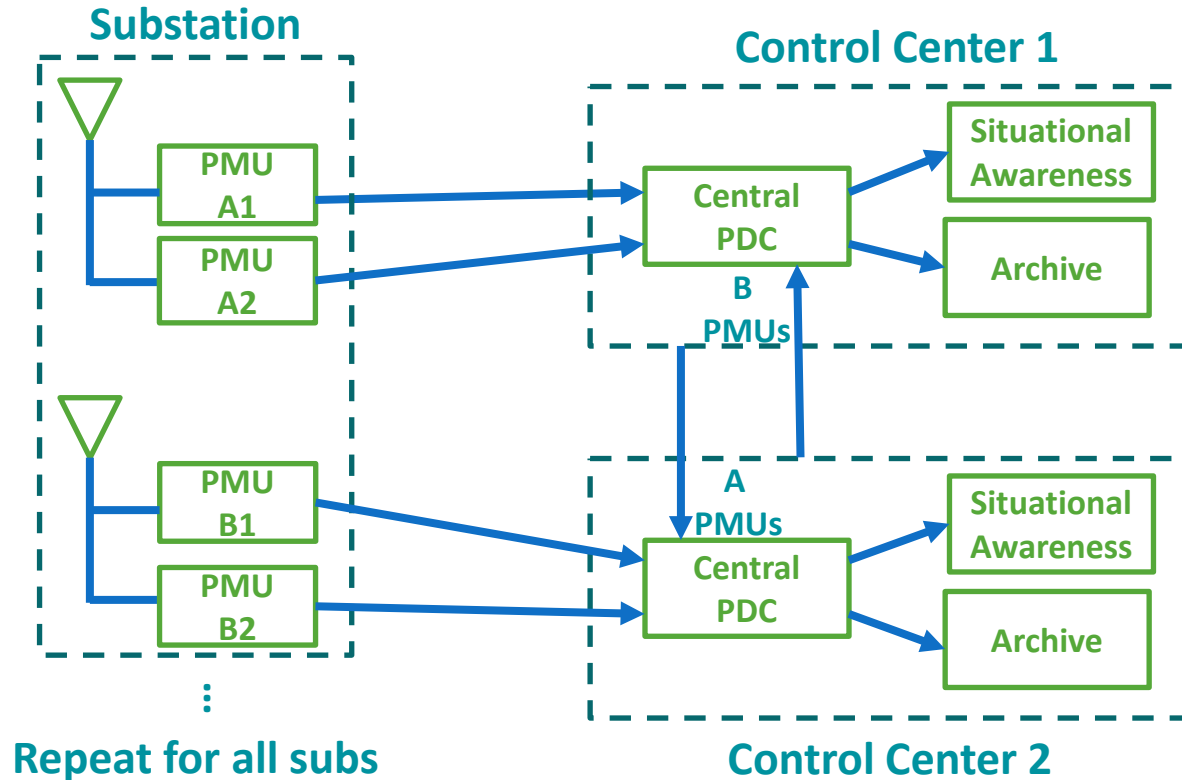
Federal Columbia River Power System



General Info

- BPA territory in 6 states in the Pacific Northwest, 20+ GW of hydro
- BPA has over 100 PMU's at 45 locations
- Alarm only when you want Dispatcher action (there are a few exceptions)
- *Oscillation events give a priority 1 **audible** alarm

System Architecture



Resources: 4 Full-time equivalents

1. Planning and Architecture
2. System Operation and Data Management
3. Labs and Development
4. Engineering and Event Analysis

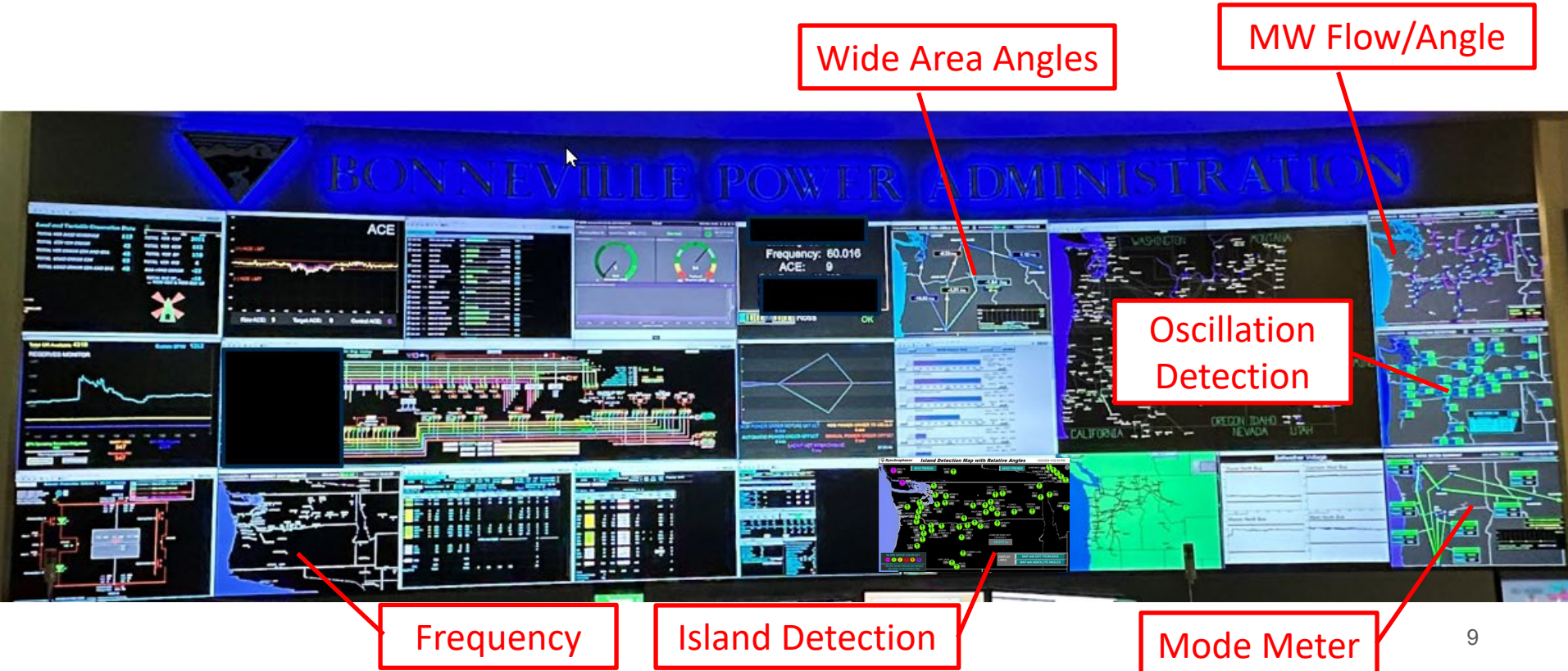
Dispatch Alarms

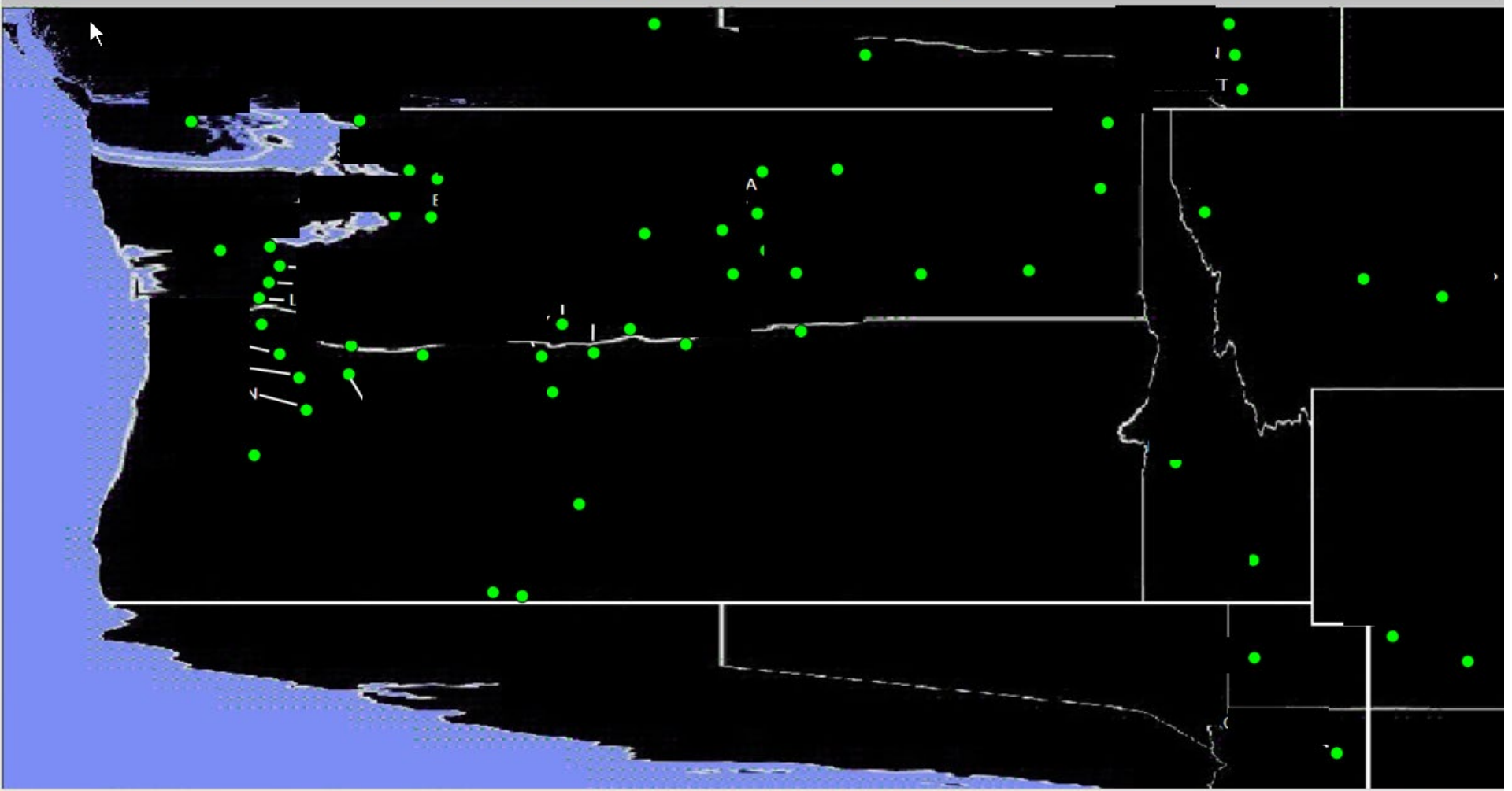
- Oscillation Detection provides an audible alarm and visual notification when triggered
- Frequency Monitor provides a visible alarm, and there is an audible one through a separate system
- Mode meter and Island Detection provide visual notification
- Wide Angle values are inputs into SCADA, and SCADA provides an audible alarm

Video Board



Video Board





Frequency Event Auto-generated e-mail

Synchrophasor Frequency Deviation Event

 Synchrophasor
To: IT
Retention Policy: BPA Capstone - 7 Year Policy (7 years)

Expires: 1/21/2031

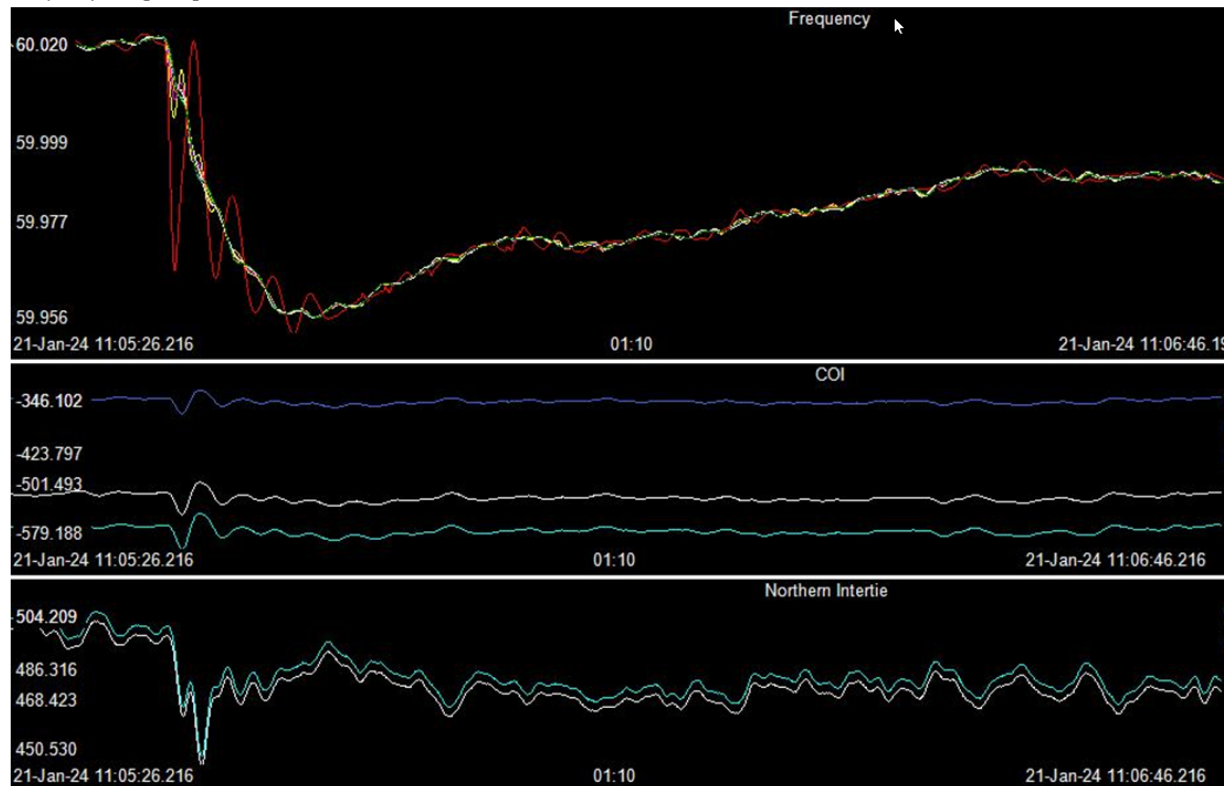
Frequency Deviation Alarm Details

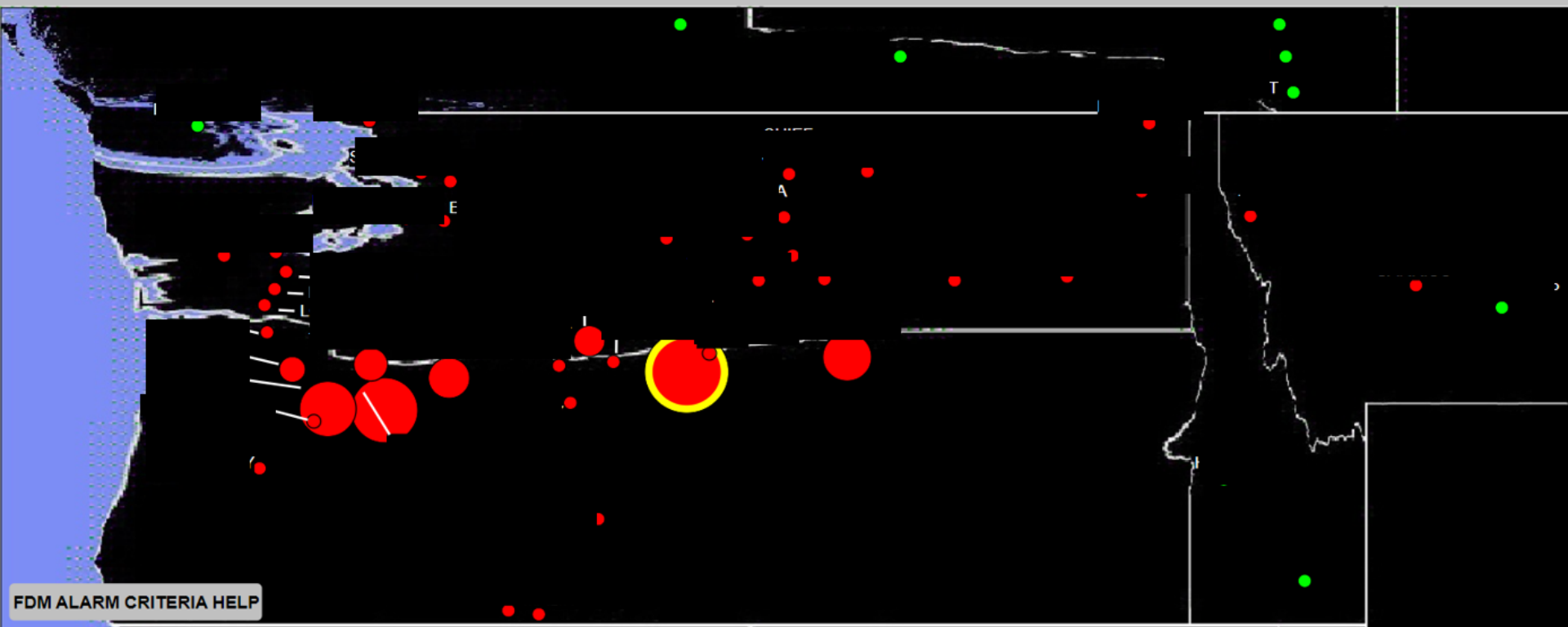
Start time: 01/21/2024 11:05:36 AM

Rank 1 PMU:

Number of PMUS Affected: 47

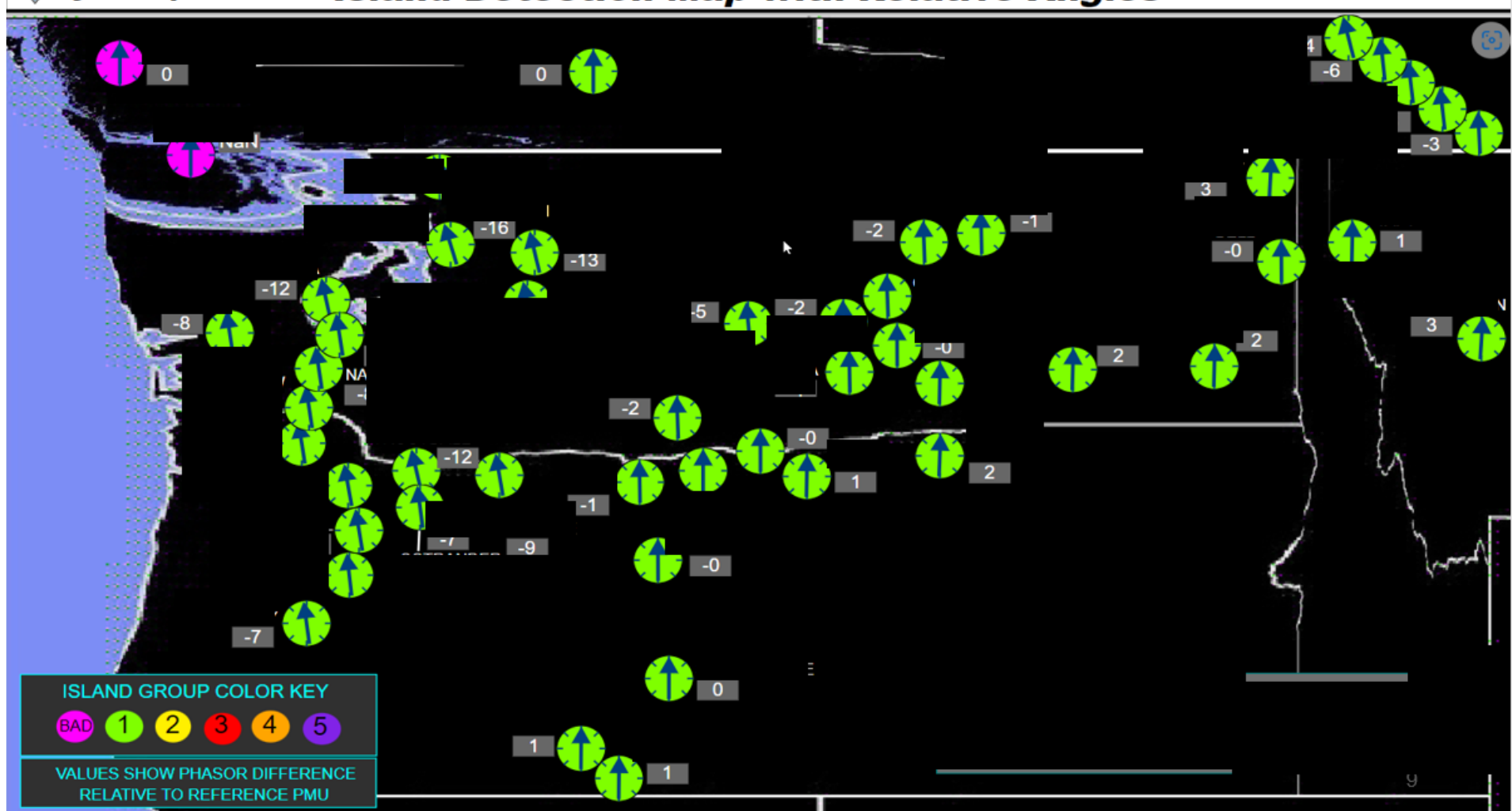
Frequency Change Magnitude: .0575

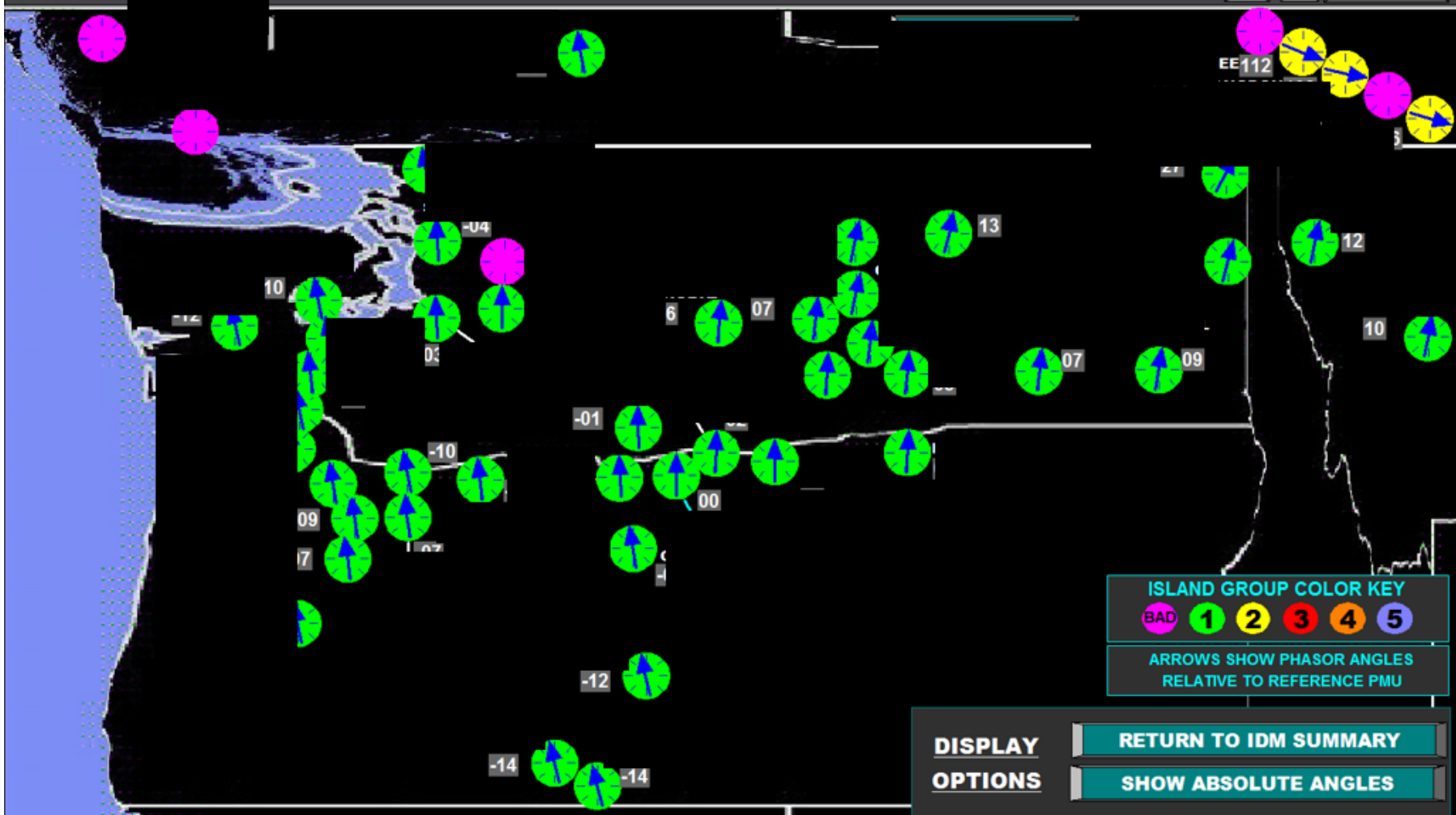




FDM ALARM CRITERIA HELP

Event Classification:	NOT ALARM
Event Time:	12/19/2023 6:00:21 AM
Frequency Change:	0.049304
Number of PMUs:	42
Rank1 PMU:	





ISLAND GROUP COLOR KEY

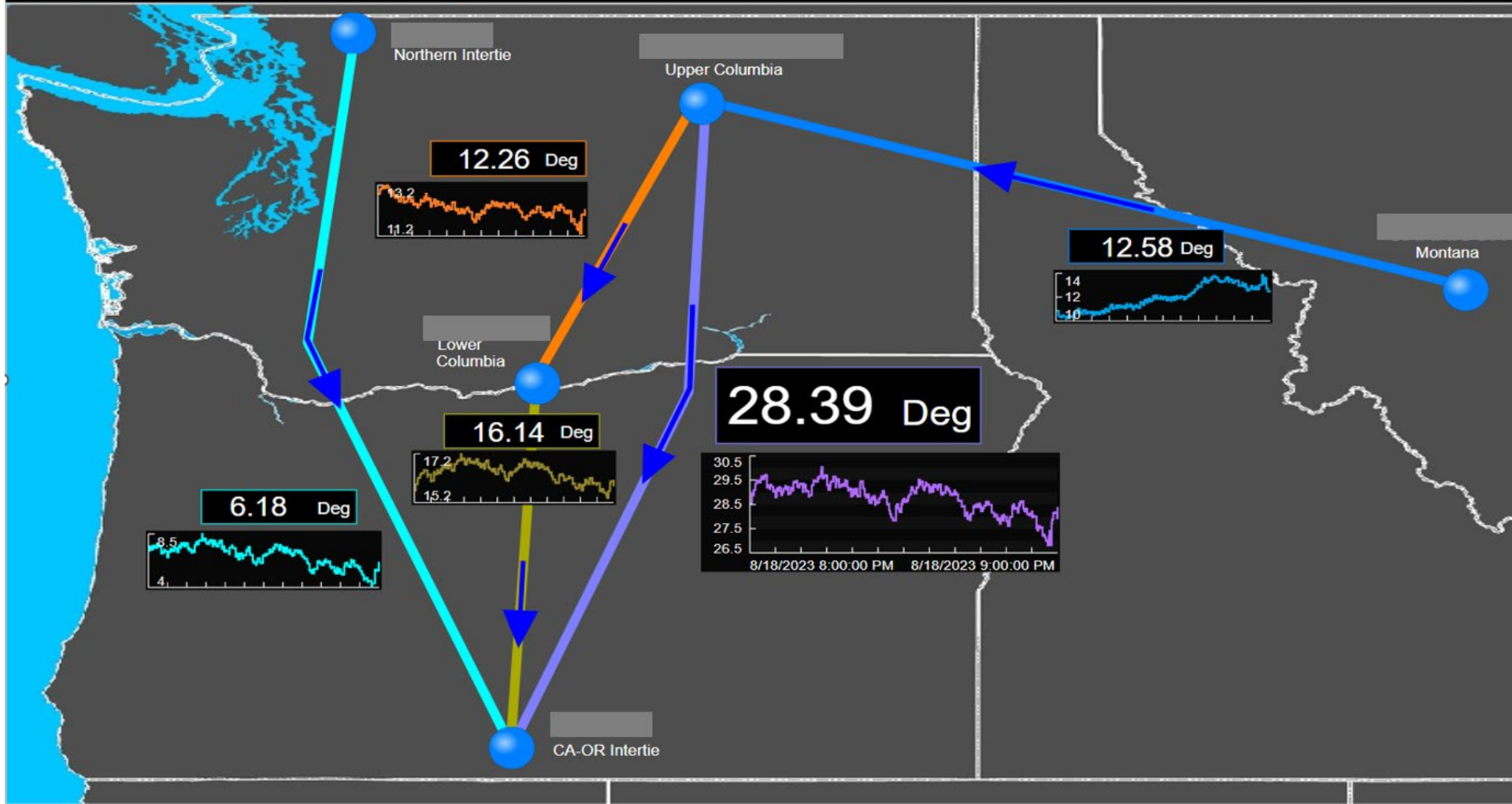
- BAD
- 1
- 2
- 3
- 4
- 5

ARROWS SHOW PHASOR ANGLES
RELATIVE TO REFERENCE PMU

DISPLAY
OPTIONS

RETURN TO IDM SUMMARY

SHOW ABSOLUTE ANGLES



Phase Angle Difference

08:12:36
09-Jan-2024

Phase Angle Monitor (Wide Area Angle Summary Monitor)

LEVEL 1	LEVEL 2
ANGLE EXCEEDS 55	ANGLE EXCEEDS 58

PHASE ANGLE DIFFERENCE		
ANGLE	ANGLE	
		-8.85
		(-) -3.49
	TOTAL	-5.40

N-S MODE MONITOR

DAMPING TRENDS

BC/NW MODE

%Damping	1.24 %
Frequency	0.60 Hz

Montana/NW2 MODE

%Damping	0.00 %
Frequency	0.00 Hz

North/South A MODE

%Damping	18.15 %
Frequency	0.24 Hz

Montana/NW MODE

%Damping	7.07 %
Frequency	0.76 Hz

North/South A2 MODE

%Damping	17.13 %
Frequency	0.24 Hz

North/South B MODE

%Damping	17.05 %
Frequency	0.39 Hz

North/South B2 MODE

%Damping	17.24 %
Frequency	0.39 Hz

DAMPING NOTES:
< 3% IS POOR DAMPING
> 15% IS GOOD DAMPING



BPA's Mode Meter Monitor

- Uses MAS (Modal Analysis Software), developed by Montana Tech



Modes of Inter-Area Power Oscillations in the Western Interconnection

Western Interconnection Modes Review Group
2021

<https://www.wecc.org/Reliability/Modes%20of%20Inter-Area%20Power%20Oscillations%20in%20the%20WI.pdf>

Summary of mode properties.

Mode	Freq. (Hz)	Shape	Interaction Path(s)	Controllability	Grade
NSA	0.20–0.30	Alberta vs. System	Alberta–BC (Path 1) Northwest–CA (Path 3)	Alberta	Well understood
NSB	0.35–0.45	Alberta vs. (BC + N. U.S.) vs. S. U.S.	COI (Path 66)	Widespread, incl. PDCI	Well understood
EWA	0.35–0.45	(Colorado + E. Wyo.) vs. System	Wyoming–ID (Path 19) Colorado–UT (Path 30) Colorado–NM (Path 31)	Colorado area	Marginally understood
BCA	0.50–0.72	BC vs. N. U.S. vs. S. U.S.	Unknown	Unknown	Not understood
BCB	0.60–0.72	W. edge vs. System vs. E. edge	Unknown	Unknown	Not understood

MODE METER SUMMARY

9/20/2023 16:24:50



CLOSE

BC/NW MODE

%Damping	7.27
Frequency	0.55

BC/NW SHAPE

North/South A MODE

%Damping	2.29
Frequency	0.20

N/S A SHAPE

North/South A2 MODE

%Damping	2.47
Frequency	0.20

North/South B MODE

%Damping	14.55
Frequency	0.40

North/South B2 MODE

%Damping	14.41
Frequency	0.40

N-S MODE WARNING MONITOR

MODE METER DAMPING TRENDS

Montana/NW2 MODE

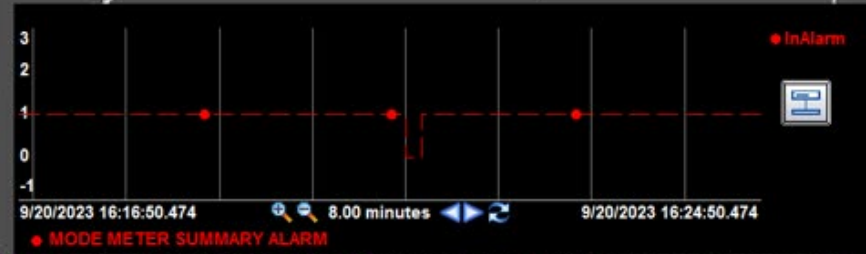
%Damping	---
Frequency	---

Montana/NW MODE

%Damping	GOOD
Frequency	0.81

MONTANA-NW SHAPE

DAMPING NOTES:
< 2% IS POOR DAMPING
> 15% IS GOOD DAMPING



N-S MODE WARNING MONITOR

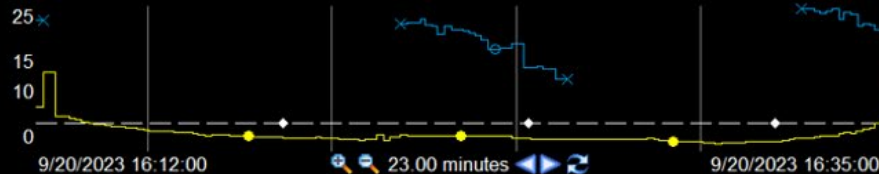
9/20/2023 16:35:00

12:00



CLOSE

N-S MODE DAMPING



% DAMPING

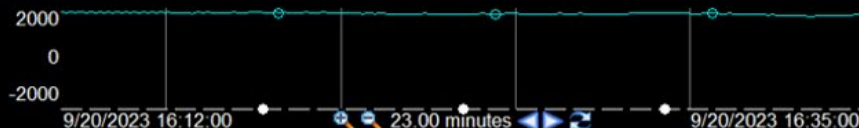
A 5.3 %

B 21.4 %

LOW LIMIT

5.0 %

POWER FLOW



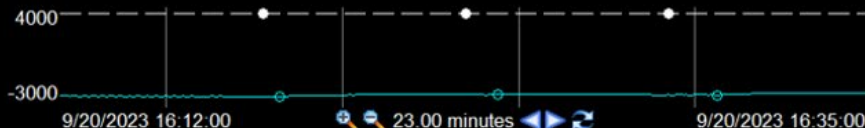
POWER

1,789 MW

HIGH LIMIT

-2,000 MW

POWER FLOW



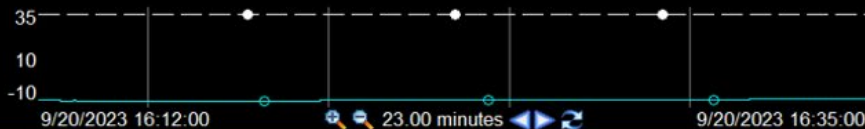
POWER

-1,940 MW

HIGH LIMIT

3,600 MW

ANGLE DIFFERENCE



ANGLE DIFF

-5.7 Deg

HIGH LIMIT

32.0 Deg

ANGLE DIFFERENCE



ANGLE DIFF

-4.1 Deg

HIGH LIMIT

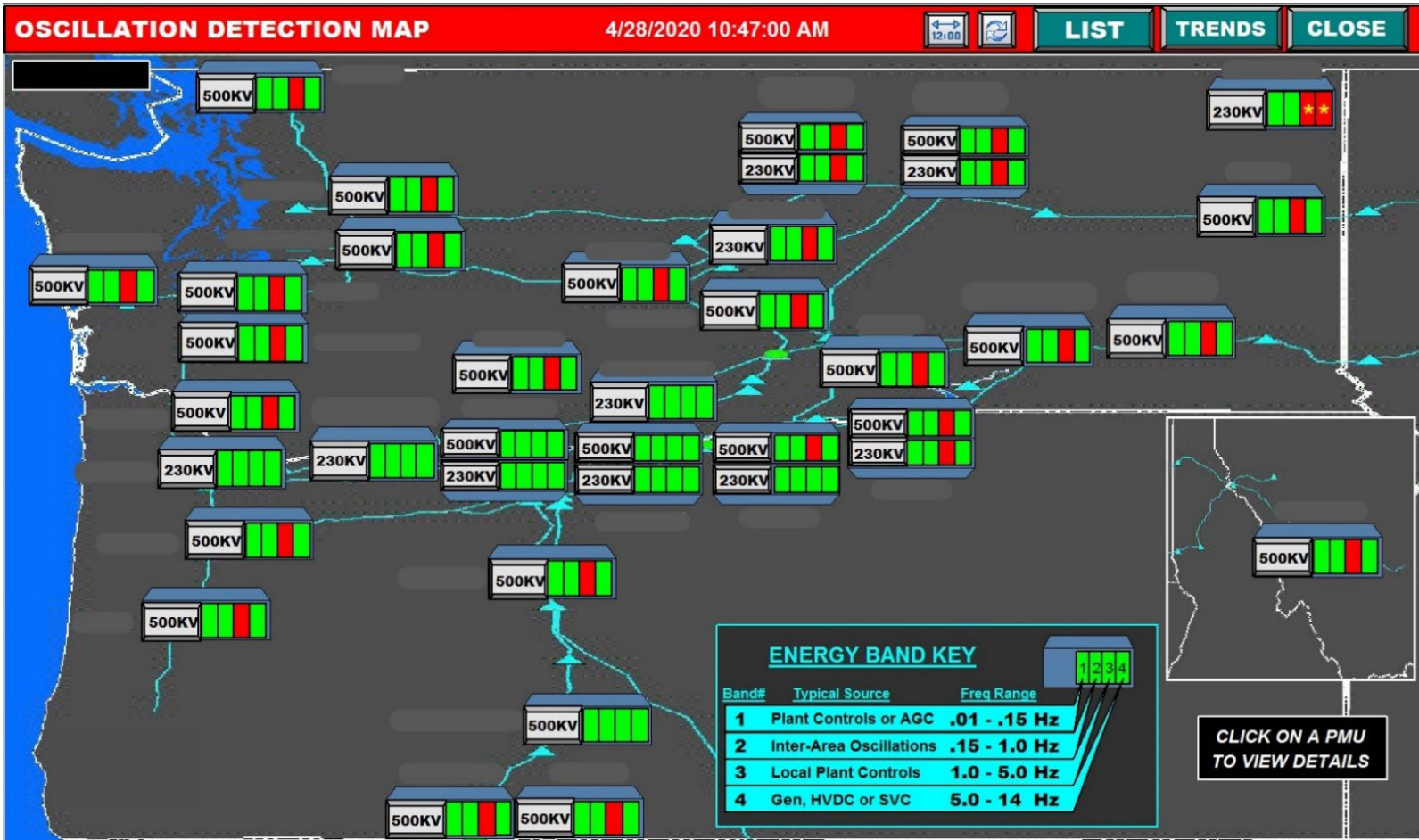
54.0 Deg

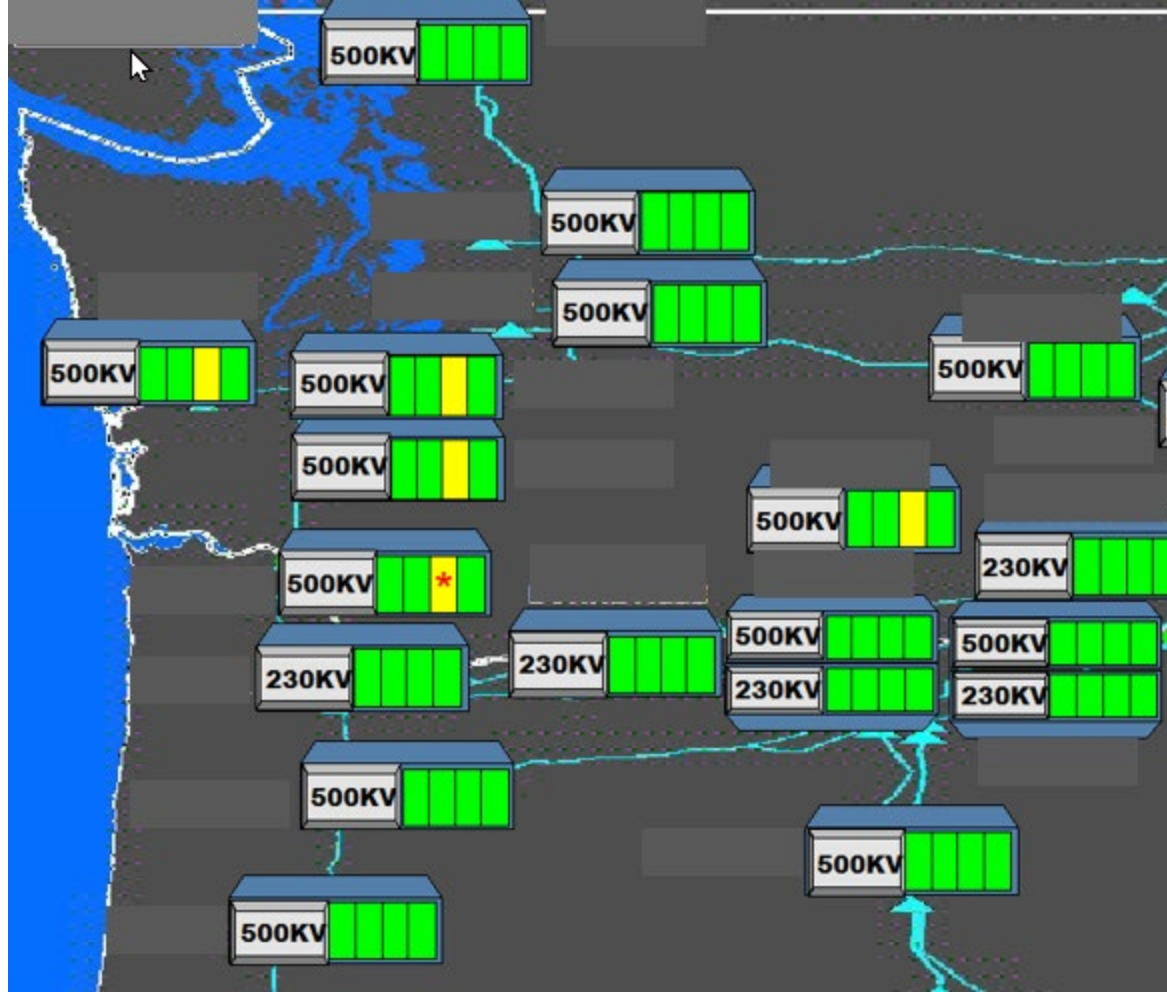
OR

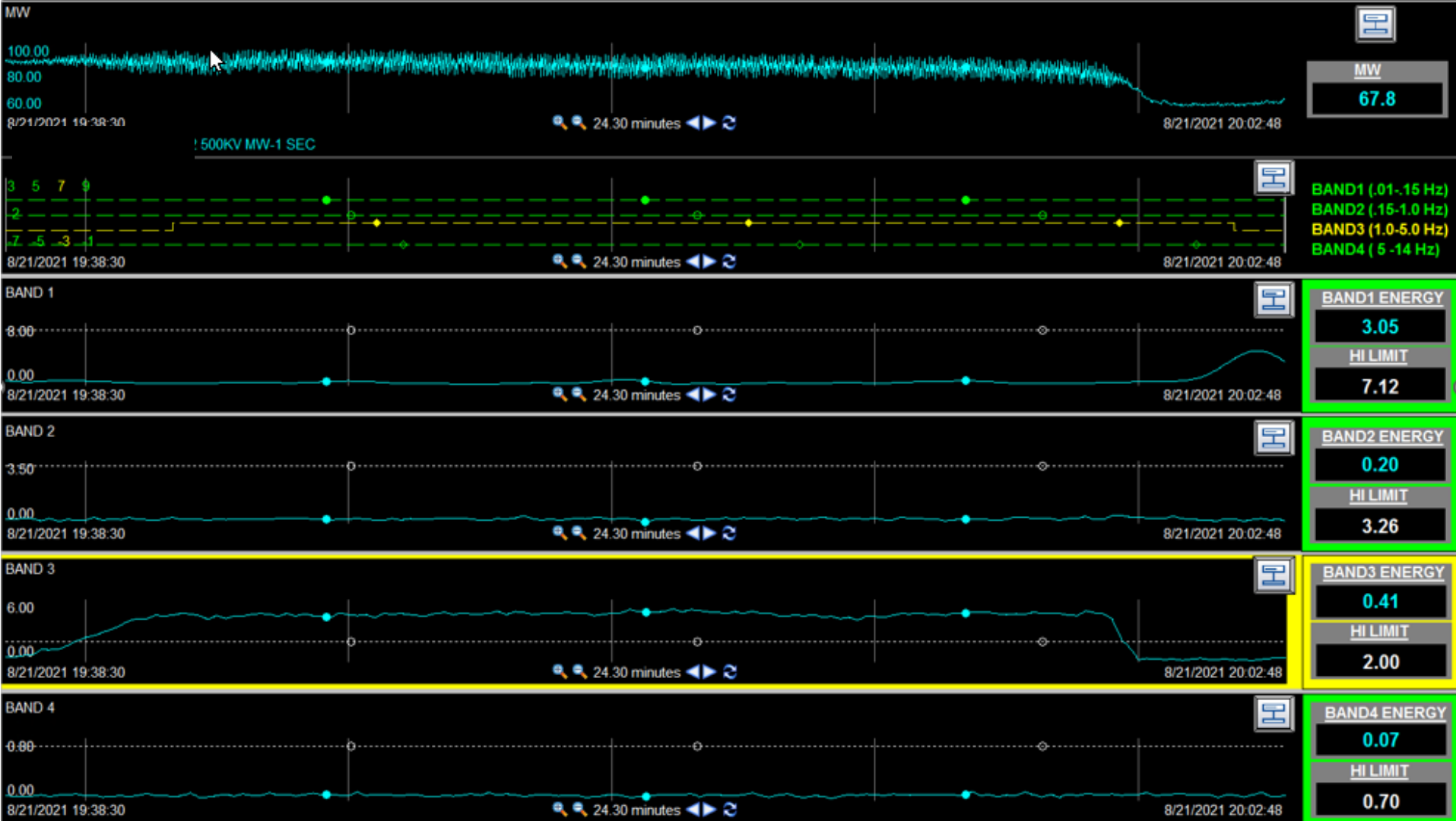
AND

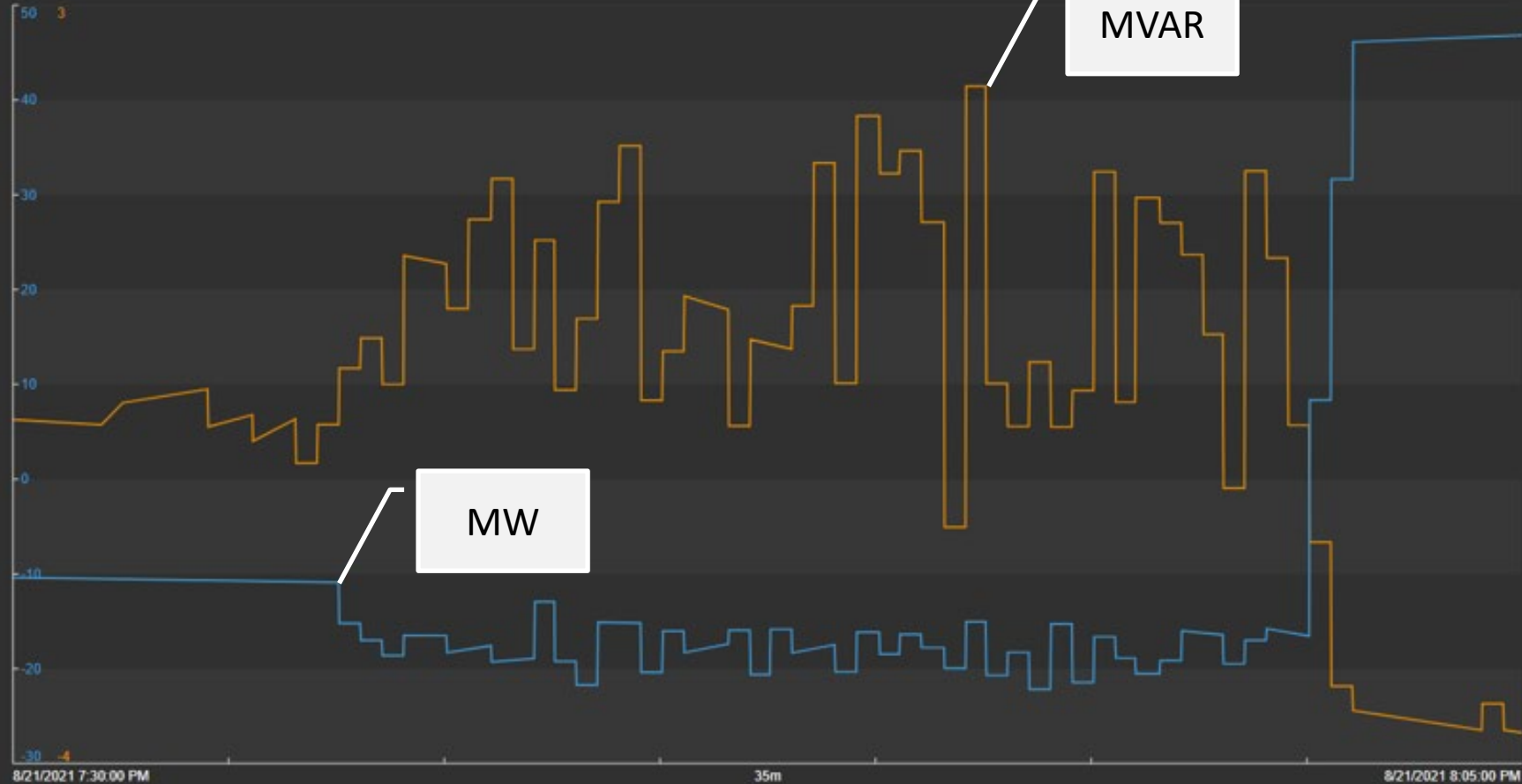
60 SEC
ALARM
TIMER

NS
MODE
WARNING







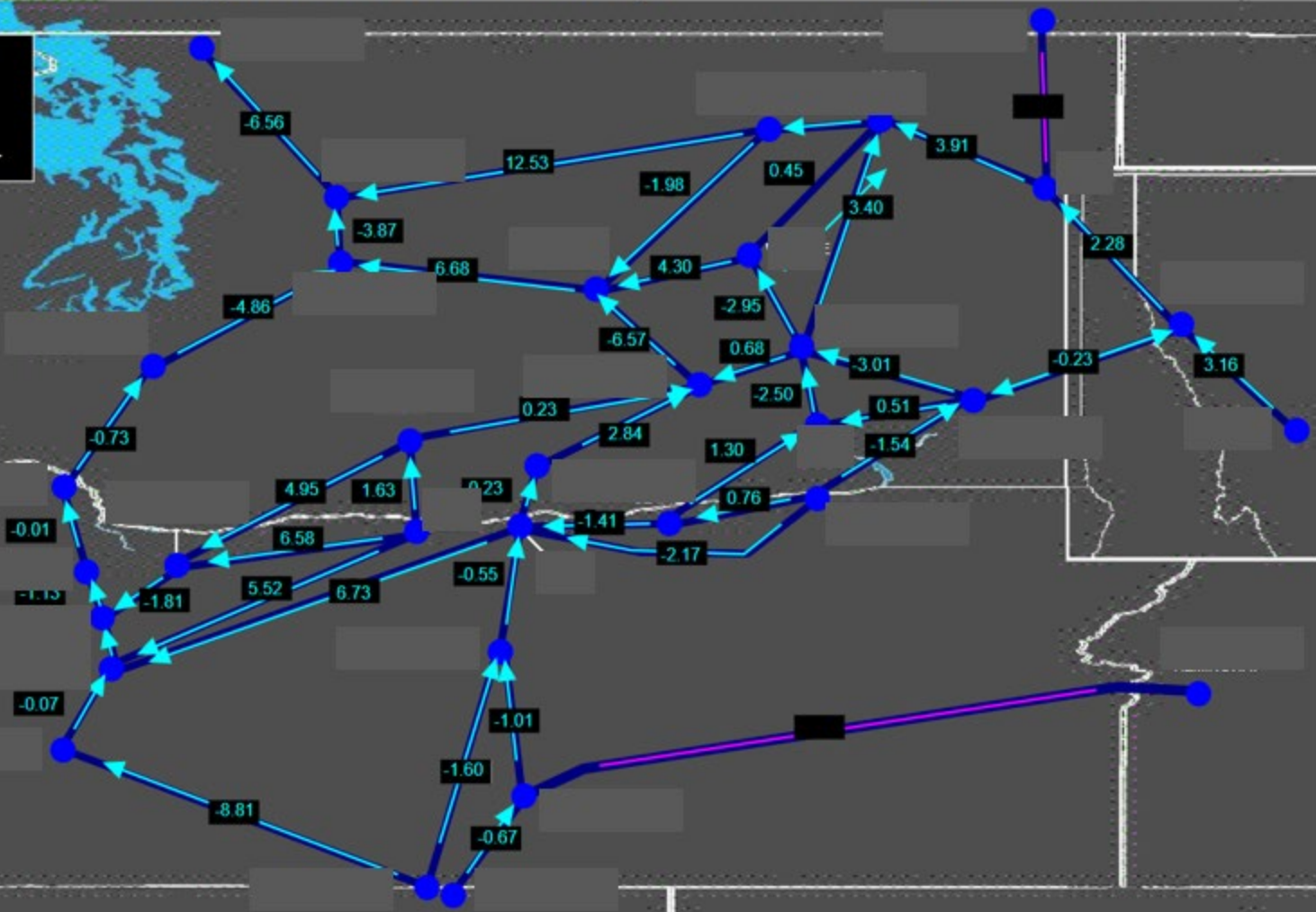


8/21/2021 7:30:00 PM

35m

8/21/2021 8:05:00 PM

Click on the angle difference for any path to open a display with detail data including referenced voltages.



Synchrophasor Remedial Action Scheme (RAS)

- Response Based RAS
 - Operational in April 2017
 - First PMU sourced RAS system in Western Interconnection
- Used as a ‘safety net’ to minimize the reliability risk for low probability contingencies.
- It triggers the insertion of capacitors and removal of reactors.

Synchrophasor RAS

- Intended to operate for large system events and prevent separations like the July 1996 event such as:
 - Intertie faults
 - Outages of the DC intertie from Oregon to Los Angeles
 - Large generation losses in the Southwest
 - BC Hydro and Alberta separations
- GPS issue

Dispatch Alarms

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Video Board

