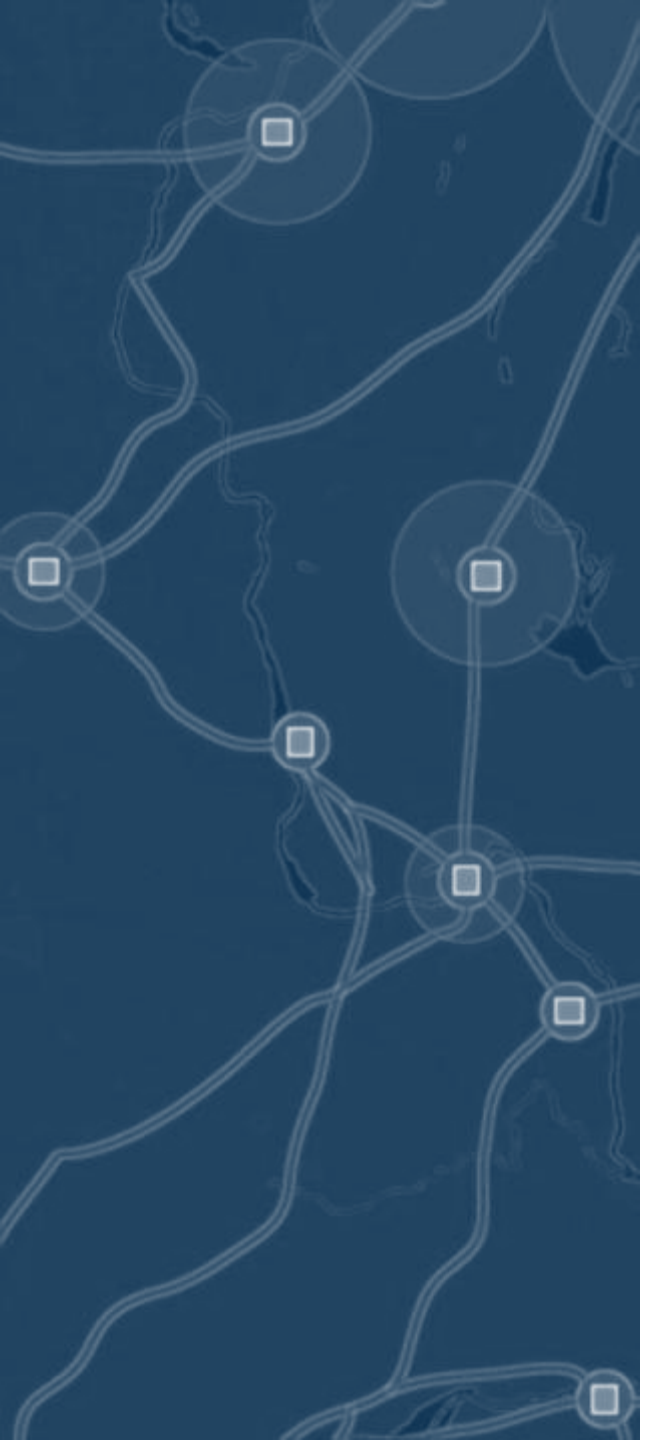

Generation loss source location for grid operations with synchrophasor data

Tariq Rahman
San Diego Gas & Electric®

Jared Bestebreur
Schweitzer Engineering Laboratories, Inc.

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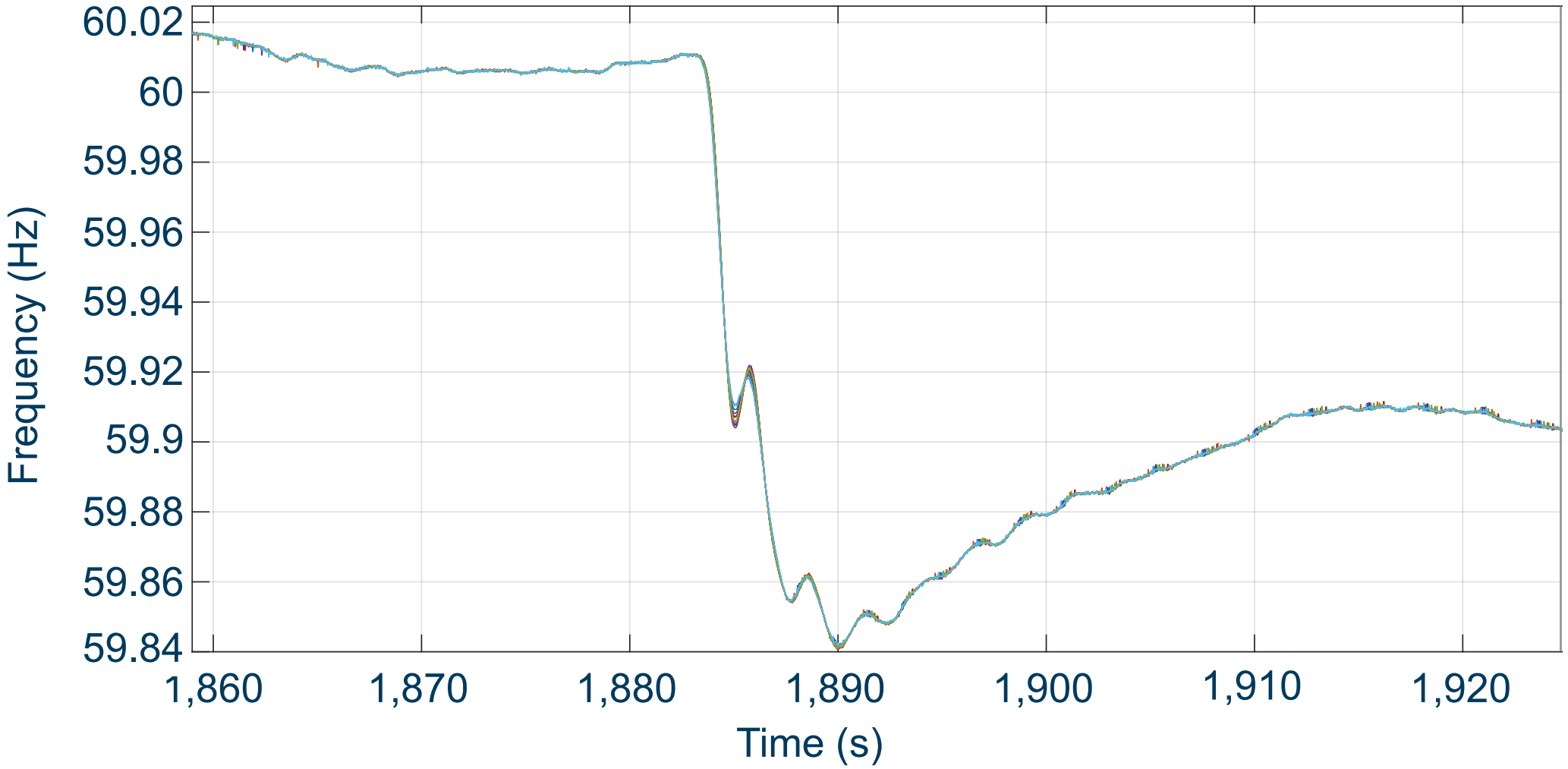
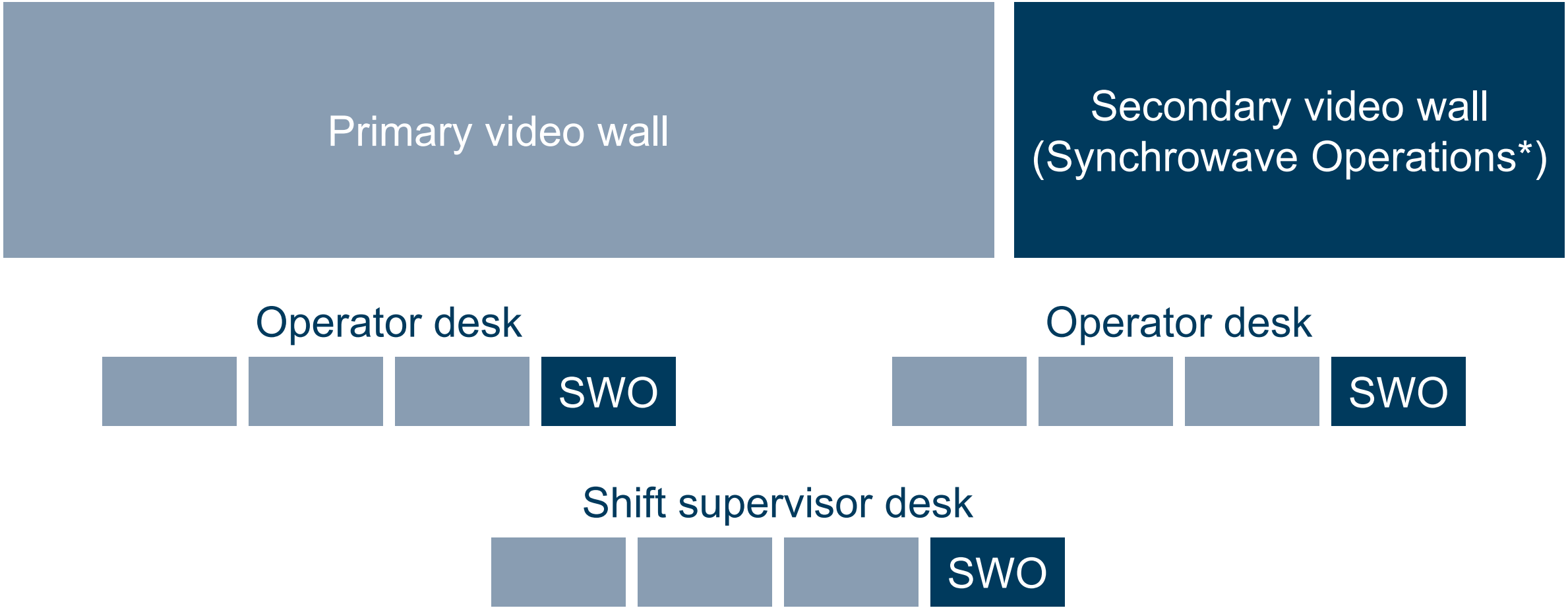
Frequency response to generation loss



SDG&E® mission control room



*SEL-5702 Synchrowave® Operations Software

SDG&E primary video wall

SDG&E secondary video wall

SDG&E secondary video wall

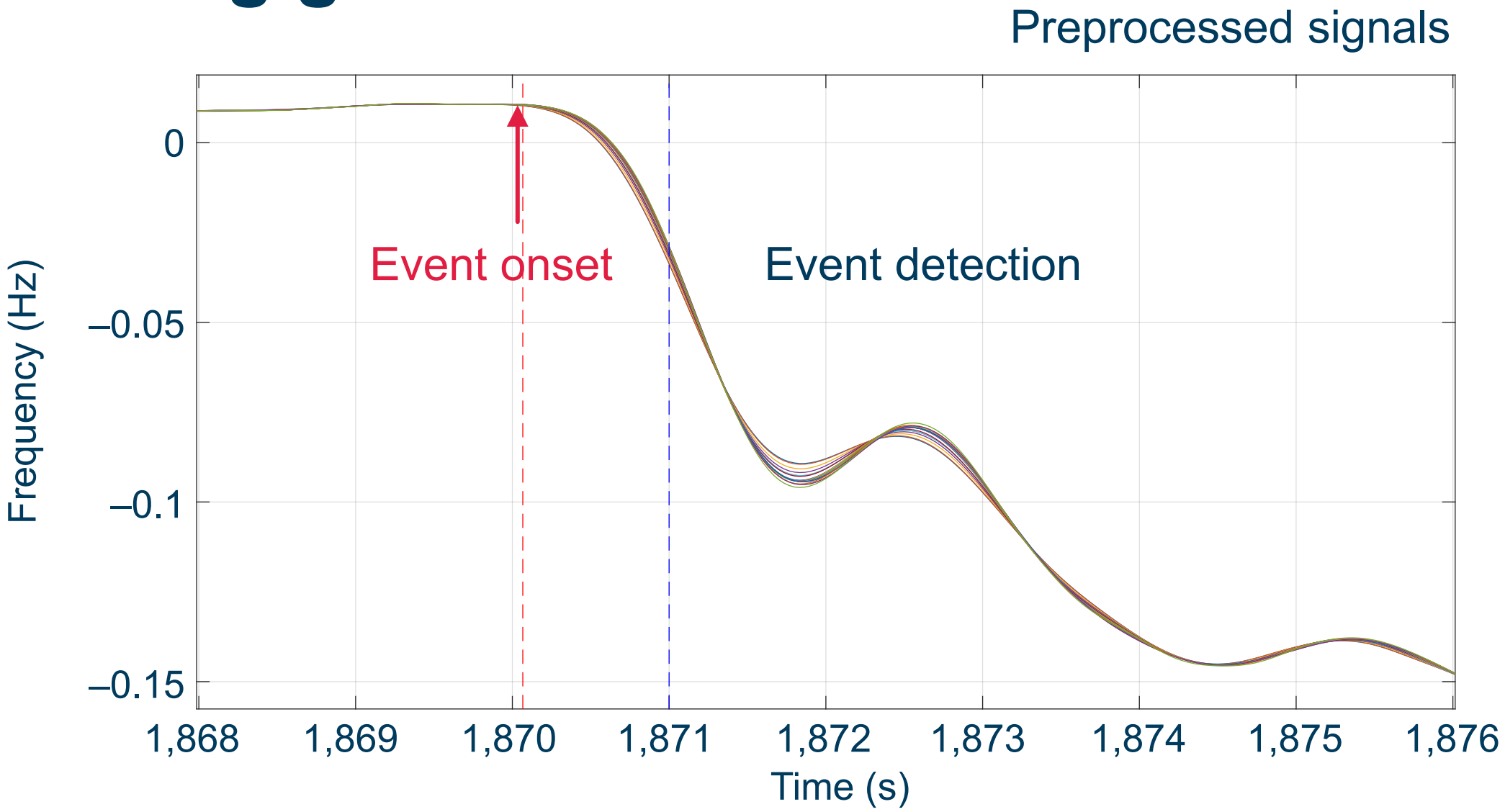
Why start with generation loss events?

- It is hard to detect location by simply looking at frequency data on video walls
- System events are often significant
- Generation loss events are common in WECC

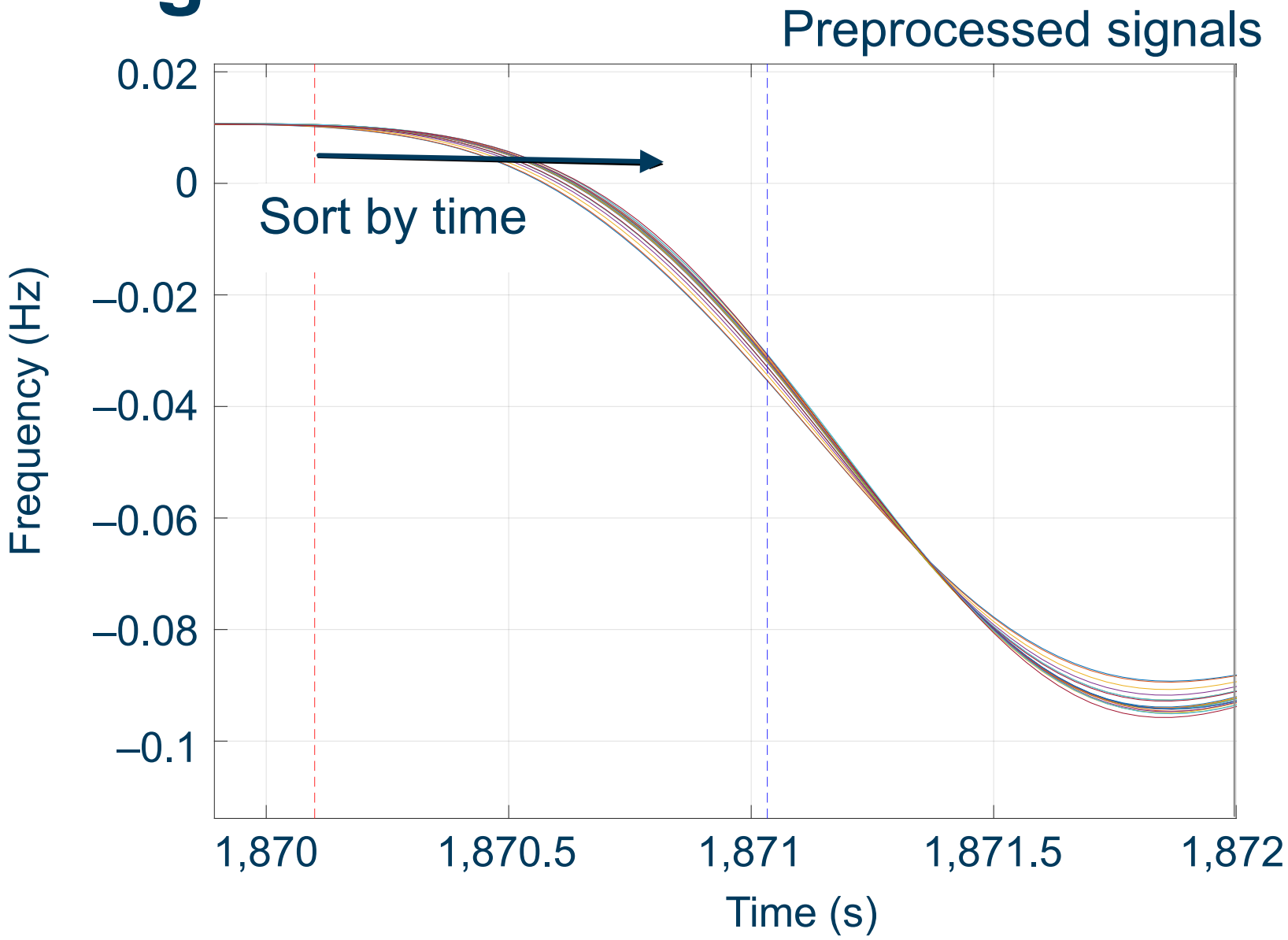
20 generation loss events were detected in 2-week period between September 1 and September 15, 2021

SEL
Synchrowave Operations
JBeslebr
Historical Data
Sep 08, 2021
19:20
19:30
19:40
19:50
20:00
20:10
20:20
20:30
20:40
20:50
Historical Data
09/11/2021
10m
Minute Chart Range
User
Frequency
Angle
Power
General
Oscillation
Voltage
All
Dashboards
Video Wall
Alt GC Video Wall Display
GC Alt Display Data
GC Display Test 1
GC VIDEO WALL
Panel
Dashboard
Frequency
60.020
60.000
59.980
59.960
Hz
Out-of-system
generation loss
Substation X
19:14
19:15
19:16
19:17
19:18
19:19
19:20
19:21
19:22
19:23
Frequency
59.972 Hz
59.973 Hz
59.973 Hz
LL Voltage Magnitude
240.000
235.000
230.000
225.000
220.000
kV
LL Voltage Magnitude
231.054 kV
231.003 kV
230.036 kV

Detecting generation loss

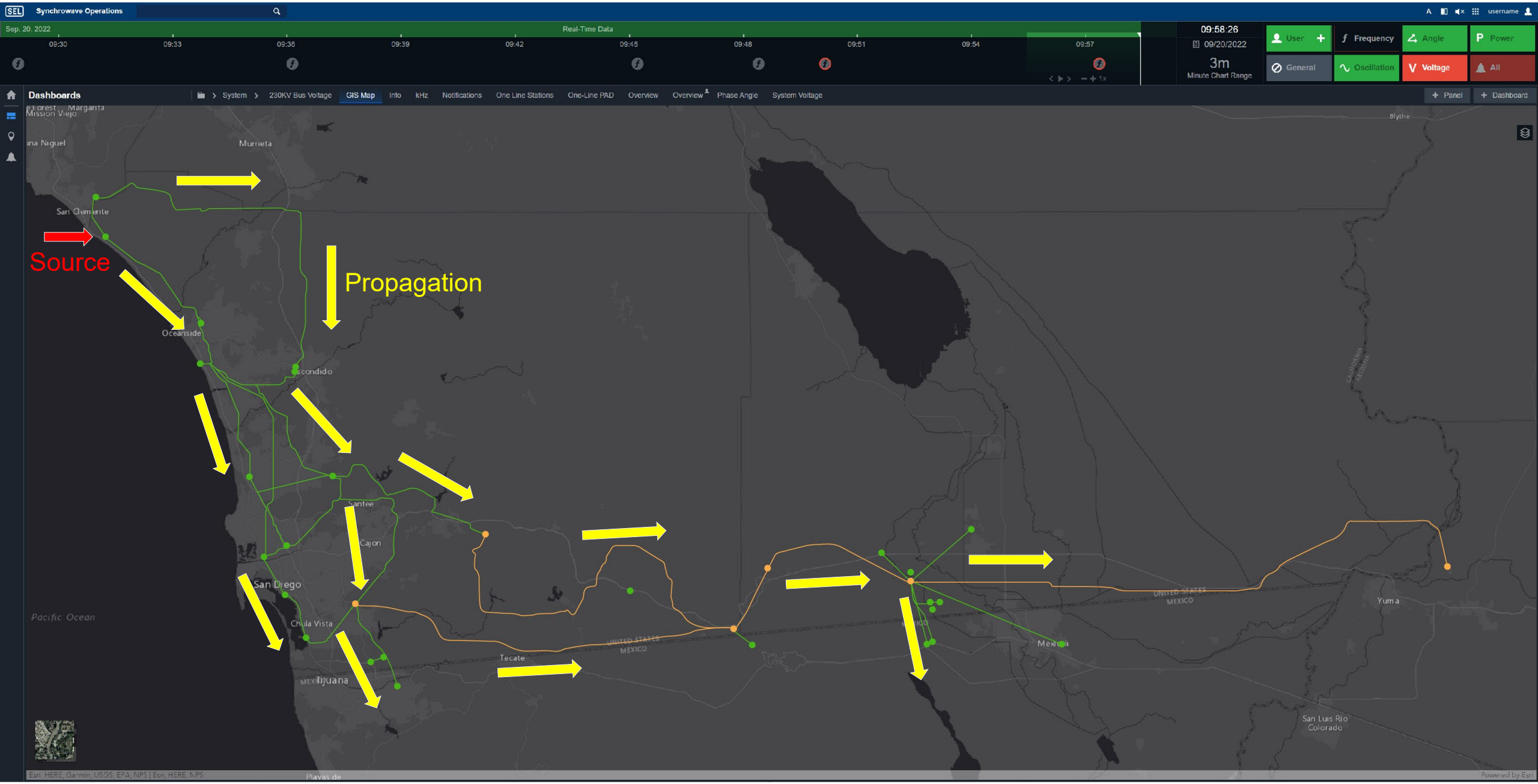


Determining source

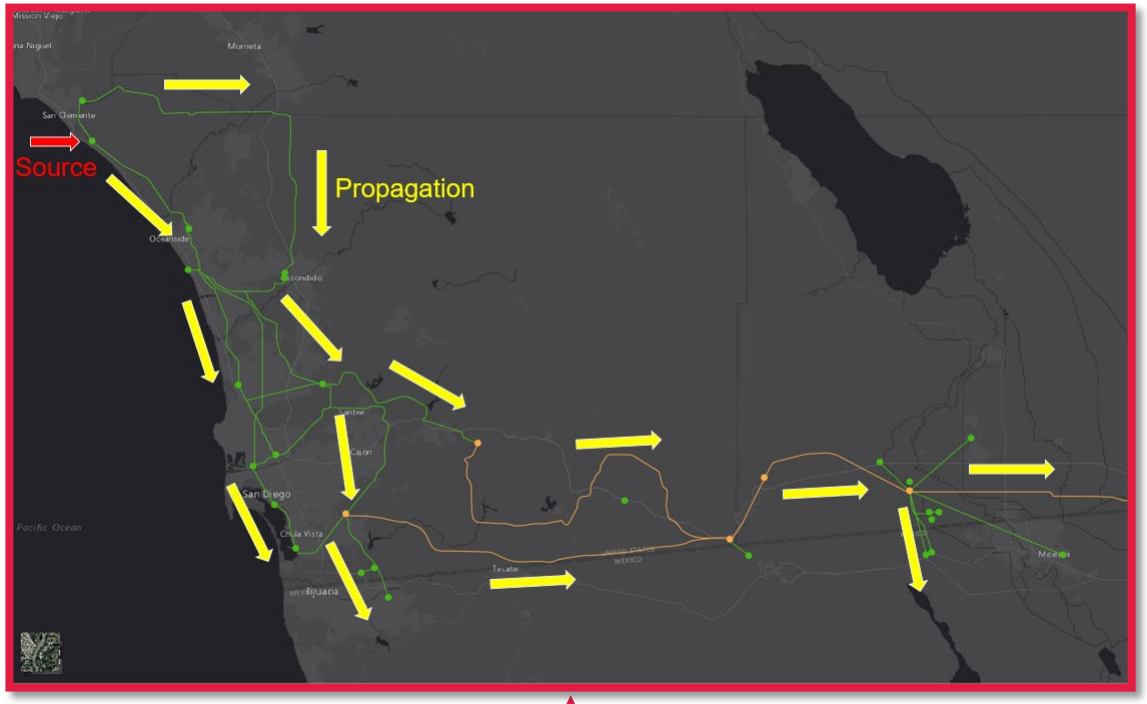


Challenges determining location

- Lower PMU data rate
- PMU data quality
- PMUs that filter differently
- Generation trip detection
- Onset detection
- Inertia


Synchrowave Operations
Sep. 20, 2022
Real-Time Data
09:30
09:33
09:36
09:39
09:42
09:45
09:48
09:51
09:54
09:57
09:58:26
09/20/2022
3m
Minute Chart Range
User
Frequency
Angle
Power
General
Oscillation
Voltage
All
Dashboards
System
230KV Bus Voltage
GIS Map
Info
kHz
Notifications
One Line Stations
One-Line PAD
Overview
Overview
Phase Angle
System Voltage
Panel
Dashboard
Source
Propagation
Murrieta
San Clemente
Oceanside
Escondido
Santee
Cajon
San Diego
Chula Vista
Tijuana
Tecate
Pacific Ocean
Mexicali
Yuma
San Luis Rio Colorado
Blythe
Esri, HERE, Garmin, USGS, EPA, NPS | Esri, HERE, NPS
Powered by Esri

WECC synchrophasor data help determine location



WECC generation loss events and results

Date (2021)	Generation loss (MW)	Public location	Algorithm results (proximity to actual location)
Aug 20	1,460	Coal/steam in Montana	✓
Sep 8	420	Hydro in Northeast Washington	✓
Sep 13	1,030	Hydro in British Columbia	✓
Nov 15	470	Hydro in Northeast Washington	✓
Dec 4	620	Hydro in North Central Washington	✓

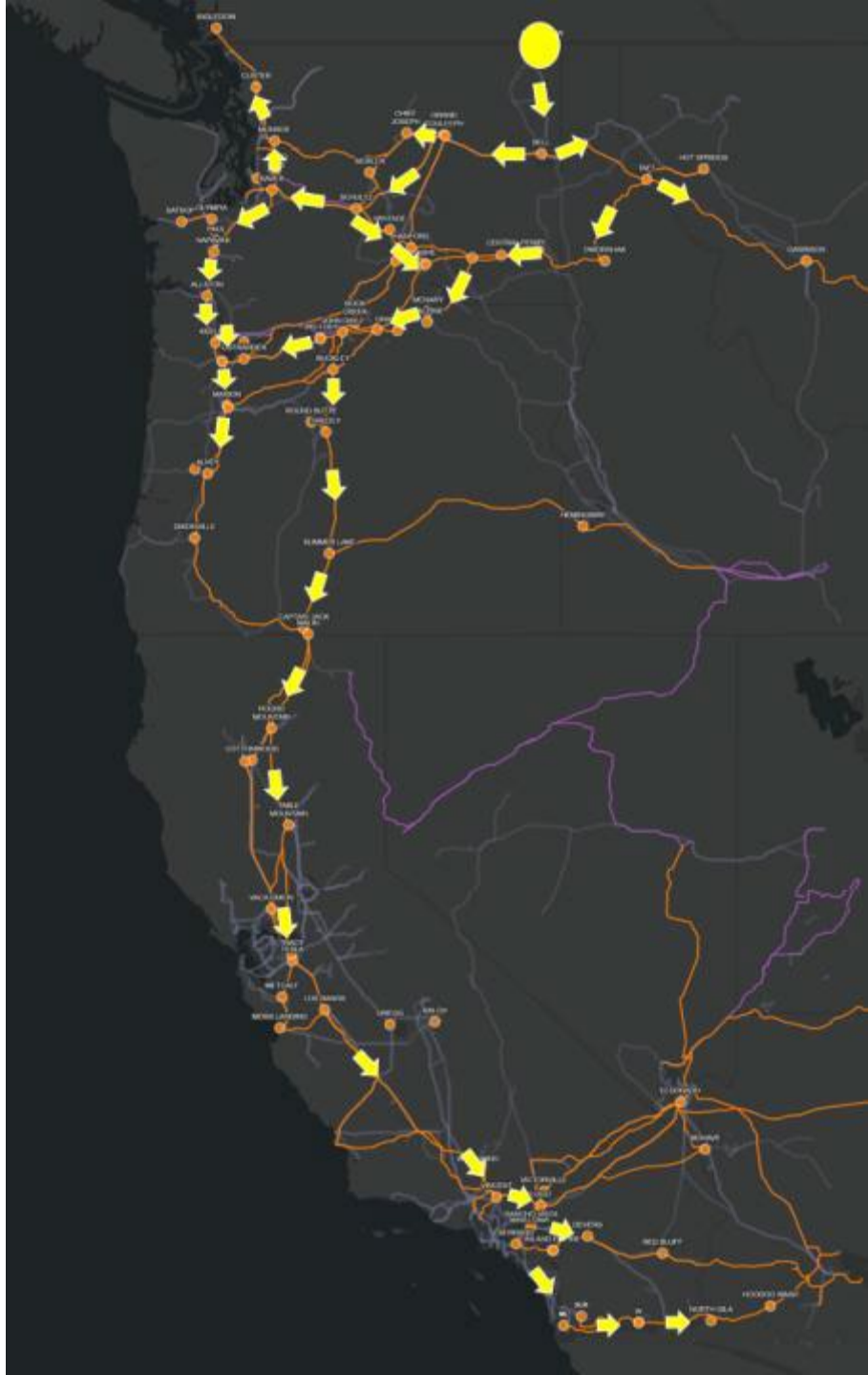
Coal/steam in Montana

WECC GENERATION LOSS EVENT 1

SEL
Synchrowave Operations
JBestebr
Aug. 20, 2021
Historical Data
01:15
01:20
01:25
01:30
01:35
01:40
01:45
01:50
01:55
02:00
Historical Data
08/20/2021
5m
Minute Chart Range
User
Frequency
Angle
Power
General
Oscillation
Voltage
All
Dashboards
Video Wall
GC VIDEO WALL
Panel
Dashboard
Frequency
60.000
59.950
59.900
Hz
01:35
01:36
01:37
01:38
01:39
Out-of-system
generation loss
Montana
Frequency
59.946 Hz
59.946 Hz
59.946 Hz
59.946 Hz
LL Voltage Magnitude
232.000
231.000
230.000
229.000
228.000
kV
231.727 kV
229.931 kV
231.554 kV

Hydro in Northeast Washington

WECC GENERATION LOSS EVENT 2



SEL
Synchrowave Operations
JBestebr
Sep. 08, 2021
Historical Data
18:30
18:35
18:40
18:45
18:50
18:55
19:00
19:05
19:10
19:15
Historical Data
09/08/2021
5m
Minute Chart Range
User
Frequency
Angle
Power
General
Oscillation
Voltage
All
Dashboards
Video Wall
GC VIDEO WALL
Panel
Dashboard
Frequency
60.020
60.010
60.000
59.990
59.980
59.970
59.960
Hz
18:50
18:51
18:52
18:53
18:54
Out-of-system
generation loss
Northeast Washington
Frequency
59.996 Hz
59.996 Hz
59.996 Hz
59.996 Hz
LL Voltage Magnitude
233.000
232.000
231.000
230.000
kV
232.975 kV
230.004 kV
233.336 kV

Hydro in British Columbia

WECC GENERATION LOSS EVENT 3

SEL
Synchrowave Operations
JBestebr
Sep. 13, 2021
Historical Data
11:55
12:00
12:05
12:10
12:15
12:20
12:25
12:30
12:35
12:40
Historical Data
09/13/2021
5m
Minute Chart Range
User
Frequency
Angle
Power
General
Oscillation
Voltage
All
Dashboards
Video Wall
GC VIDEO WALL
Panel
Dashboard
Frequency
60.020
60.000
59.980
59.960
59.940
59.920
59.900
59.880
Hz
12:17
12:18
12:19
12:20
12:21
Out-of-system
generation loss
British Columbia
Frequency
59.963 Hz
59.962 Hz
59.962 Hz
59.962 Hz
LL Voltage Magnitude
232.000
231.000
230.000
229.000
228.000
227.000
kV
231.261 kV
230.562 kV
230.002 kV

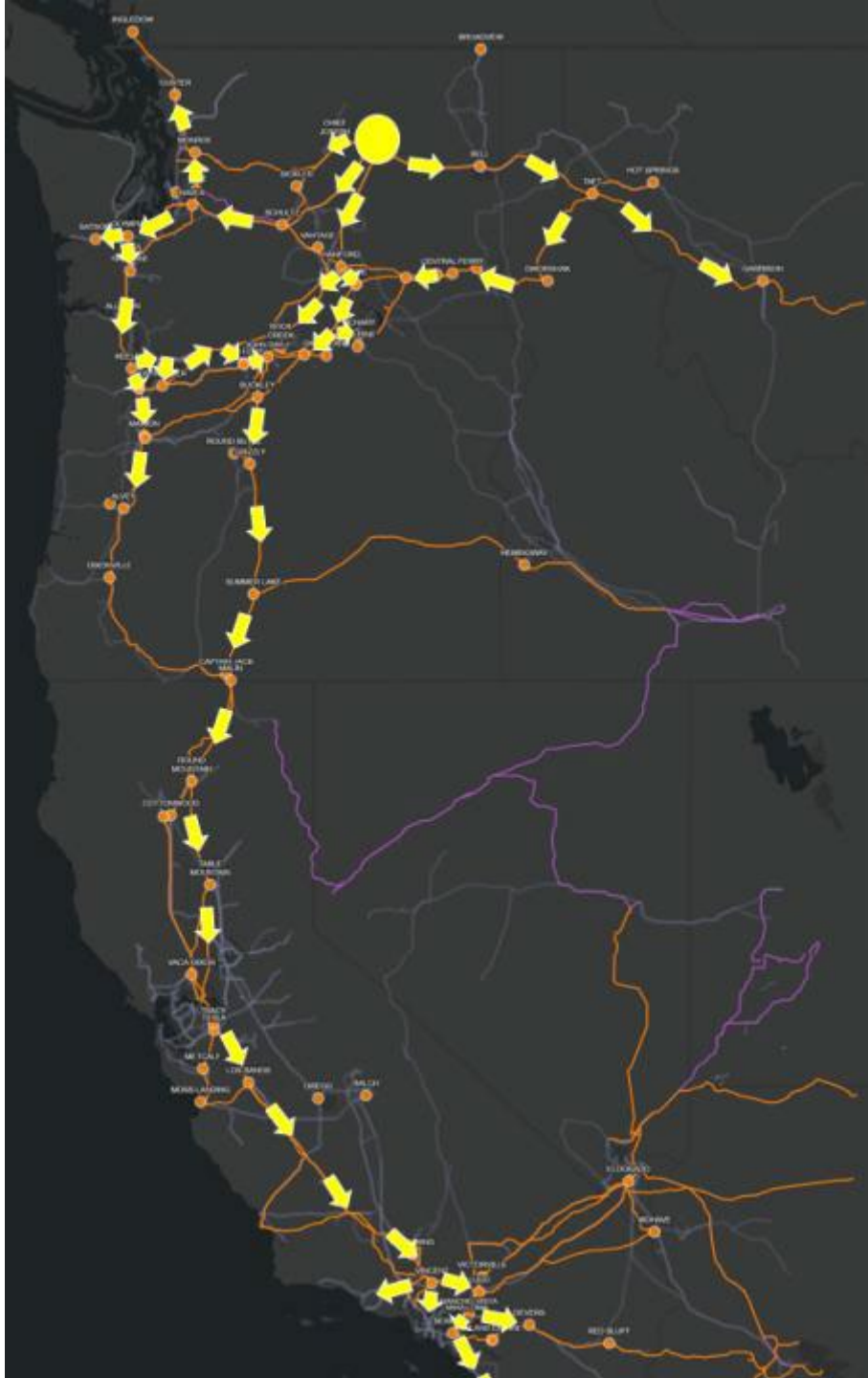
Hydro in Northeast Washington

WECC GENERATION LOSS EVENT 4

SEL
Synchrowave Operations
JBestebr
Nov. 15, 2021
Historical Data
20:00
20:05
20:10
20:15
20:20
20:25
20:30
20:35
20:40
20:45
Historical Data
11/15/2021
5m
Minute Chart Range
User
Frequency
Angle
Power
General
Oscillation
Voltage
All
Dashboards
Video Wall
GC VIDEO WALL
Panel
Dashboard
Frequency
60.040
60.020
60.000
59.980
59.960
59.940
Hz
Out-of-system
generation loss
Hydro Northeast Washington
20:21
20:22
20:23
20:24
20:25
Frequency
59.995 Hz
59.995 Hz
59.995 Hz
59.995 Hz
LL Voltage Magnitude
232.000
231.500
231.000
230.500
230.000
kV
232.018 kV
229.986 kV
233.415 kV

Hydro in North Central Washington

WECC GENERATION LOSS EVENT 5



SEL
Synchrowave Operations
JBestebr
Dec. 04, 2021
Historical Data
13:30
13:35
13:40
13:45
13:50
13:55
14:00
14:05
14:10
14:15
Historical Data
12/04/2021
5m
Minute Chart Range
User
Frequency
Angle
Power
General
Oscillation
Voltage
All
Dashboards
Video Wall
GC VIDEO WALL
Panel
Dashboard
Frequency
60.020
60.000
59.980
59.960
59.940
59.920
Hz
13:52
13:53
13:54
13:55
13:56
Out-of-system
generation loss
North Central Washington
Frequency
60.006 Hz
60.006 Hz
60.006 Hz
60.006 Hz
LL Voltage Magnitude
233.000
232.000
231.000
230.000
kV
232.622 kV
229.945 kV
232.991 kV

02/21/2022
User
Frequency
Angle
Power
10m
Minute Chart Range
General
Oscillation
Voltage
All
Event Reports
Relay Targets
Three Phase Power
Panel
Dashboard
690.000
680.000
670.000
660.000
PhaseA Current Magnitude
EL.TL23051
678.457 A
GC.TL23051
676.748 A
770.000
760.000
750.000
740.000
730.000
PhaseB Current Magnitude
EL.TL23051
759.633 A
GC.TL23051
757.496 A
710.000
700.000
690.000
680.000
PhaseC Current Magnitude
EL.TL23051
701.101 A
GC.TL23051
699.392 A

Questions?