

Integrating Synchrophasors and Oscillography for Wide-Area Power System Analysis

Dora Nakafuji

Hawaiian Electric Company

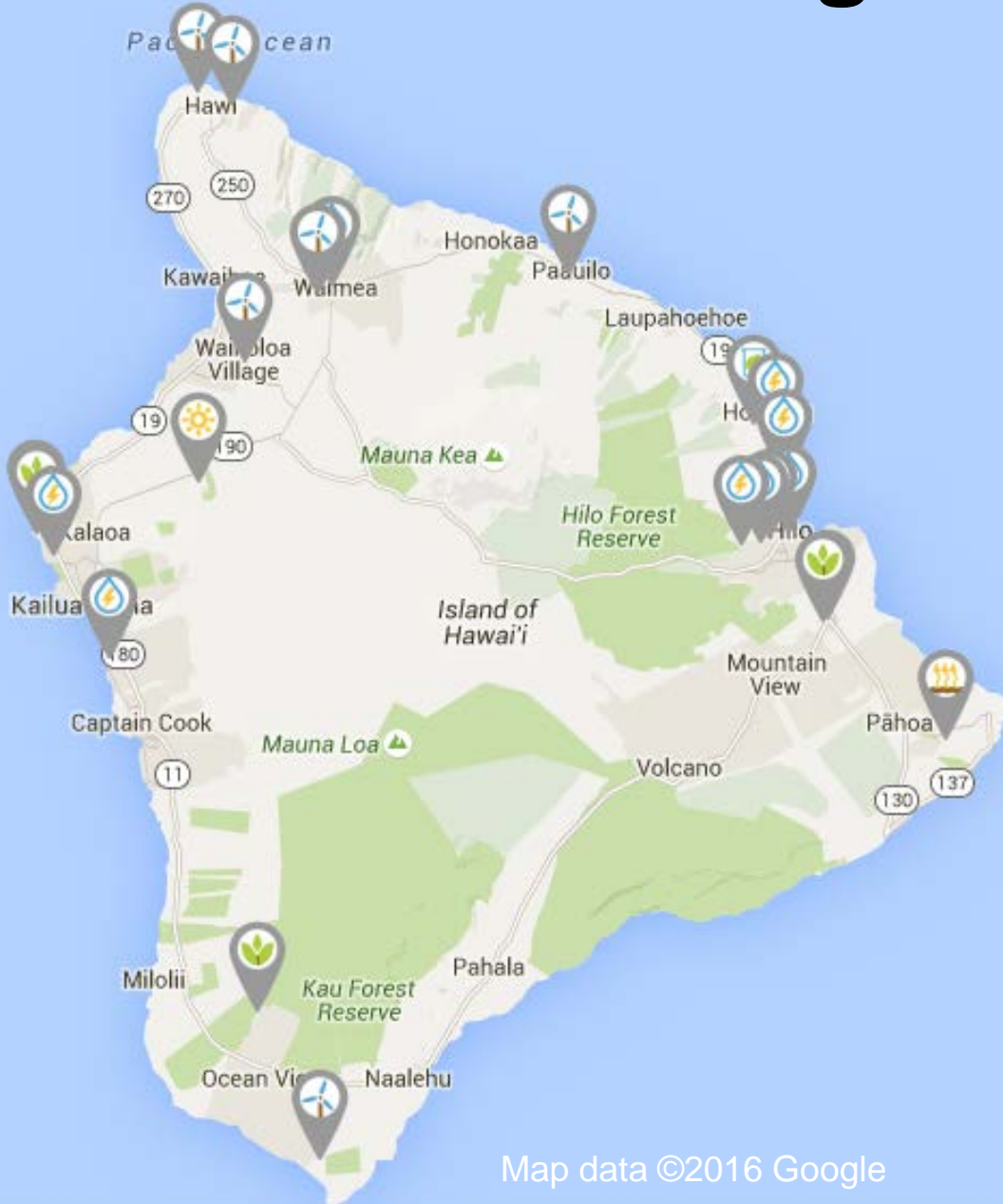
Laura Rogers

Hawaii Electric Light Company

Jared Bestebreuer, Michael Rourke, and Greg Zweigle

Schweitzer Engineering Laboratories, Inc.

Hawaii Electric Light Company (HELCO)



**50% Renewable Power
Regularly Integrated**

Challenges With Islanded Systems

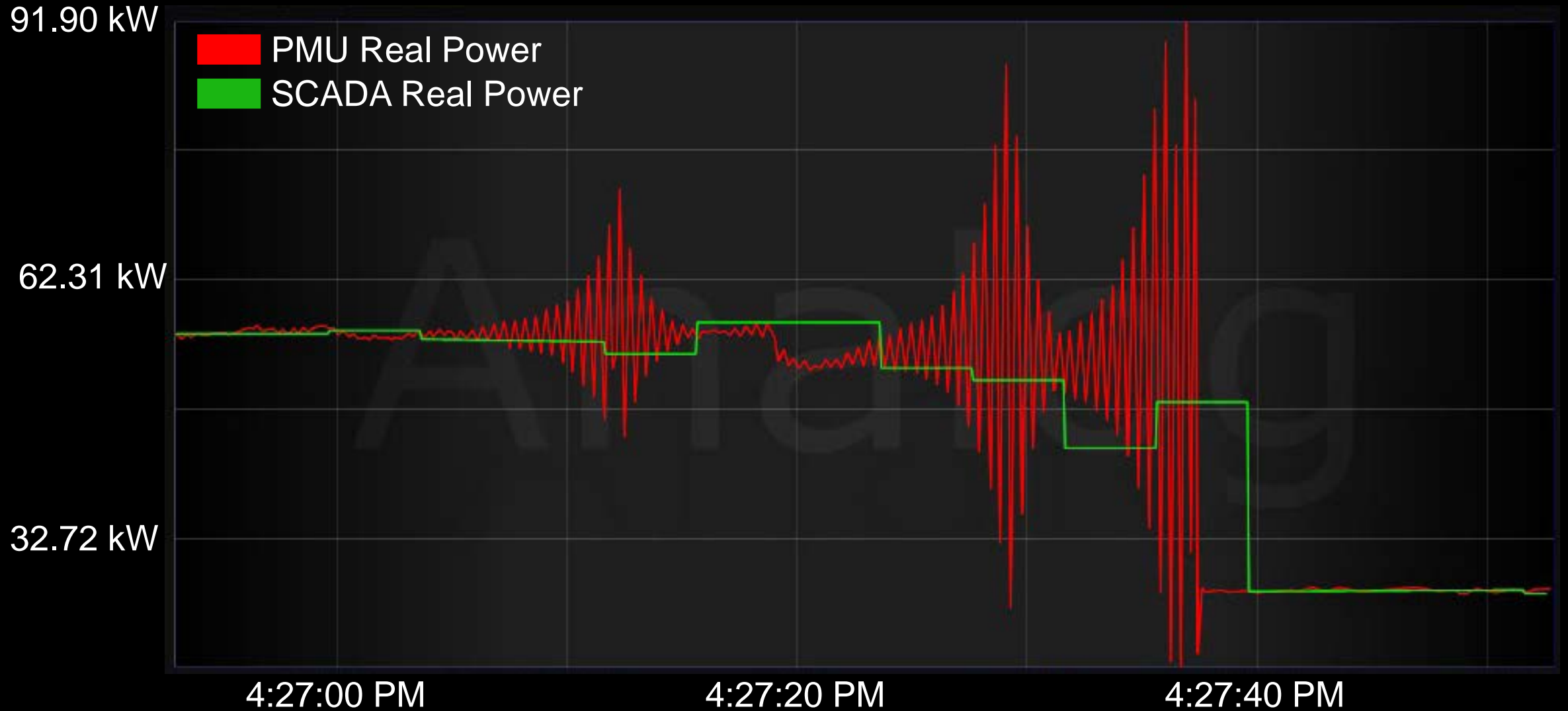
Significant Voltage, Frequency, and Power Swings



Renewables Introduce Faster Dynamics



SCADA Misses Information

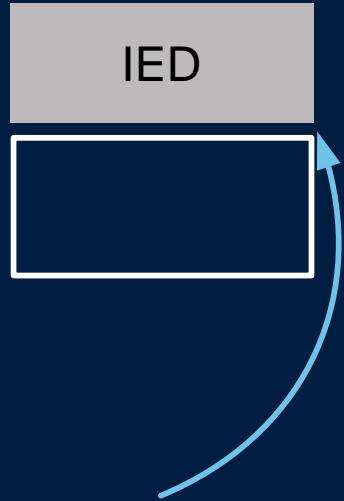


Traditional Monitoring and Analysis



- Post-fault event report is saved to IED's nonvolatile memory
- Voltage and current measurements are sent to SCADA from IED or remote terminal unit (RTU) every few seconds

What Is an Event Report?

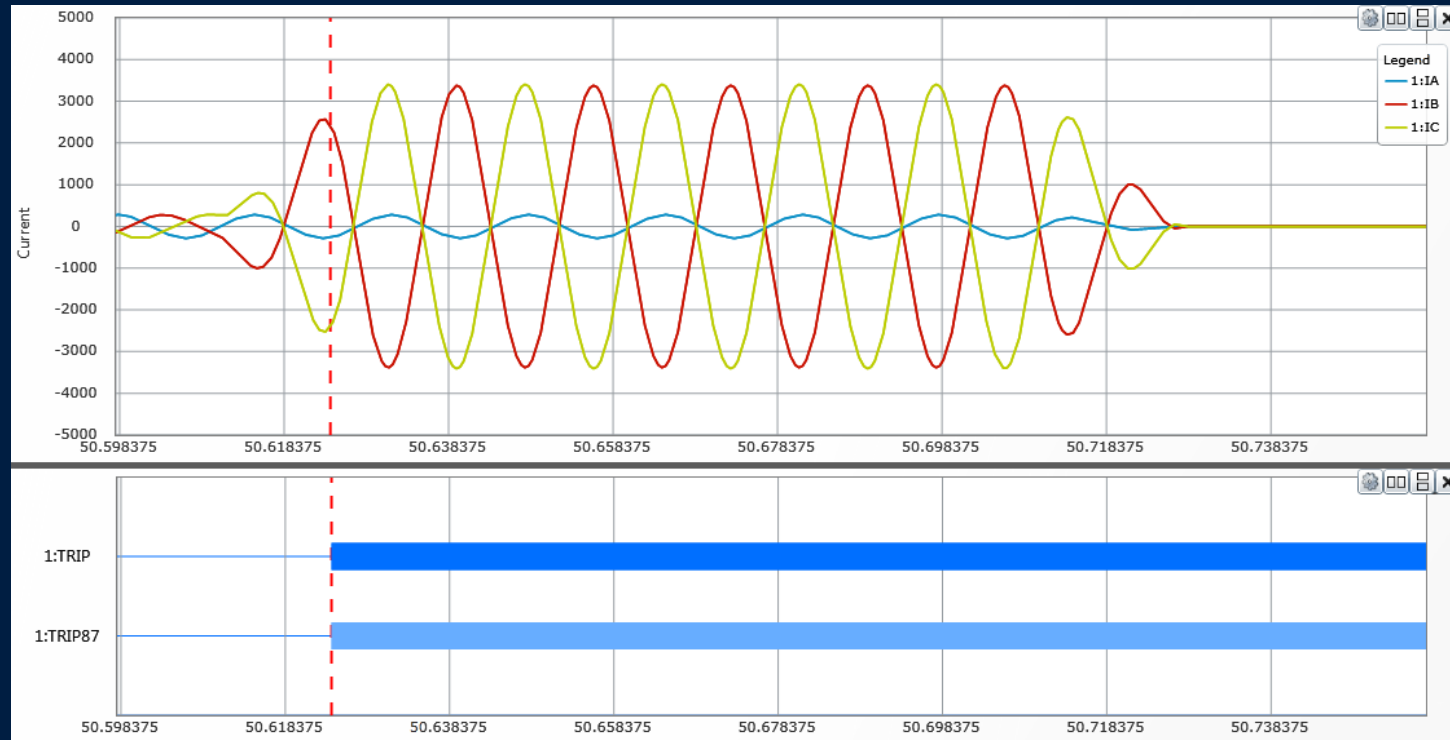


Prefault Data

Fault Data

Post-Fault Data

- Currents
- Voltages
- Digitals



Report Analysis Before Software Tools

	Currents			Voltages			P	Q	N	I	Out	In	
	A pri			V pri									
IR	IA	IB	IC	VA	VB	VC	555T	55	555	D	7B	T13A	135
							100C	10	100	E	9K	&&&L	&&&
							LHI		LH	M	R	C24R	246
10	32	-148	129	1968	-7126	5158	...V	..	...	..	...	...	...
-24	158	-73	-114	7206	-1853	-5225	...V	..	...	..	...	...	...
-12	-32	148	-129	-1976	7129	-5153	...V	..	...	..	...	...	...
32	-229	151	117	-6881	1517	5230	...V	..	...	..	...	...	...
10	-44	-80	129	1466	-6600	5146	...V	..	...	..	...	...	...
-36	552	-472	-119	6468	-1120	-5228	....	..	...	..	...	...	...
-2	109	24	-136	-538	5663	-5136	....	..	...	..	...	...	...
27	-895	803	124	-6417	1113	5206	.p..	..	...	..	...	...	...
-2	-122	-24	146	22	-5160	5134	.p..	..	...	..	...	...	...
-17	1002	-900	-129	6446	-1178	-5179	.p..	p.	...	..	...	...	...
10	146	17	-153	96	5050	-5134	.p..	p.	...	..	...	...	...
15	-1022	915	129	-6422	1185	5165	.p..	p.	...	..	...	...	...
-17	-153	-22	161	-115	-5028	5127	.p..	p.	...	..	...	...	...
-17	1024	-919	-126	6408	-1185	-5158	.p..	p.	...	..	...	...	...
17	158	24	-165	82	5045	-5115	.p..	p.	...	..	...	...	...
19	-854	764	112	-6823	1557	5230	.T..	..	...	..	T...	...	...
-32	-114	-39	117	697	-5828	5069	.T..	..	...	..	T...	...	...
7	426	-367	-54	7261	-1776	-5444	....	..	...	..	T...	...	...
29	44	29	-41	-1868	6924	-4944	...V	..	...	..	T...	...	...
-19	-95	73	7	-7225	1519	5612	...V	..	...	..	T...	...	...

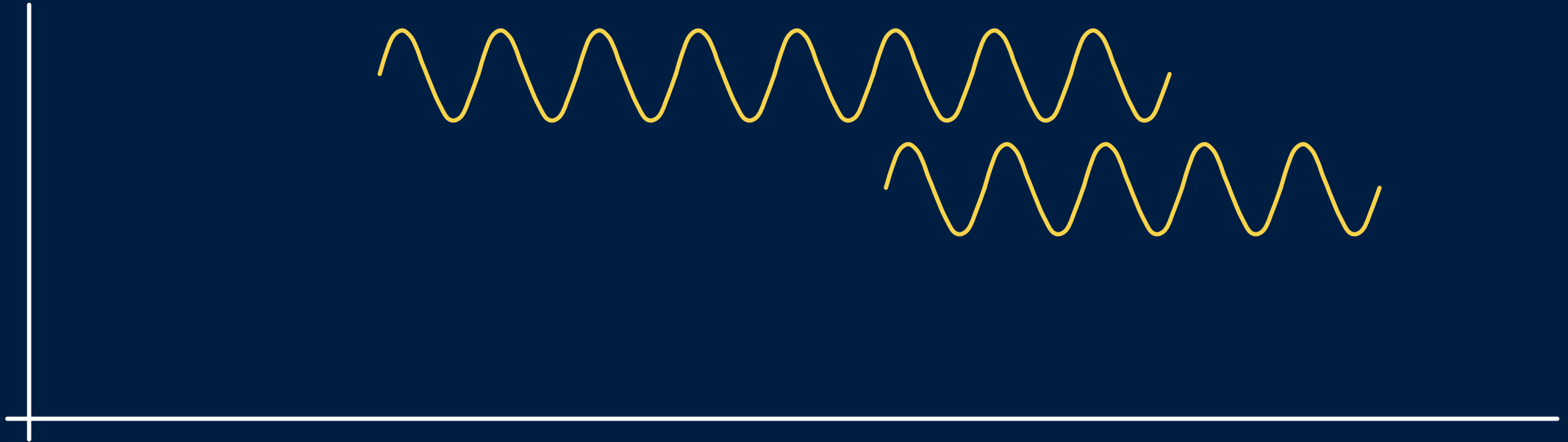
What Is a Synchrophasor?



Architecture for Data Synchronization

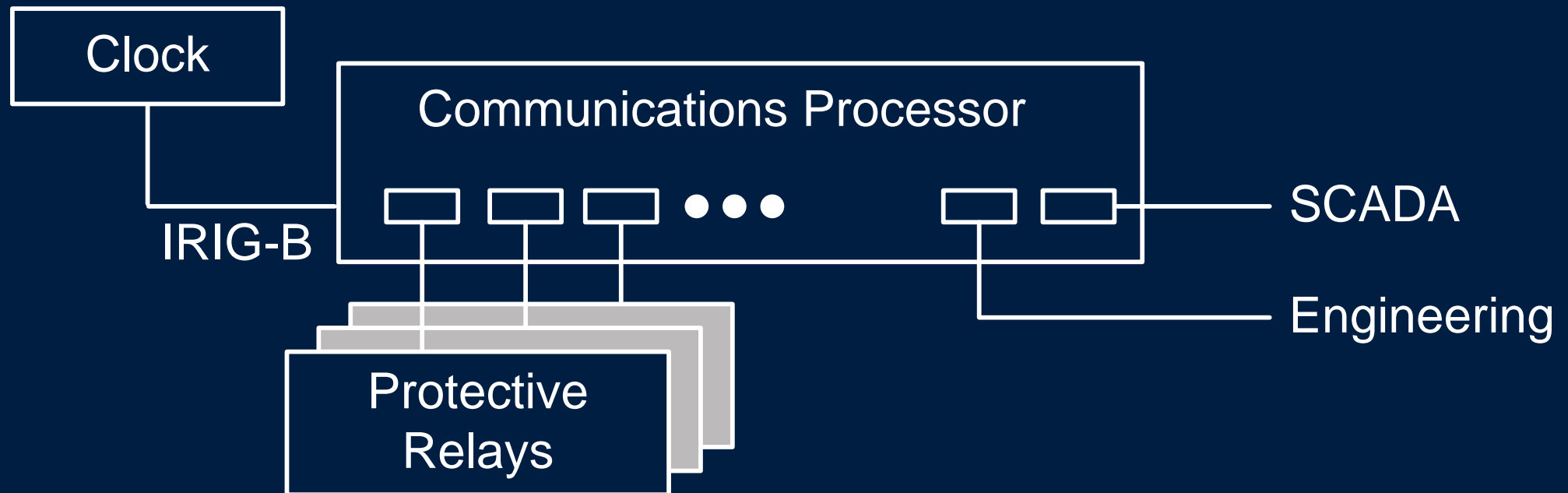


Correlation of Time-Stamped Data Types

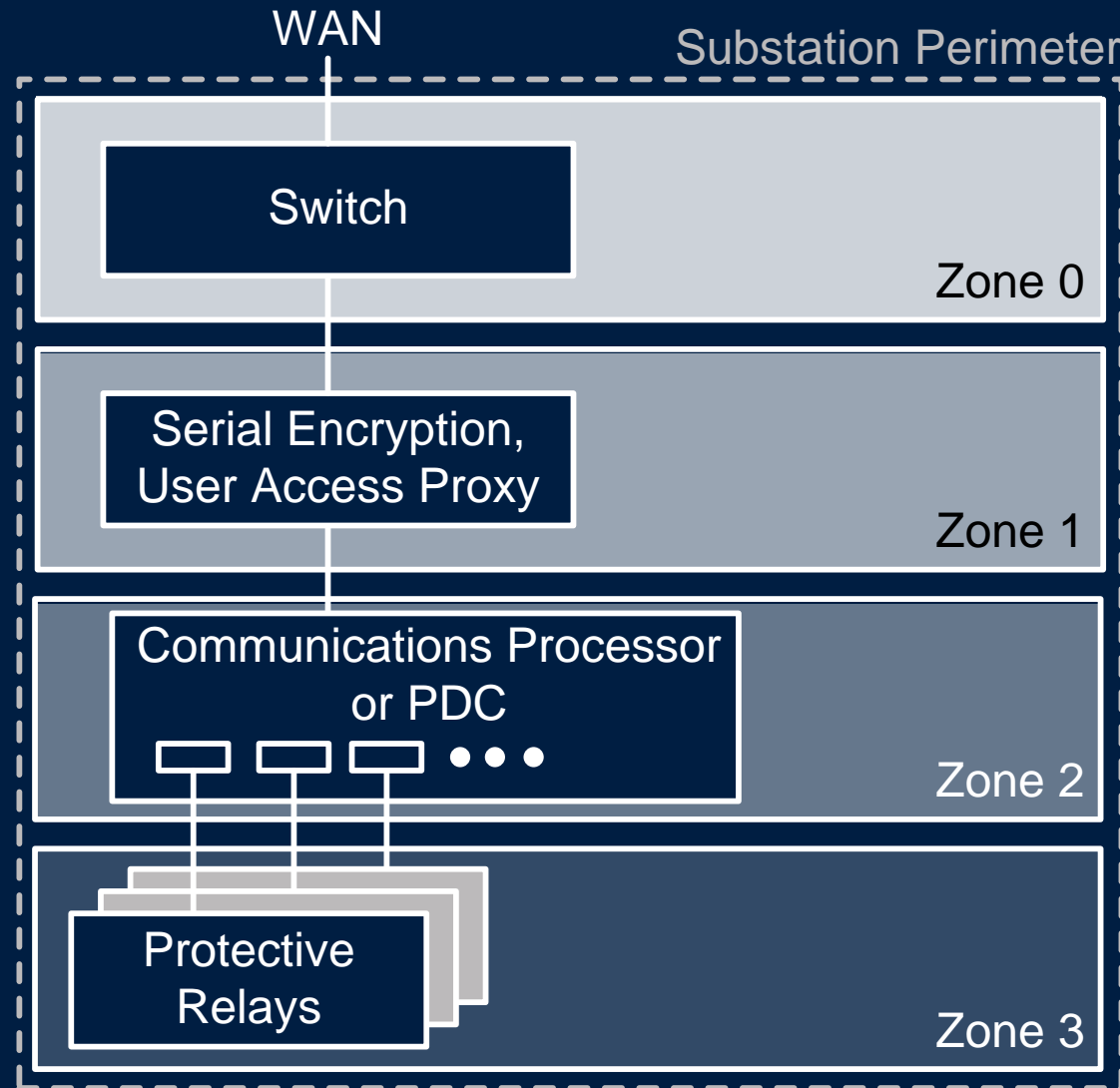


Traditional Event Report Collection Systems

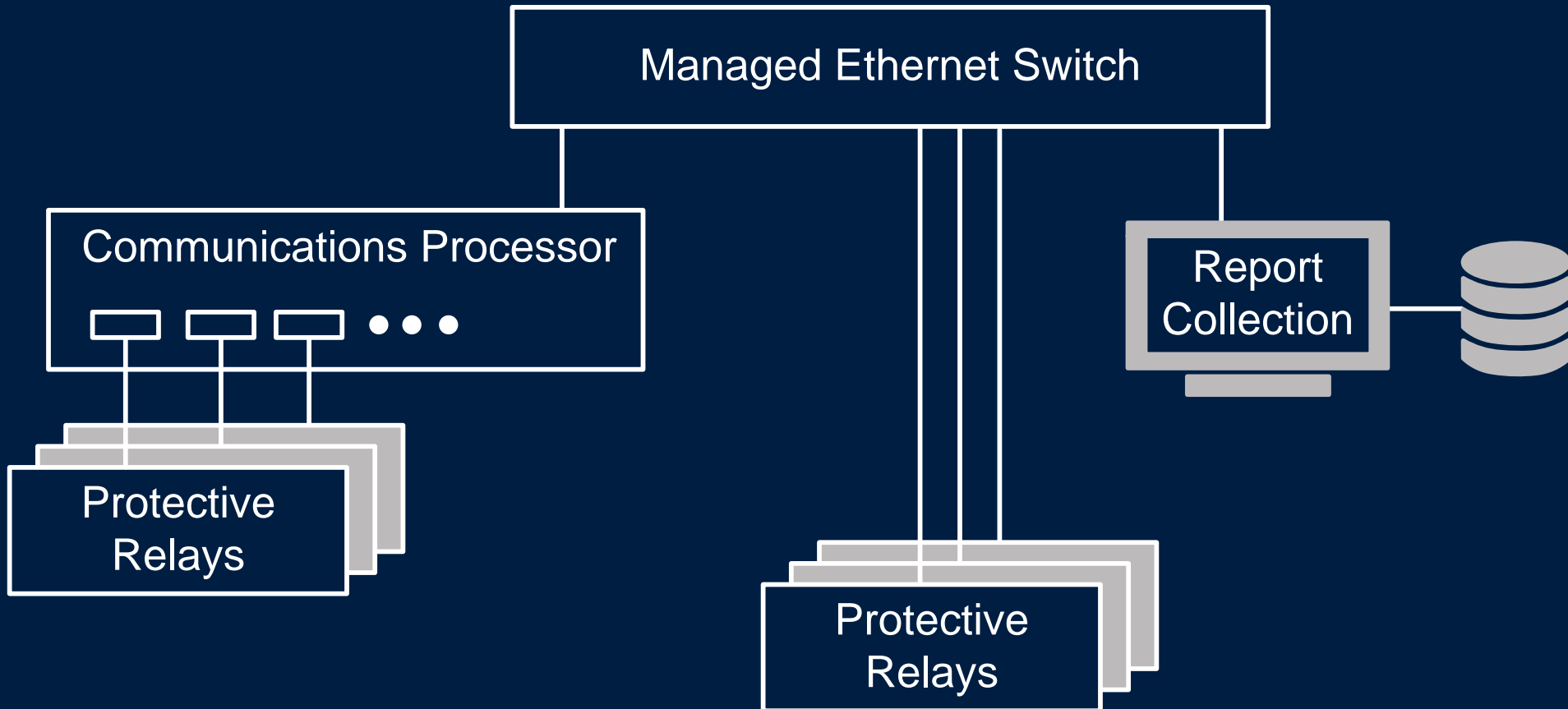
- Remote download via communications processor
- Local download at substation



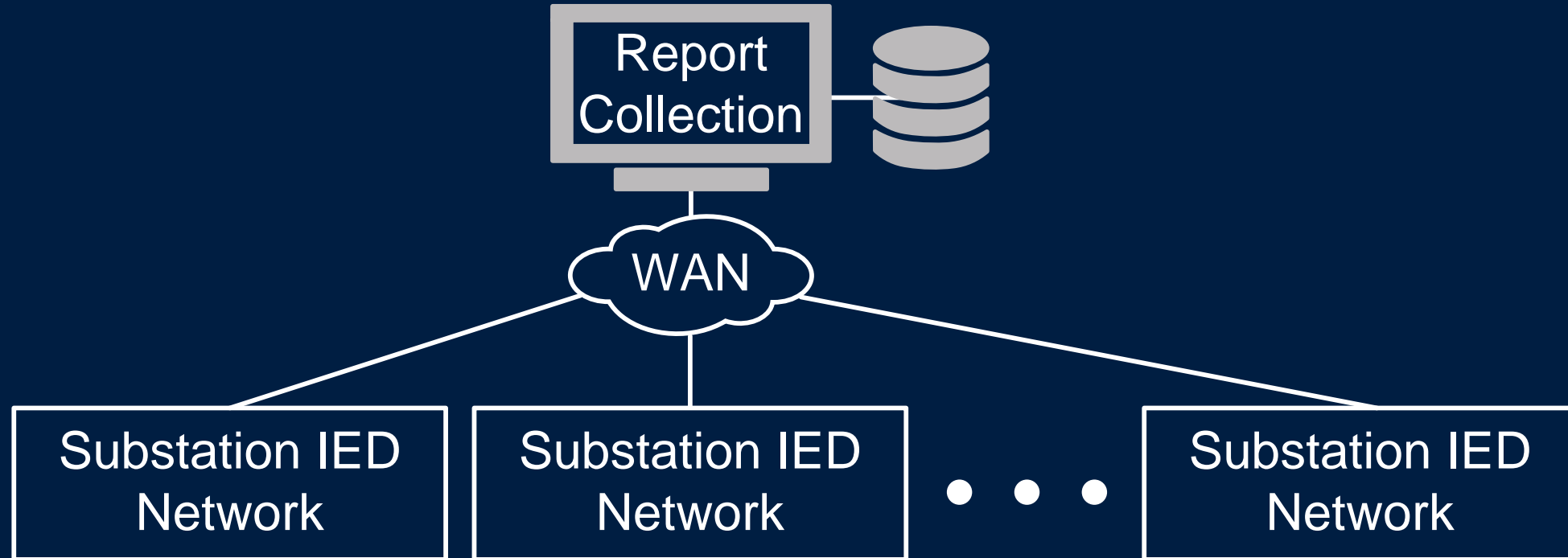
Defense-in-Depth Security Approach



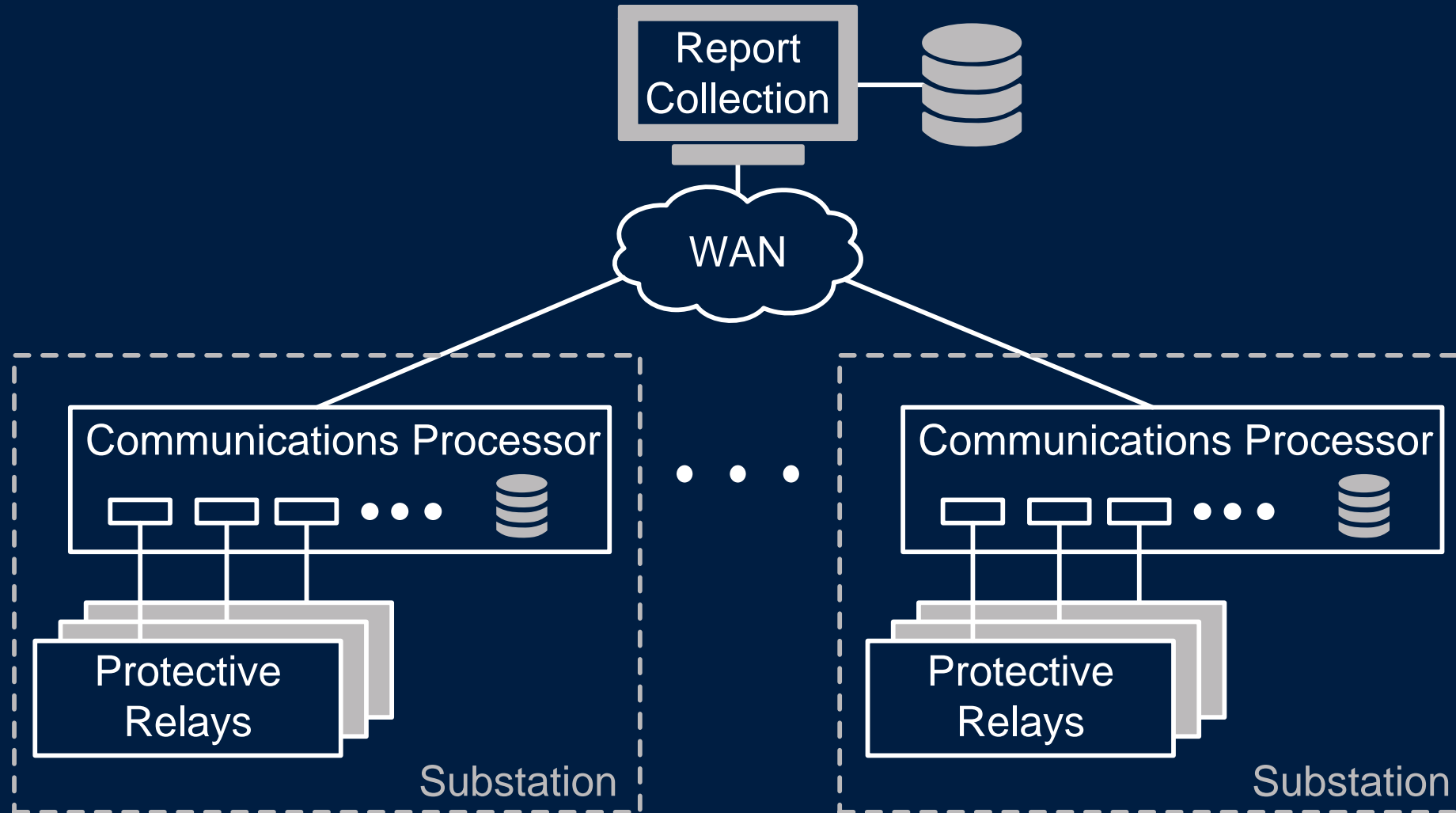
Local Collection for Simplicity



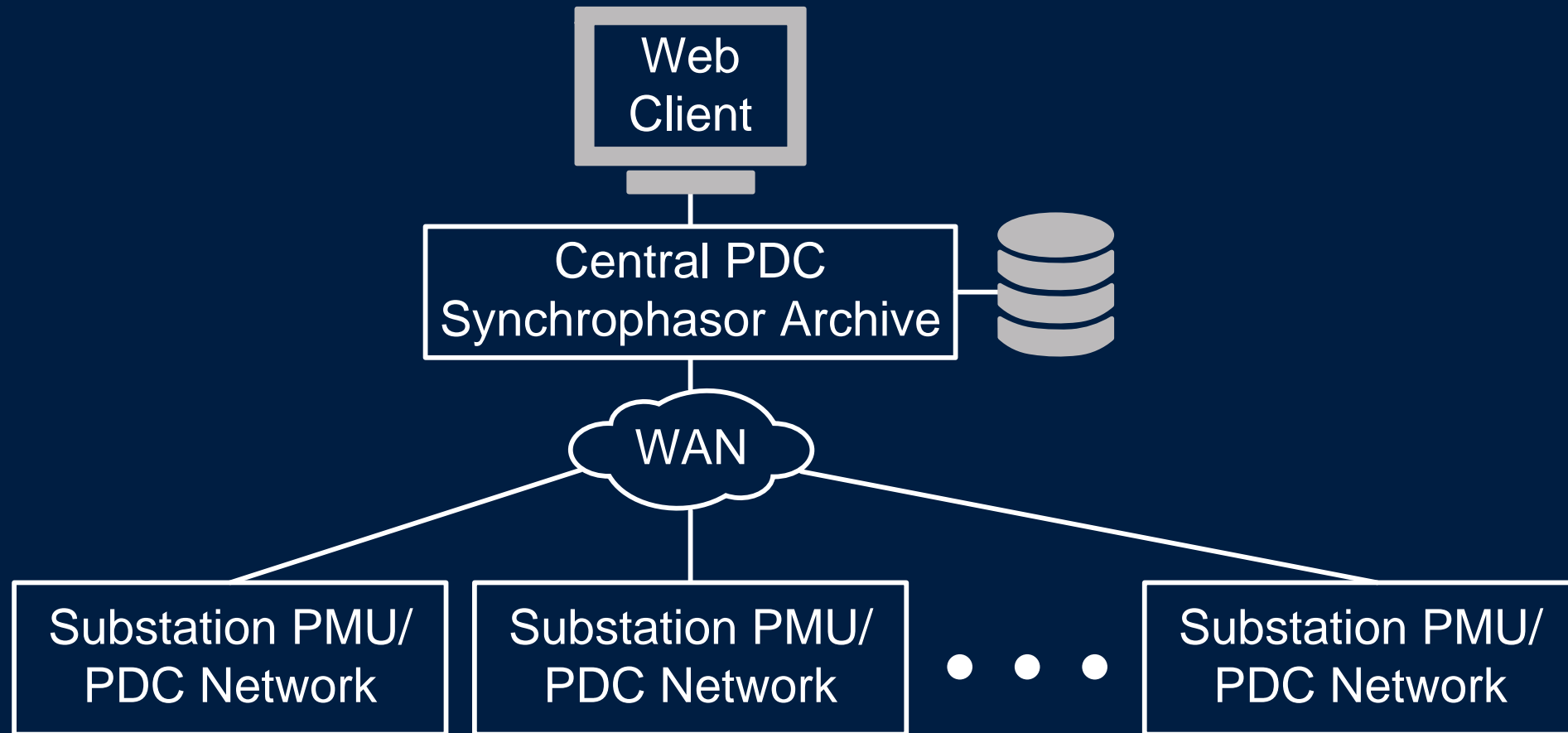
Wide-Area Collection for High-Speed Networks



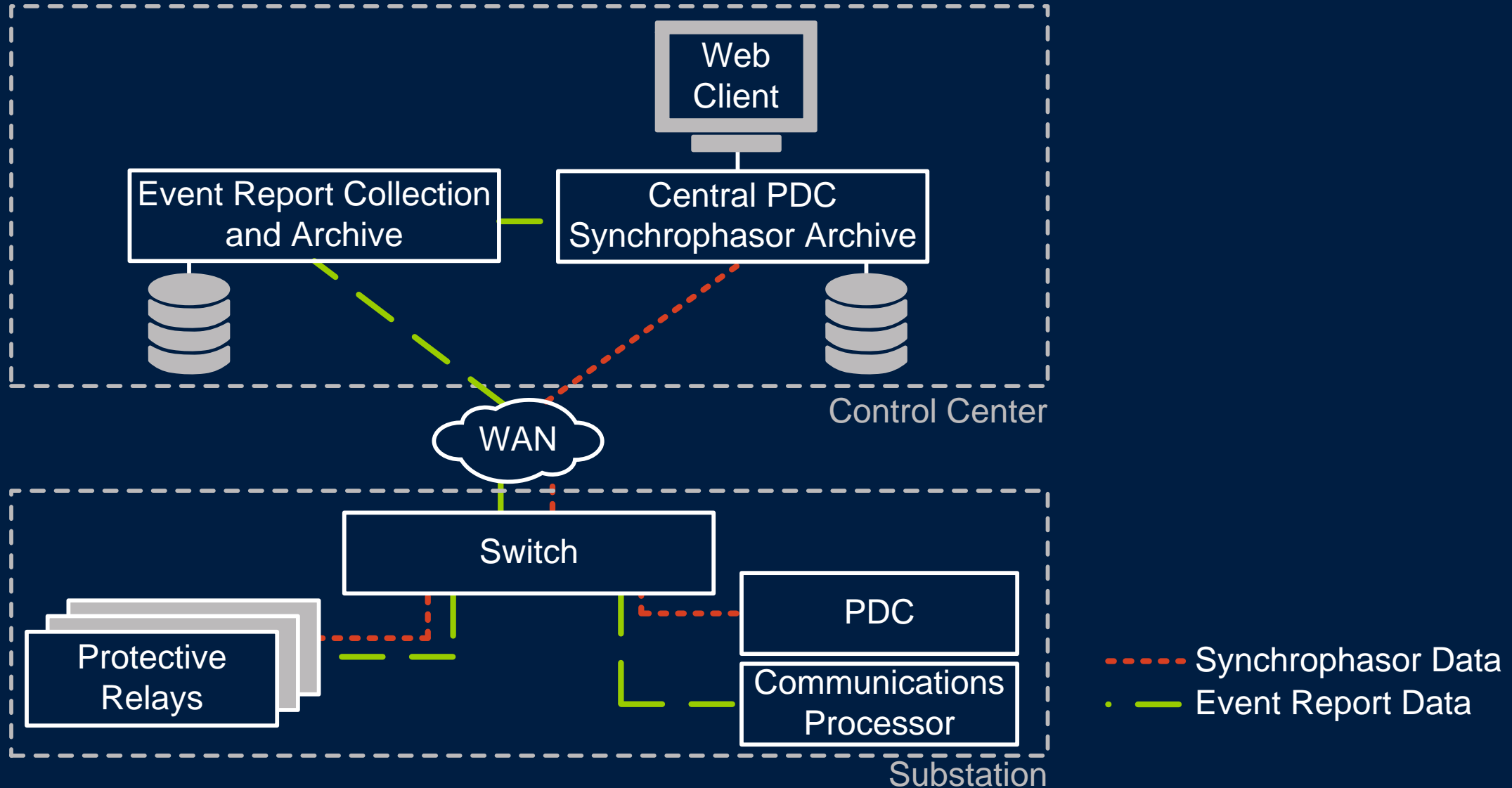
Hybrid Collection for Performance and Security



Architecture for Streaming Synchrophasors



Collection Architecture Implemented at HELCO



HELCO Lightning Strike

60.564 Hz

PMU Frequency

60.014 Hz

59.647 Hz

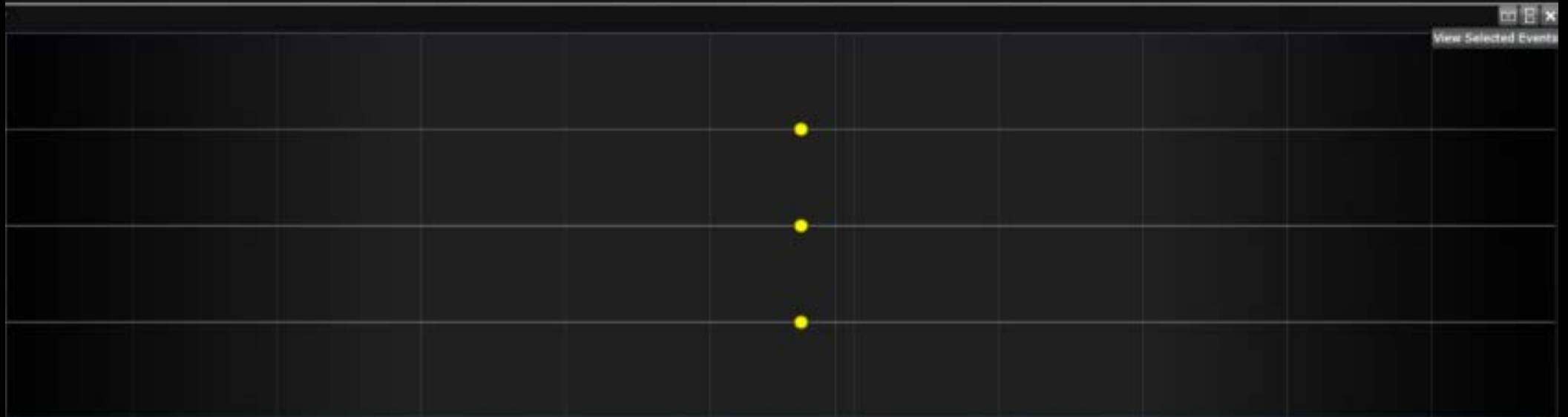


12:40:00 AM 12:43:20 AM 12:46:40 AM 12:50:00 AM 12:53:20 AM 12:56:40 AM 1:00:00 AM 1:03:20 AM 1:06:40 AM 1:10:00 AM

IED 1

IED 2

IED 3



12:40:00 AM

12:53:20 AM

1:10:00 AM

Data Correlation for Added Context



Event Summary Data for Operations

60.564 Hz

60.014 Hz

59.647 Hz



IED 1

IED 2

IED 3

IED Event
Report Summary



TL #1
Event Type:
Location:
Global Id:
Fault Location:
Trigger Time:
Targets:
Fault Currents:
Acknowledged:
File Type:

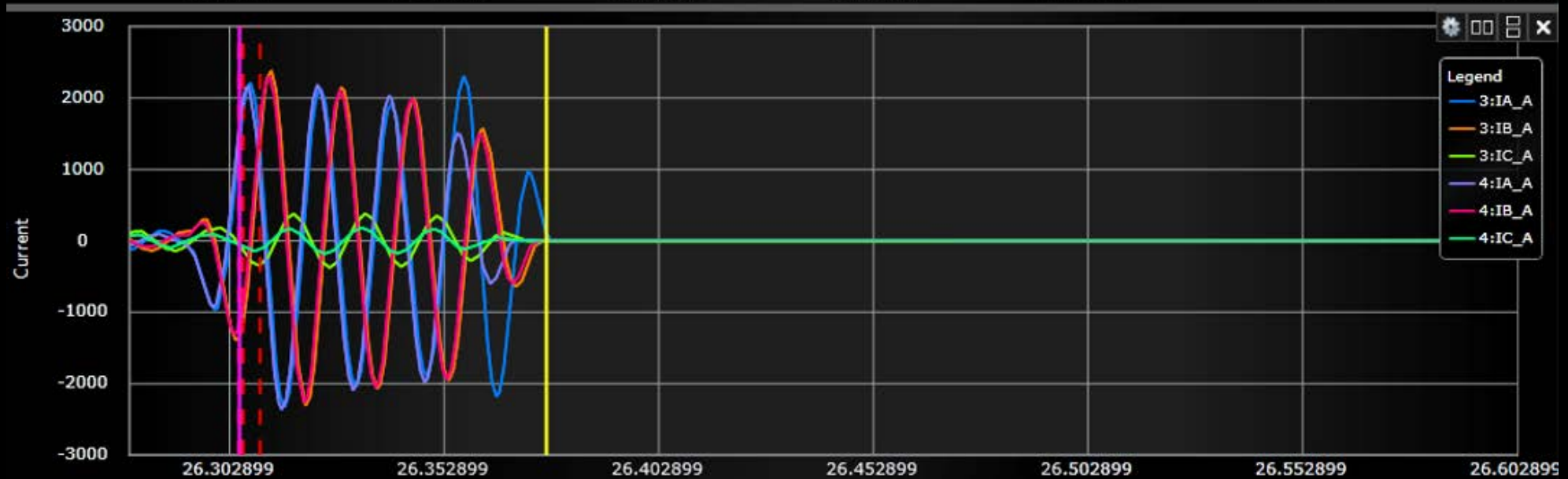
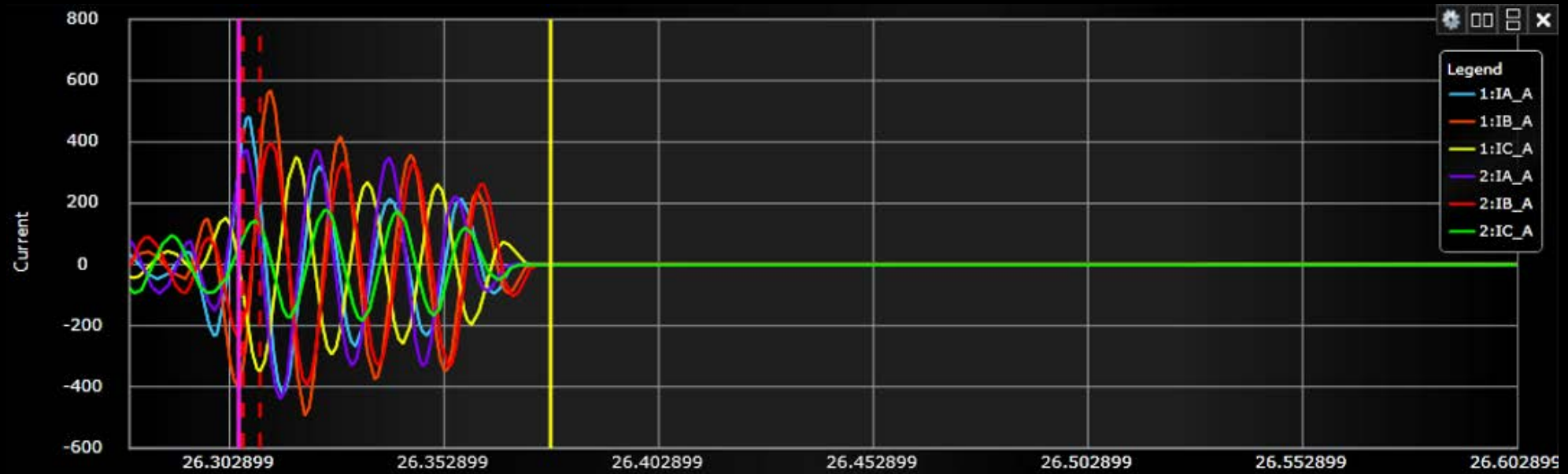
**Event
Summary**

12:40:00 AM

12:53:20 AM

1:10:00 AM

Event Reports for Detailed Analysis



HELCO Benefits

- Faster analysis of system events
- Better understanding of renewable impact on system during disturbances
- Situational awareness for operations

Questions?

