Wide Area Monitoring and Control

Schweitzer Engineering Laboratories

André du Plessis

SEL

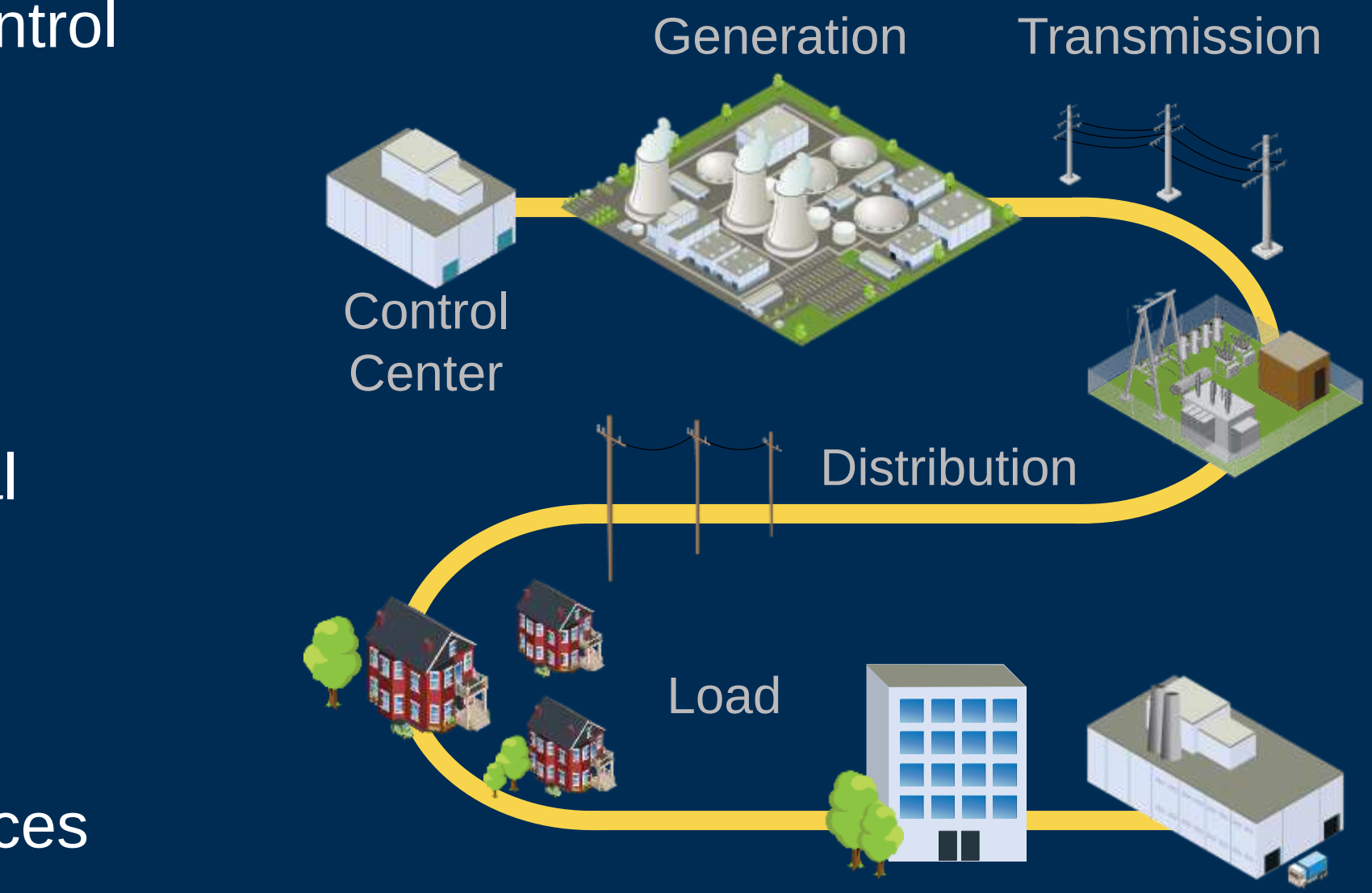
- Headquarters: WA
- US Manufacturing: ID, IL, WA
- Invent, Design, Build, and Support the Systems That Protect and Control Power Systems
- 5600 employees
- Product in 161 countries
- Africa offices: South Africa, Ghana





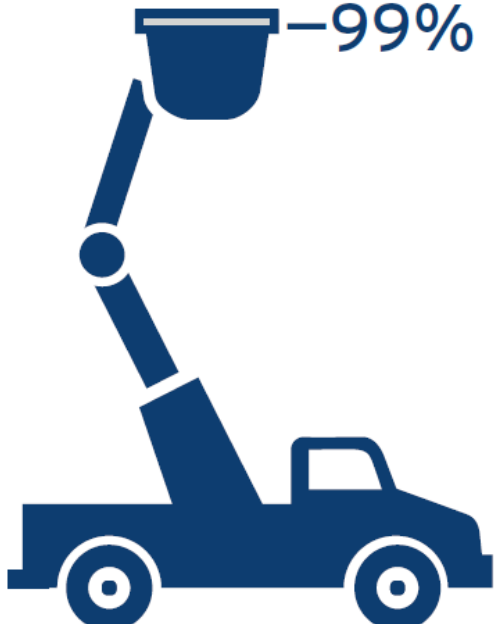
We Provide End-to-End Solutions

- Protection and control
- Automation
- Computing
- Software
- Precise time
- Security for critical infrastructure
- Metering
- Communications
- Engineering services
- Training



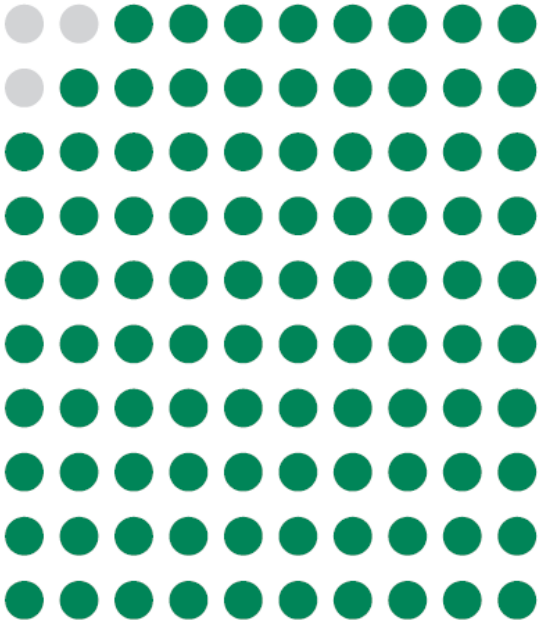
A Household Name in the US Top U.S. Utilities Trust SEL

99% of top investor-owned utilities use SEL

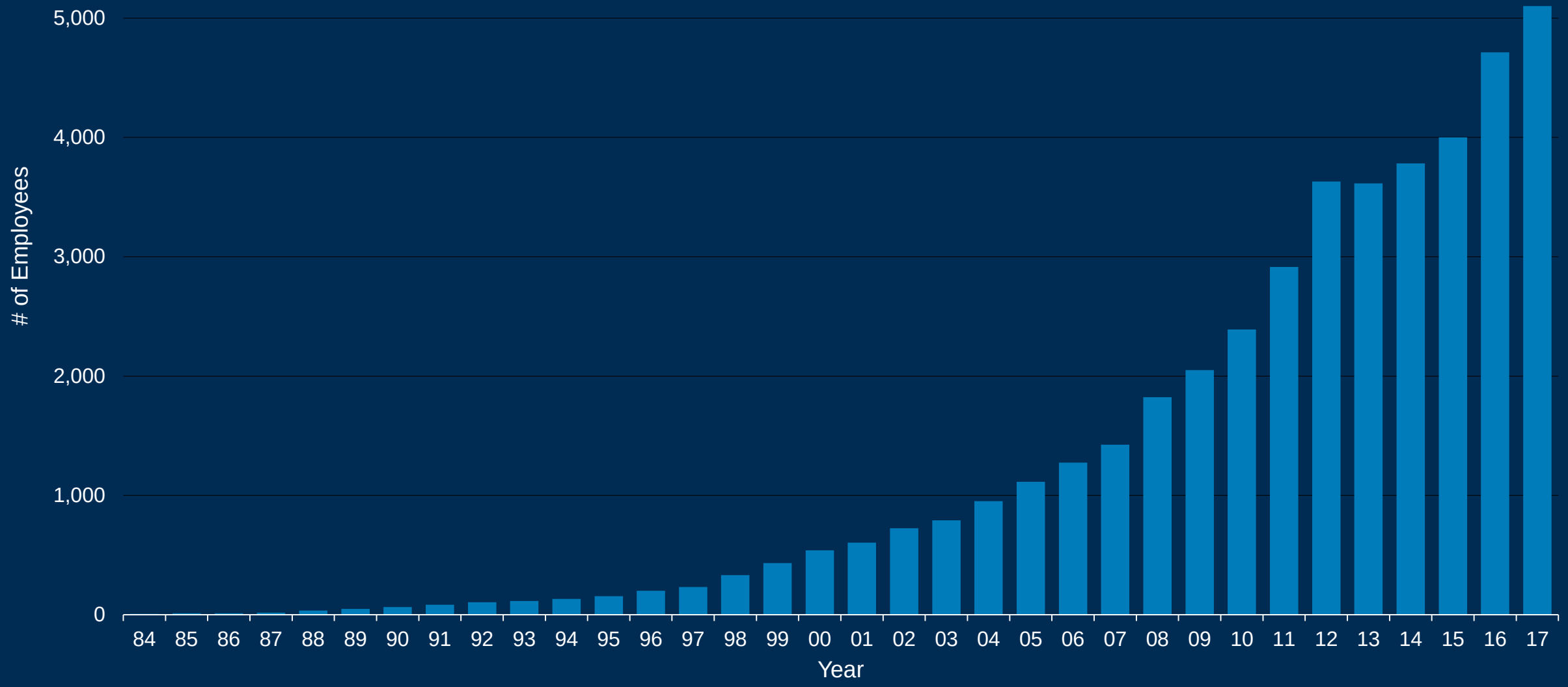


198 of 200 municipal utilities are SEL customers

97 of 100 rural electric co-ops use SEL



Sustained Employee Growth

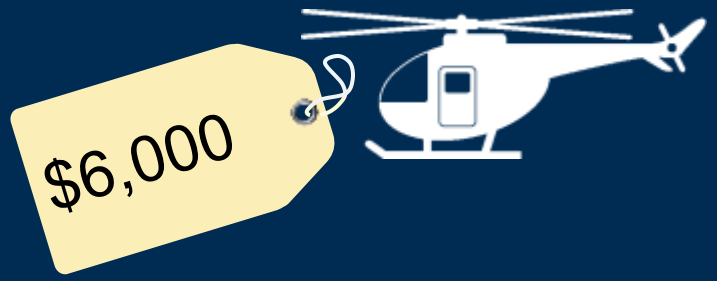


Content

- Challenges
- Solutions
- Case Studies

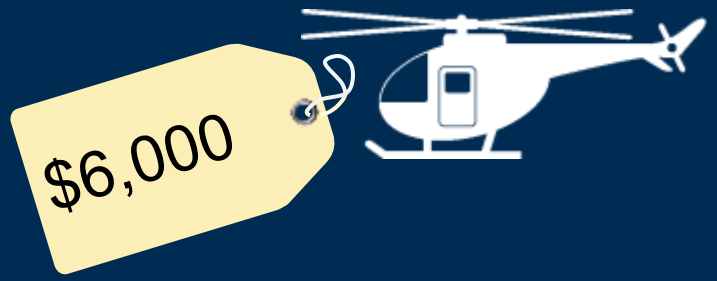
Problem

When the power went out, linemen had to physically search power lines for the problem



Solution

SEL introduced the world's first all-digital protective relay with fault-locating technology



Performance and Reliability Matter

- SEL 10 Year Warranty
- Mean Time Between Failure (MTBF)
- Life Cycle Costing
- Type Testing

Problems and Solutions

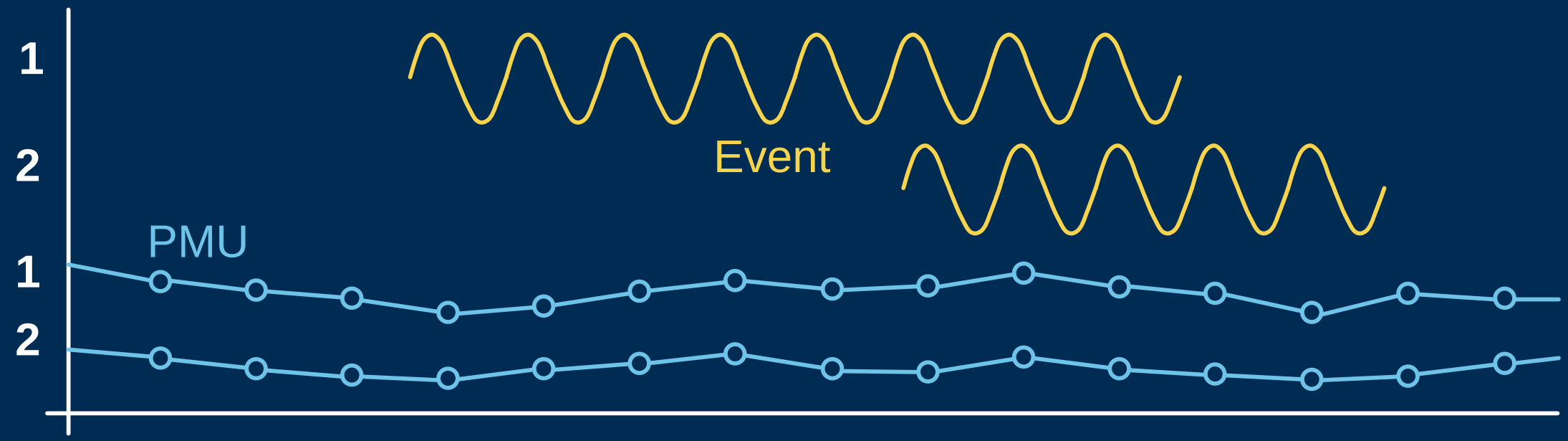
We learn from our mistakes to find solutions that work

2003 Northeast Blackout
Lessons Learned

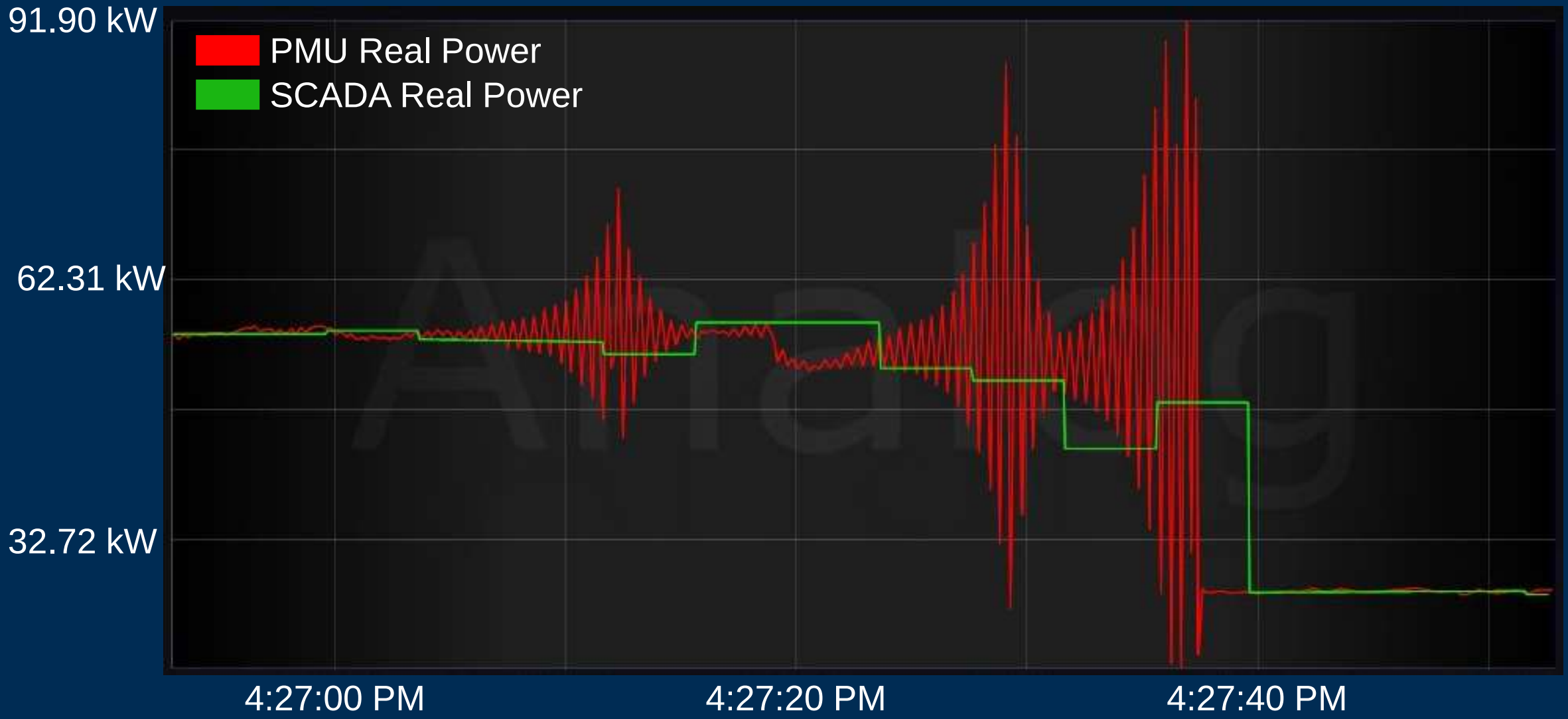
- Time synchronization for digital fault recorders (DFRs)
- Phasor measurement units (PMUs) for better system-level view
- Events time-tagged within 4 ms accuracy

NOAA

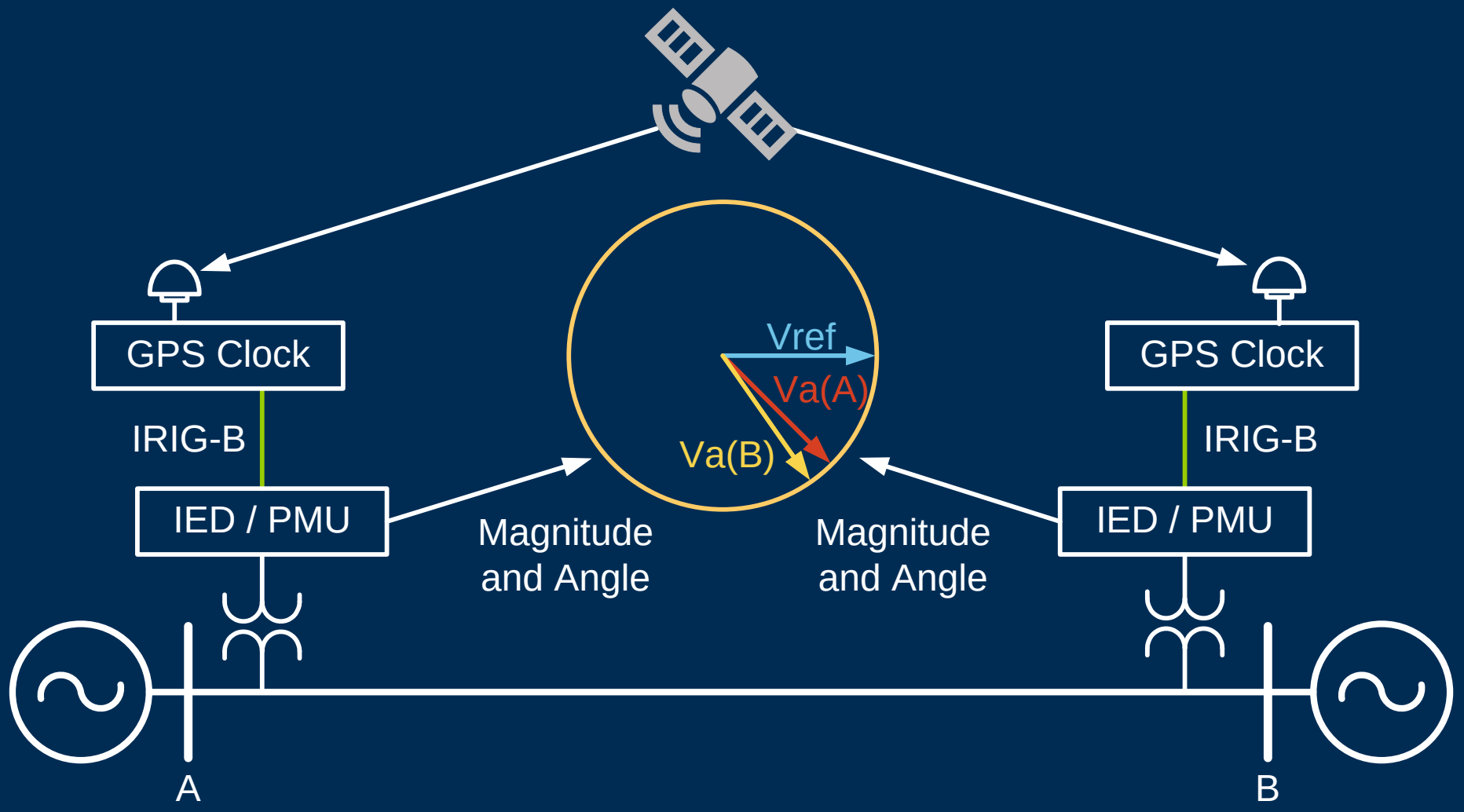
Correlation of Time-Stamped Data
Real-time as opposed to estimated time



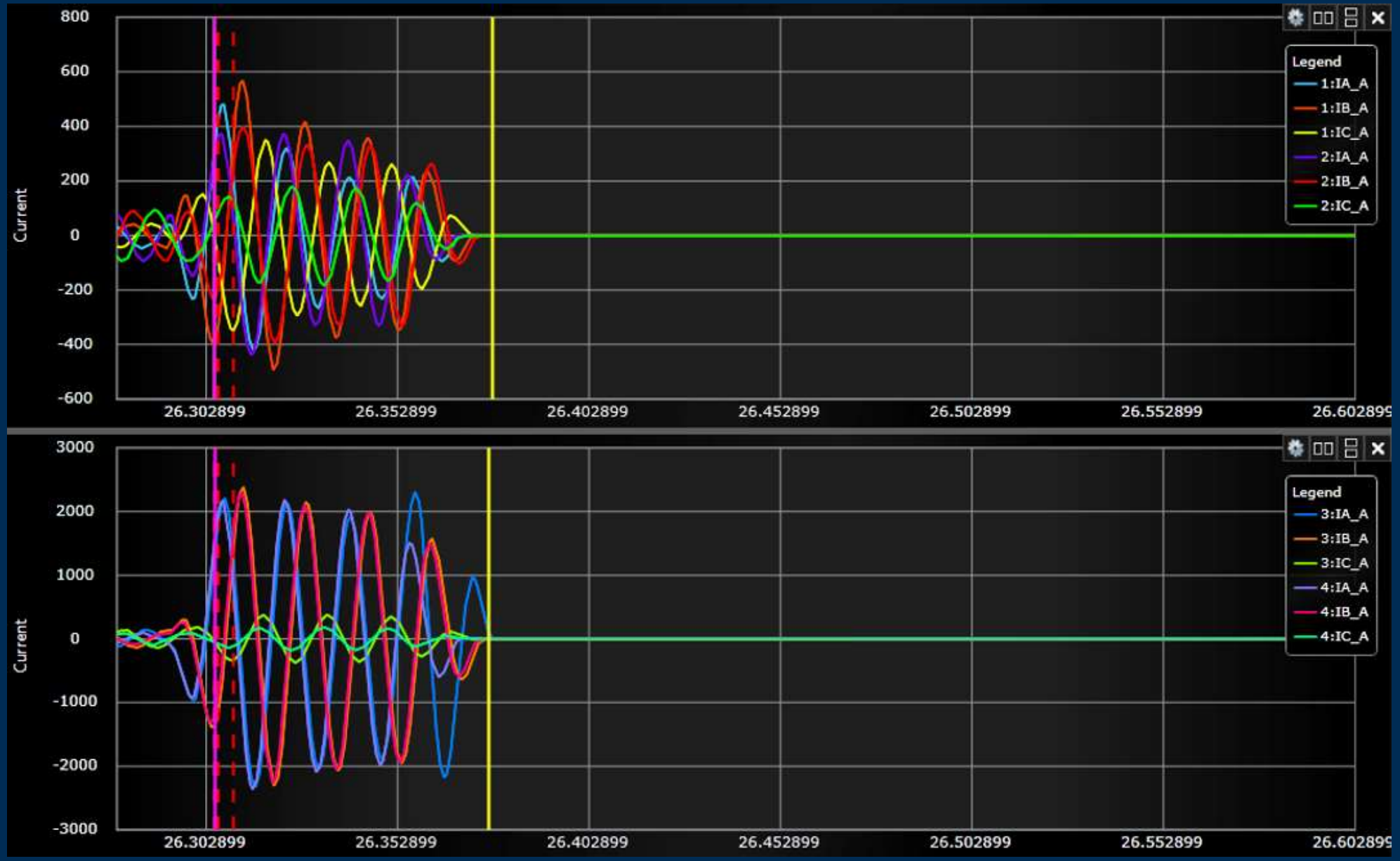
SCADA Misses Information



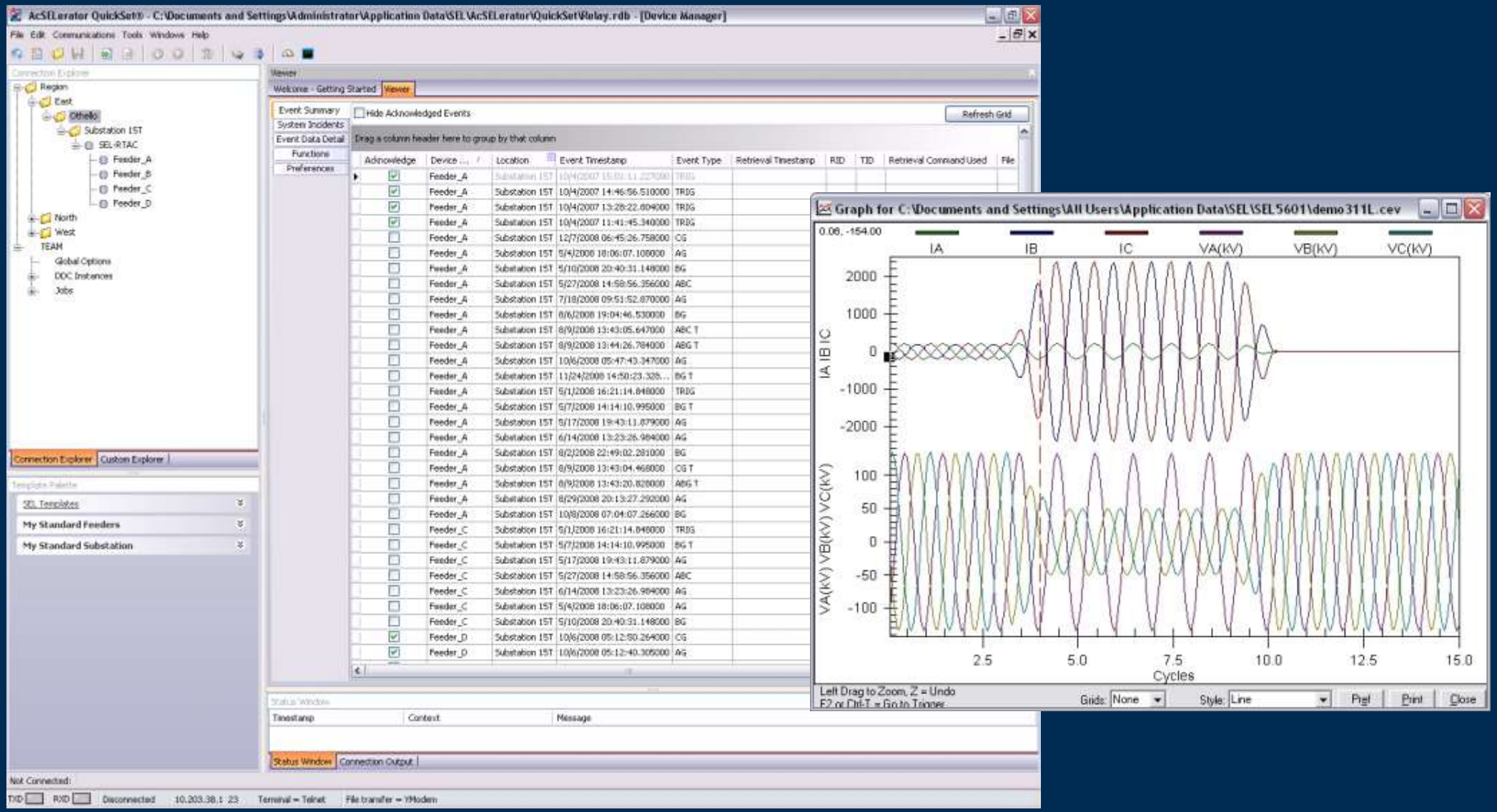
What Is a Synchrophasor?



Event Reports for Detailed Analysis



Event Database for Analysis



Benefits

- Faster analysis of system events
- Better understanding of power system during disturbances
- Situational awareness for operations

Cost Effective Solutions

Wide area monitoring and control pays itself when it operates:

- Cost of a Blackout
- Social Implications
- Political Implications
- Better Power System

Which Power Systems?

- Weak power system
- Radial power systems with concentrated generation
- Intentionally or unintentionally created Islands
- Isolated power systems (MicroGrids)
    - Small populated areas with generation-load unbalance
    - Isolated Industries
        - Refineries
        - Floating Oil Platforms

Why Faster Trip Times Matter

- Better stability
- More energy transmitted
- Less loss of life and property
- Less damage from faults
- Less cascading
- Less stress from overloading
- Less stress on transformers
- Less stress on generators
- Less voltage sag
- We can because we have the technology

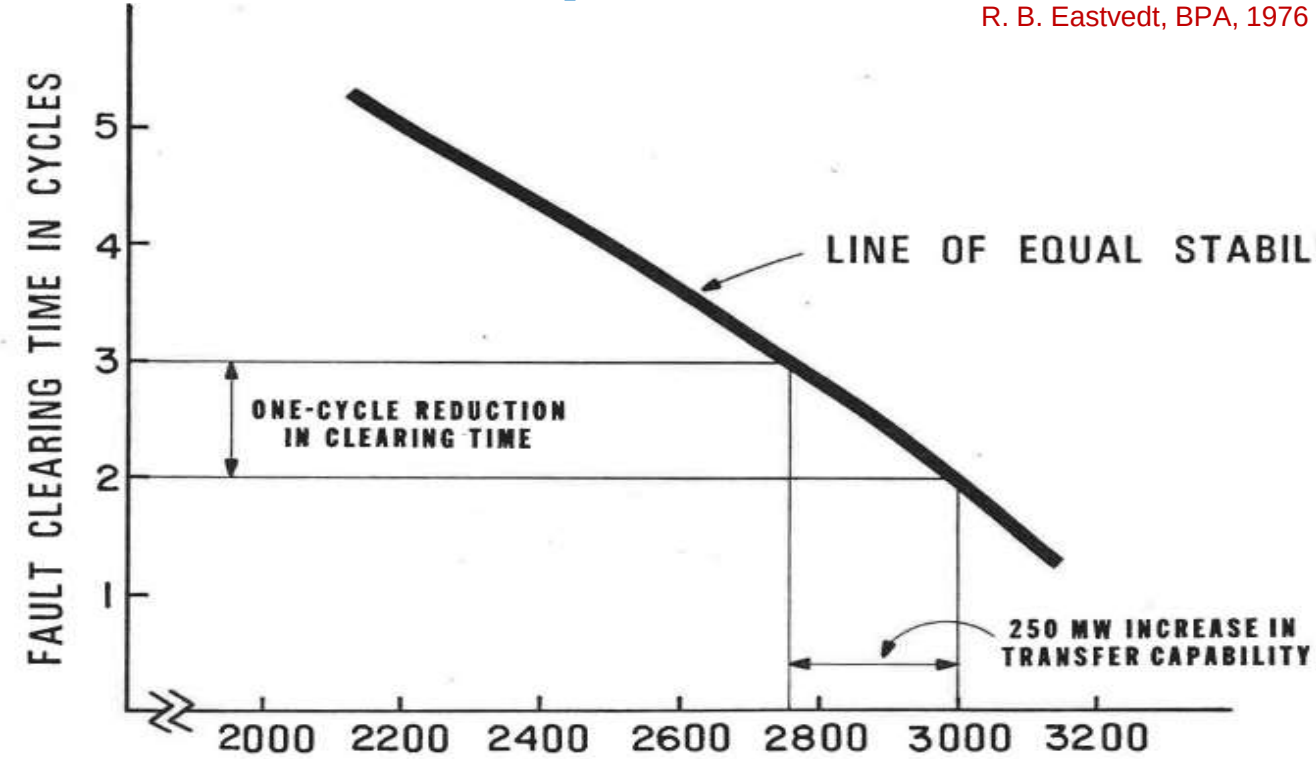
The *Need for Speed*

Moving Energy at the Speed of Light

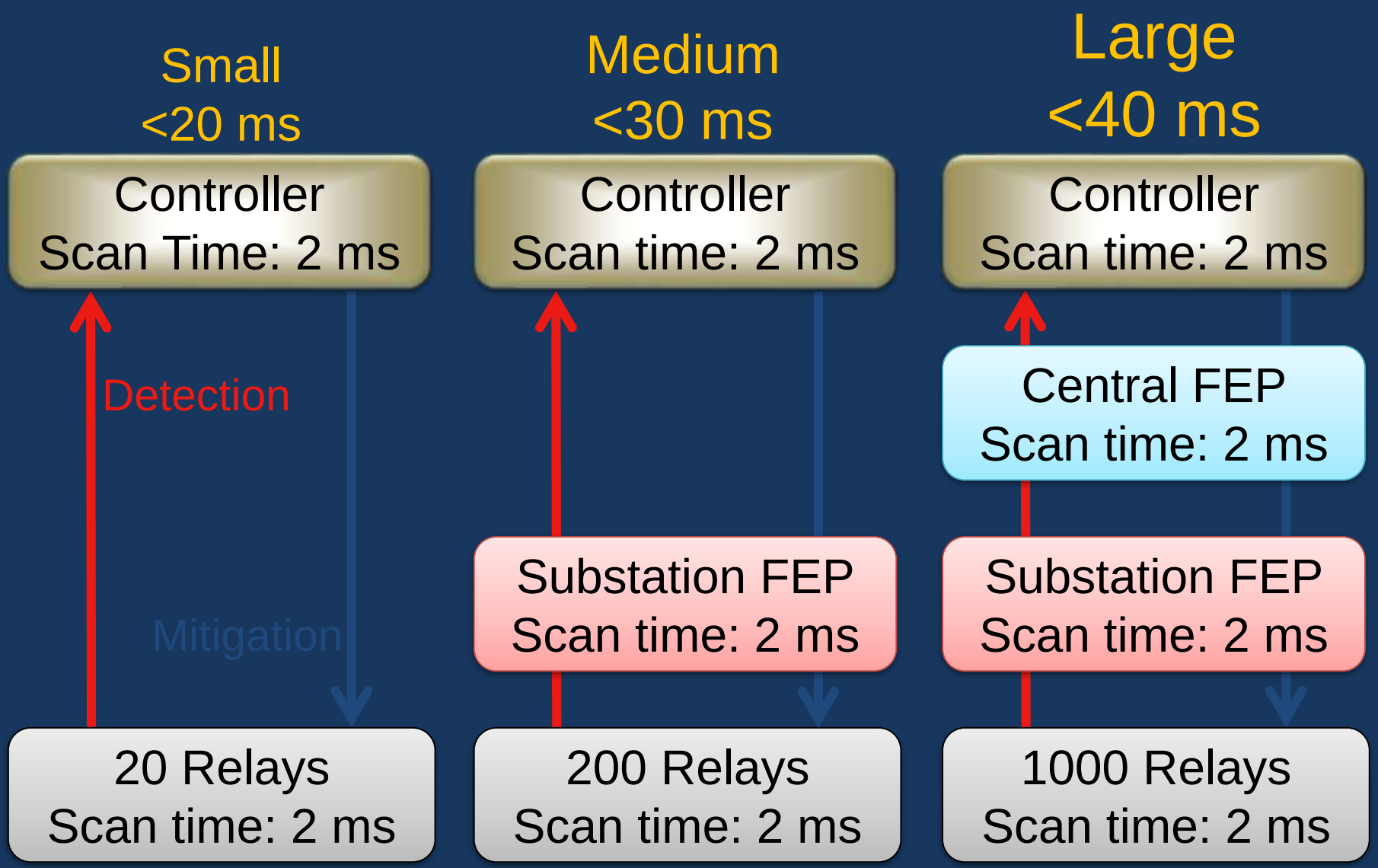
Safer • Less Damage • Improved Dynamics

15 MW more per millisecond saved

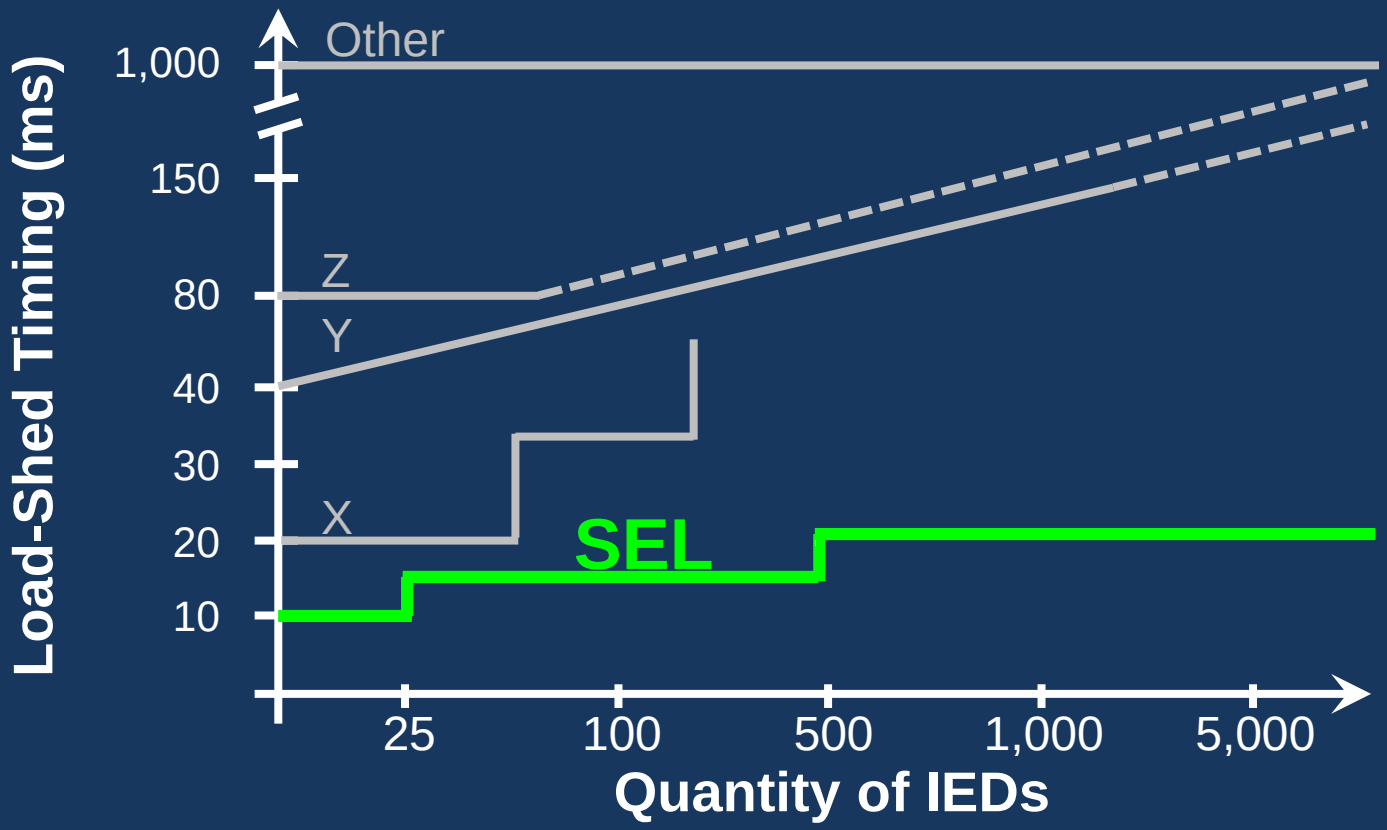
R. B. Eastvedt, BPA, 1976 WPRC



Sub 40 ms Scalable Architectures



Fast SEL Products are the *Fastest Systems* in the World



Wide Area Monitoring & Control: Microgrids

- A form of Wide Area Monitoring and Control - grid-tied microgrids
- Navigant 2018 Global Research Leaderboard for Microgrid Controls:
  - 15 vendors reviewed
  - SEL #1
- About performance (not only standards)

Wide Area Protection and Control Projects

Guatemala: *Synchrophasor control Modal analysis (MA) – Electromechanical Instability*

Republic of Georgia: *Emergency Control System – Country Wide Mitigation*

Uruguay: *Over-Load and Stability Control – Country Wide Mitigation*

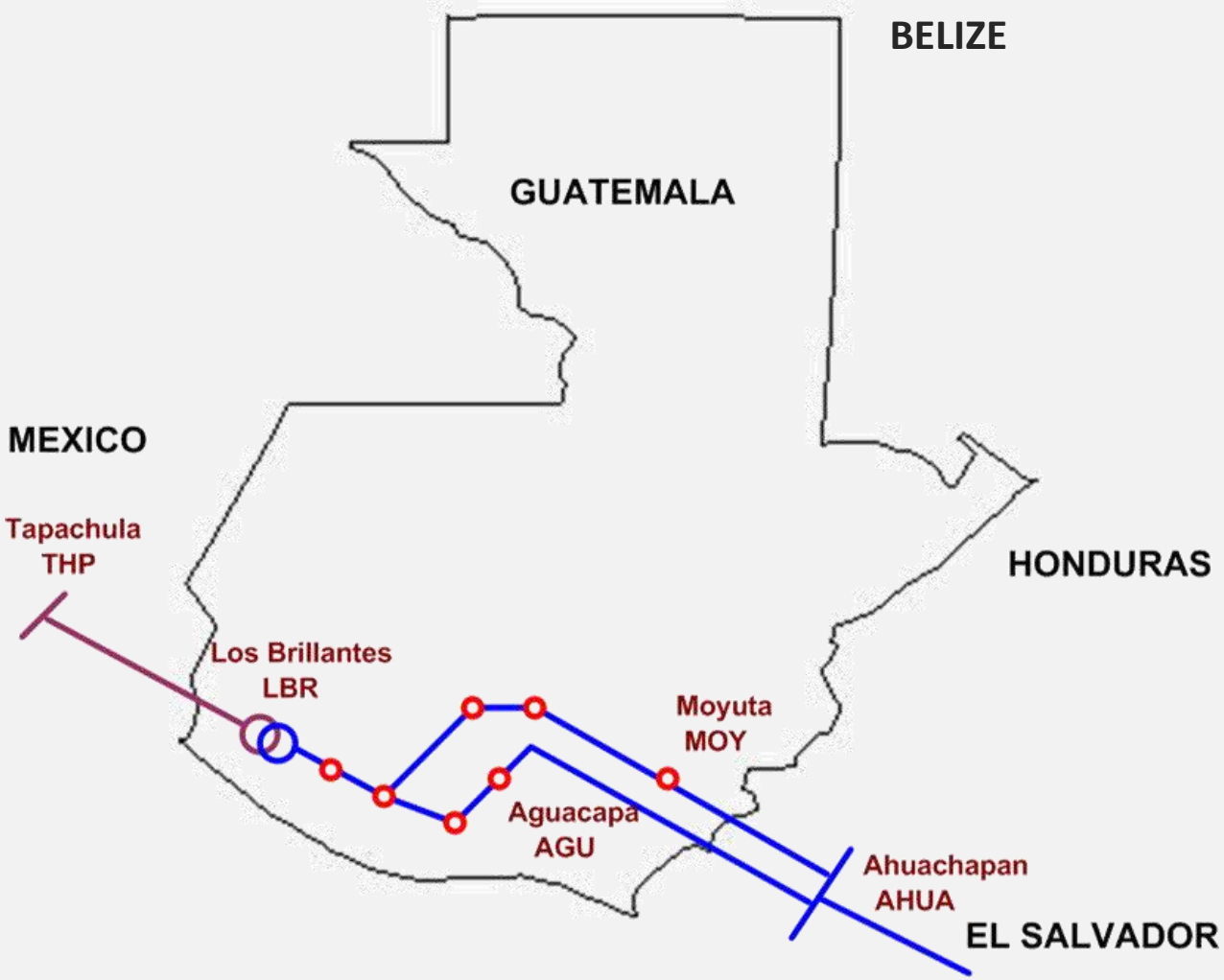
Peru: *Power Angle Control – Stability*

Spain-France: *HVDC Data for HVDC Link –Control*

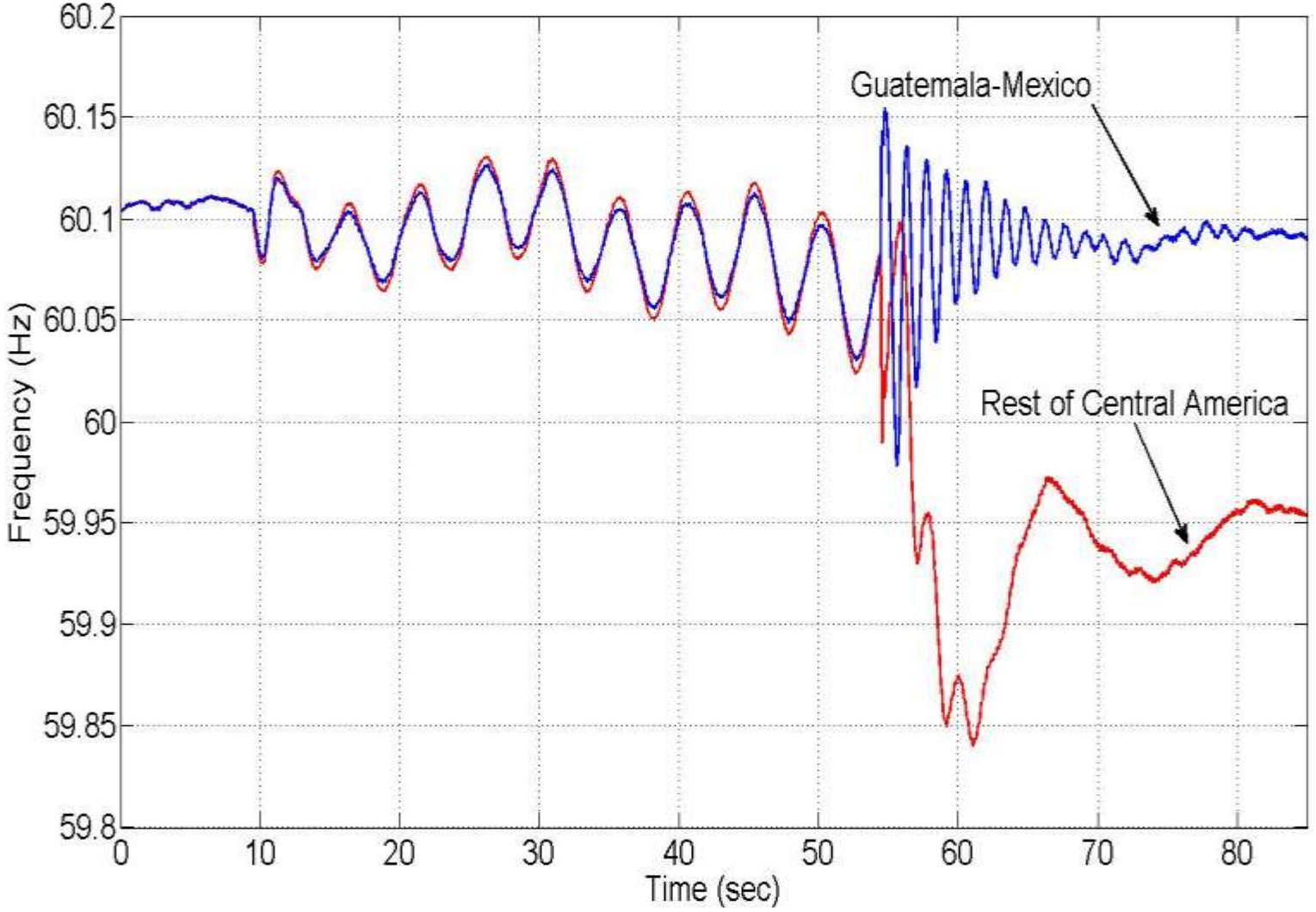
Idaho-USA: *Generation Shedding – Stability*

Central America and Its Link to Mexico

Guatemala SCS

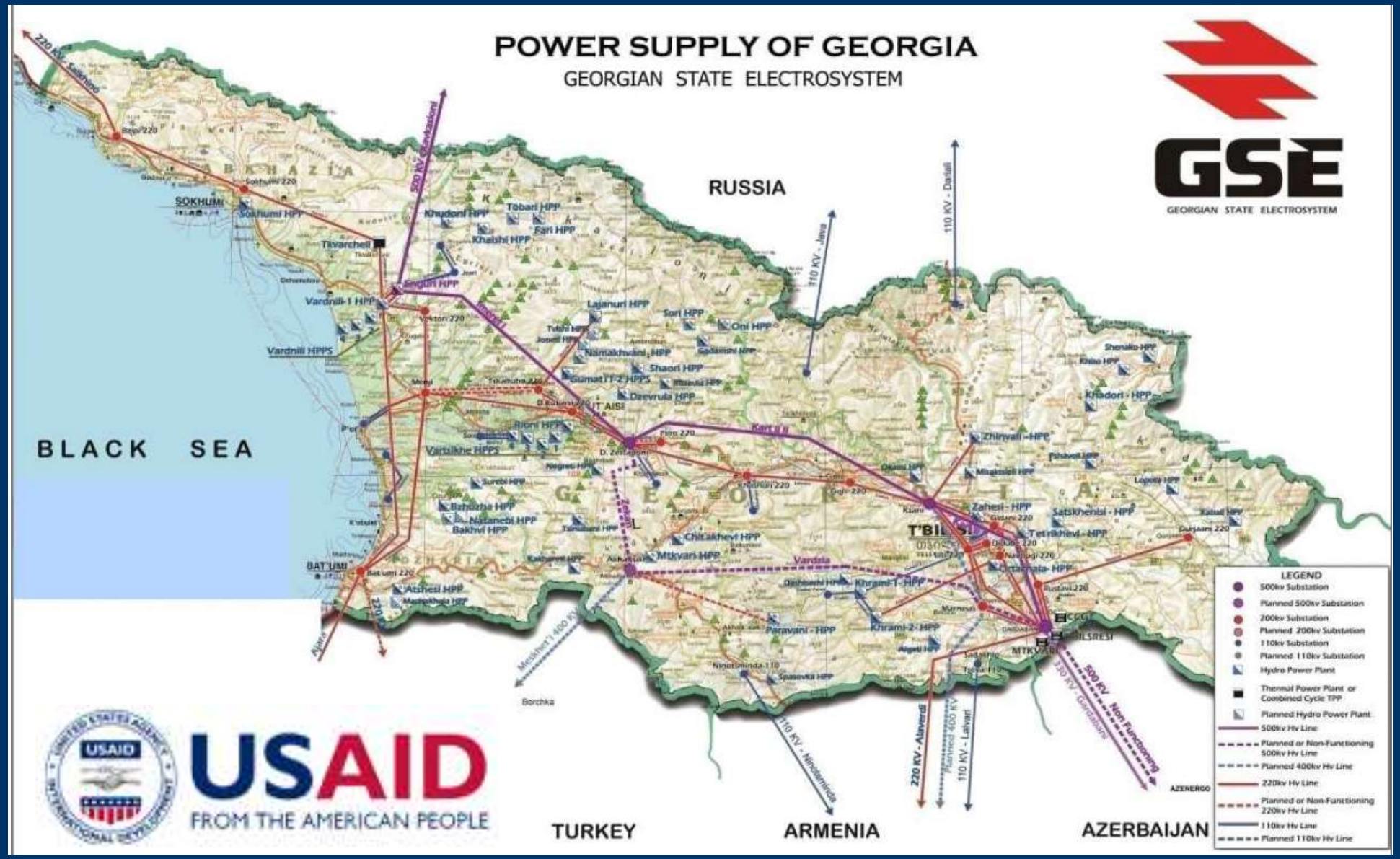


July 28, 2012 – MA Trip: Frequencies

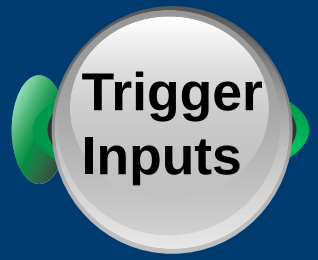


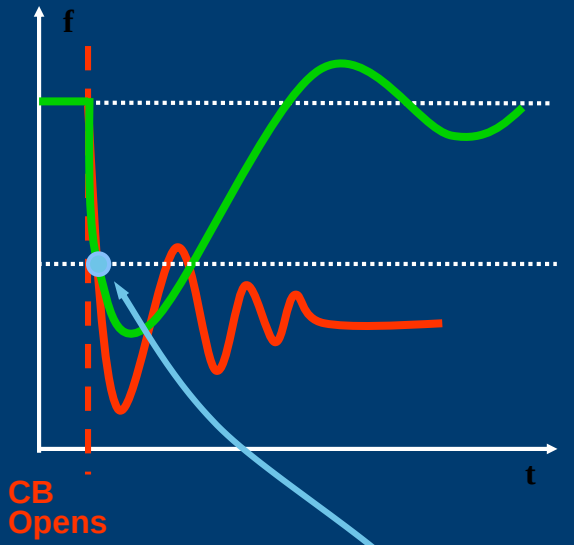
Control Center
SCADA / Synchrophasors

Georgia Power System



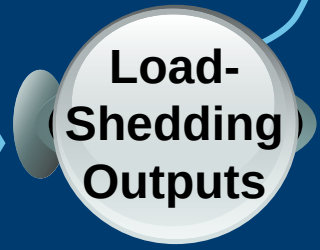
Georgia Centralized Architecture Emergency Control System or RAS/SPS



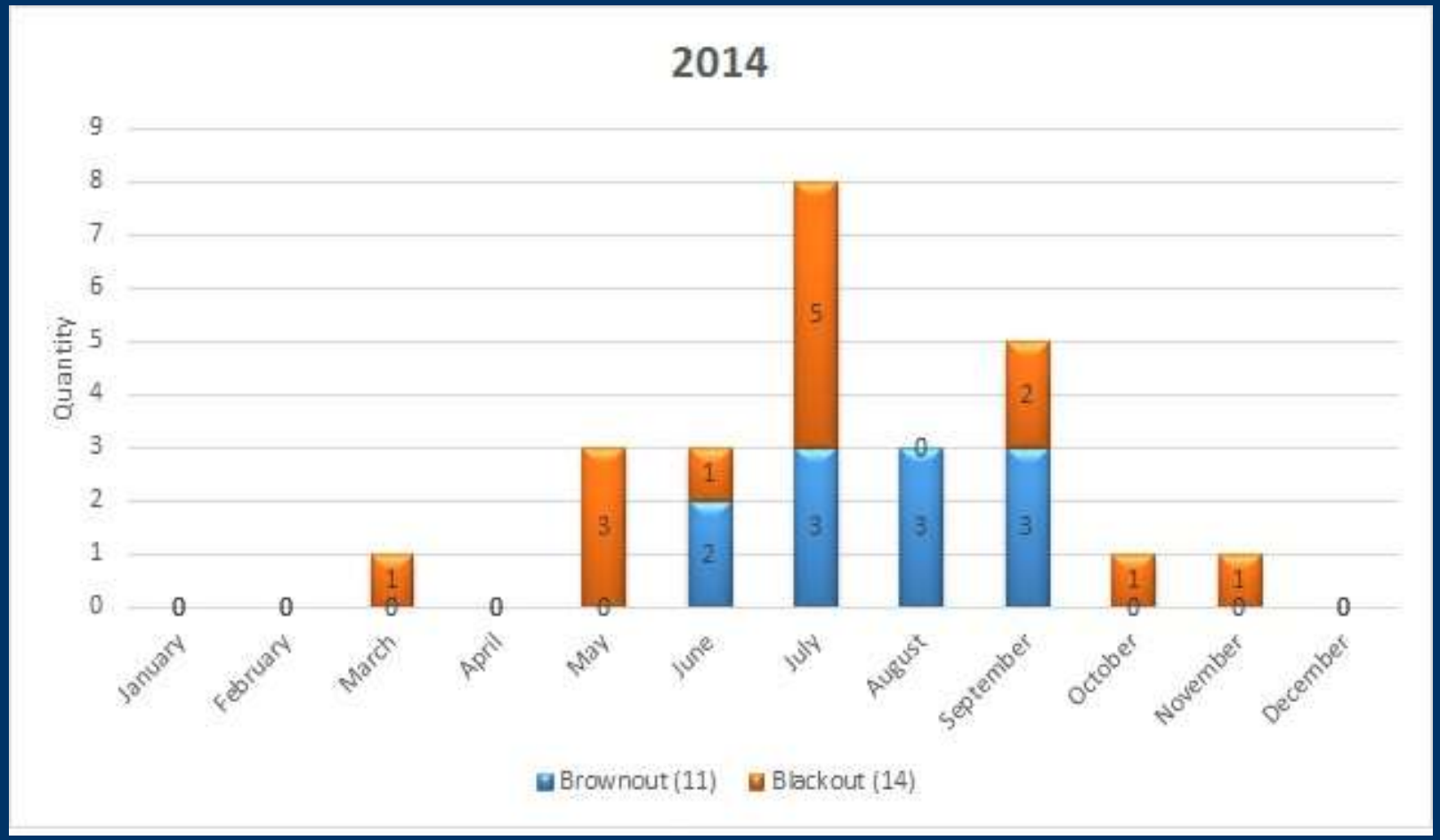


Crosspoint Switch Preloaded and Ready to Go

Contingency	Loads selected to Shed					
	Load 1	Load 2	Load 3	Load 4	Load 5	Load 6
Loss of G1		X	X			
Loss of G2	X					X
Loss of G3	X			X		
Loss of G4			X		X	X
Bus Tie		X		X	X	



Georgia Special Protection System Operations for 2014



Source: GSE

Georgia Reliability Increases

- ECS operates country-wide between 30-40ms
- Georgia's GDP during this time was about $1.95 million per hour. Assuming an average duration of 1 hour per blackout this solution has saved Georgia $39 million. The solution cost about $2 million.*
- Quality/robustness of equipment allows installation in the yard, not control room (Certified: -40 to +90 C, Margin testing included: -45 to +95 C). Philosophy of Quality. Not standards.

** GSE statistics*

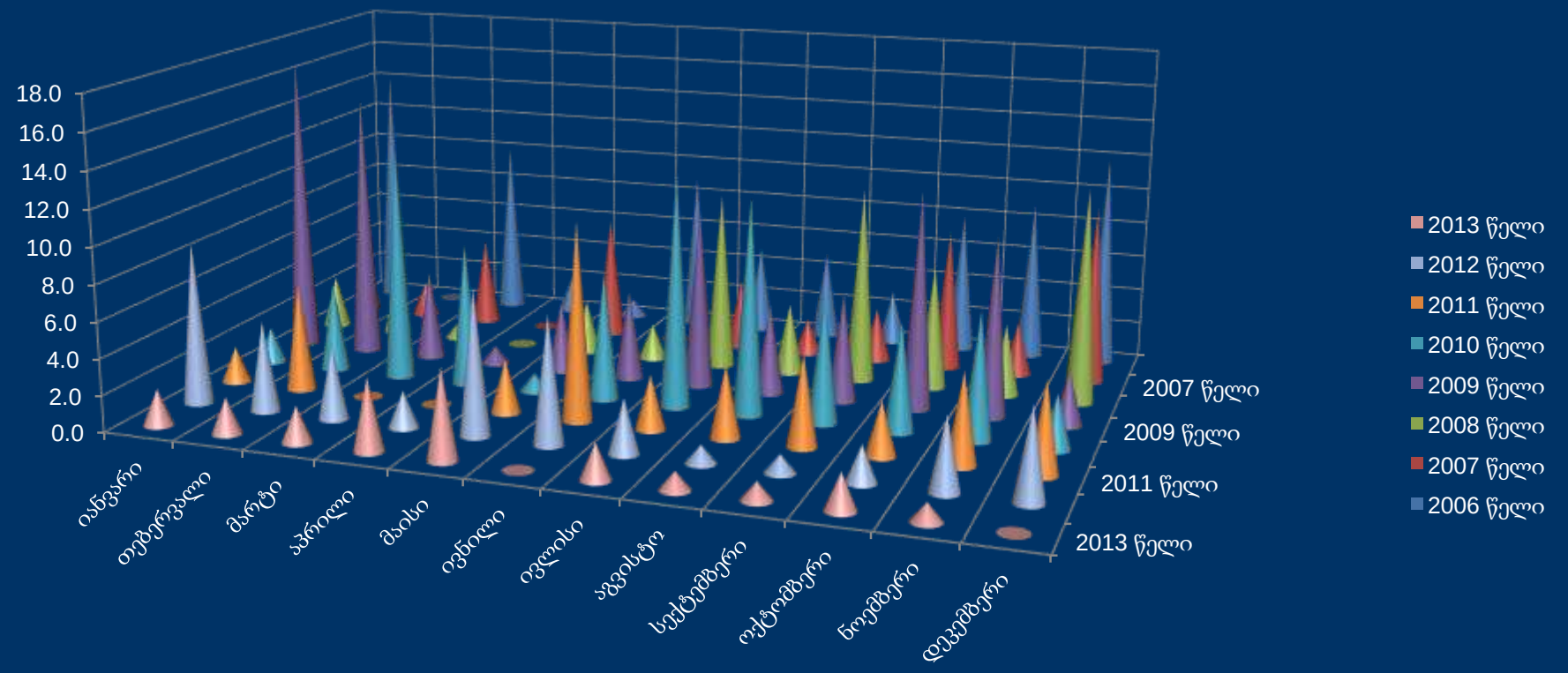
USAID GSE Substation Project

- 12 Substations renovated
- Project finished 1 year ahead of schedule – USAID request
- Why mention of protection and wide area monitoring together?
  - In combination, protection rehabilitation and wide area monitoring we observed a significant increase in reliability

USAID
FROM THE AMERICAN PEOPLE

GSE 12 Substation Rehabilitation Project

Relay Maloperation due to Complex Circuits



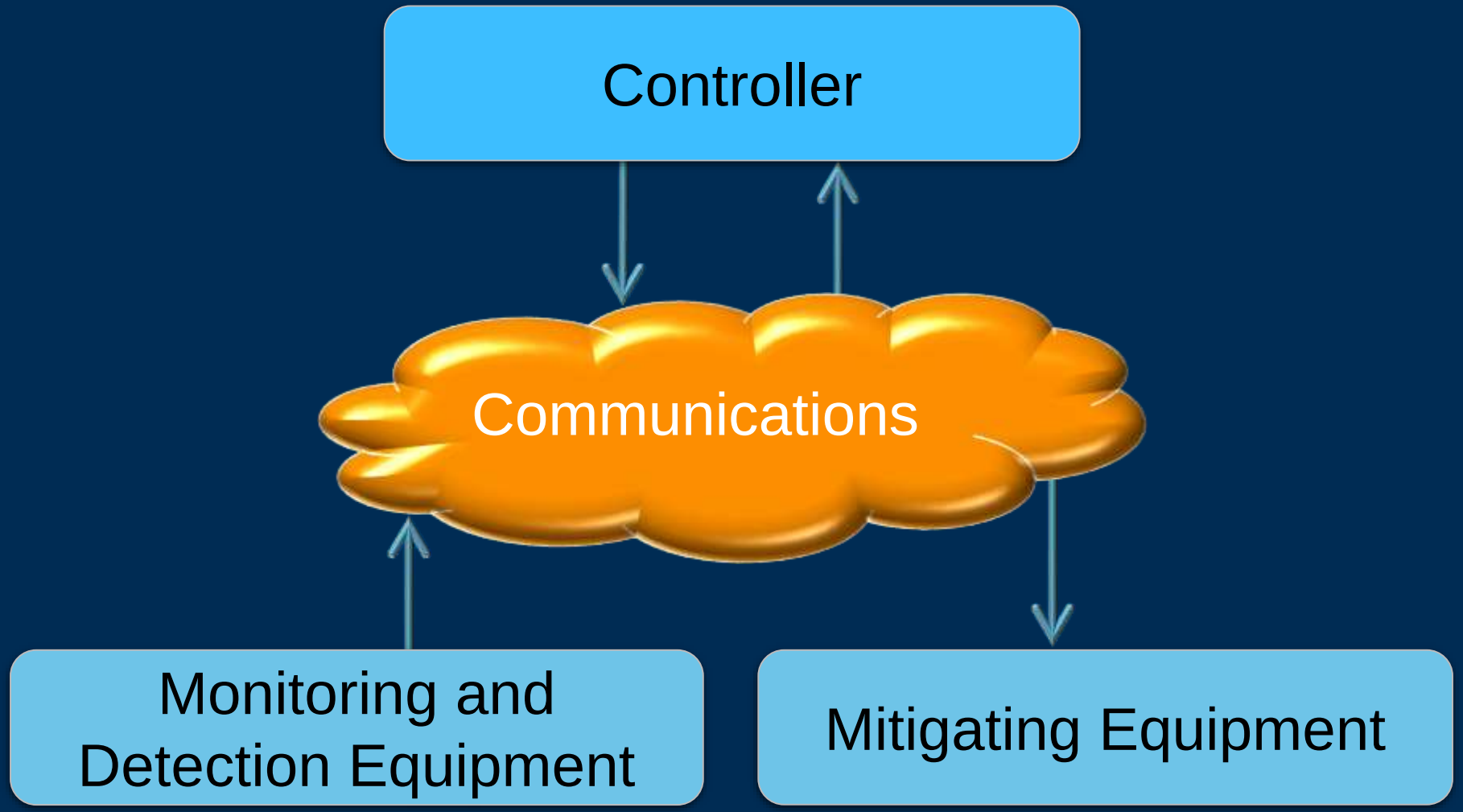
Source: GSE

Georgia Reliability Increases

- Protection devices serve dual purpose: protection as well as wide area monitoring & control
  - Synchrophasors imbedded in conventional protection equipment such as relays, meters, etc.
  - Complex circuits reduced

→

Basic Monitoring and Control



CONCLUSIONS

WIDE AREA MONITORING PROTECTION AND CONTROL NEEDED

- Human control too slow and risky – we get speed and automation
- Need power system visibility
- Angular Instability
- Electromechanical Oscillations
- Instantaneous load shedding of non-critical load
- Islanding
- Accurate fault location
- Reliability and revenue

Making Electric Power Safer, More Reliable, and More Economical for Over 30 Years