

*Real-Time Monitoring Tools and Multi-View  
Visualization For Wide-Area Operations*

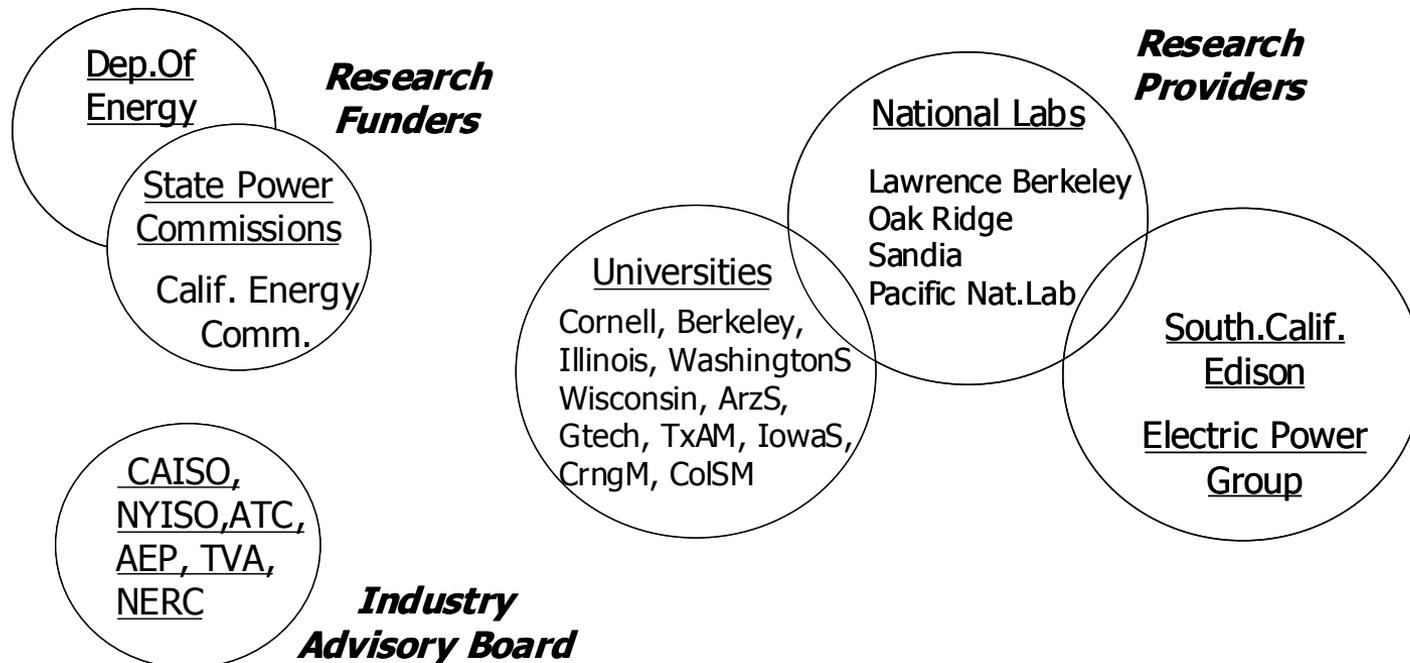
**Distribu TECH  
Transmission Reliability Panel  
San Diego, California  
January 25<sup>th</sup> , 2005**

**By  
Carlos Martinez – EPG/CERTS**

# Consortium for Electric Reliability Technology Solutions (CERTS)

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**Conduct needed public interest research on reliability technology solutions, tools, models, systems, and management processes required in competitive electric markets for improving reliability and market efficiency of the U.S. electric grid**



# Integrated Real-Time Wide-Area Monitoring, Control and Protection System

## OPERATIONAL LEVELS

### DATA

### MONITORING & CONTROL

Level 1

**LOCAL CONTROL SUBSTATIONS**

§ Substation Automation

**LOCAL CONTROL GENERATION PLANTS**

§ Local Generation Control

Level 2

**SCADA - REGIONAL CONTROL CENTER**

§ Generation  
§ Transmission  
§ Substations

Regional Real Time Control:  
§ Local Load-Generation Balance/AGC  
§ Local Grid Switching

Level 3

**EMS - CONTROL AREA**

§ Grid High Voltage  
§ Interconnection Frequency-Ace

§ State Estimation  
§ Grid Security Analysis  
§ Security Constrained Dispatch

**Emerging Level 4**

**REAL TIME WIDE AREA MONITORING, CONTROL & PROTECTION-(RT-WAMCP)**

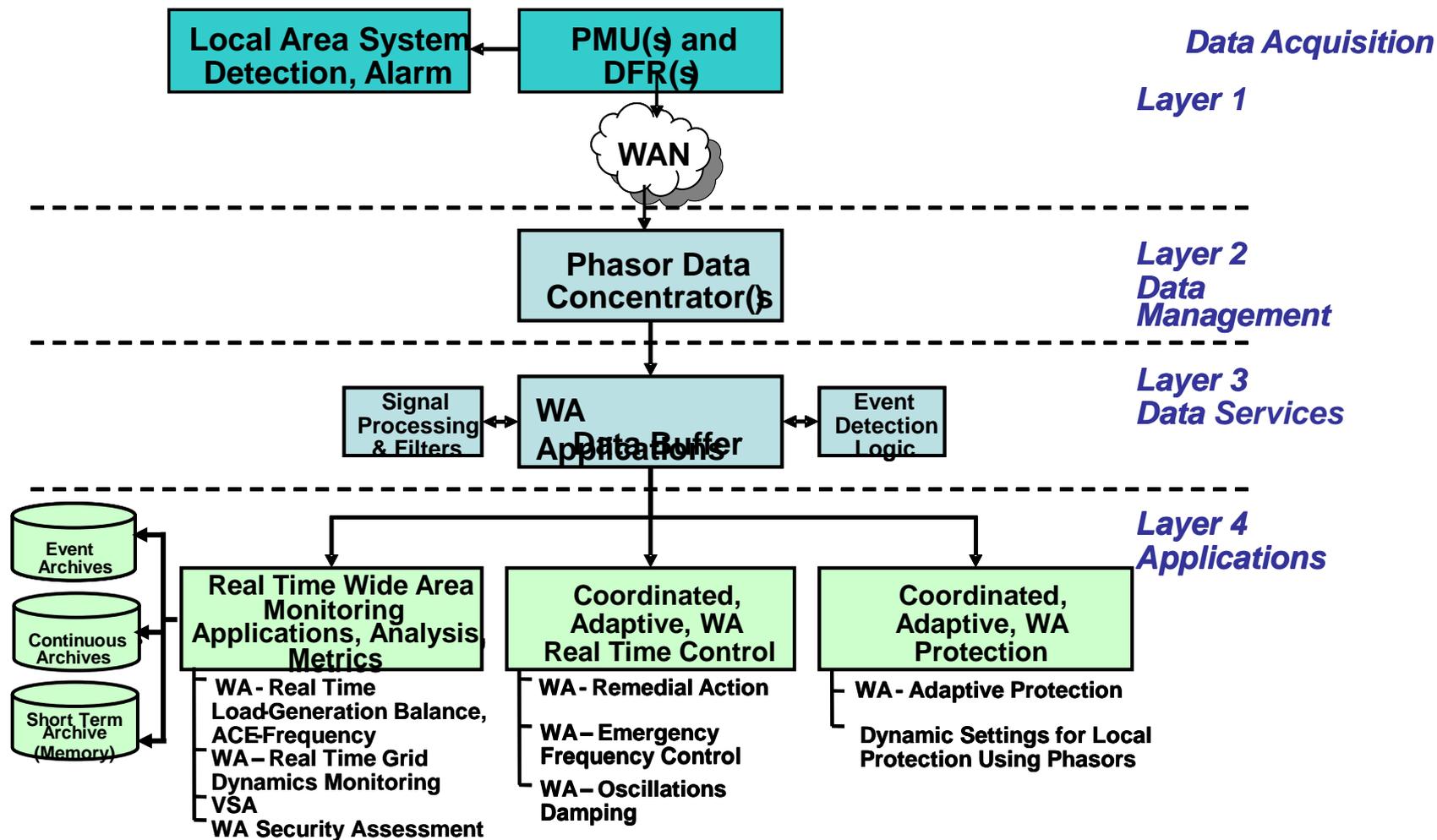
**WA Monitoring/Analysis** → **WA Real Time Control** → **WA Protection**

- WA Real Time Load-Generation Balance, ACE-Frequency
- WA Real Time Grid Dynamics Monitoring-WA-RTDMS
- WA Remedial Action
- WA Emergency Frequency Control
- WA Oscillations Damping
- WA Adaptive Protection
- Dynamic Settings for Local Protection Using Phasors

Synchronized Phasor Measurements

C. Martinez – CERTS / EPG

# Real-Time Wide-Area Monitoring, Control and Protection System Architecture

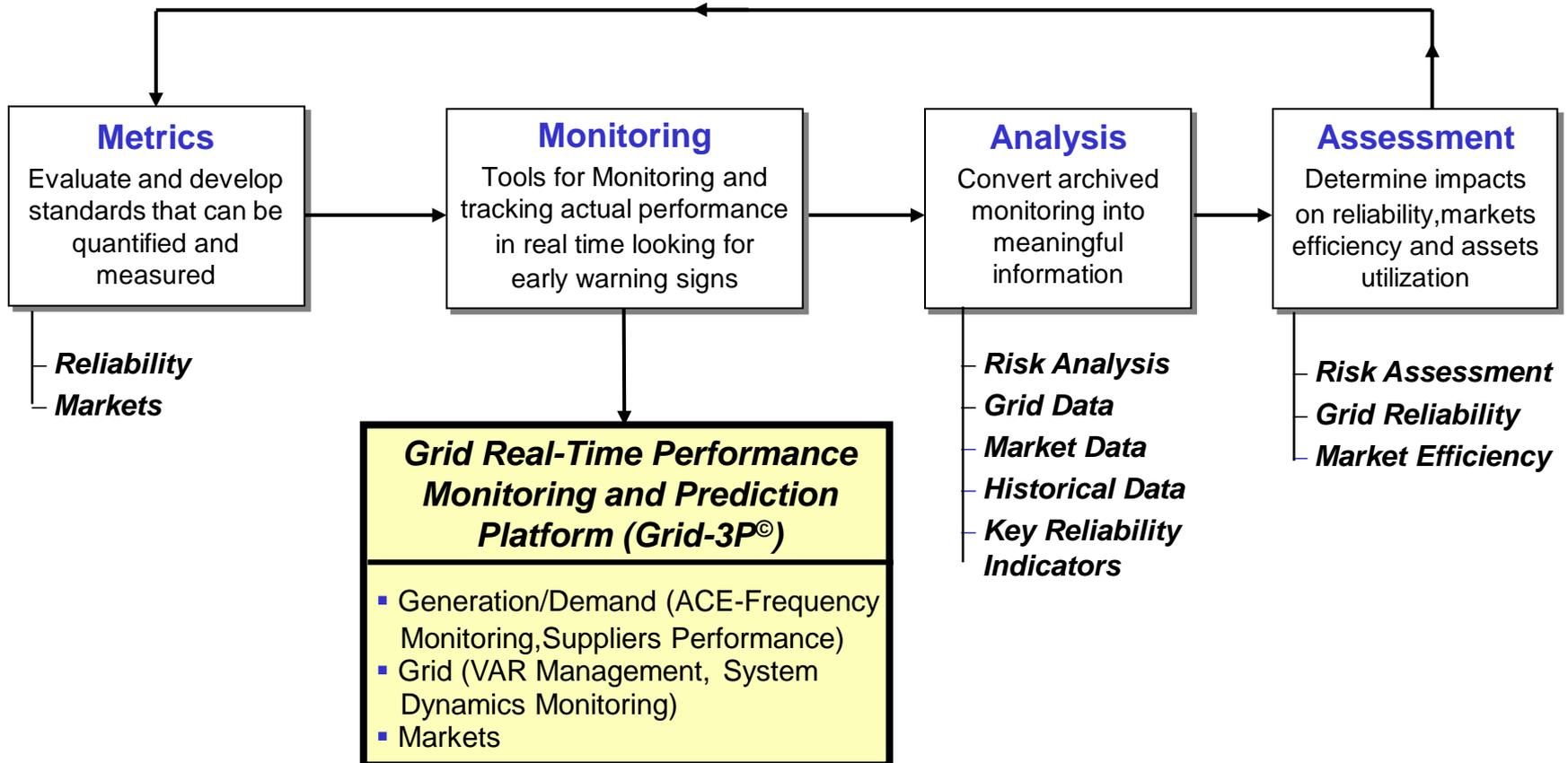


# *CERTS Performance Management Strategy*

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# *CERTS Performance Management Strategy and Interface with RTPM tools*

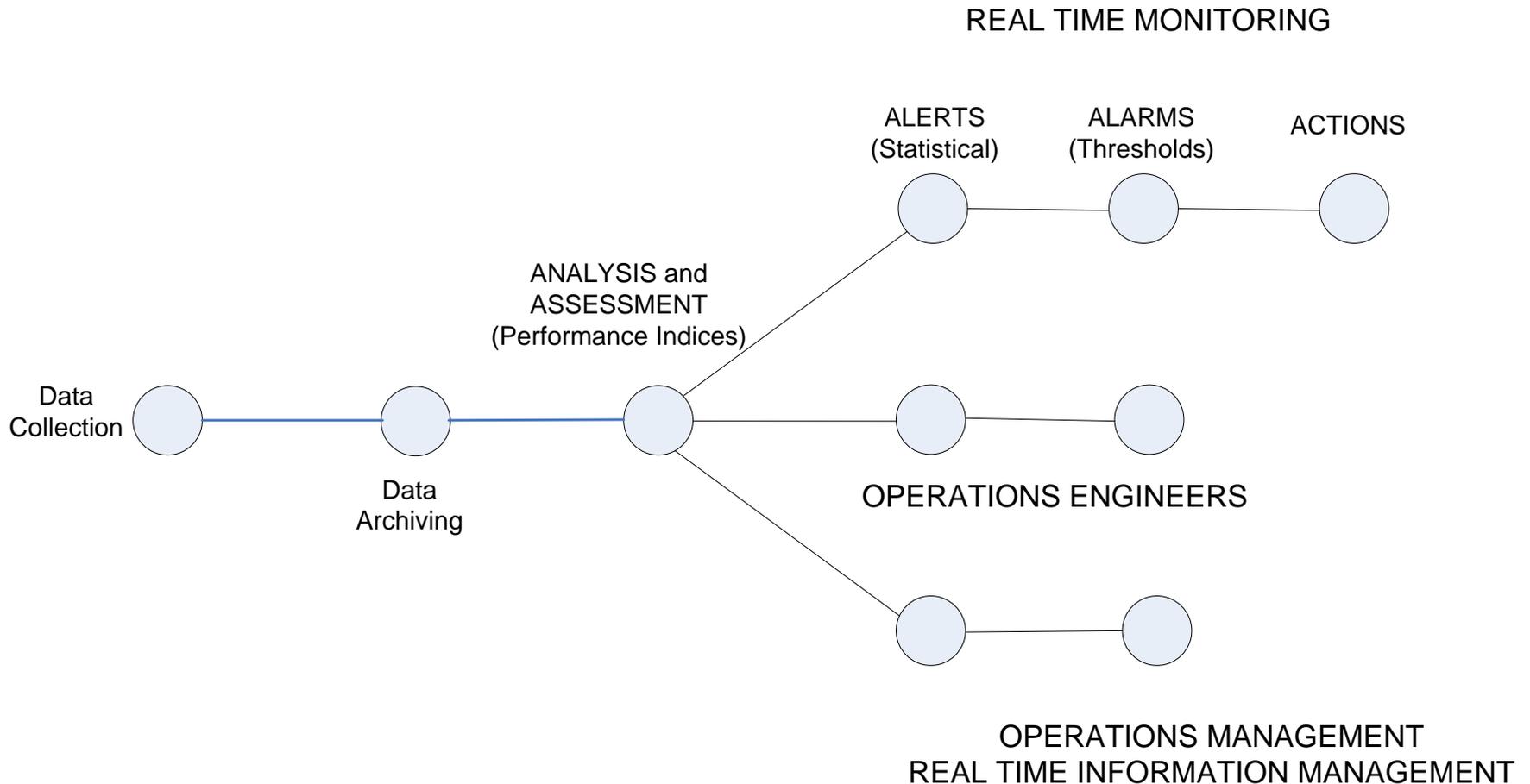


# Grid Performance Monitoring and Prediction Platform Architectural Layers

<b>Layer 4 – Visualization, Wide and Local Area</b>				
Geo-Graphic	Multi-View	Multi-Layer	Auto-Onelines	RESEARCH FOR FUTURE VISUAL ENHANCEMENTS
<b>Layer 3 - Real-Time Performance Monitoring Applications</b>				
Real-Time ACE-Frequency, AIE, CPS and Inadvertent Monitoring	Real Time Dynamics Monitoring System (RTDMS)	Voltage Security Monitoring and Assessment	Real-Time Suppliers Performance For AGC and FR	RESEARCH FOR FUTURE APPLICATIONS
<b>Optimization, Forecasting, Statistics and Probabilistic Technologies</b>				
<b>Layer 2 – Common Archiving, Event, Alarms and Logging Monitoring Services</b>				
Long Term Archiving Database With PI -Type Tagging Characteristics for Historical Data Analysis and Assessment	Real Time Event Manager Services and Database	Intelligent Alarm Processor Services and Database	Real Time Logging Services and Database	Report Generation Services Archiving/RT DB
<b>Layer 1 – Real Time Memory Based Database</b>				
<b>Layer 1 - Data Communications COM+, OPC, Web Based and Data Conversion (API)</b>				

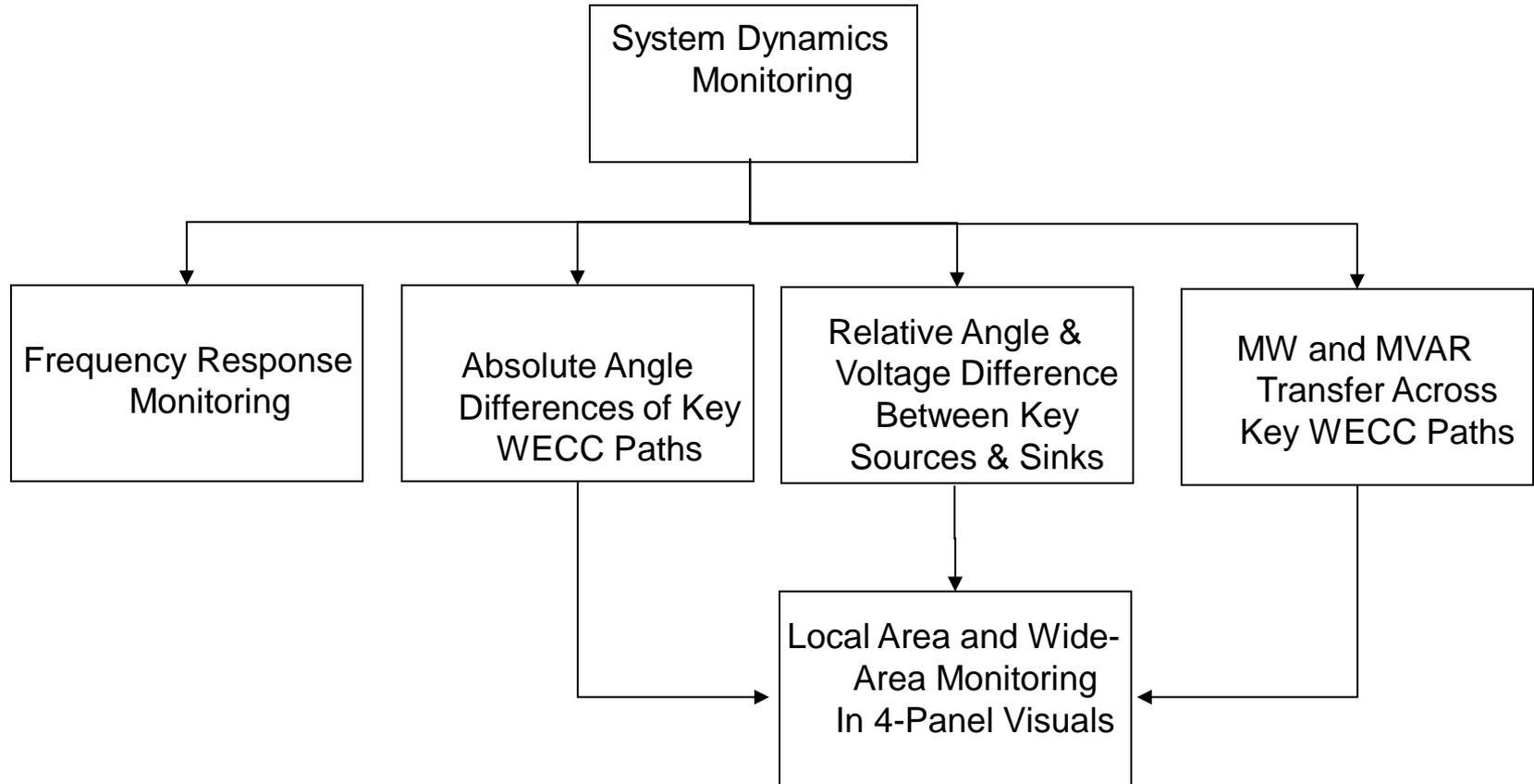
# System Performance Analysis Plan

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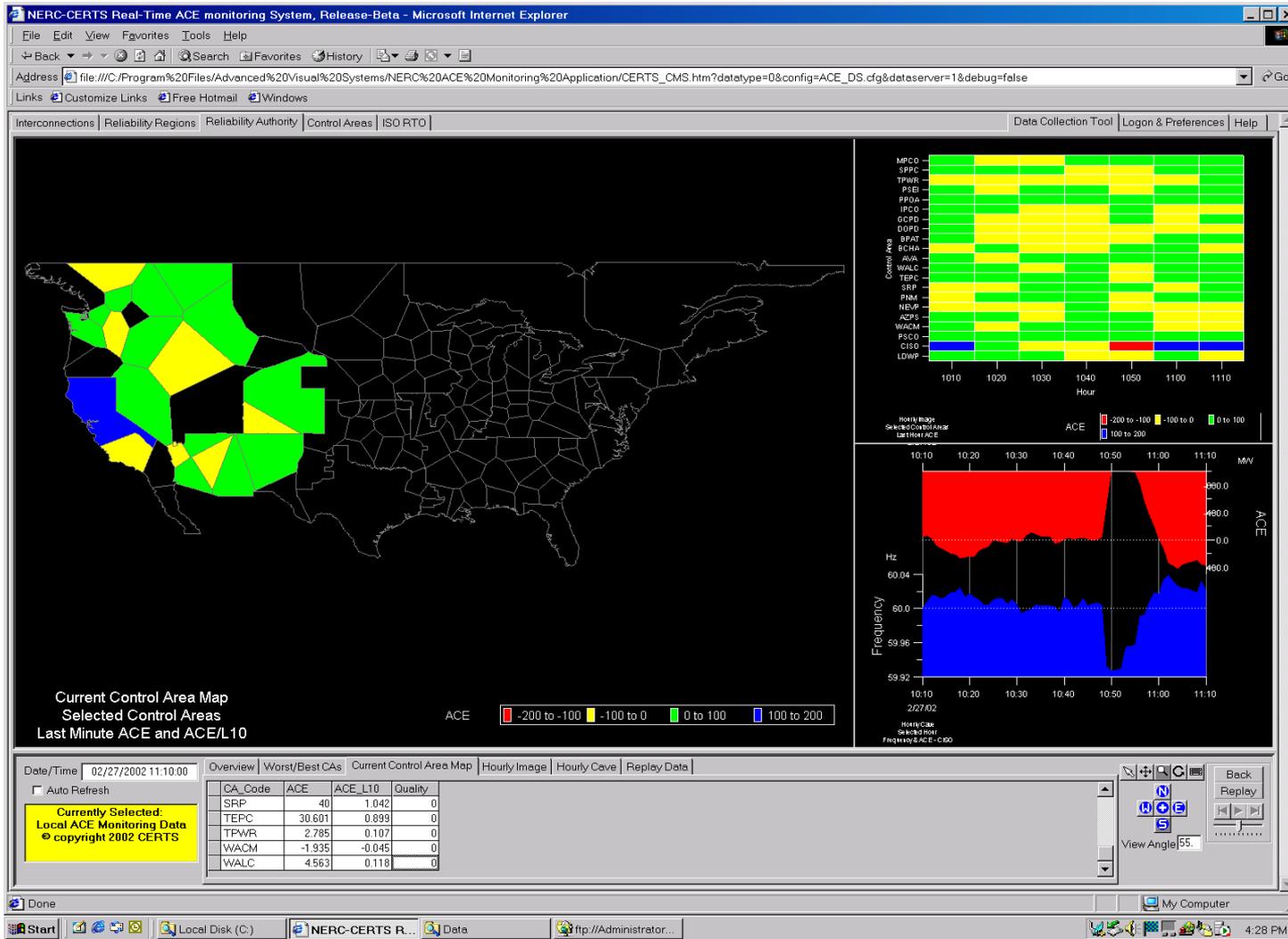


# System Dynamics Monitoring - Visualization Overview

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# Wide-Area, Multi-View ACE-Frequency Real Time Monitoring System



**Snapshot of ACE for each of the West Coast control Areas for the last 6 ten-minute periods**



**Interconnection frequency vs. ACE from selected control area above**

# *The Problem - Too Much Data No Enough Operational Information*

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***Data are produced at all different levels***

***Wide-Area integrated information is required at new levels***

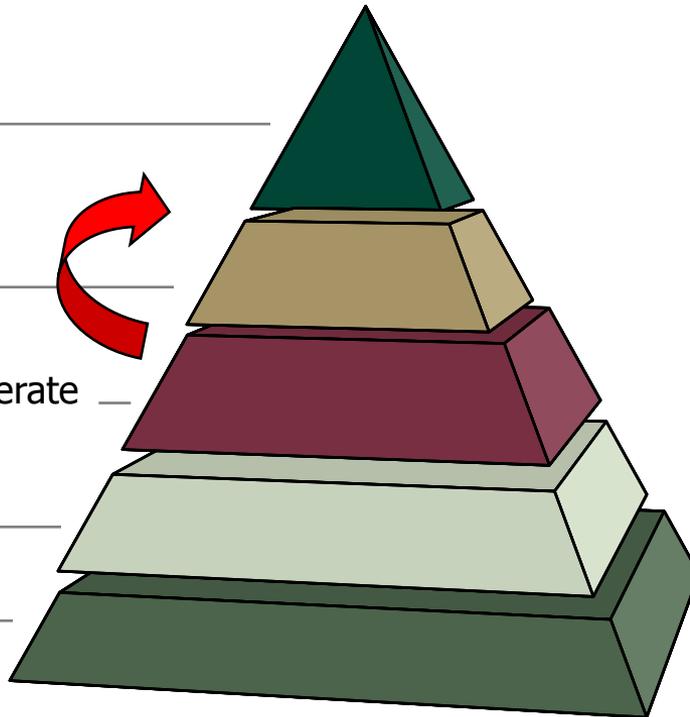
NERC Reliability Coordinators –  
Reliability Management \_\_\_\_\_

ISOs/RTOs/IMO – Markets and  
Grid Management \_\_\_\_\_

Transmission Companies – Own and Operate \_\_\_\_\_

Distribution Utilities \_\_\_\_\_

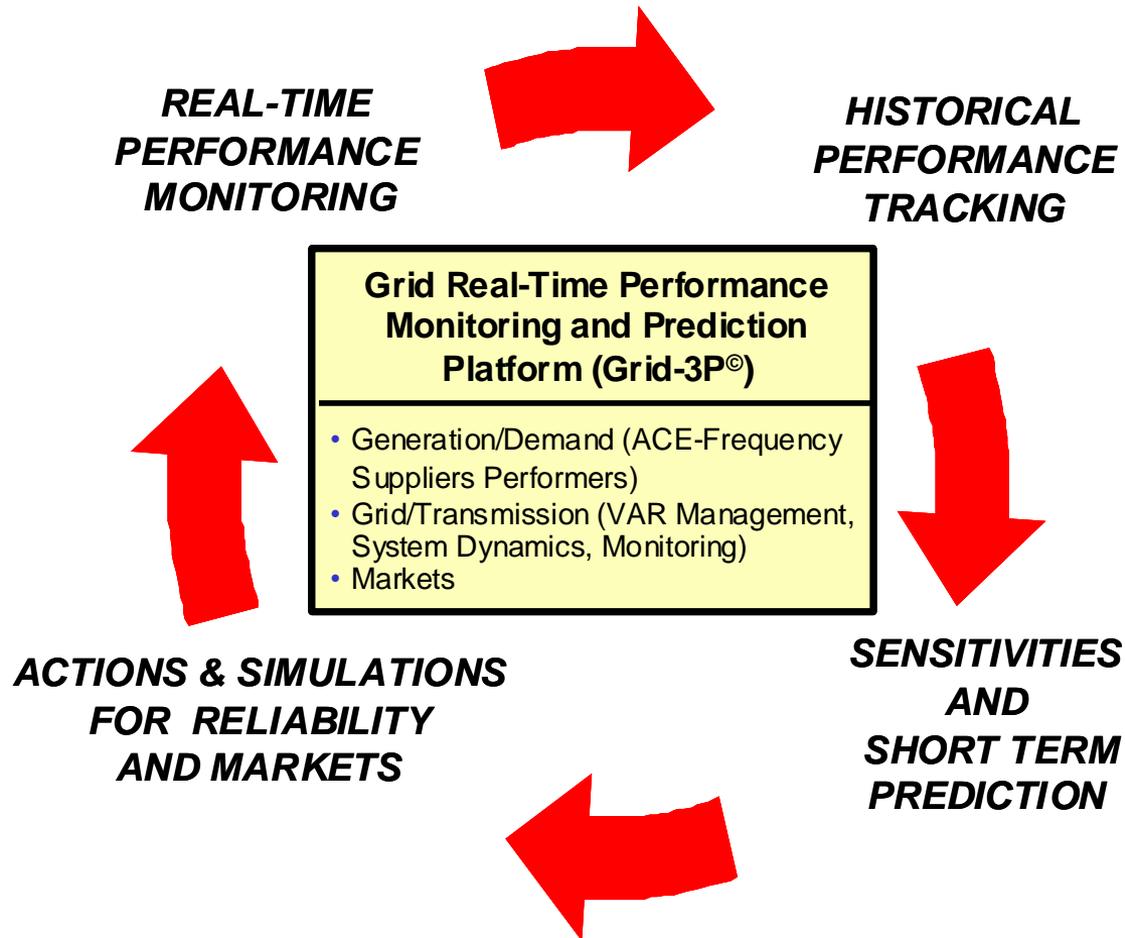
Generation Companies \_\_\_\_\_



- 10 NERC Reliability Regions
- 18 Reliability Coordinators
- 8 ISOs/RTOs/IMO Operating – Additional Planned
- 135 Control Areas

# Visual Information Wheel

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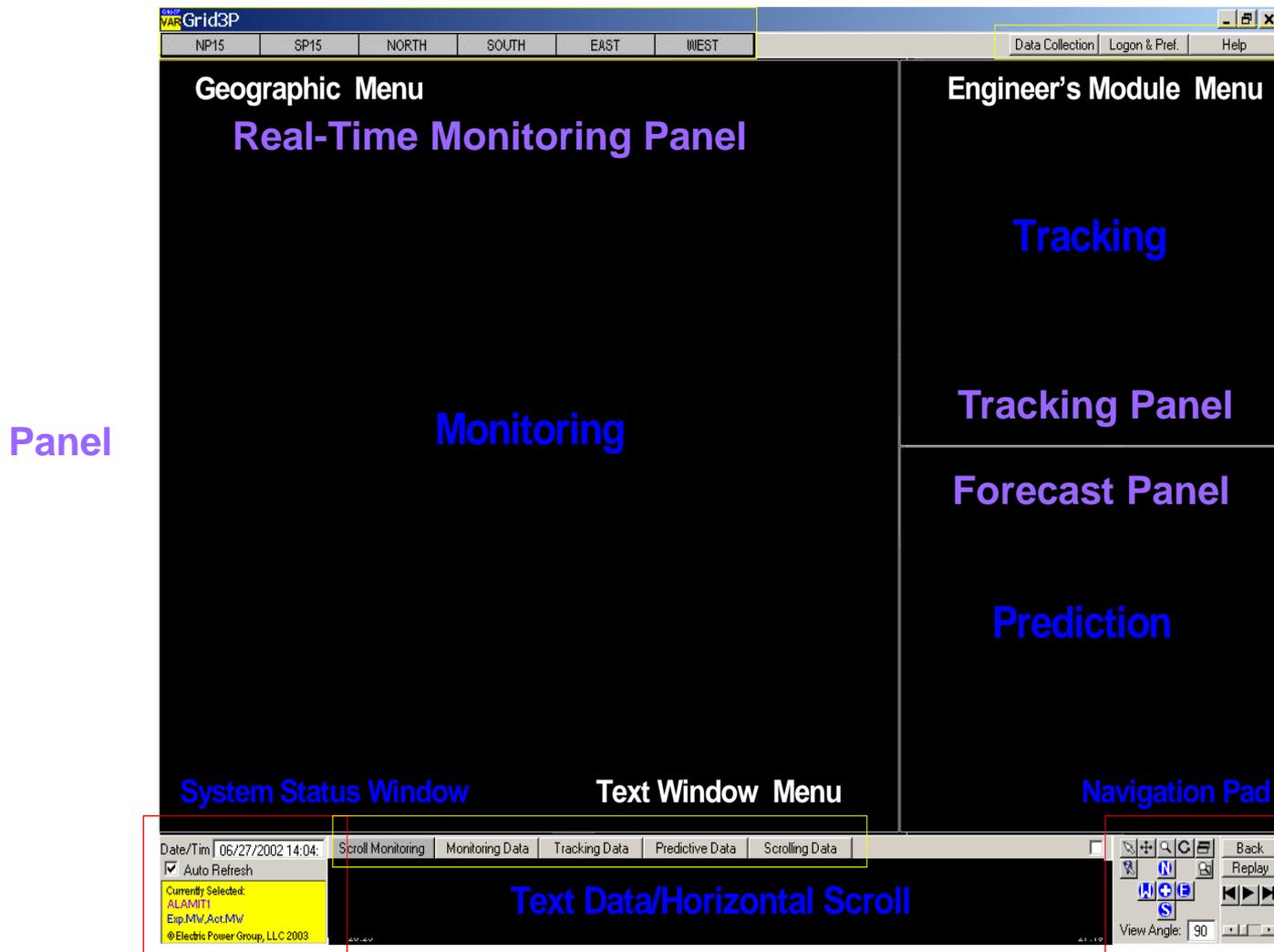
# Multi-View Visualization Design Criteria

<b>Design Rules</b>	<b>Objectives To Select The Multiple Views</b>
Diversity	<i>Use multiple views when there is a diversity of attributes, models, geographic jurisdictions and user profiles</i>
Complementarity	<i>Use multiple views when different views bring out correlations and/or disparities</i>
Decomposition	<i>Partition complex data into multiple views to create manageable chunks and to provide insight into the interaction among different dimensions</i>
Parsimony	<i>Use minimum view minimally</i>
	<b>Objectives For Presentation and Interaction</b>
Space/Time Resource Optimization	<i>Balance the spatial temporal costs of having multiple views with the spatial temporal benefits of using the views</i>
Self-Evidence	<i>Use perceptual cues to make relationships between multiple views more apparent to the user</i>
Consistency	<i>Make the interfaces and states of multiple views consistent</i>
Attention Management	<i>Use perceptual techniques to focus user's attention on the right view at the right time</i>

# Visualization Content Definition

Visual Content Views	<b>WHAT</b> is Happening	<b>WHY</b> it is Happening	<b>TREND</b> Future Near Term	<b>ACTION</b> <i>Corrective</i>
Real Time Monitoring (Now)	Abnormal Frequency Alarms	Control Areas Worst ACE	N/A	Control Area Dispatcher Communication
Historical Tracking (Most Recent)	10-Minute and 1-Hour Tracking	ACE-Frequency Correlation - Coplots	Forecast-Actual Comparison	Corrective Actions Archiving
Near Term Prediction (Next 1h-24h)	N/A	Near real time predictions for key parameters	Probabilistic Near Term Forecast	Pattern recognition approach - To be defined
Simulation and Replay	Automatic, Interactive Frequency Replay	Automatic, Interactive ACE-Frequency Replay	N/A	N/A

# CERTS Multiple-View Architecture



# *Next Steps*

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- System Dynamics monitoring
  - Definition of key WECC Paths
  - Definition of path and angle limits based on prior studies
  - Expansion the monitoring system to include SCE, PG&E and others
  - Enhancements to displays
  - PDC hardware support
  - Application software support
  - Use of WECC WAN – long term
  - Training (users guide and hands on)
    - Train the trainer or user?
- Voltage and VAR Monitoring
- Suppliers Performance