Real-Time Performance Monitoring Tools for Wide-Area Operations and Competitive Markets in the Electricity Industry

Control Center Issues

IEEE General Meeting 2003

Toronto, Ontario, Canada

July 17, 2003

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Outline

- Background – CERTS Goals and Research Roadmap
- Real Time Performance Management
  - Strategy
  - Hardware-Software-Communications Architectures
- User Interface Visualization
  - Multi-View
  - Geo-Graphic
- Real-Time Performance Monitoring Tools
  - ACE-Frequency Real Time Monitoring
  - Suppliers Performance for AGC and FR
  - VAR Management and System Dynamics Monitoring
- Development and Dissemination Experiences

Consortium for Electric Reliability Technology Solutions (CERTS)

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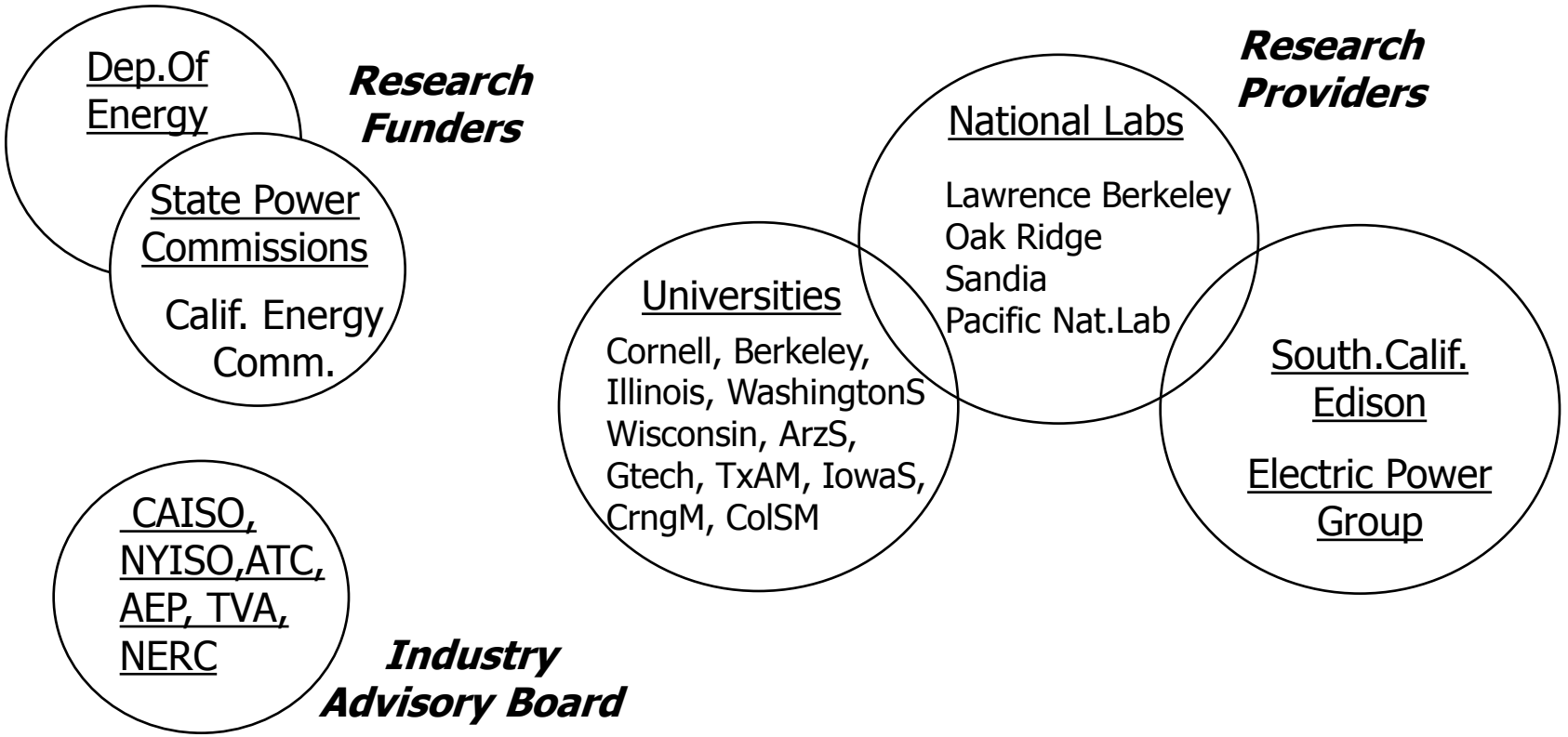
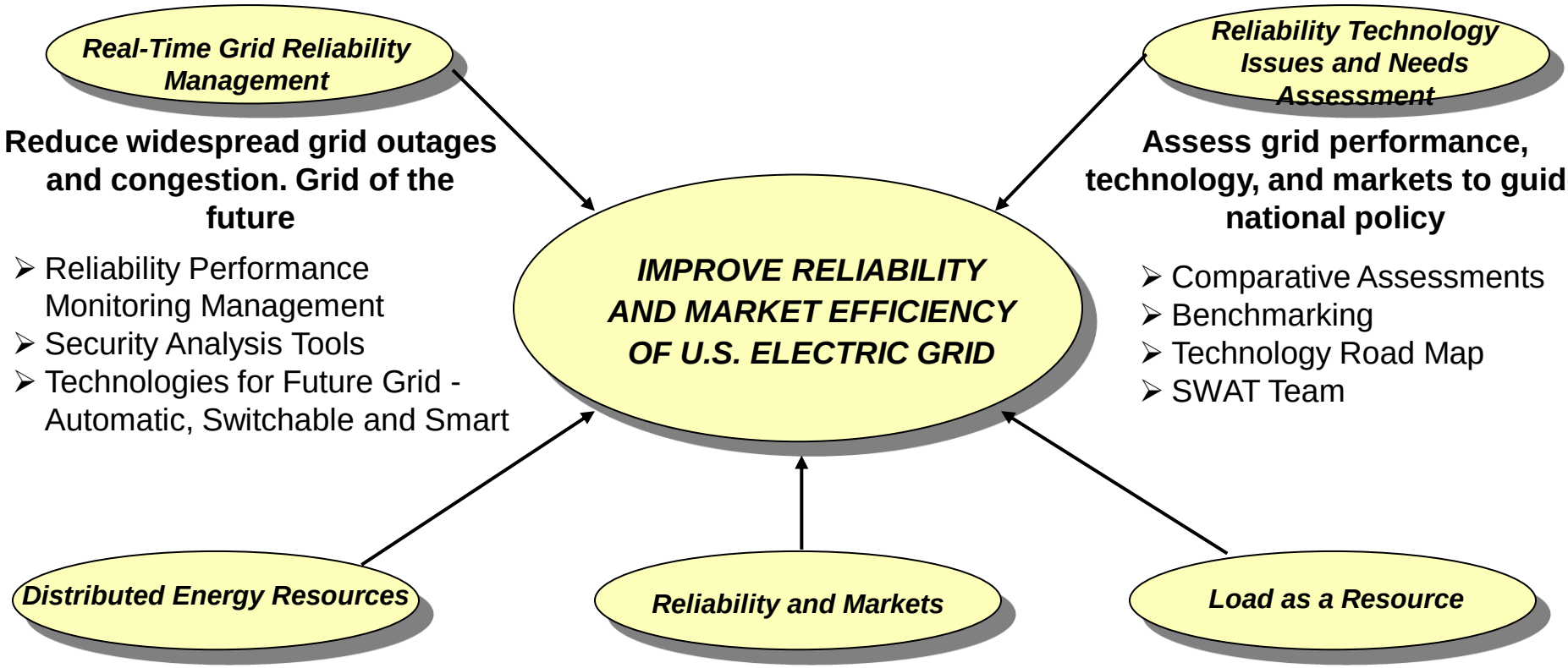
Conduct needed public interest research on reliability technology solutions, tools, models, systems, and management processes required in competitive electric markets for improving reliability and market efficiency of the U.S. electric grid



CERTS Major Research Areas



Reduce widespread grid outages and congestion. Grid of the future

- Reliability Performance Monitoring Management
- Security Analysis Tools
- Technologies for Future Grid - Automatic, Switchable and Smart

Assess grid performance, technology, and markets to guide national policy

- Comparative Assessments
- Benchmarking
- Technology Road Map
- SWAT Team

Integrate DER and improve customer and grid reliability

- Micro Grids
- Utility DER Integration
- Customer DER

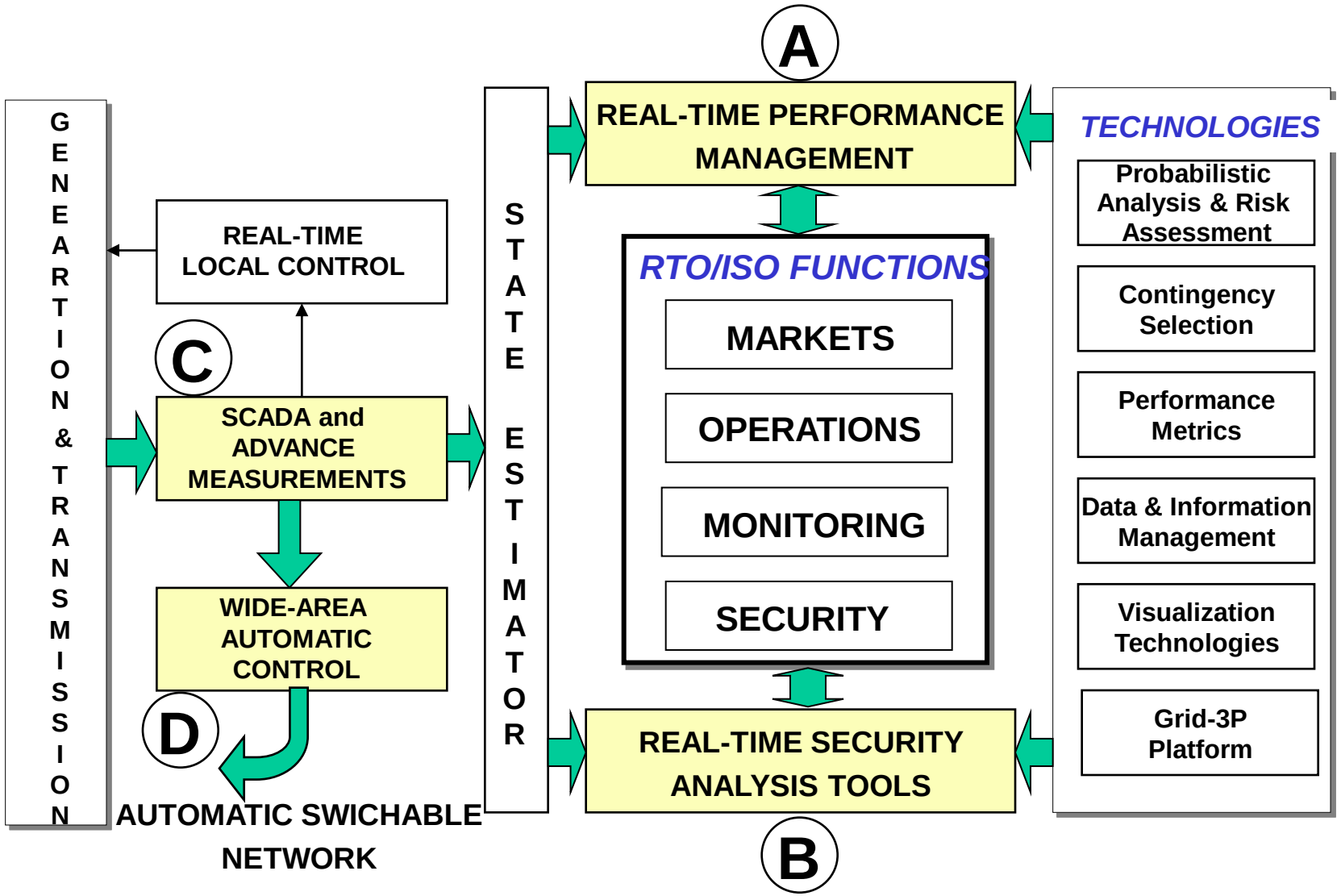
Improve Market Efficiency and Grid Reliability

- Test Market Designs
- Integrate With Market Monitoring and Controls
- Market Simulations

Integrate loads to respond to market price signals and grid reliability control

- Load Aggregation
- Pumping Load Control
- Integration With Grid Control

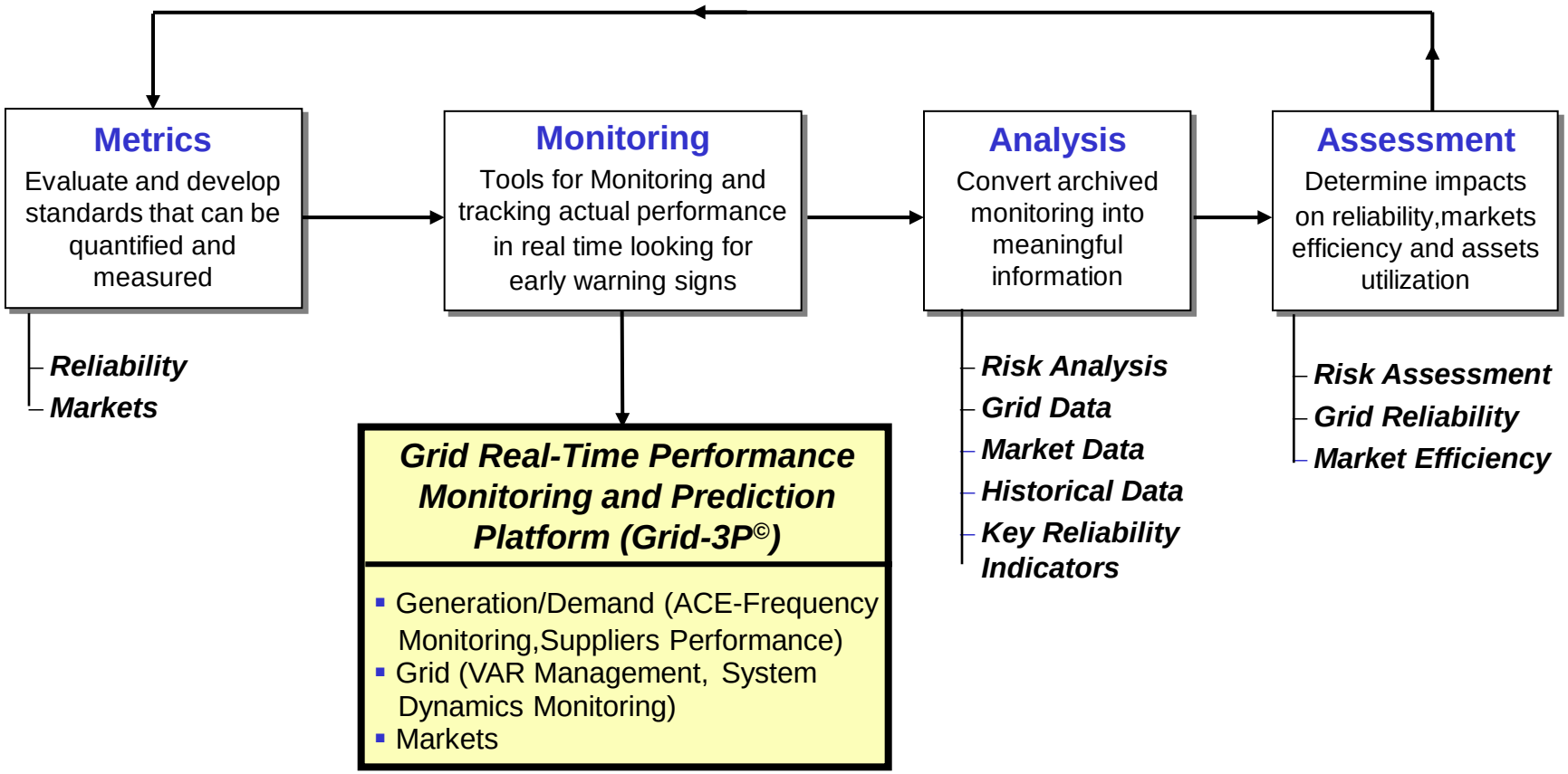
CERTS Grid Reliability Management Research Roadmap



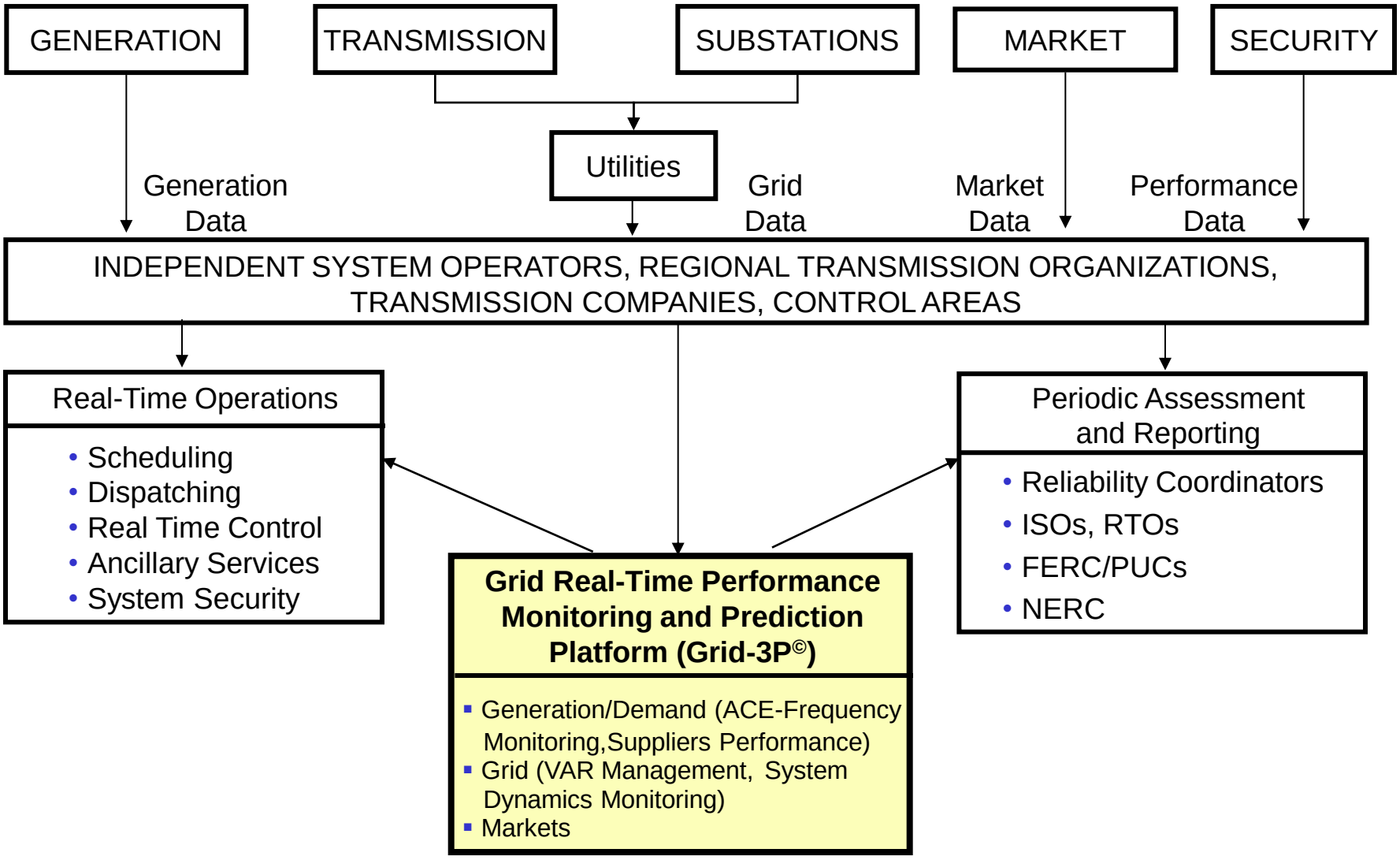
Performance Management Strategy and Real Time Performance Monitoring Tools

CERTS Performance Management Strategy

Real-Time Performance Management Process

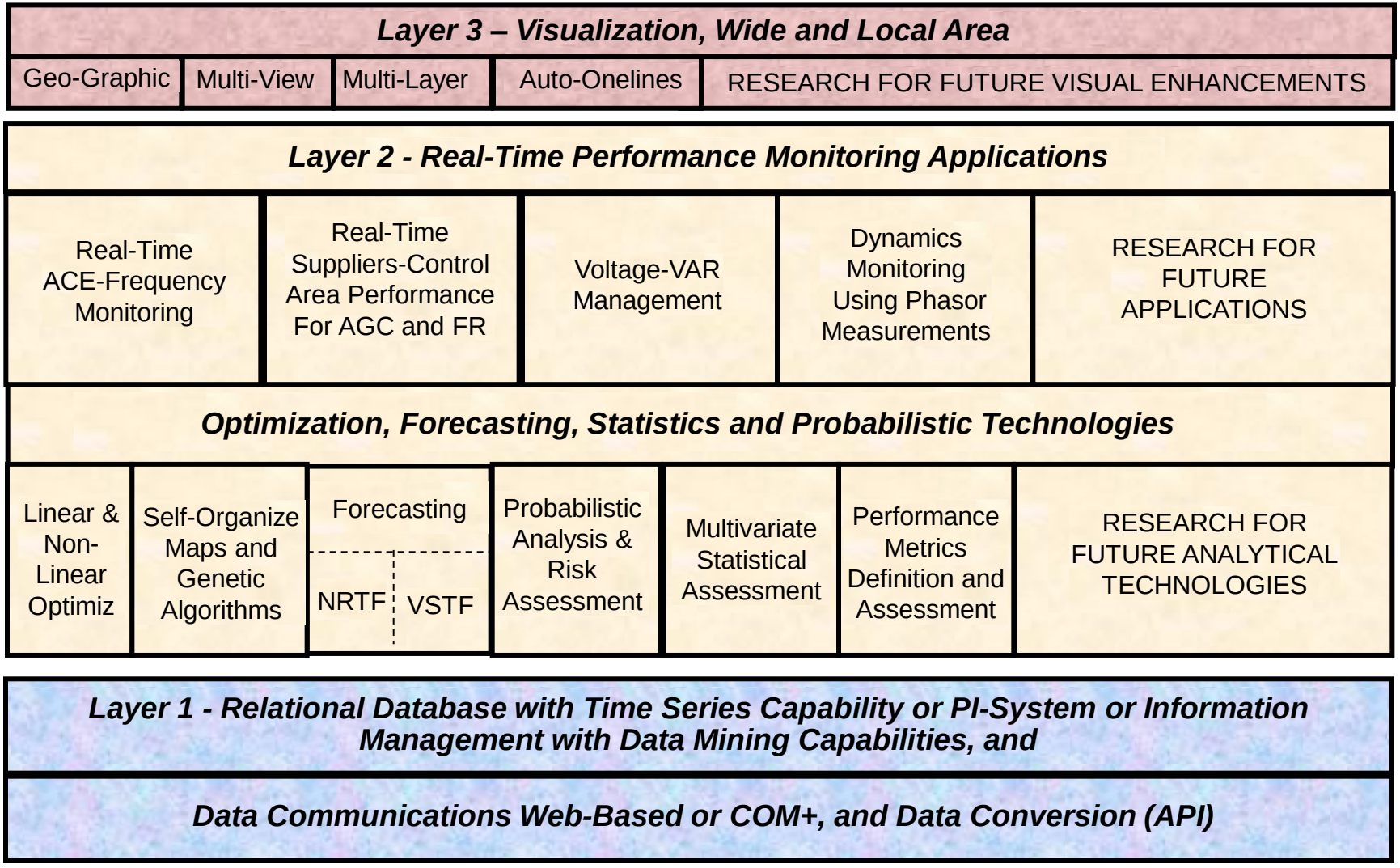


Real Time Performance Monitoring Tools Within Current Control Infrastructures

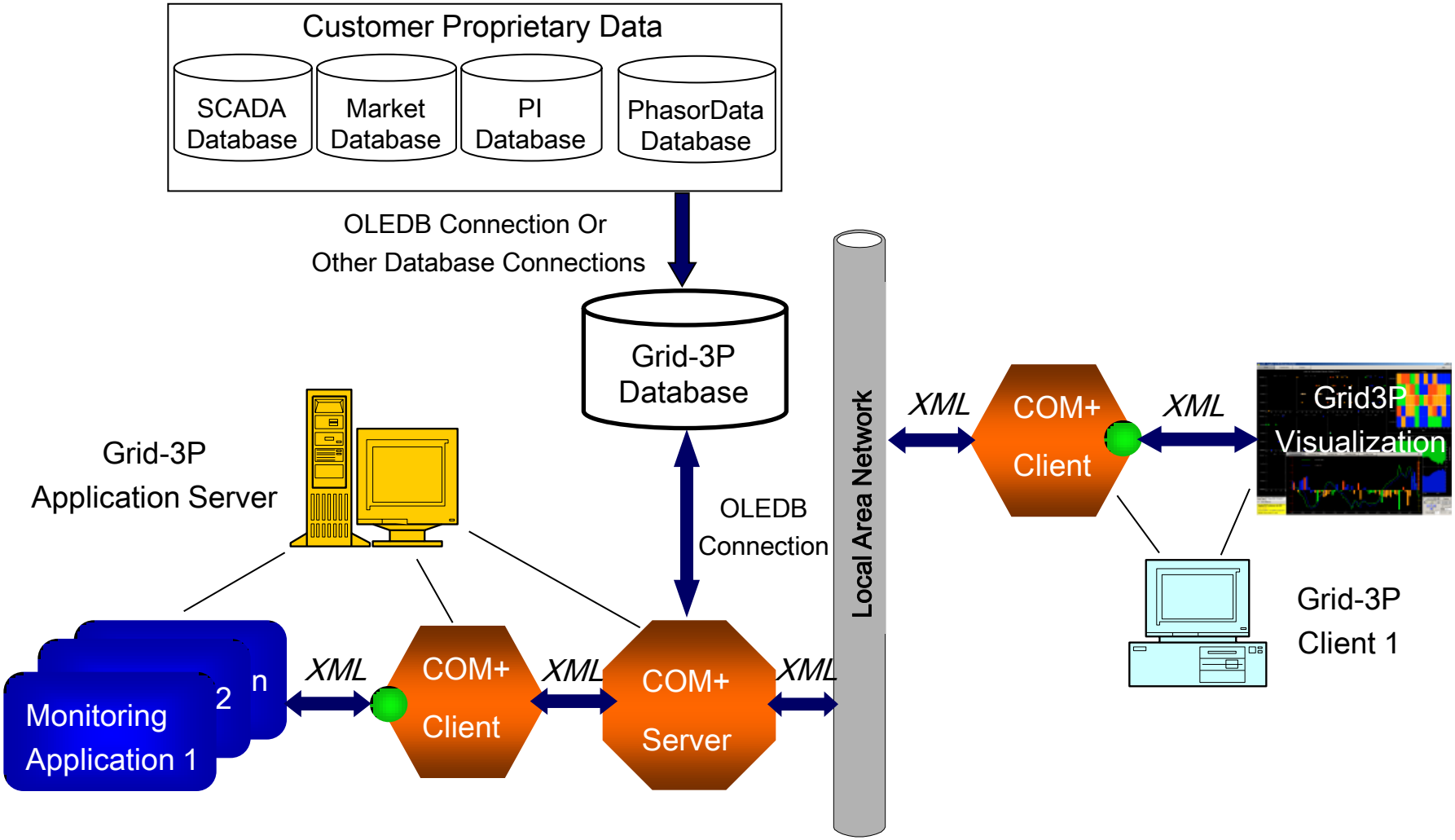


Performance Monitoring Tools Hardware, Software, Communication Architectures

Grid-3P – 3 Tier Architecture for Real Time Performance Monitoring Tools



Grid-3P Typical Data Flow



Performance Monitoring Tools
Multi-View, Geo-Graphic Visualization

CERTS Visualization Design Criteria

- Improve Operators' System Condition Knowledge
- Consider Human-Factors Requirements
- Applicable to Different Monitoring Applications
- Apply Appropriate Multi-View-Layer Design Criteria
- Minimize Support - Configuration Based
- Core System Functions and Libraries
- Pre-Defined Plotting Functions
- Adaptable Input Data Reader
- Extension by Implementing Add-in Functions

The Problem -Too Much Data Not Enough Operational Information

Data is produced at all different levels

Integrated information is required at new levels

NEW - Reliability Coordinators – Need to have a wide-area view of their jurisdictions

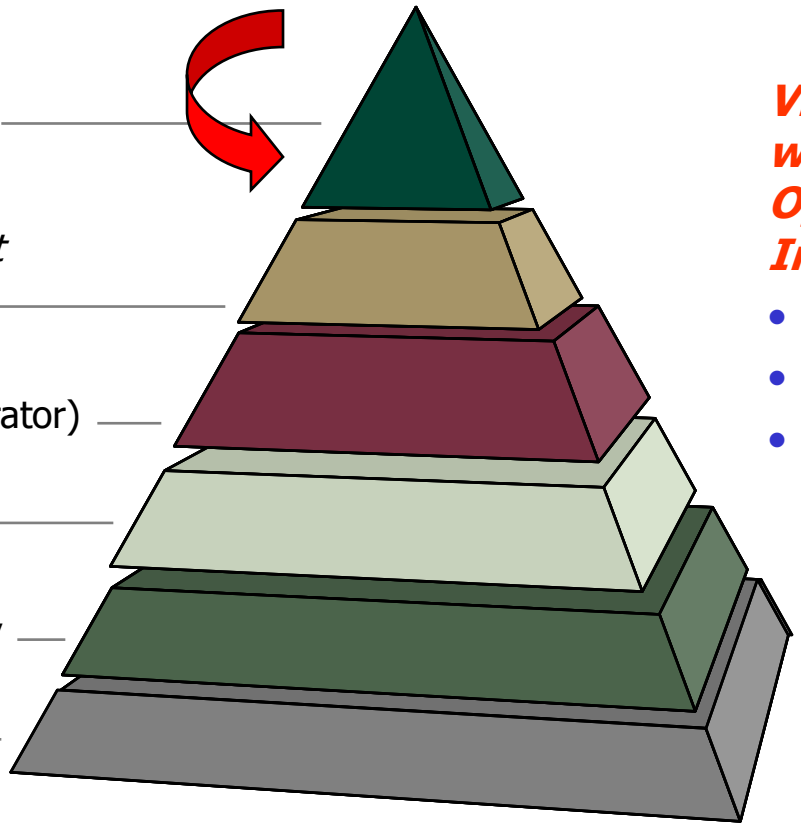
NEW- ISOs/RTOs - Need Assessment of Resources, Performance and Trends

Transmission Providers (Owner, Operator)

Central Generation Suppliers

Distributed Generation Serving Entity

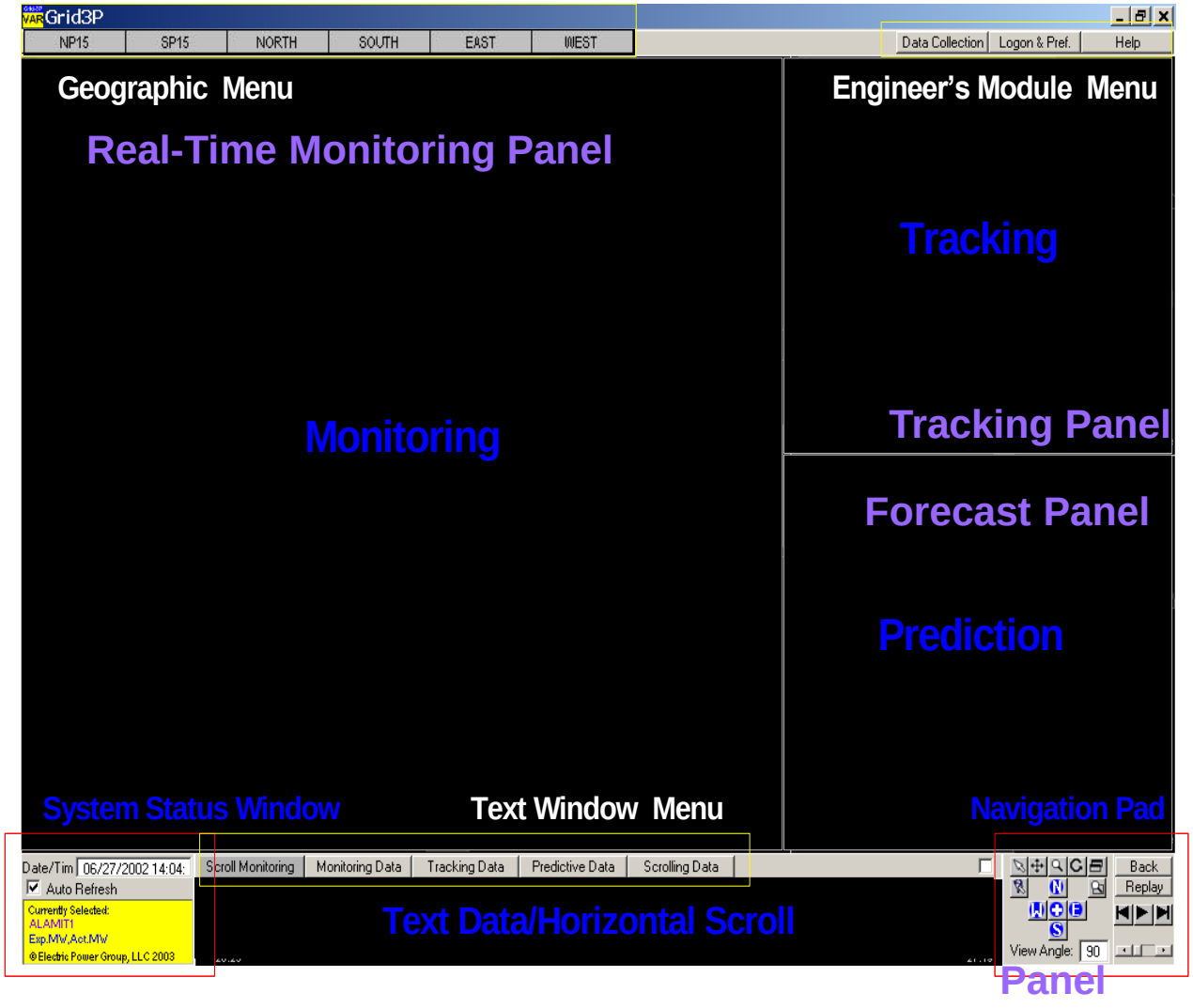
Load Serving Entity



Visualization with Adequate Operational Information:

- ***Simple***
- ***Meaningful***
- ***Intuitive***

CERTS Multiple-View Visualization Architecture

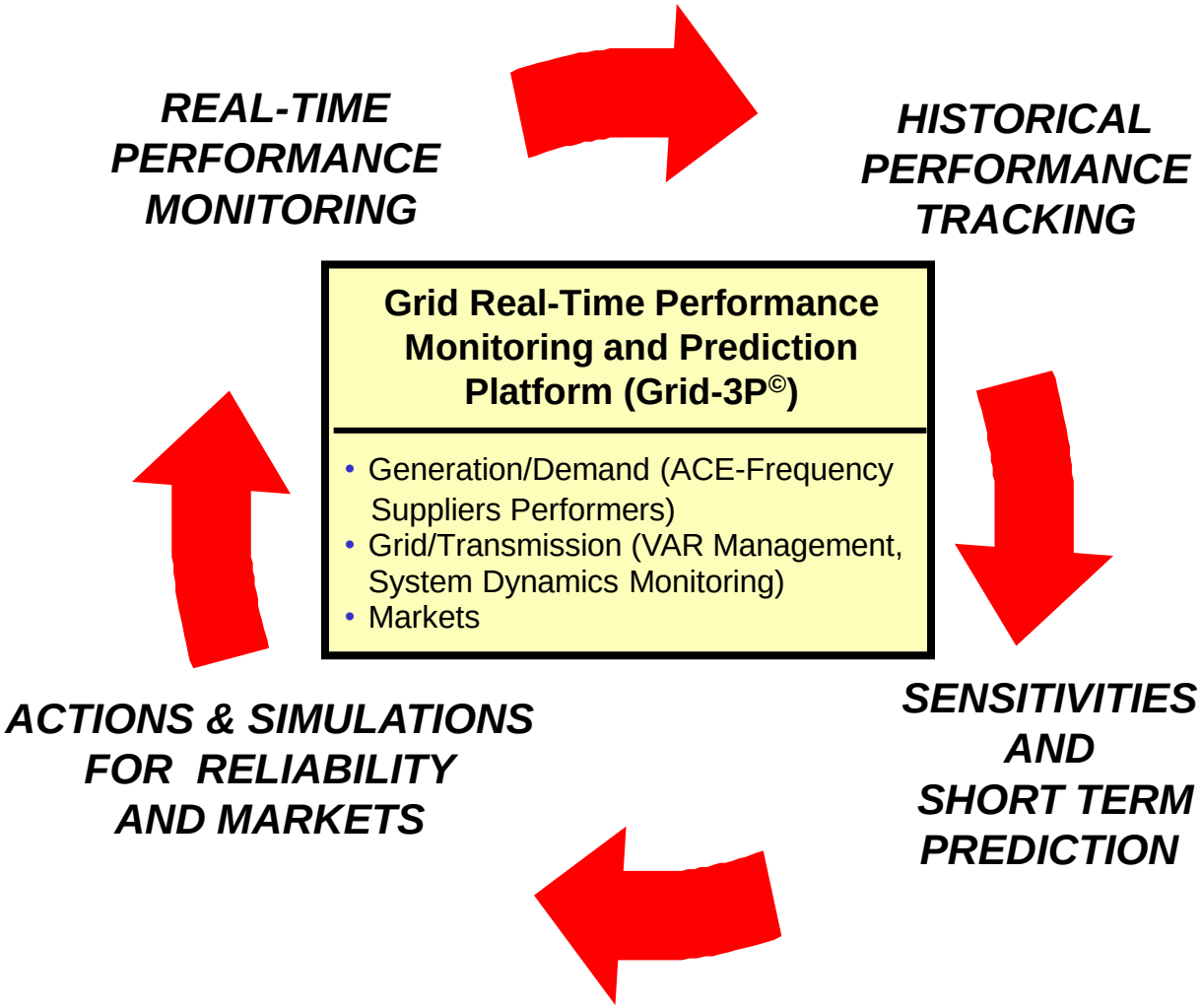


CERTS Visualization Content Definition

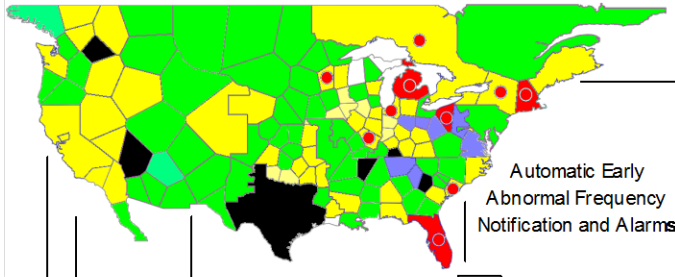
Visual Content / Visual Horizon	***WHAT*** is Happening	***WHY*** it is Happening	***TREND*** Future Near Term	***ACTION*** *Corrective*
Real Time Monitoring (Now)	Abnormal Frequency Alarms	Control Areas Worst ACE	N/A	Control Area Dispatcher Communication
Historical Tracking (Most Recent)	10-Minute and 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

Real Time Performance Monitoring Applications

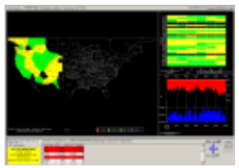
Grid-3P Applications and Major Functions



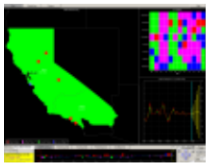
Interconnection ACE-Frequency and Suppliers Real-Time Performance Monitoring



Automatic Early Abnormal Frequency Notification and Alarms



Multi-View , Geo-Graphic
Reliability Coordinators Client (22)
For Real-Time Monitoring of Abnormal Interconnection Frequency and For Root Cause Identification



Multi-View , Geo-Graphic
Control-Area Dispatchers Client
For Real-Time Monitoring of Suppliers Performance for AGC and FR

A
- ACE-Frequency Data Collection
- Data Validation
- Data Processing

123 CONTROL AREAS SEND 1-MINUTE DATA THROUGH SECURE NERC-NET

NERC Database Server

NERC Secure Ethernet (Princeton)

B
- Abnormal Frequency Notification
- Frequency Alarms

ACE-AIE KEY DATA BROADCAST OVER WEB TO RELIABILITY COORDINATORS EVERY MINUTE

NERC Web Server

C
- Real-Time Monitoring and Tracking
- Root Cause Identification

D
- Data Acquisition - Suppliers

CONTROL AREA/ISO/RTO SECURE MONITORING AND CONTROL WIDE-AREA NETWORK

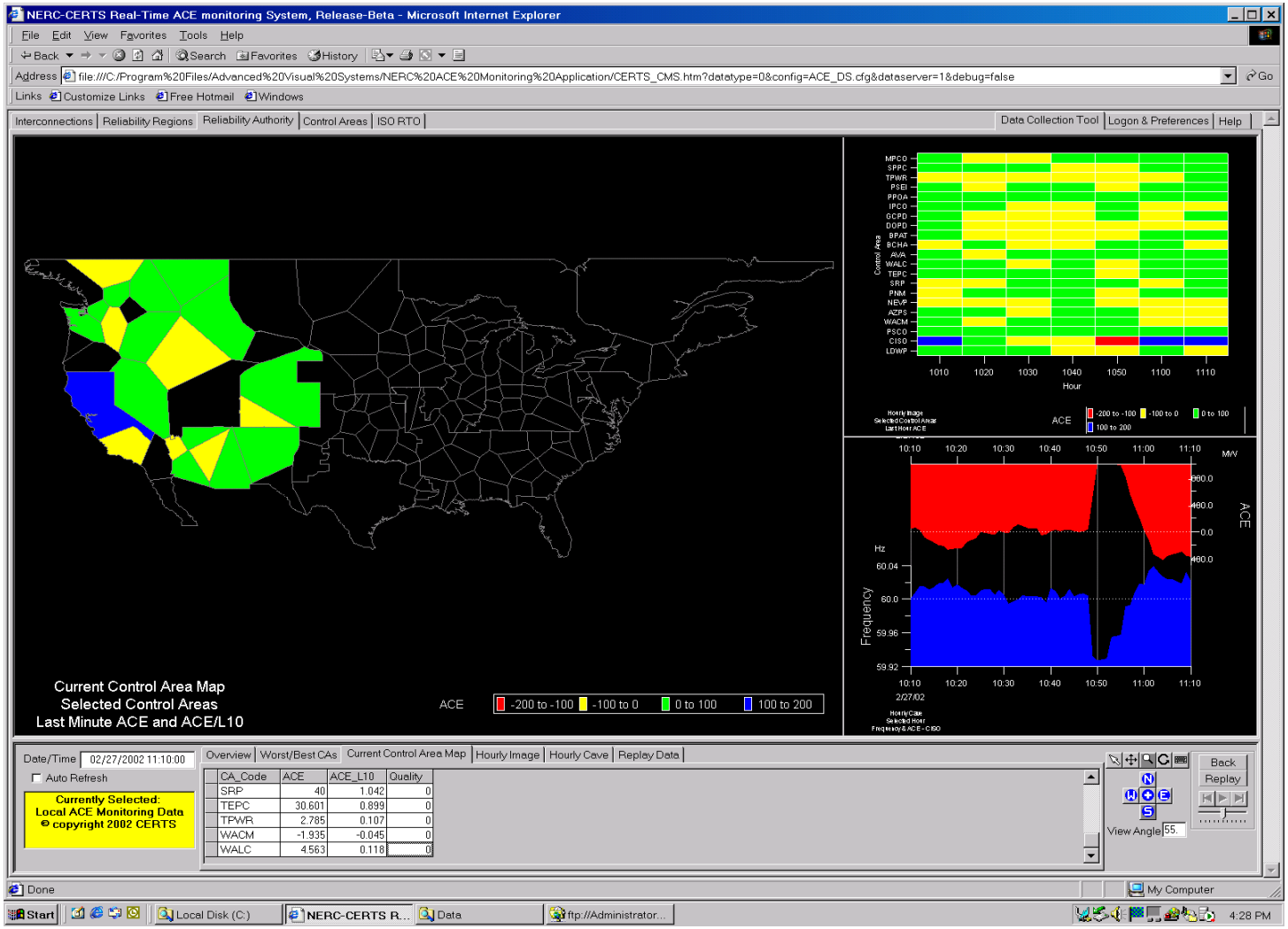
Secure Monitoring and Control Local Area Network

SCADA, EMS or Information System

Real-Time Suppliers Monitoring Server

E
- Suppliers Real-Time Monitoring
- Historical Tracking
- Near Real-Time Prediction
- Remedial Action

Reliability Coordinators ACE-Frequency Real Time Monitoring System



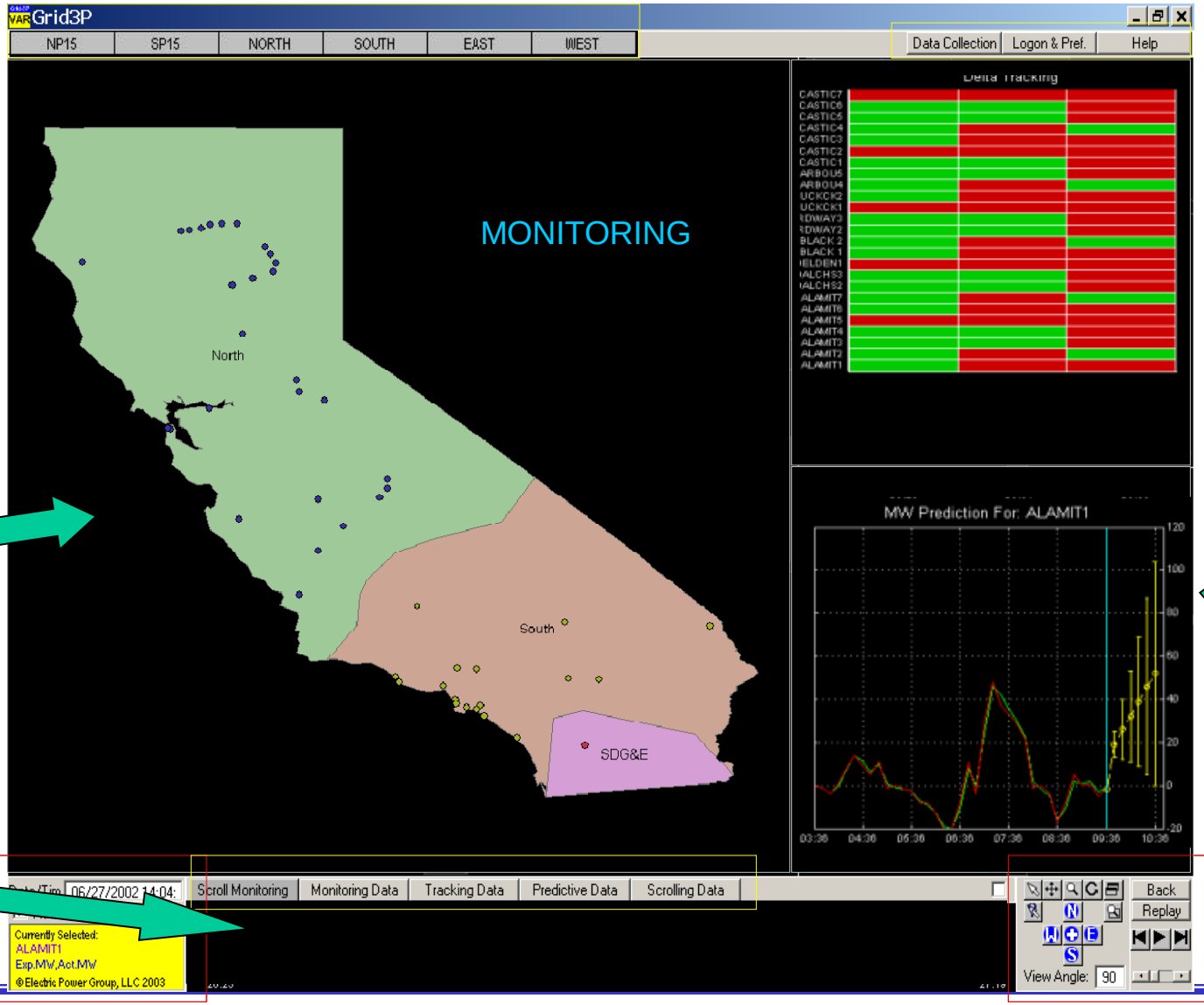
Snapshoot of ACE for each of the West Coast control Areas for the last 6 ten-minute periods

Interconnection frequency vs ACE from selected control area above

Grid-3P -- Supplier-Control Area Performance For AGC and Frequency Response Application

Performance Response By:
- **Portfolio**
- **Control Area**
- **Owner**
- **Resource Type**

Actions
- **Notifications**
- **Add Reserves**
- **Re-dispatch**



Historical Performance Tracking

Forecast Response for 1 to 2 Hours

Grid-3P VAR Management Application

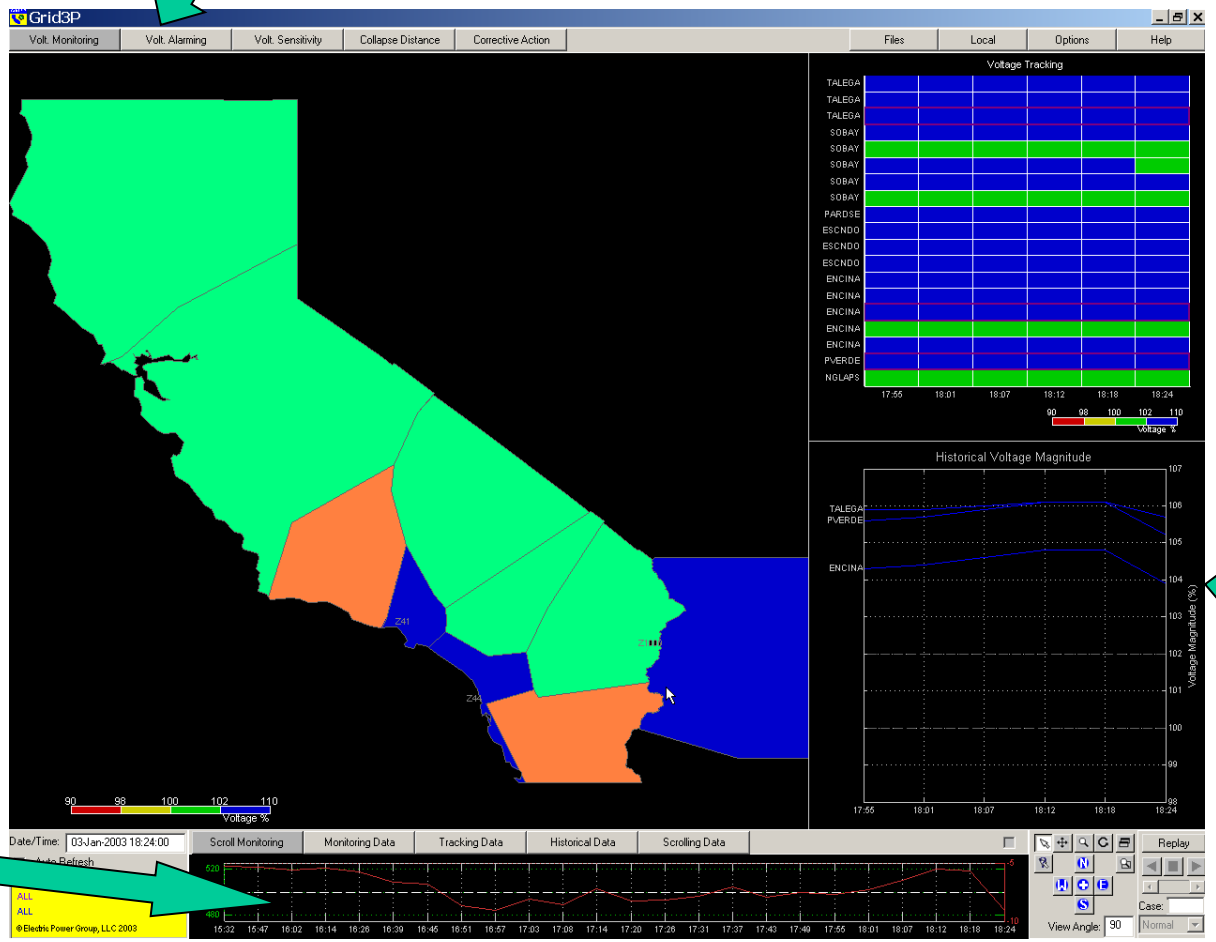
Jurisdiction Assessment: Voltage Sensitivity, Distance from Point of Collapse, Remedial Action

Color code Voltage Profiles by:

- **Control Area**
- **Congestion Path**
- **Zone**
- **Substation**

Remedial Actions

- **Generation VARs**
- **Capacitor Switching**



Historical Performance Tracking by:

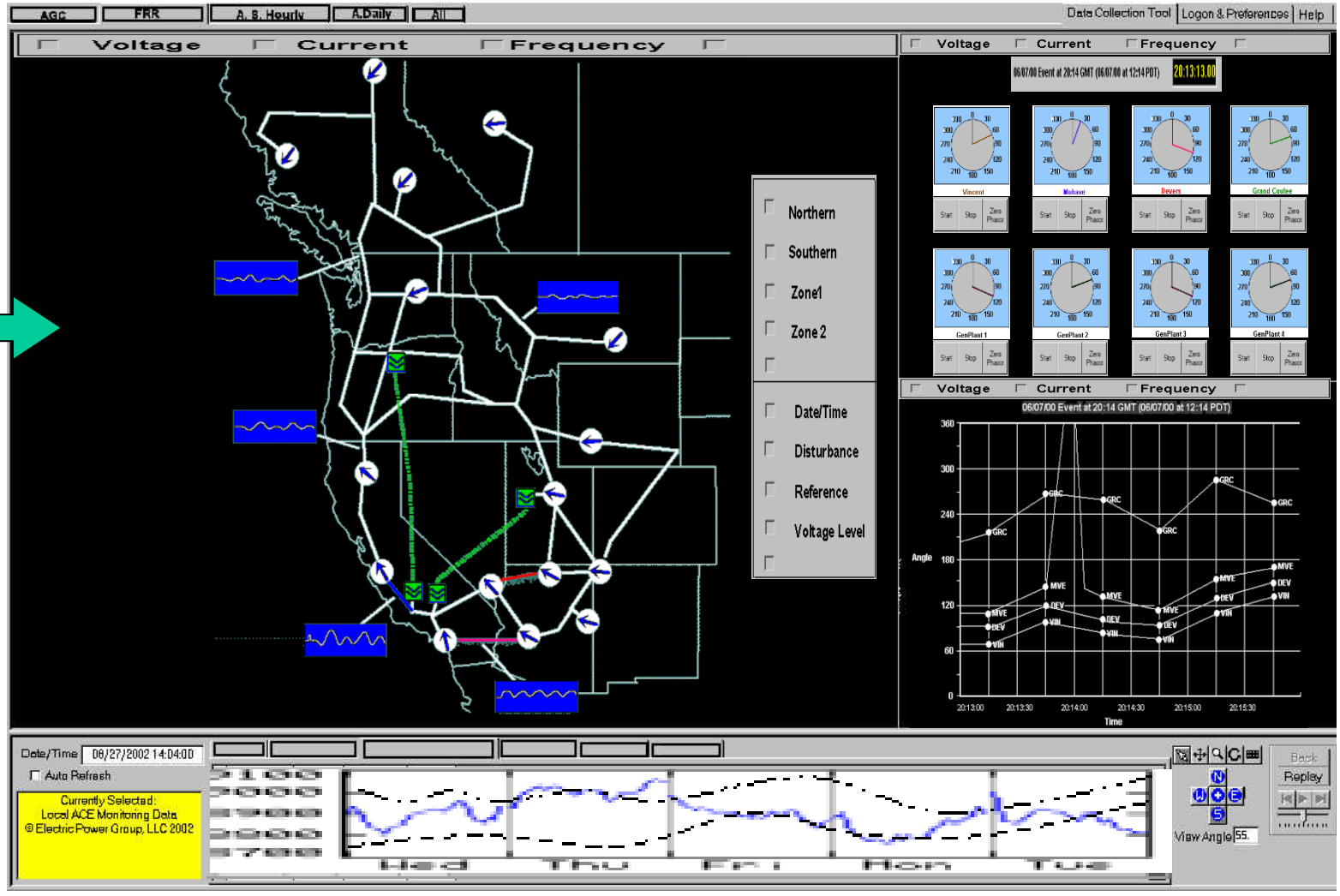
- **CongPath**
- **Substation**
- **Control Area**

Historical Voltage Pattern by:

- **CongPath**
- **Substation**
- **Control Area**

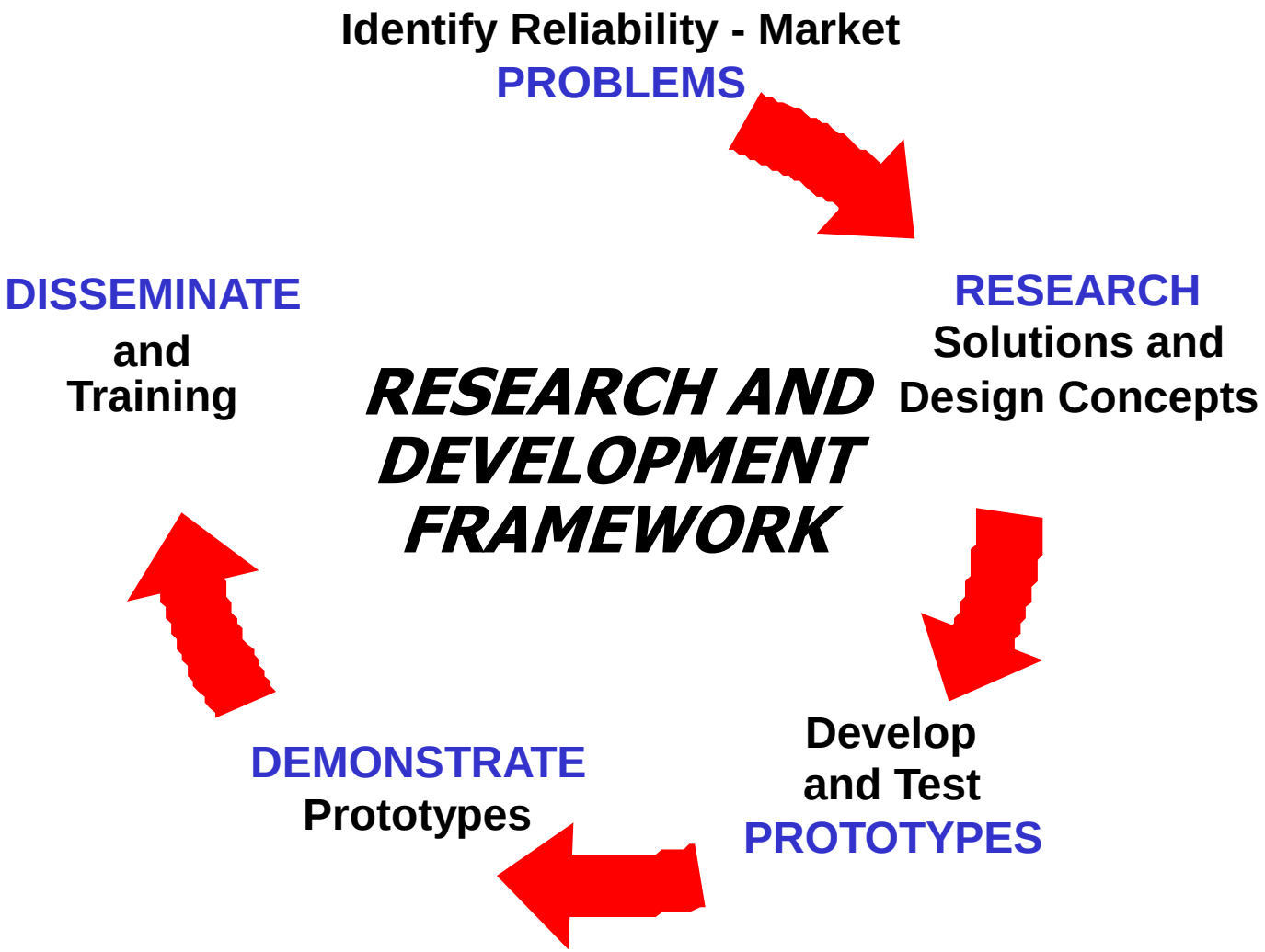
Grid-3P Real Time System Dynamics Monitoring

Real time monitoring and alarming of regional angle differences against predefined thresholds



Development and Dissemination Experiences

CERTS Research and Development Framework and Experiences



Real Time Performance Monitoring Applications

Summary and Future Work

Summary and Future Work

- Performance management strategies are required for maintaining and improving high reliability levels and markets efficiency
- Real time performance monitoring tools are key for effective implementation of performance management strategies
- New operational requirements and tools require new user interfaces based on multi-view and geo-graphic visualization
- Required performance monitoring tools can be effectively integrated into current control and operational environments
- Current real time performance monitoring hardware, software and visualization architectures can also be applied for real time markets monitoring and infrastructure security