# Building a Real-Time Event-Driven Enterprise Infrastructure

# 建立一个实时事件驱动的企业"信息化"平台基础

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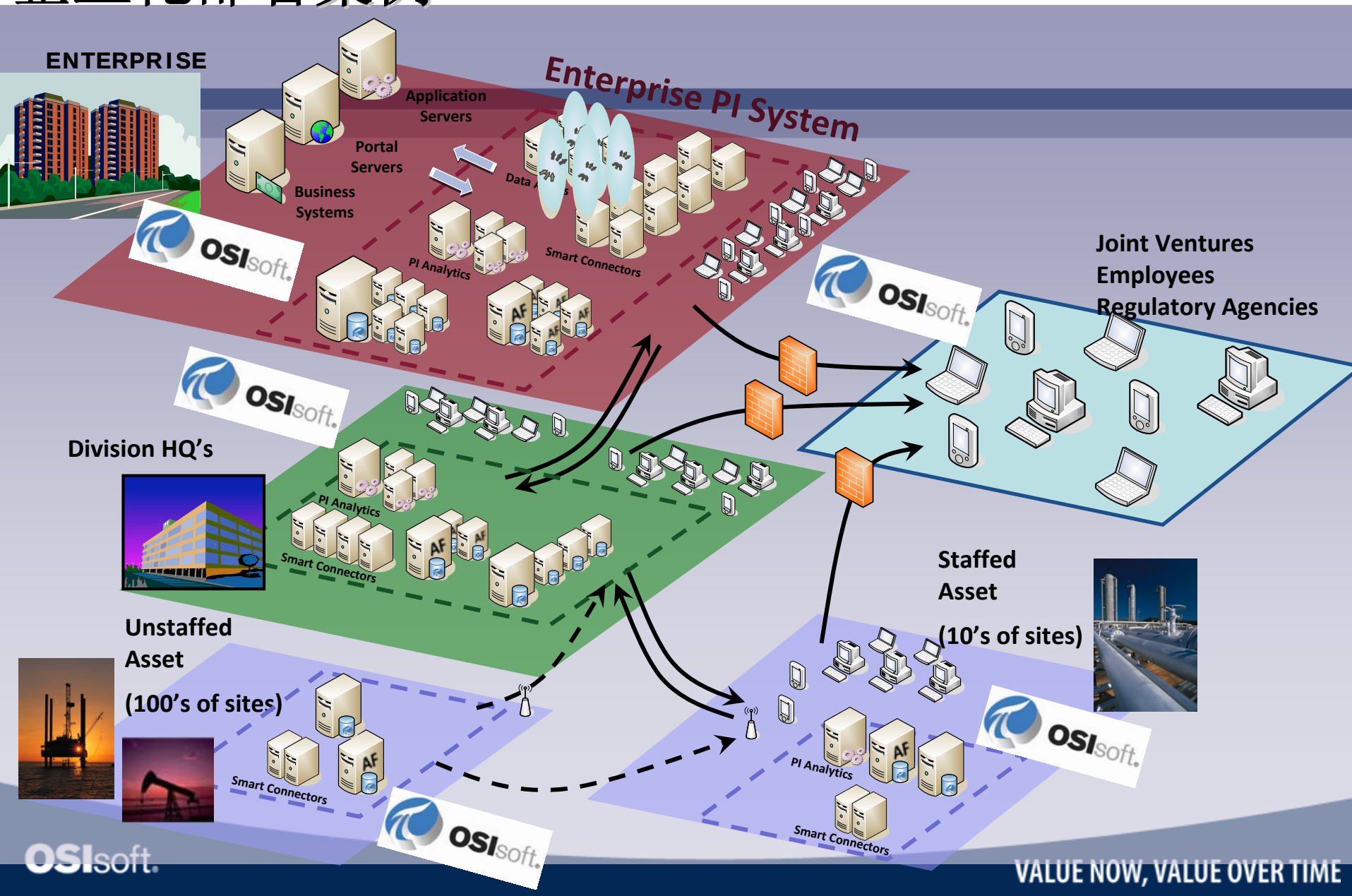
策略事务开发总监

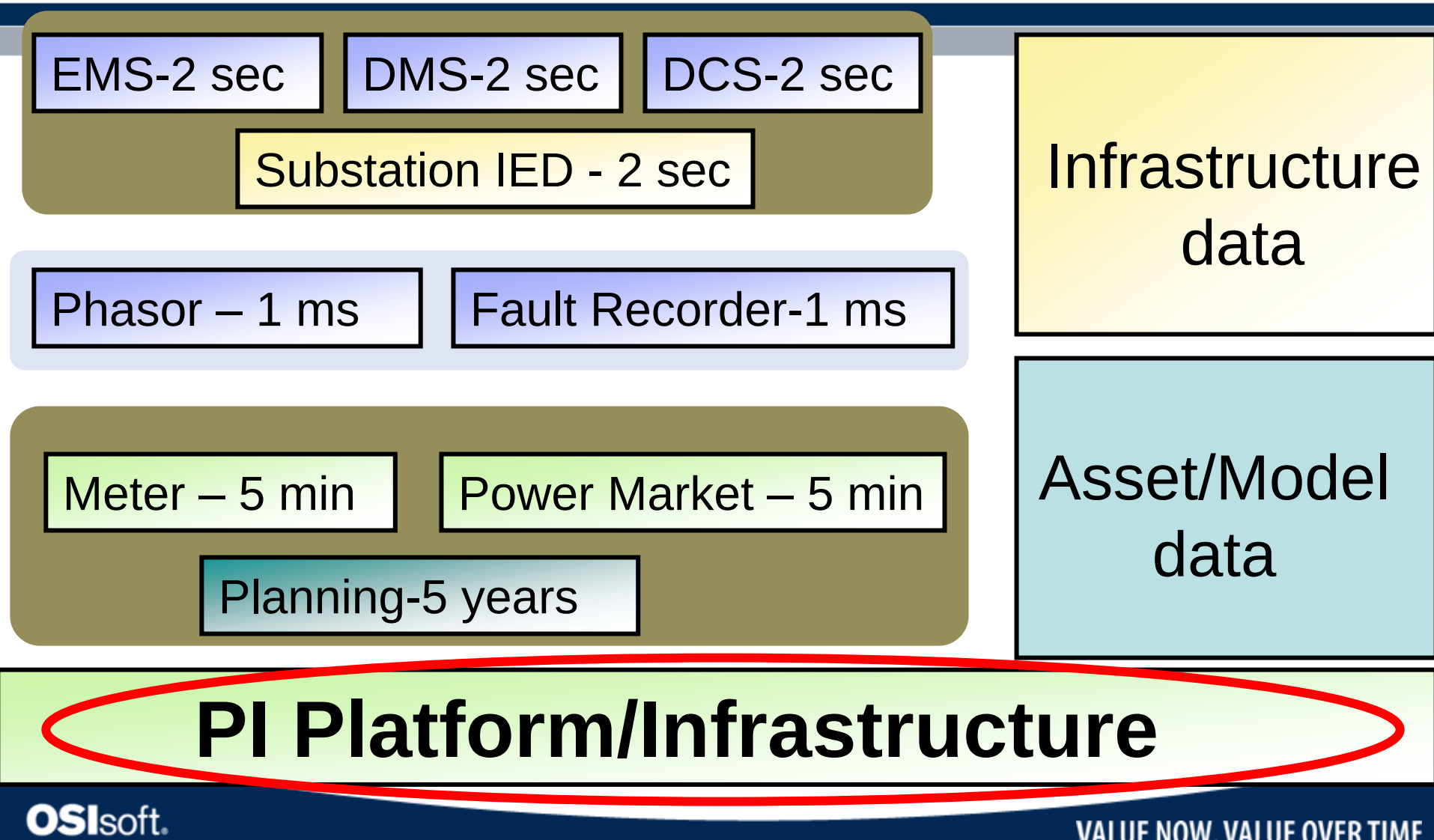
# Agenda 议程

- **PI for Enterprise Infrastructure**
  **(PI是企业"信息化"的平台基础)**
- **Utility Industry Use Cases (电力公司应用案例)**
  - **Operational Data (操作运行数据)**
  - **Non-Operational Data (非操作运行数据)**
  - **Asset/Model and Analytics (资产模型与分析)**
  - **Critical Infrastructure Monitoring**
    **(关键平台基础监视)**
- **Summary and Q&A (结语和问题与答疑)**

# Enterprise Deployment Example
# 企业化部署案例



# PI Centric Infrastructure
# 以PI为中心平台基础



# Proven Utility Industry Use Cases
# 经过证明的电力公司应用案例

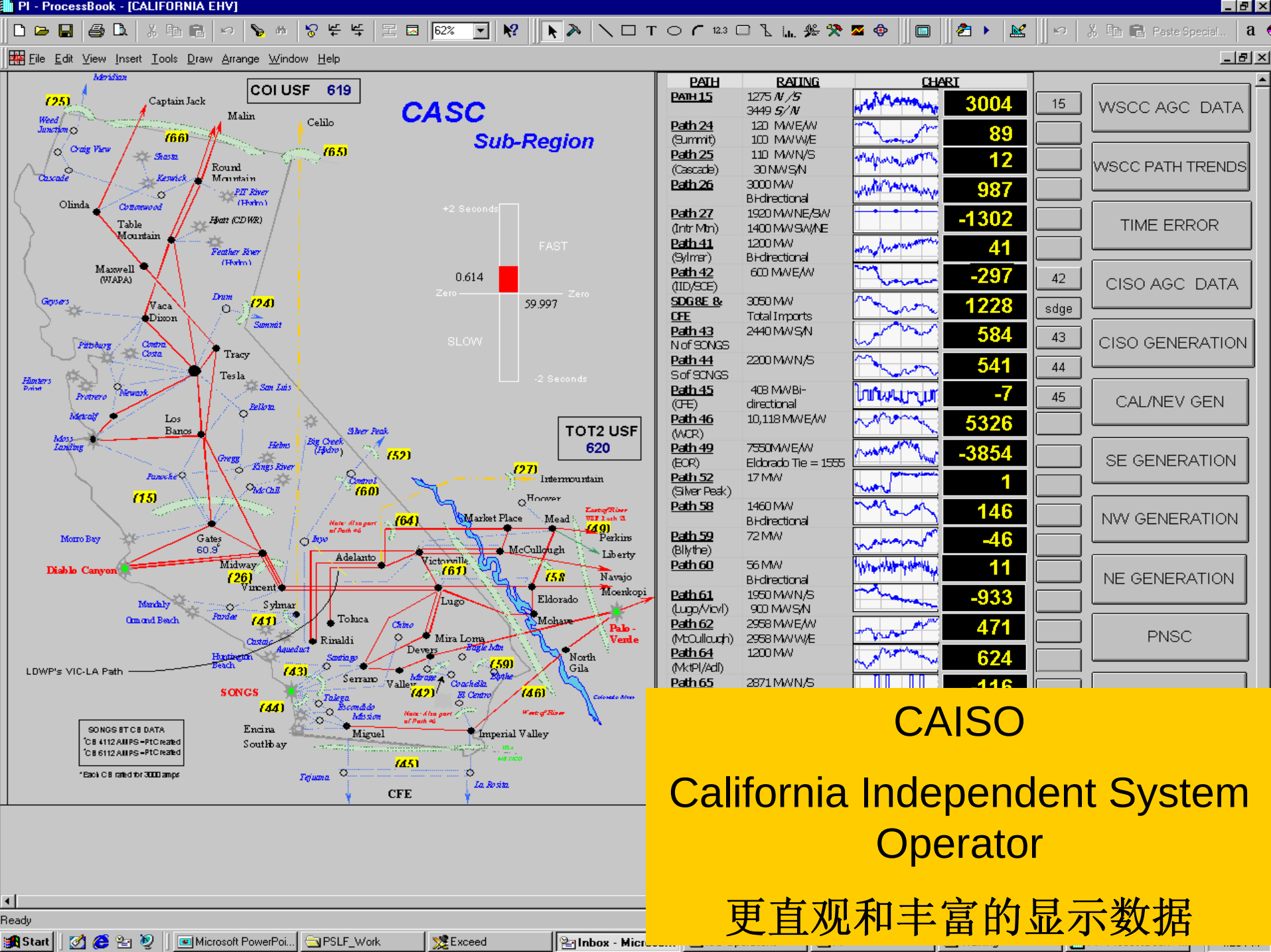
- **Operational**: EMS/DMS/DCS/SCADA data monitoring, archiving, event reporting and analysis
  **(操作运行:监视,存储,事件报告与分析)**
- **Non-operational:** substation field device non-SCADA data monitoring and archiving
  **(非操作运行:子站设备装置数据监视与存储)**
- **Asset/Model 资产模型:** metadata management and analytics
- **Security/Infrastructure:** Critical Infrastructure Protection (CIP) and monitoring **(安全/平台基础:保护与监视)**
- **Enterprise:** integration, correlation and repository
  **(企业信息化:整合相关资源数据集中库)**

# Utility Use Cases

# 应用案例

# PI for Operational Data

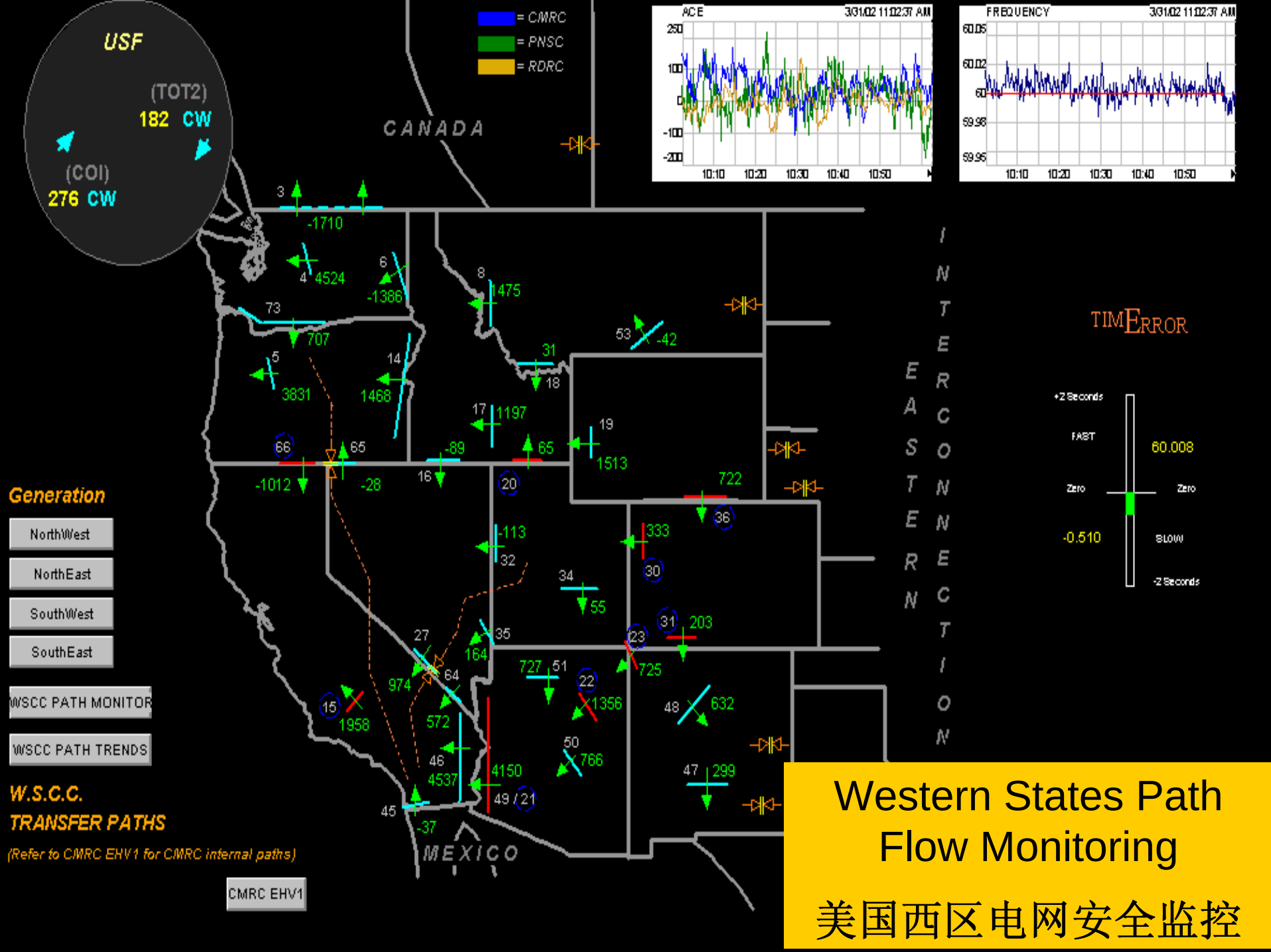
# 操作运行数据




CAISO

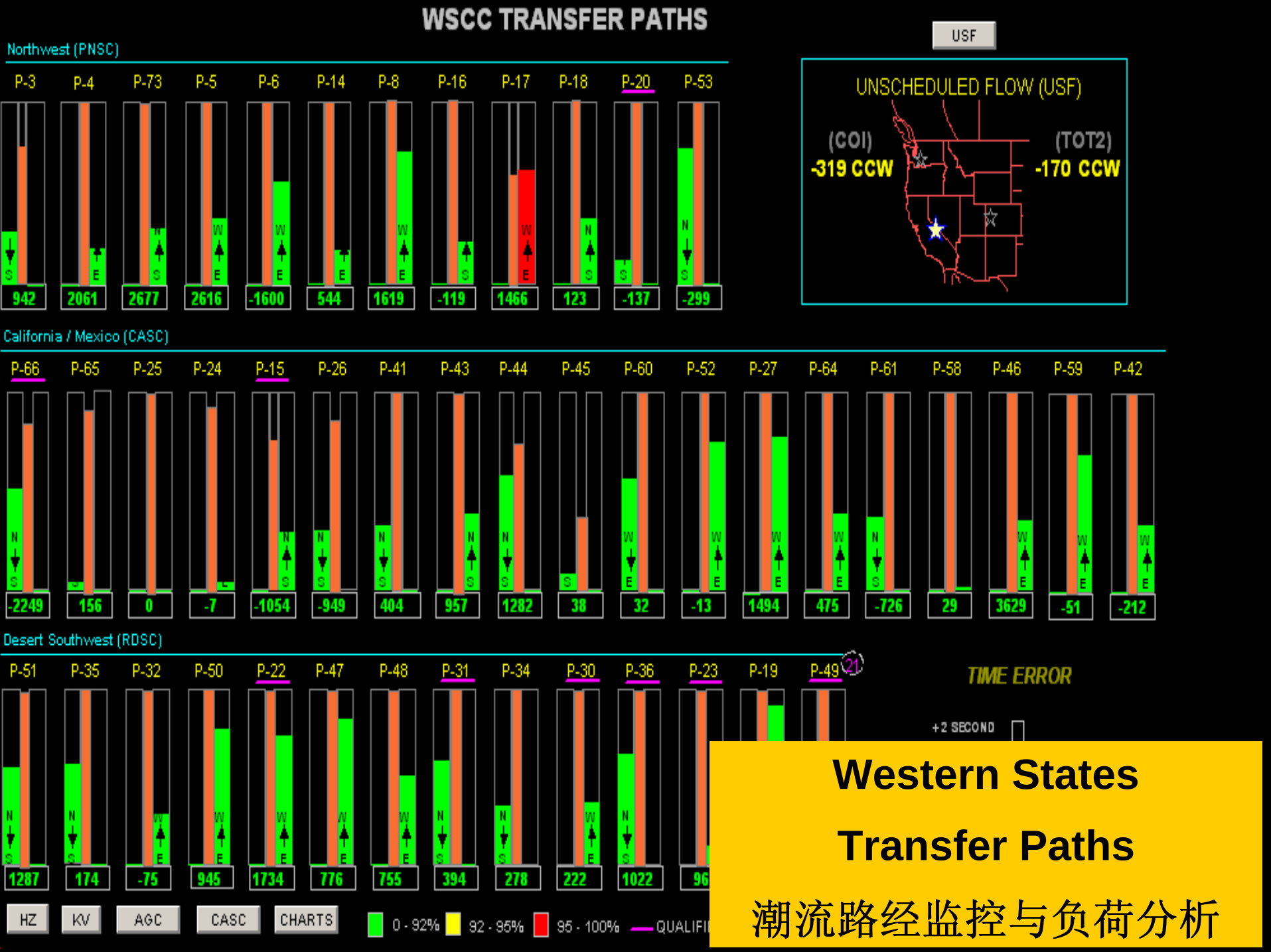
California Independent System Operator

更直观和丰富的显示数据



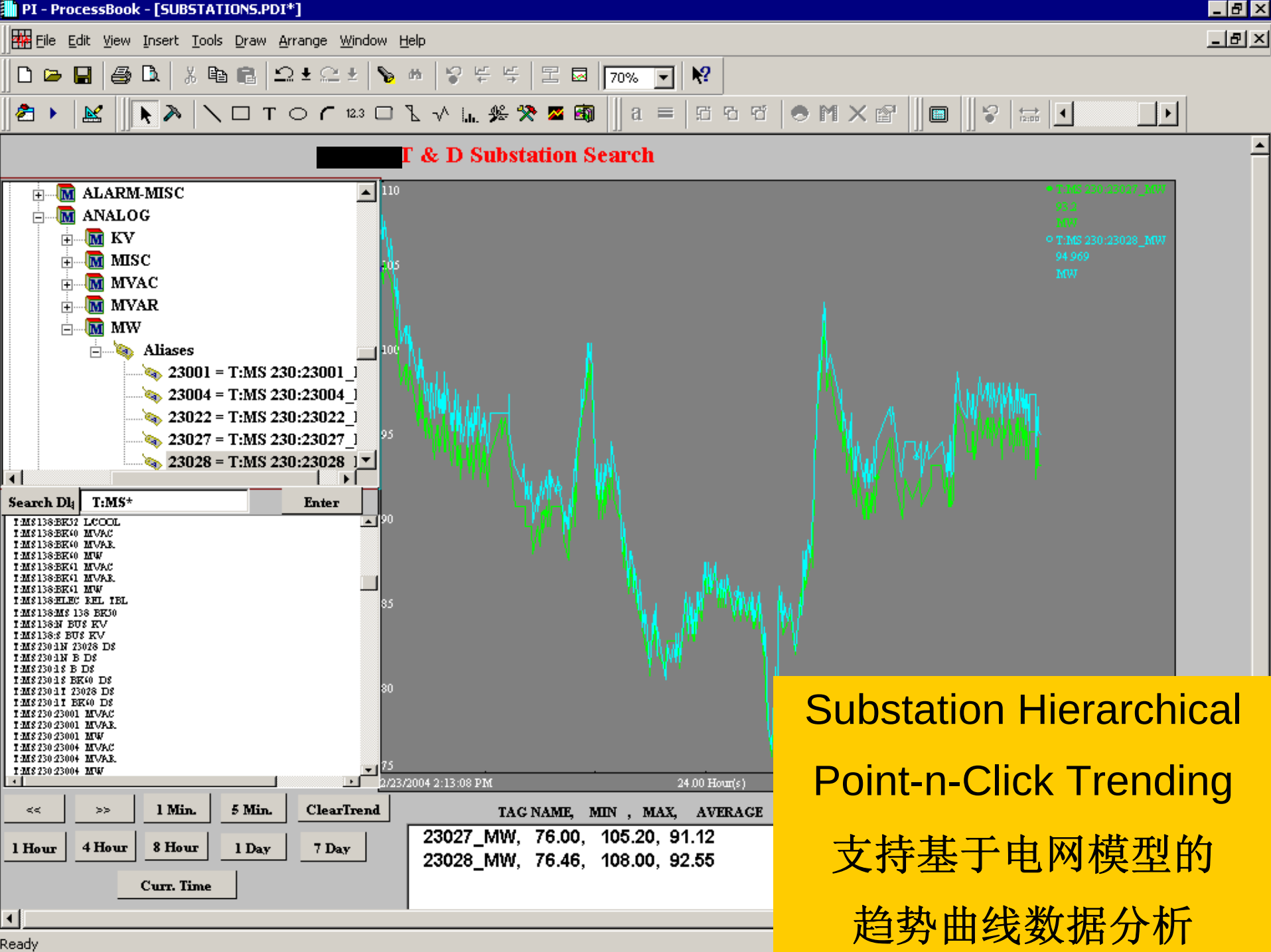

# Western States Path Flow Monitoring

# 美国西区电网安全监控



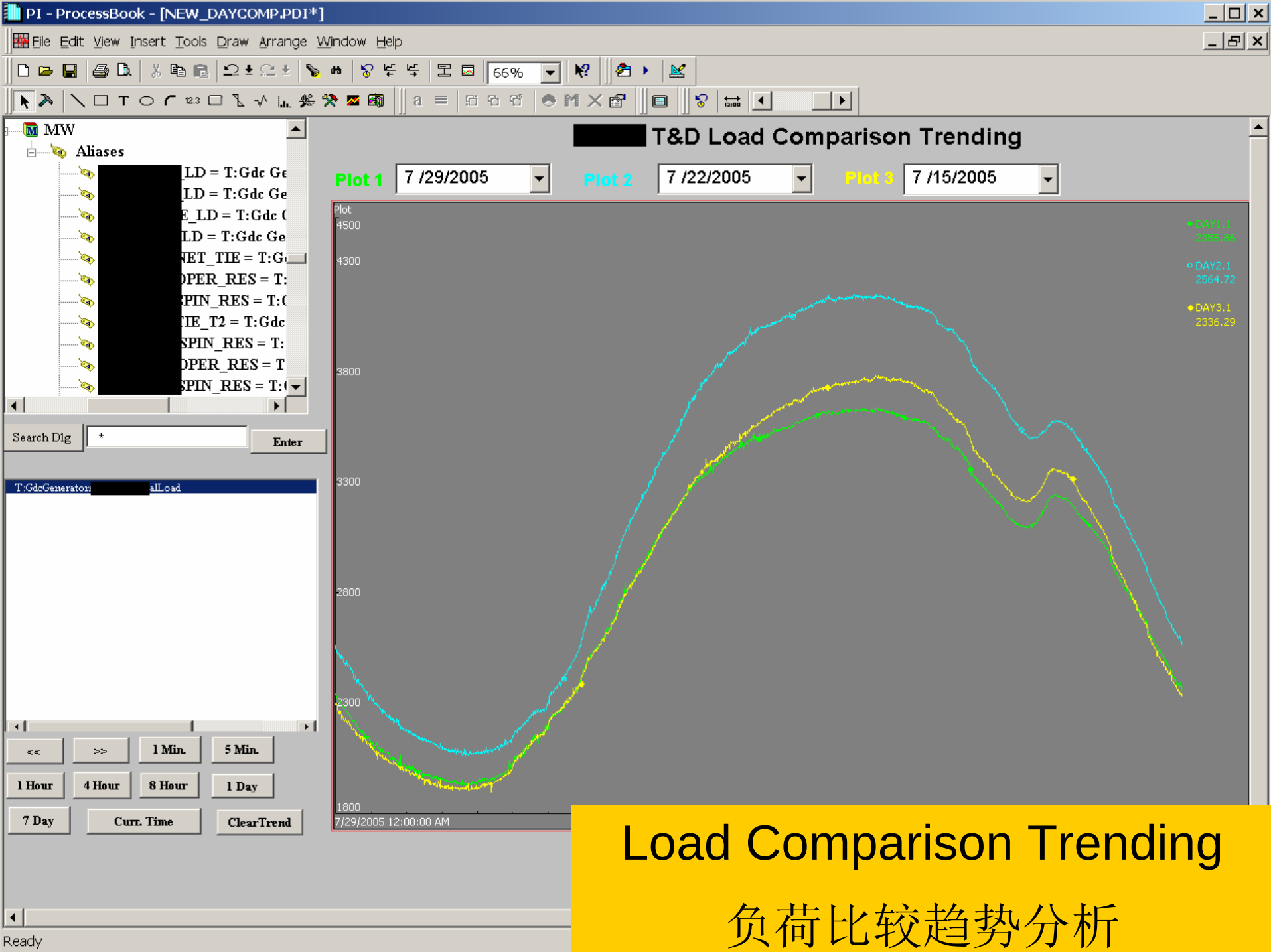

# Western States Transfer Paths

# 潮流路经监控与负荷分析




Substation Hierarchical Point-n-Click Trending

支持基于电网模型的趋势曲线数据分析

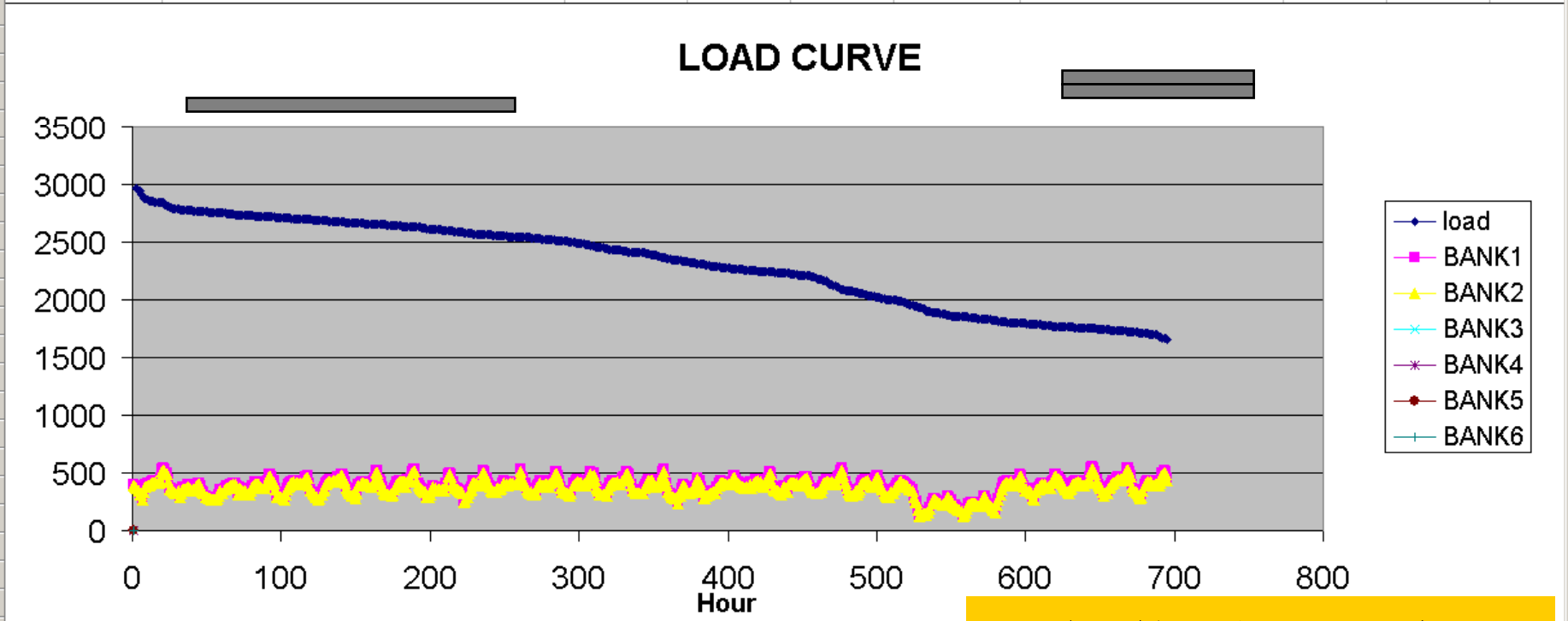

PI - ProcessBook - [NEW_DAYCOMP.PDI*]
File Edit View Insert Tools Draw Arrange Window Help
66%
MW
Aliases
Search Dlg
Enter
<< >> 1 Min. 5 Min.
1 Hour 4 Hour 8 Hour 1 Day
7 Day Curr. Time ClearTrend
[redacted] T&D Load Comparison Trending
Plot 1 7 /29/2005
Plot 2 7 /22/2005
Plot 3 7 /15/2005
Plot
4500
4300
3800
3300
2800
2300
1800
DAY1.1
DAY2.1
2564.72
DAY3.1
2336.29
7/29/2005 12:00:00 AM
Ready
Load Comparison Trending
负荷比较趋势分析

Microsoft Excel - LOAD DURATION CURVE.xls

File Edit View Insert Format Tools Data Window PI PI-SMT Help

C1 = LOAD DURATION CURVE

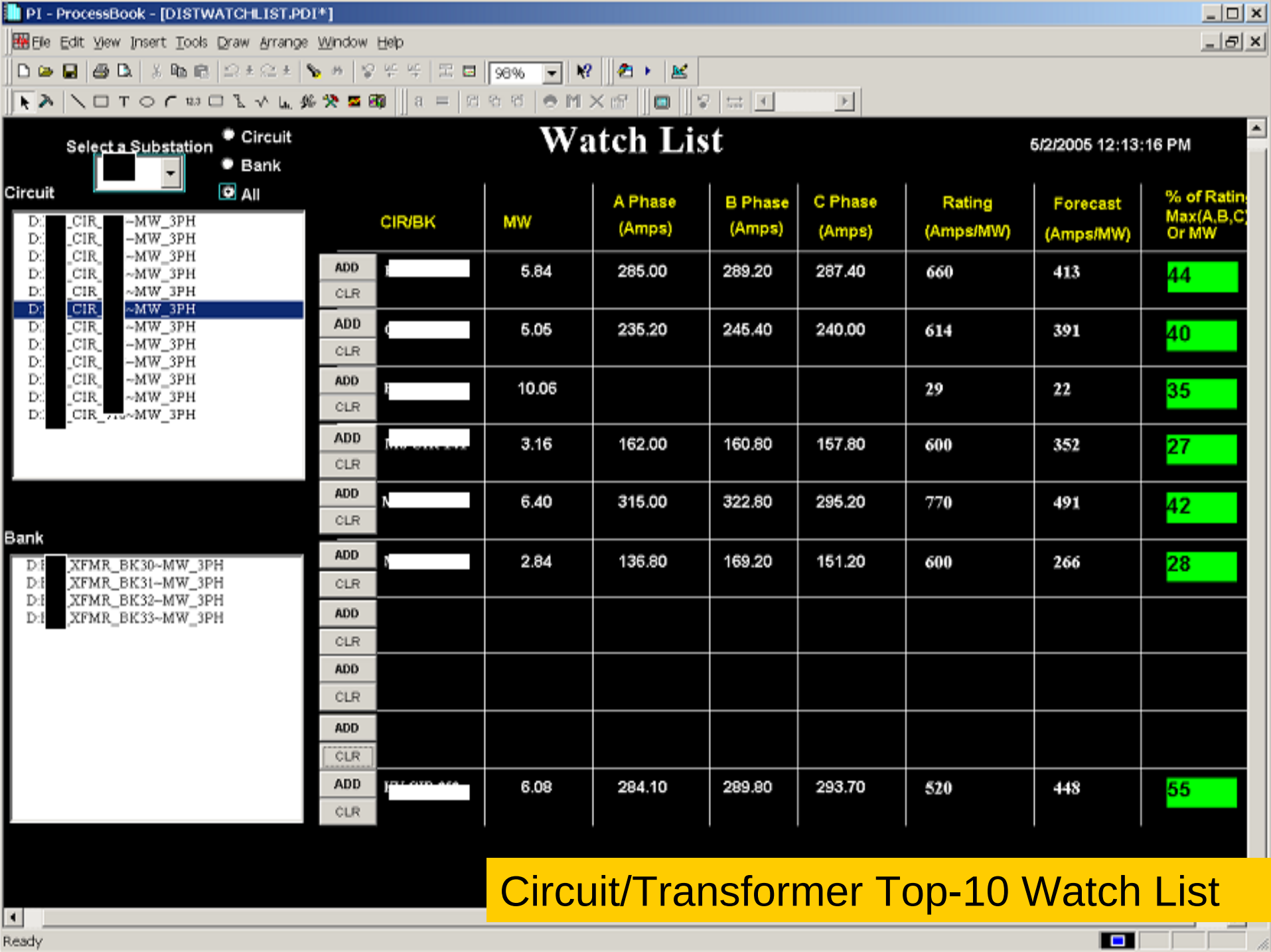
| | A | B | C | D | E | F | G | H | I | L |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | LOAD DURATION CURVE | | | | | | | |
| 2 | | *Change dates, interval, tag names, toggle to "YES" and enter <Refresh> | | | | | | | | |
| 3 | Start Date | 4/1/2005 | | | | | | | | |
| 4 | End Date | 4/30/2005 | | Refresh | | | | | | |
| 5 | Interval | 1h | | | | Tag#1 | T:ML 500:500_BK_80_MW | YES | | |
| 6 | Tag#1 | T:GdcGenerators:SDG&ETotalLoad | YES | | | Tag#2 | T:ML 500:500_BK_81_MW | YES | | |
| 7 | Tag#2 | | | | | Tag#3 | | | | |
| 8 | Tag#3 | | | VS | | Tag#4 | | | | |
| 9 | Tag#4 | | | | | Tag#5 | | | | |
| 10 | Tag#5 | | | | | Tag#6 | | | | |




负荷时段分析

LOAD DURATION | PI RAW DATA

Ready Calculate


PI - ProcessBook - [DISTWATCHLIST.PDI*]
File Edit View Insert Tools Draw Arrange Window Help
Select a Substation
Circuit
Bank
All
Circuit
Bank
Watch List
5/2/2005 12:13:16 PM
CIR/BK
MW
A Phase (Amps)
B Phase (Amps)
C Phase (Amps)
Rating (Amps/MW)
Forecast (Amps/MW)
% of Rating Max(A,B,C) Or MW
ADD
CLR
5.84 285.00 289.20 287.40 660 413 44
5.05 235.20 245.40 240.00 614 391 40
10.06 29 22 35
3.16 162.00 160.80 157.80 600 352 27
6.40 315.00 322.80 295.20 770 491 42
2.84 136.80 169.20 151.20 600 266 28
6.08 284.10 289.80 293.70 520 448 55
Circuit/Transformer Top-10 Watch List
Ready

## MSNBC Weather

Tucker

**Current conditions** | **Tomorrow**

75°

Wind: 7VAR
Baro: 29.81"
Humidity: 31%

75°/43°

All temps shown in F° | Change to C°

For extended forecasts, go to MSNBC.com

## Web Links

New | Organize

- http://schedmem.gasoc.com
- http://ecs_team2/tms

## Microsoft Outlook Messages - Inbox

New | Delete

| From | Subject | Received |
|---|---|---|
| Sarracini, Loreto | FW: Dat... | Wed 10/22/... |
| Taganajan, Tito | Owner ... | Wed 10/22/... |
| McCafferty, ... | Comput... | Wed 10/22/... |
| Taganajan, Tito | Question | Tue 10/21/2... |
| Devnet SL | OSI Dev... | Mon 10/20/2... |
| Denning, Helen | RE: Req... | Fri 10/17/20... |
| Paschall, Sara | Benefits... | Mon 10/13/2... |

## PI Graphic - emc_ld_sum_v1.0.svg

### EMC Load Summary

ECS/PI Link
Receiving

| EMC | Load (MW) | CurHr (MWh) | EMC | Load (MW) | CurHr (MWh) | EMC | Load (MW) | CurHr (MWh) |
|---|---|---|---|---|---|---|---|---|
| Altamaha | 93.66 | 76.68 | Irwin | 21.52 | 17.23 | Slash Pine | 19.85 | 15.94 |
| Amicalola | 51.61 | 41.44 | Jackson | 459.67 | 376.79 | Snapping Shoals | 150.74 | 122.94 |
| Canoochee | 42.00 | 34.09 | Jefferson | 58.22 | 47.24 | Sumter | 38.77 | 30.91 |
| Carroll | 93.28 | 75.25 | Lamar | 29.74 | 24.14 | Three Notch | 25.51 | 20.40 |
| C. Georgia | 89.64 | 72.27 | L. Ocmulgee | 20.73 | 17.15 | Tri-County | 32.71 | 26.66 |
| Coastal | 35.10 | 28.84 | Middle GA. | 15.74 | 12.68 | Troup | 50.16 | 40.45 |
| Cobb | 377.40 | 308.72 | Mitchell | 53.46 | 43.26 | Upson | 13.52 | 11.01 |
| Colquitt | 135.39 | 109.82 | Ocmulgee | 19.11 | 15.18 | Walton | 220.58 | 179.62 |
| Coweta-Fayette | 138.08 | 112.05 | Oconee | 25.11 | 19.69 | Washington | 43.38 | 35.49 |
| Excelsior | 39.80 | 32.22 | Okefenoke | 61.82 | 49.32 | Sterling Pulp | 11.58 | |
| Flint | 168.51 | 137.42 | Pataula | 10.67 | 8.64 | Total System Load | 3658.70 | |
| Grady | 38.97 | 31.63 | Planters | 23.58 | 18.51 | System Frequency | 60.00 Hz | |
| Greystone | 202.94 | 165.88 | Rayle | 25.81 | 20.48 | Temperature | 76.88 F | |
| Habersham | 43.19 | 35.03 | Satilla | | | | | |
| Hart | 54.30 | 44.16 | Sawne | | | | | |

Web Portal Enterprise

Data Repository

实时数据直接在门户中展现

Forecast - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address [redacted] Go Links

Forecast

Welcome | LogOut | Publish | Adhoc Trend | Content | Layout | Settings

Welcome Forecast Save All USER ID: PIWEB1\MPRICE

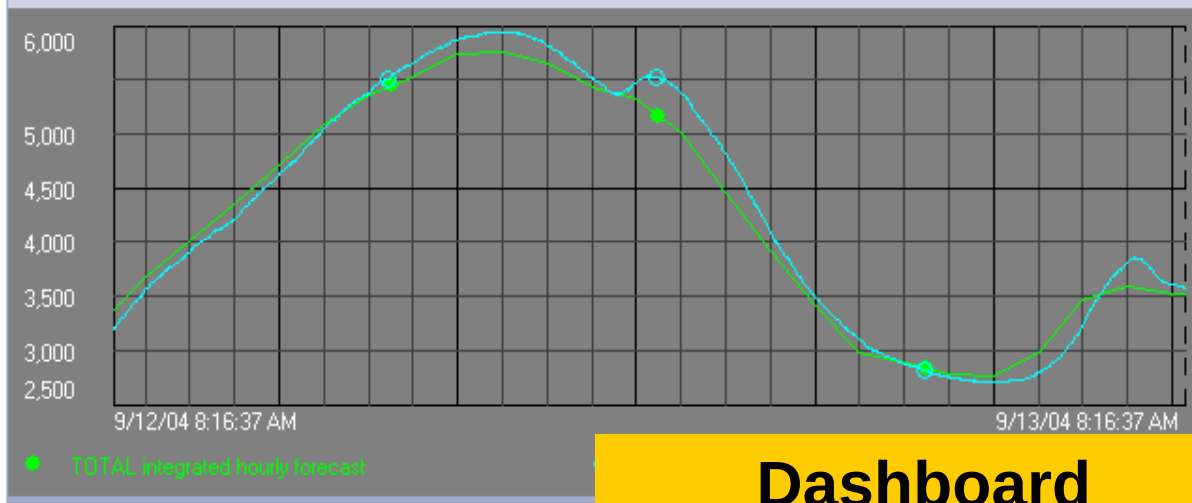
**Day Ahead Load Forecast**

First Back Next Last

| Date | Hour | Load(MWh) | Current State |
|---|---|---|---|
| 9/13/2004 1:00:00 AM | 1 | 2973 | 0.0000 12,000. |
| 9/13/2004 1:00:00 AM | 2 | 2886 | 0.0000 12,000. |
| 9/13/2004 1:00:00 AM | 3 | 2780 | 0.0000 12,000. |
| 9/13/2004 1:00:00 AM | 4 | 2770 | 0.0000 12,000. |
| 9/13/2004 1:00:00 AM | 5 | 2978 | 0.0000 12,000. |
| 9/13/2004 1:00:00 AM | 6 | 3467 | 0.0000 12,000. |

Showing 1 to 6 of 48

**Load-Forecast vs Actual**



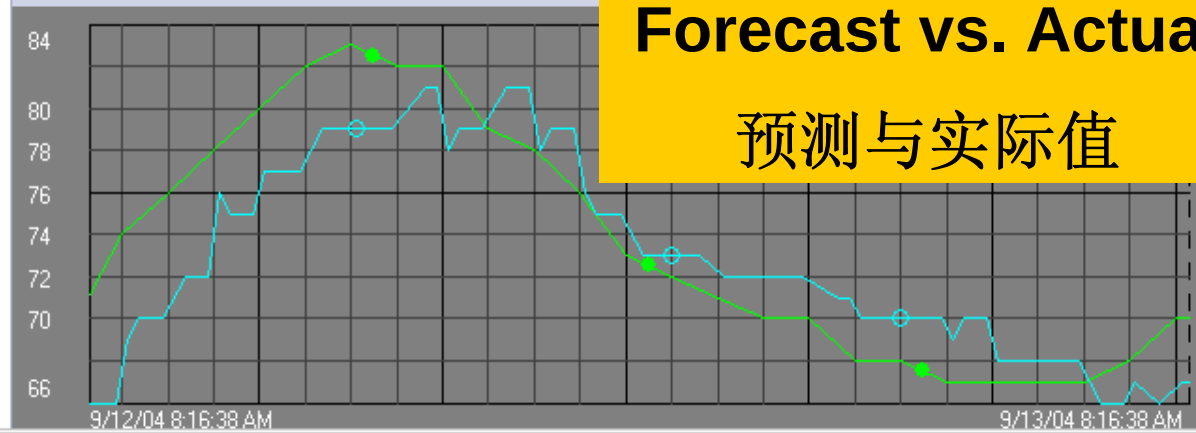

**Day Ahead Temperature Forecast**

First Back Next Last

| Date | Hour | Temp(F) | Current_State |
|---|---|---|---|
| 9/13/2004 1:00:00 AM | 1 | 68 | 32.000 100.00 |
| 9/13/2004 1:00:00 AM | 2 | 68 | 32.000 100.00 |
| 9/13/2004 1:00:00 AM | 3 | 67 | 32.000 100.00 |
| 9/13/2004 1:00:00 AM | 4 | 67 | 32.000 100.00 |
| 9/13/2004 1:00:00 AM | 5 | 67 | 32.000 100.00 |
| 9/13/2004 1:00:00 AM | 6 | 67 | 32.000 100.00 |

Showing 1 to 6 of 48

**Temperature-Forecast vs Actual**




# Dashboard

# Forecast vs. Actual

# 预测与实际值

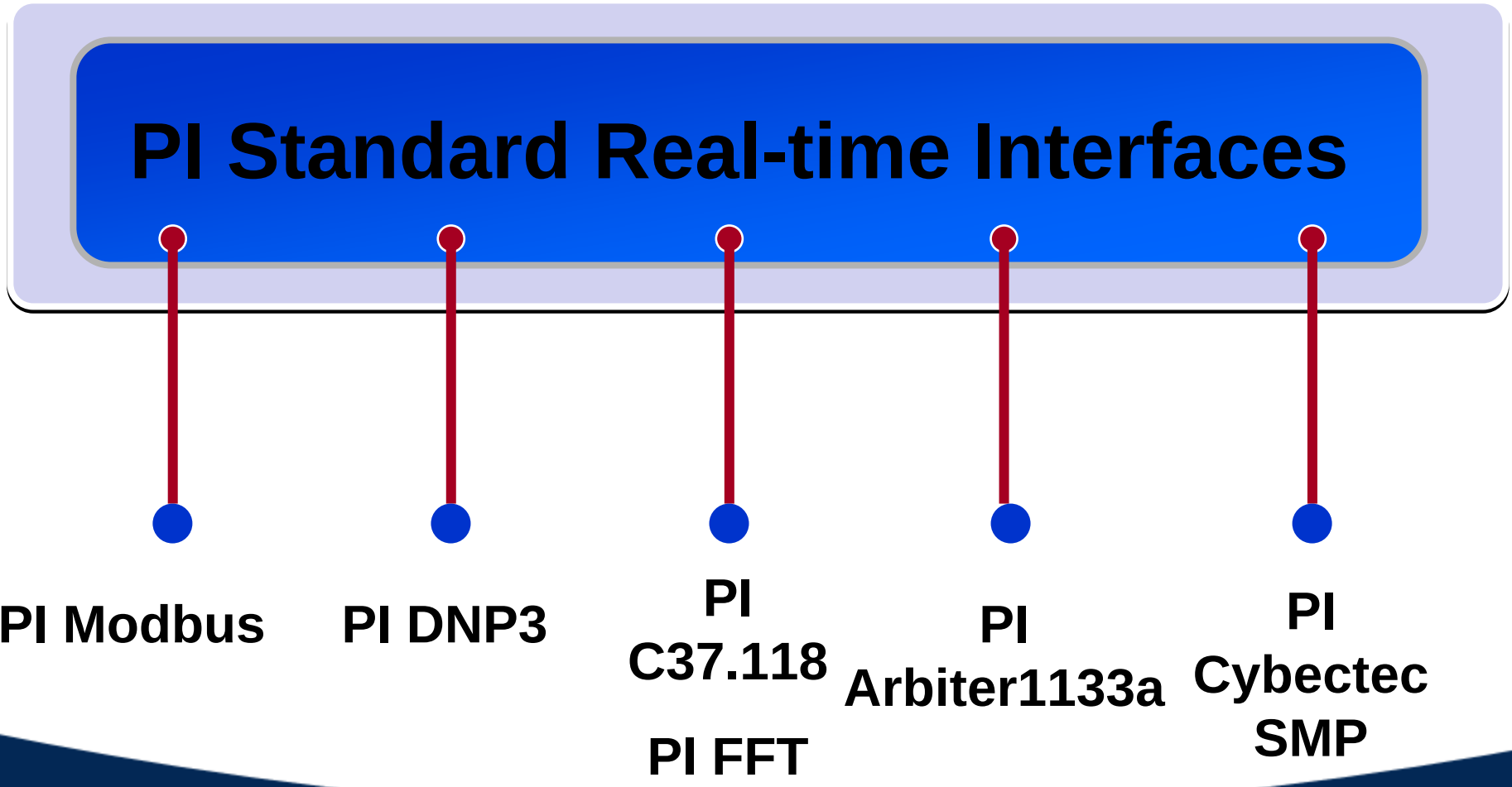
Done Trusted sites

# PI for Non-Operational Data
# 非操作运行数据

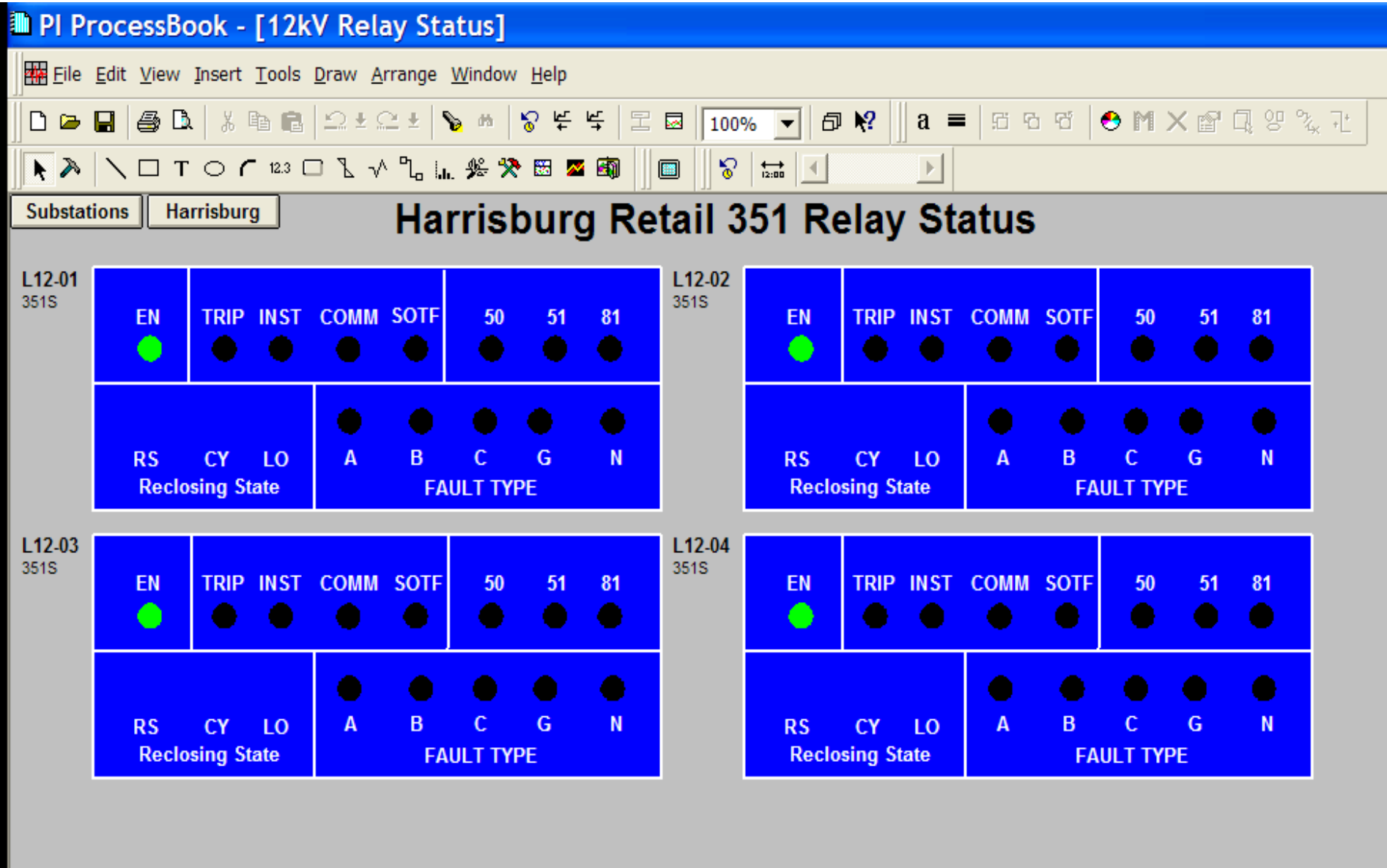
# PI T&D Trends (趋势)

- Distributed Generation
- Power Quality/Transient/Disturbance Data
- Fast Sampling PMU Phasor data
- Condition Based Maintenance/Monitoring
- Asset Management
- AMR
- Substation/Distribution Automation
- Smart Grid/Intelligent Grid

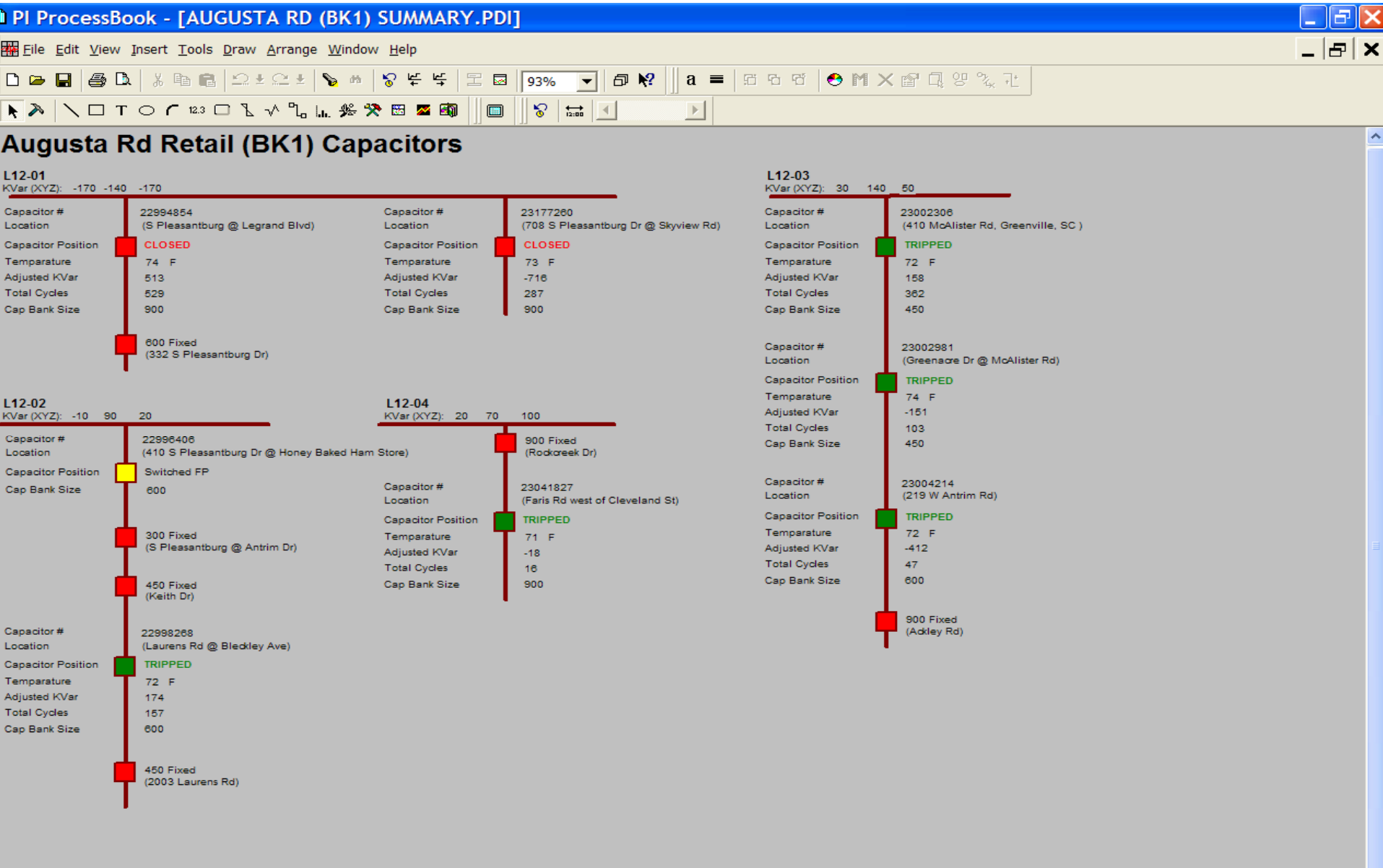
# Substation Interfaces 接口



# PI DNP3 Circuit Relay Status



# Line Capacitor Status

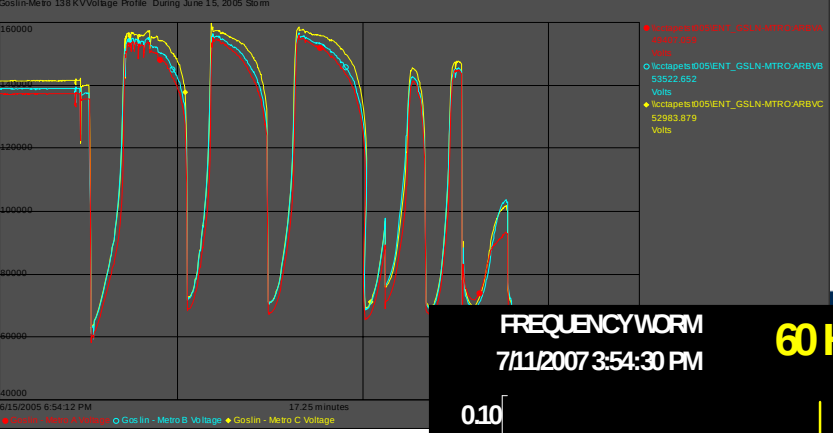


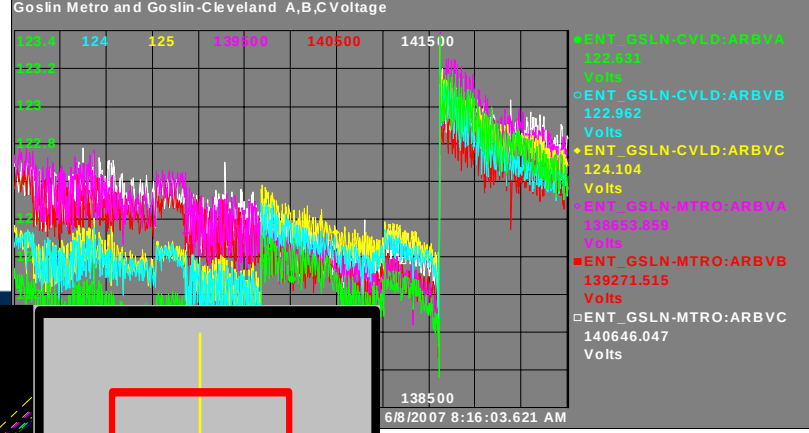
# Protocol Standard IEC61850

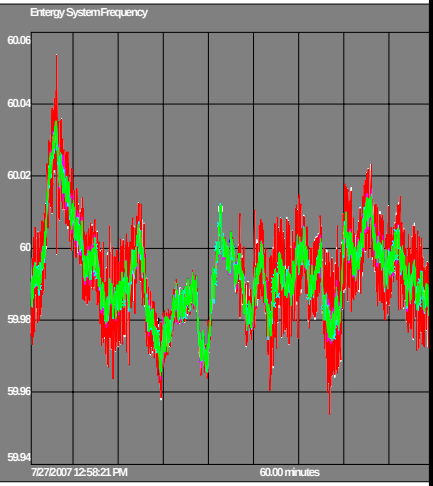
- IEC61850 is an object oriented substation automation standard that defines:
  - Standardized naming convention and object models
  - Standardized meaning of data
  - Standardized abstract services
  - Standardized device behavior models
  - Standardized protocols for:
    - ***Control***
    - ***SCADA***
    - ***Protection***
    - ***Transducers***
  - Self-describing devices
  - Common configuration language

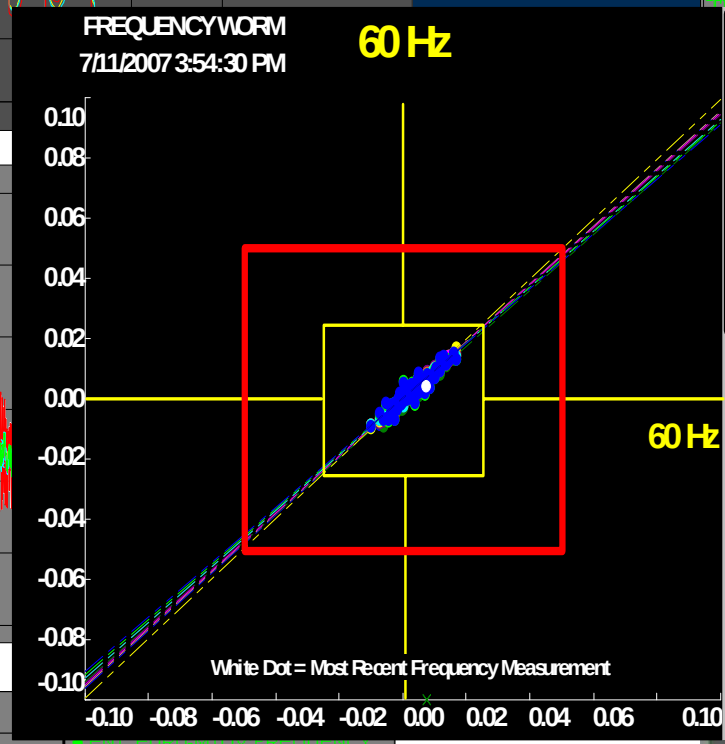
# PI-based WAMS Wide Area Measurement System
# 广域相角监测系统

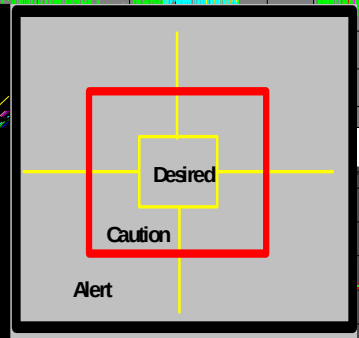
- Streaming Server
  - Very fast synchronized同步sampling with standard PI **IEEE C37.118** Interface
- Real-time Analytics
  - Fast and synchronized real-time calculations同步实时计算(**phase angle difference, FFT**, etc.)
- Visualization/Alerts **(可视化/告警)**
  - Enhance operations and early warning to prevent grid instability and cascade collapse



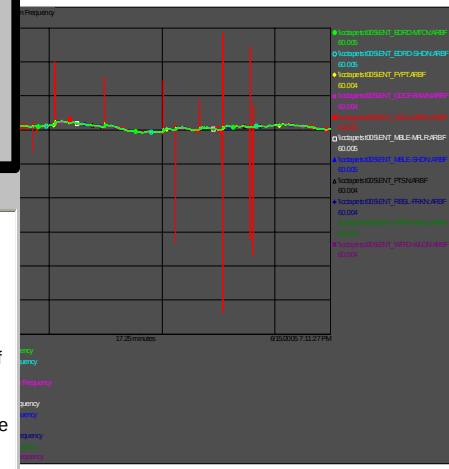



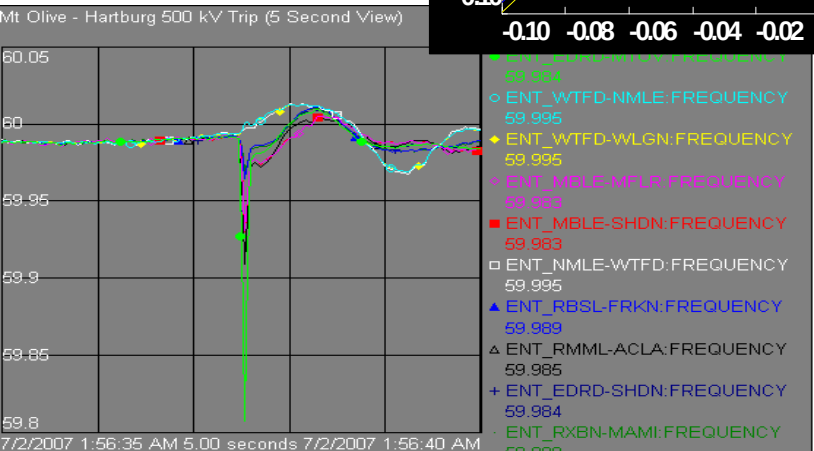

This chart represents your operating frequency domain. Frequency here is represented as a difference from 60 Hz.

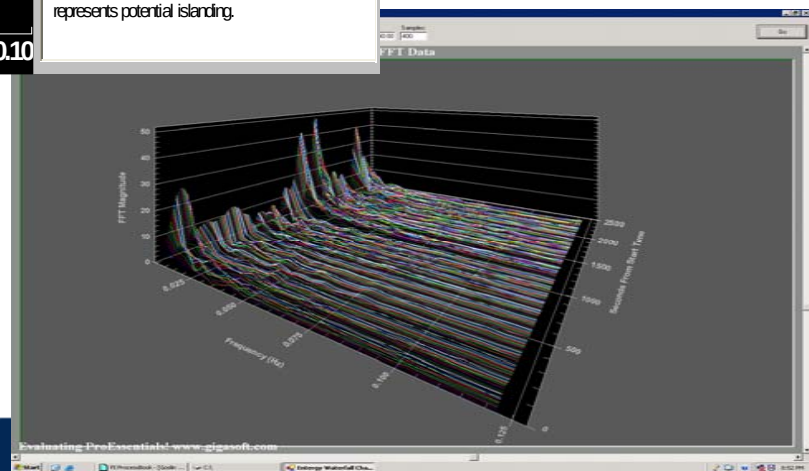
The system should be operated within the desired range (the yellow dashed box). Caution should be noted when frequencies begin to migrate outside of the yellow dashed box.

Frequencies falling in the alert region (outside of the red box) should be closely monitered.

If the frequency worm begins to scatter, this represents potential islanding.

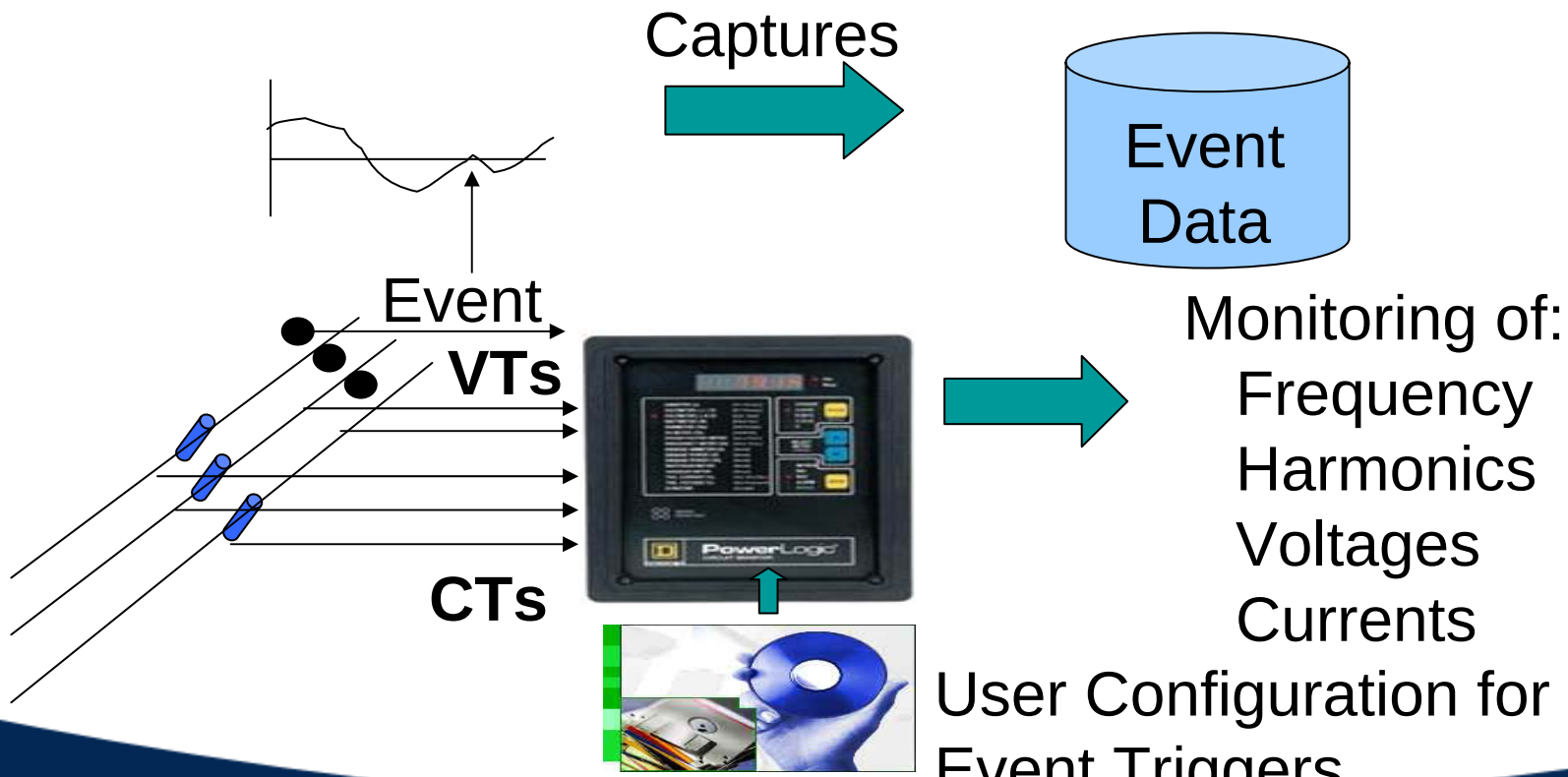




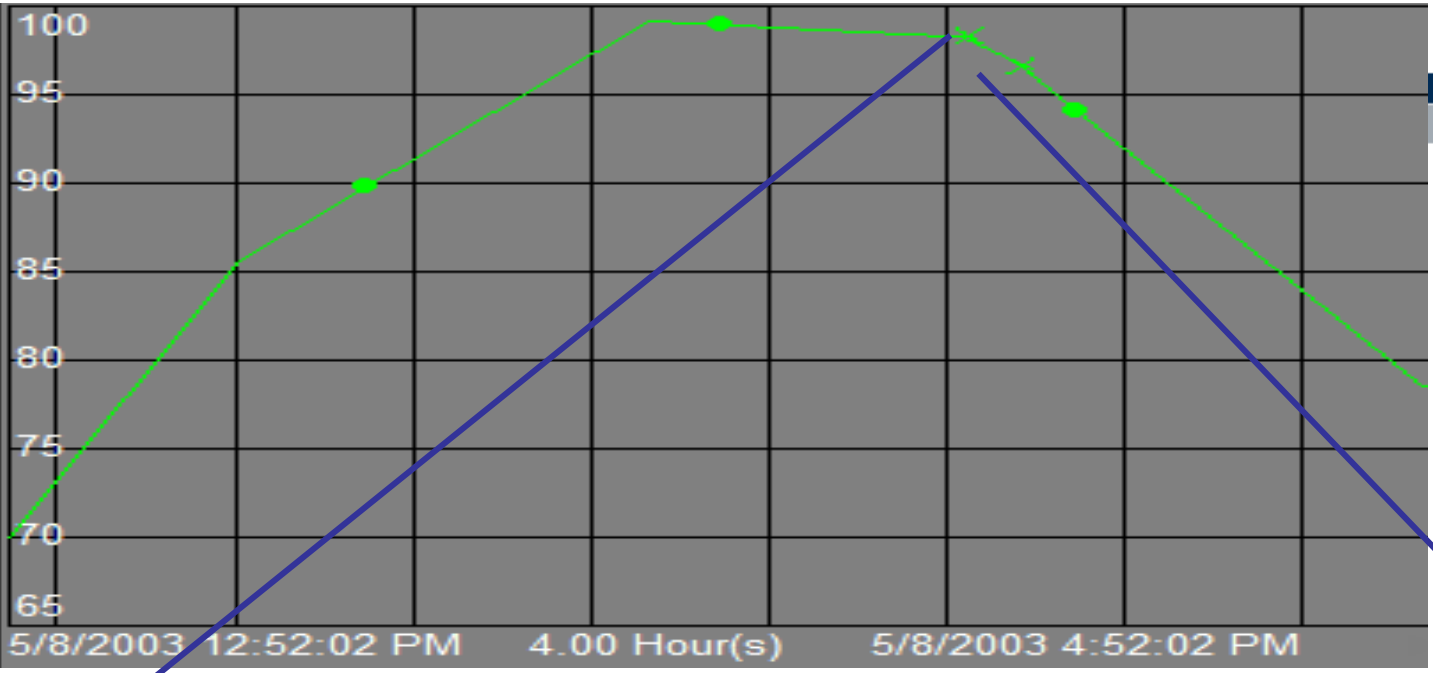



# Transient Data in PI
# 暂态数据可存入PI

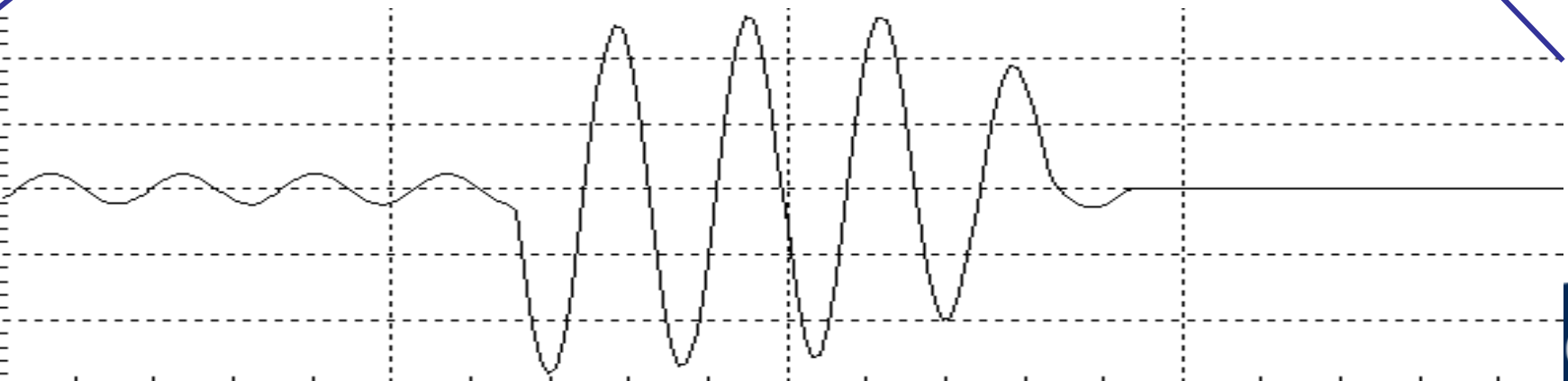
## IEEE C37.111-1997 COMTRADE 故障滤波
## Common Format for Transient Data Exchange



# Process Information Integration

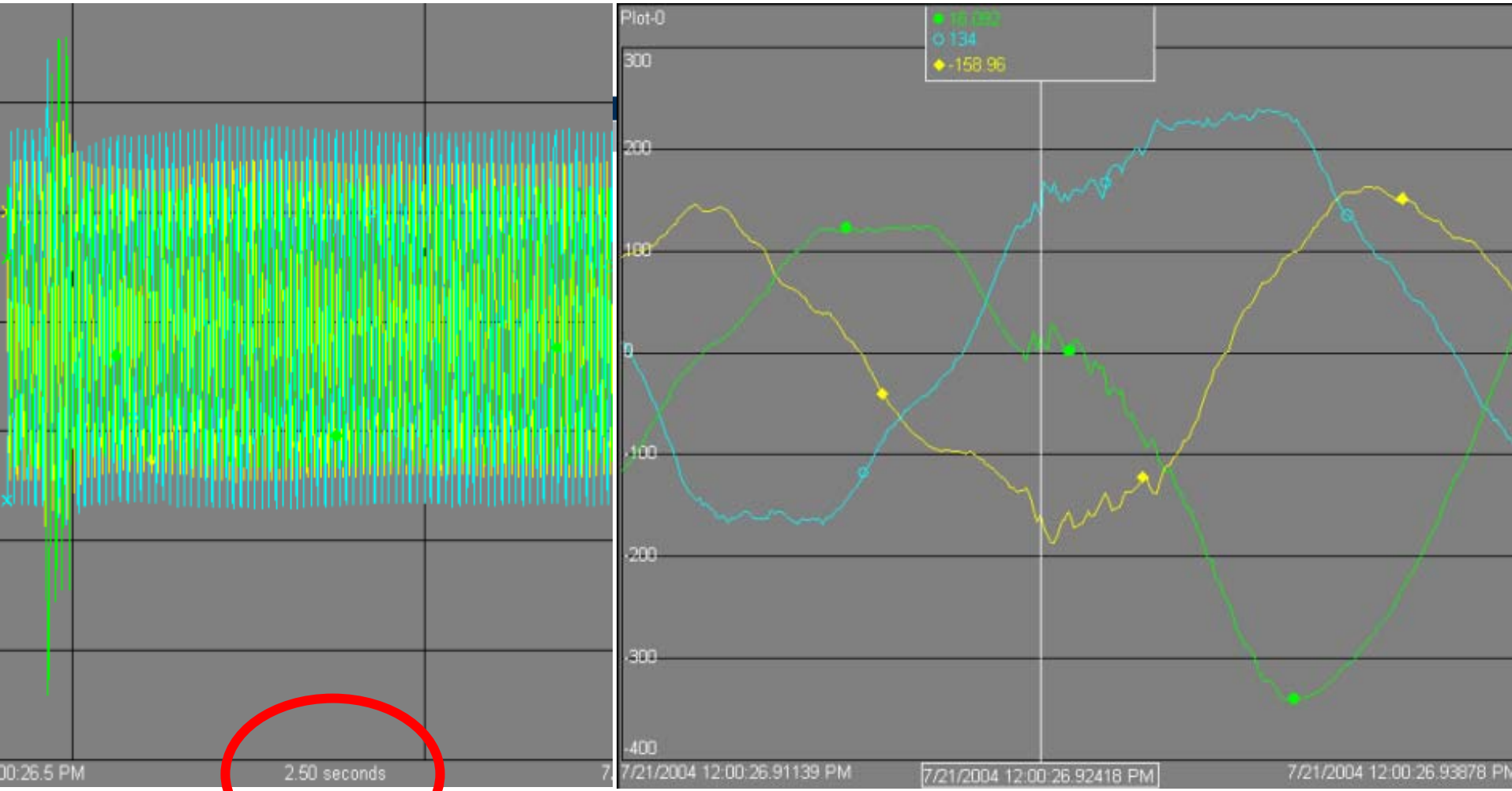



What really happened?



OVER TIME

# Waveforms in PI




**2.5 seconds**

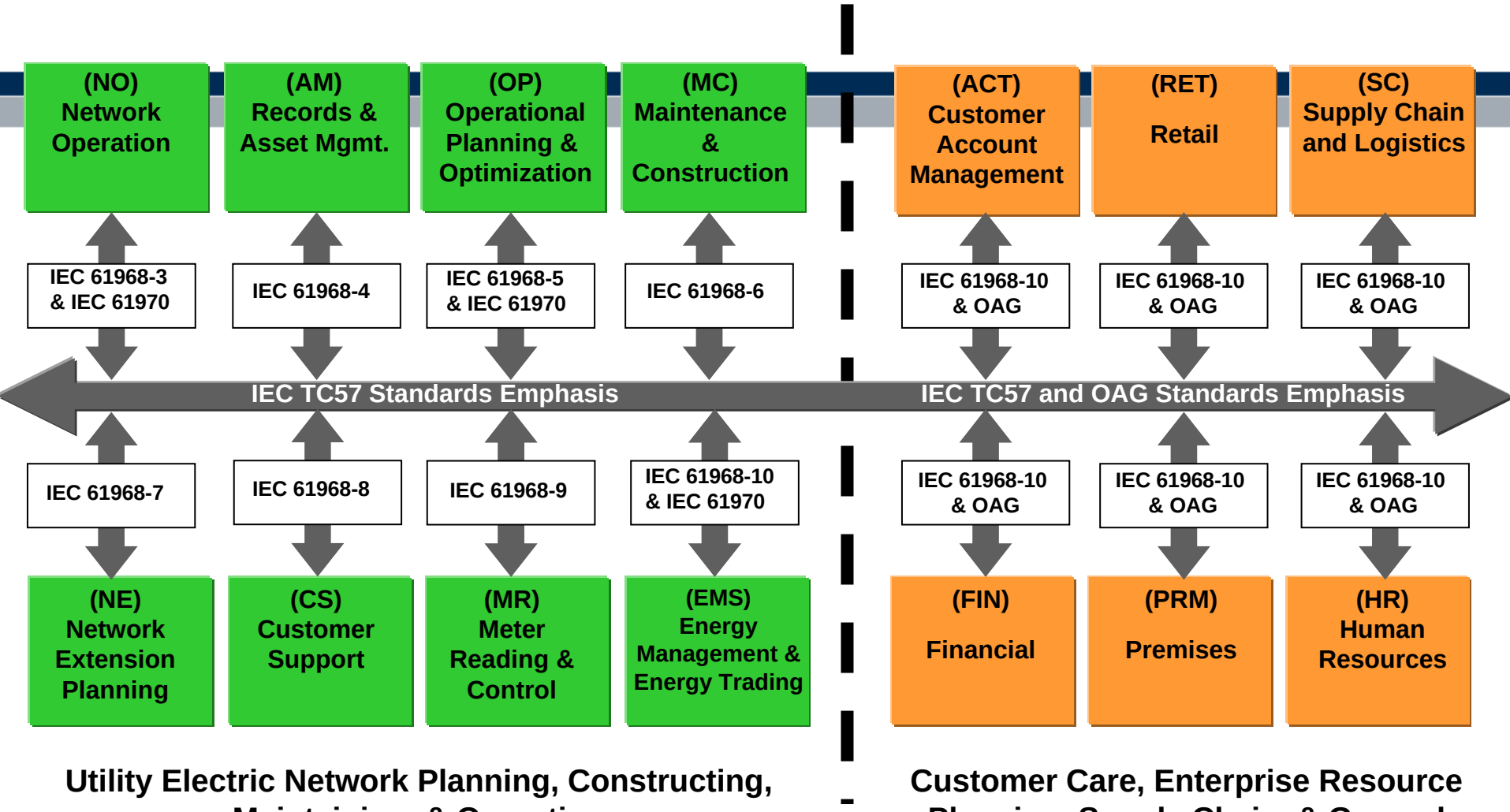
**12:00:26:91139** **12:00:26:92418** **12:00:26:93878**

hundredth of second

# PI for Asset Models and Analytics

# 资产模型与分析

# Common Information Model (CIM)




**Utility Electric Network Planning, Constructing, Maintaining, & Operating**

**Customer Care, Enterprise Resource Planning, Supply Chain, & General Corporate Services**

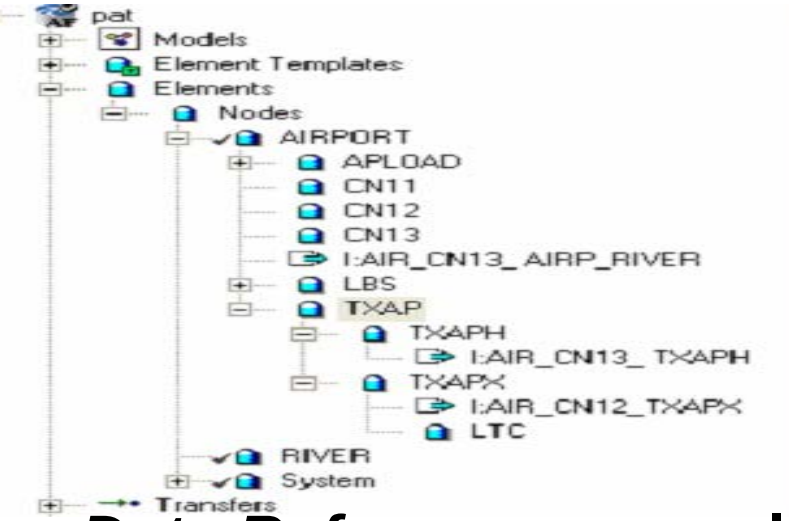
# Why CIM Matters to PI Analysis Framework (AF)

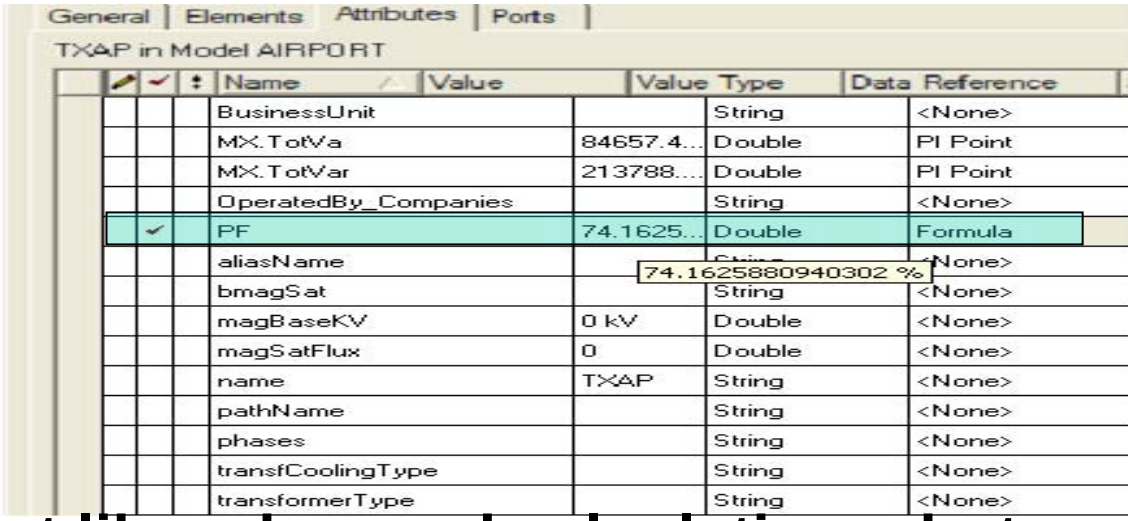
- Both about modeling the business
  - PI brings history to the model
  - CIM brings deep definition to the model
- PI is moving from "tag-centric" to **"asset-centric"**
- The industry has moved along in parallel
  - T&D has always been a real-time, no-inventory business – measurements matter
  - A smart grid without standards is a dumb grid
  - AF + CIM makes sense
- AF is a **"Measurement Model Manager"**

# CIM Model in Analysis Framework

- Models can be built manually, using the downloading, or programmatically
- Building the template for elements (i.e. line)
- Elements have attributes
  - Another measurements, line rating, power factor, graphic symbols
- Elements have connections
- Building analysis rules (calculations, schedules)
- Values back into any other sources

# Data References ease Analysis




***Data References* are a lot like advanced calculations, but**

A ***Data Reference*** can be:

- PI Points
- A calculation
- A reference to data in other systems
- XML Web Services
- Relational Databases (IEEE specs, line ratings, etc.)
- A reference to a CIM model

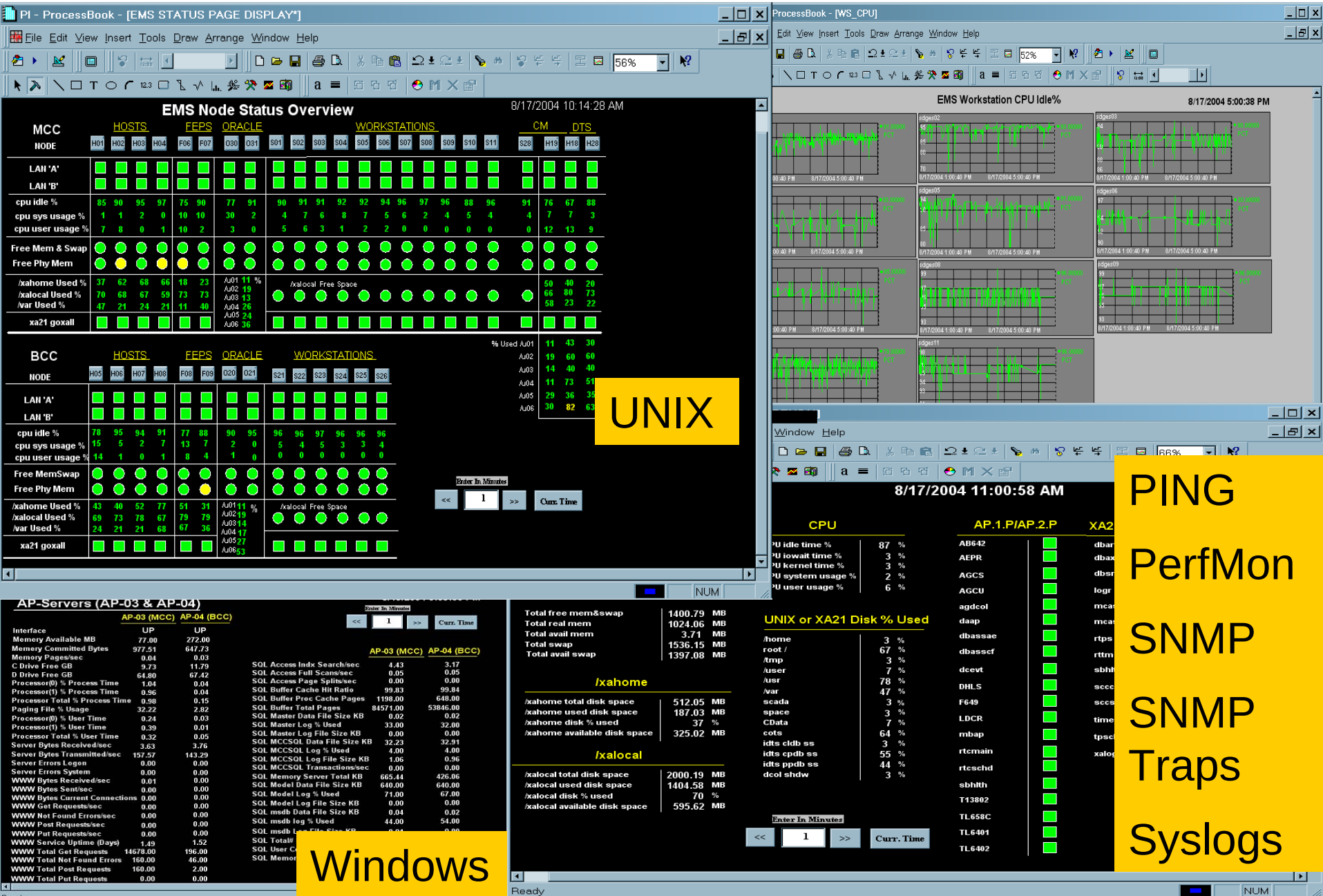
# Other Possible Analysis

- Telemetry Analysis
- Peak Load
- Peak Circuit Load
- Dynamic Line Ratings
- Load Distribution
- Transformer Gas/Oil Analysis
- Harmonics
- VAR Calculations

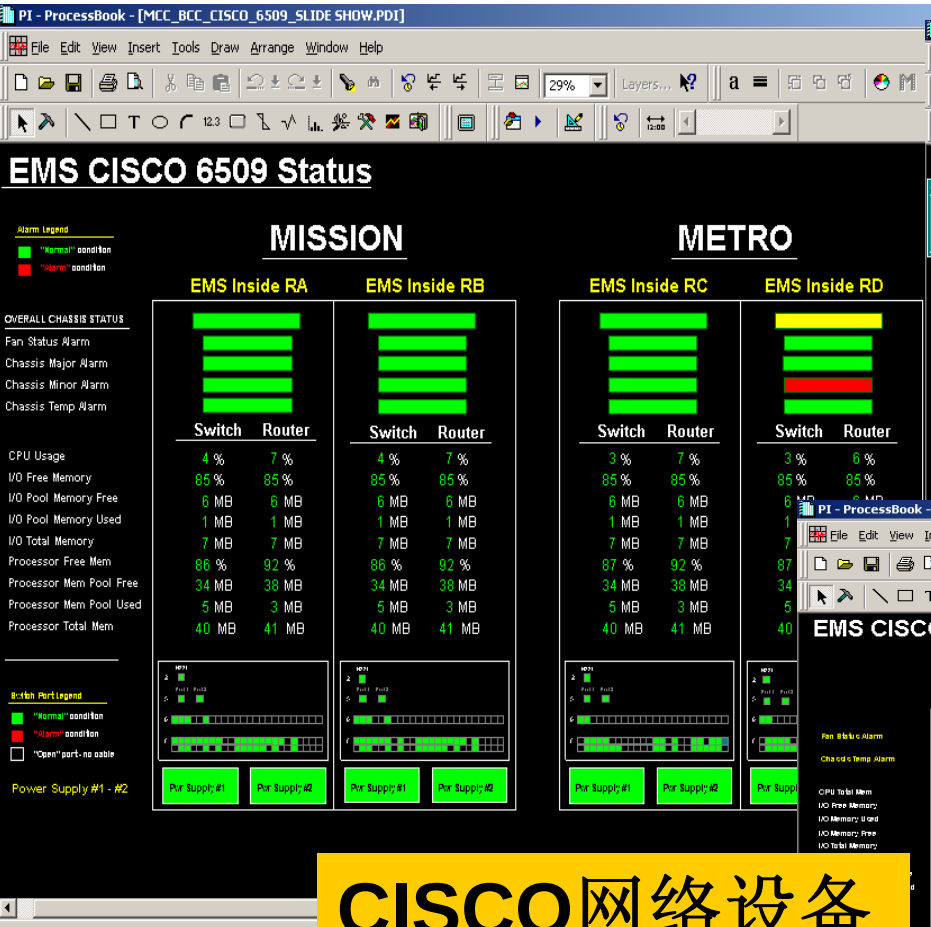
# PI for Control System and Critical Infrastructure

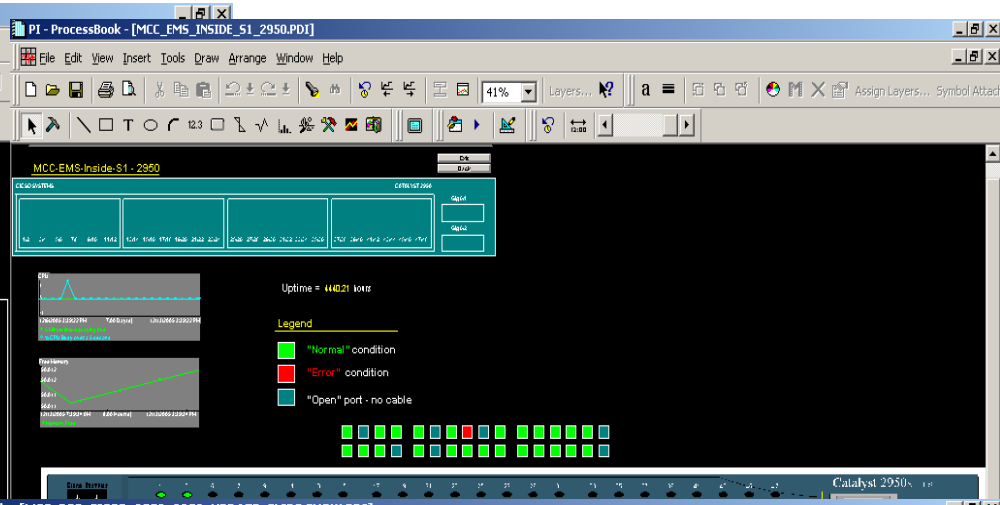
# 控制系统与关键平台基础

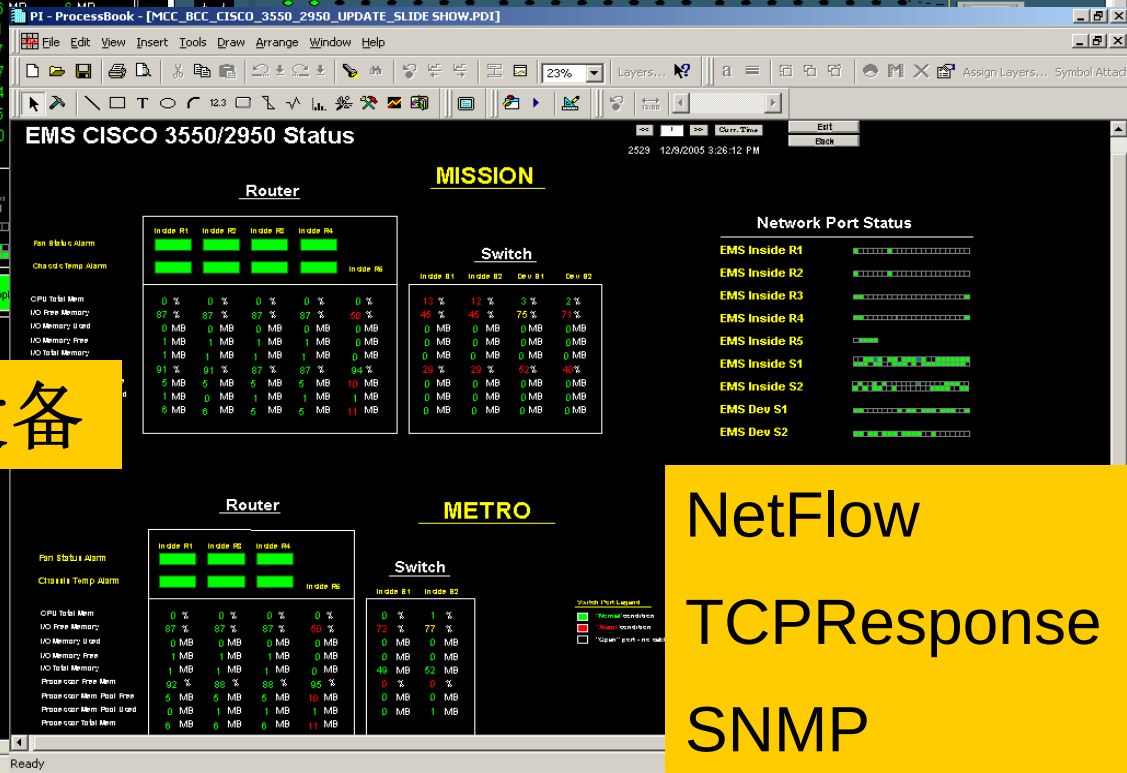
# 重要调度主站设备系统的监控和保护



# 重要网络的监控和保护



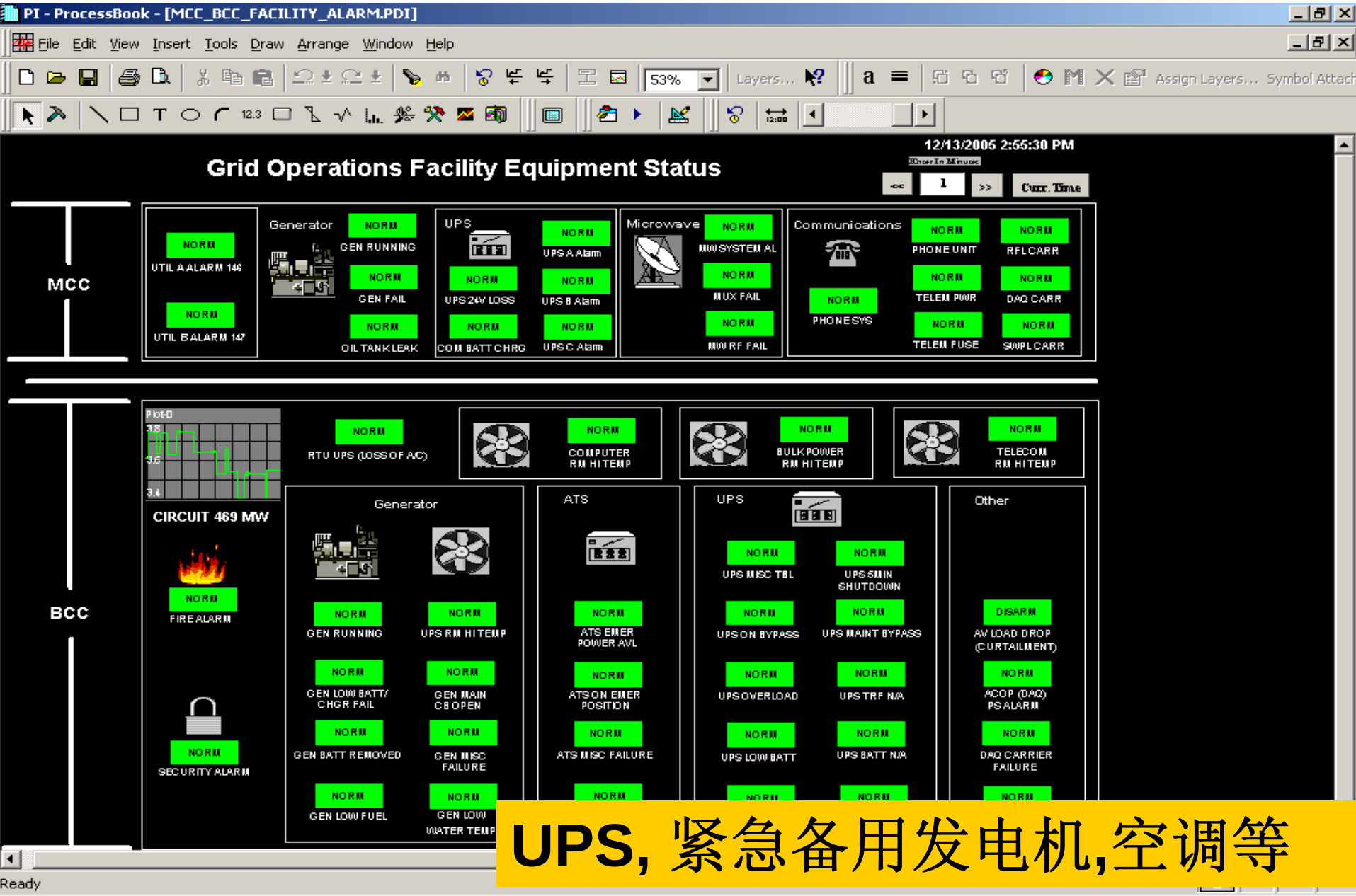

CISCO网络设备

NetFlow

TCPResponse

SNMP

# 重要设施的监控和保护




**UPS, 紧急备用发电机,空调等**

# 结语

- 利用PI系统,建立一个实时事件驱动的企业"信息化"平台基础
- 扩大价值效益,由操作运行, 工程,计划, 保护, 维修和资产管理, 到整体企业

谢谢 !!