

Beyond Visualization

California ISO & Synchrophasors

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California ISO
Your Link to Power



Electric Power Group

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Advanced Synchrophasor
Technology for the Integration
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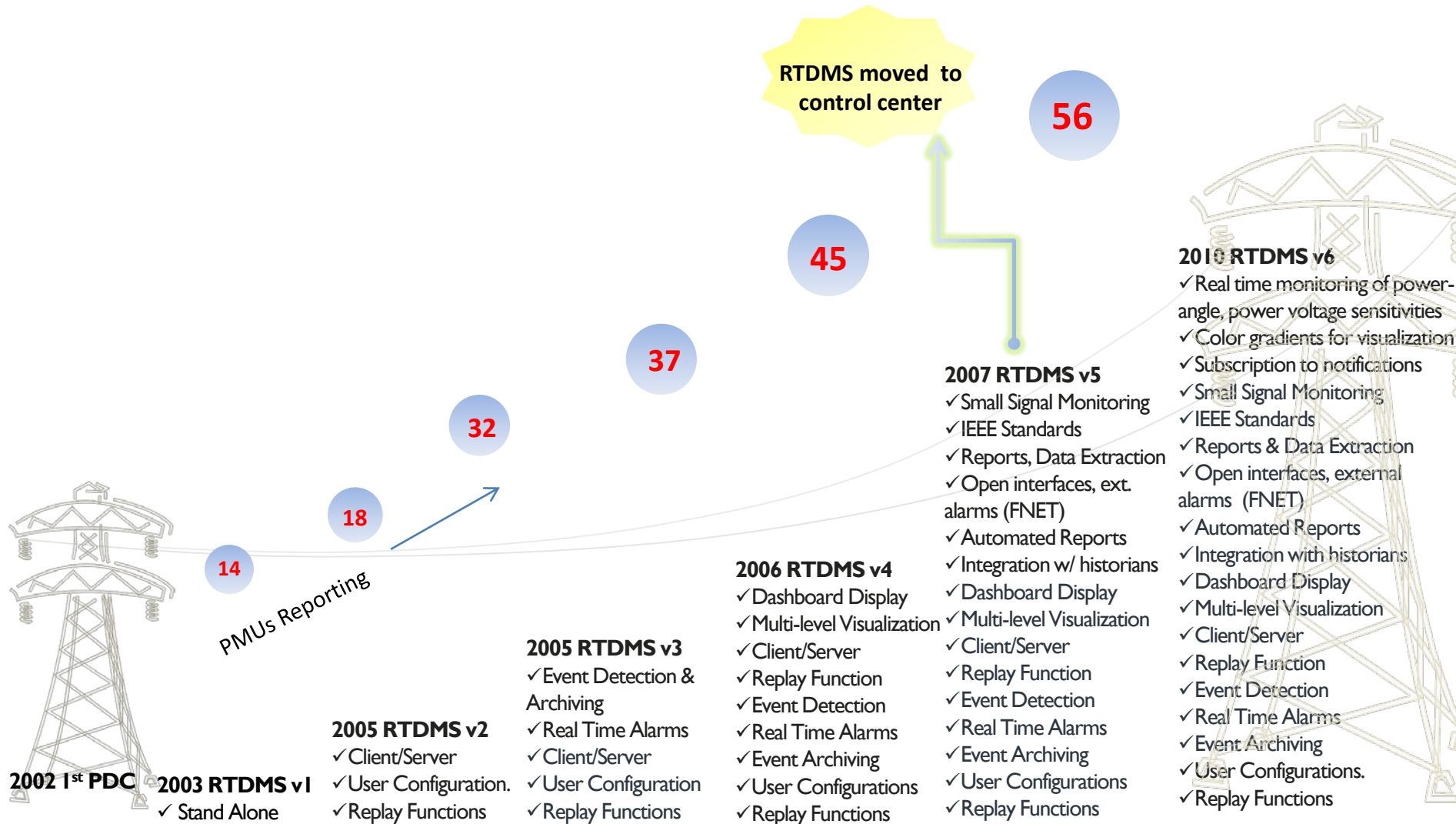
Synchrophasors for Visualization

- Blackouts of 1996 (and 2003) underscored the criticality of real time wide area awareness
- CAISO Phasor Initiative began in September 2002 with the installation of a PDC
- Initial data from 14 PMUs in the BPA area
- Followed by data from SCE, PG&E and WAPA came online
- RTDMS Application developed by EPG

The Goal:
Real-time, Wide-area Situational Awareness



From Concept to Control Center

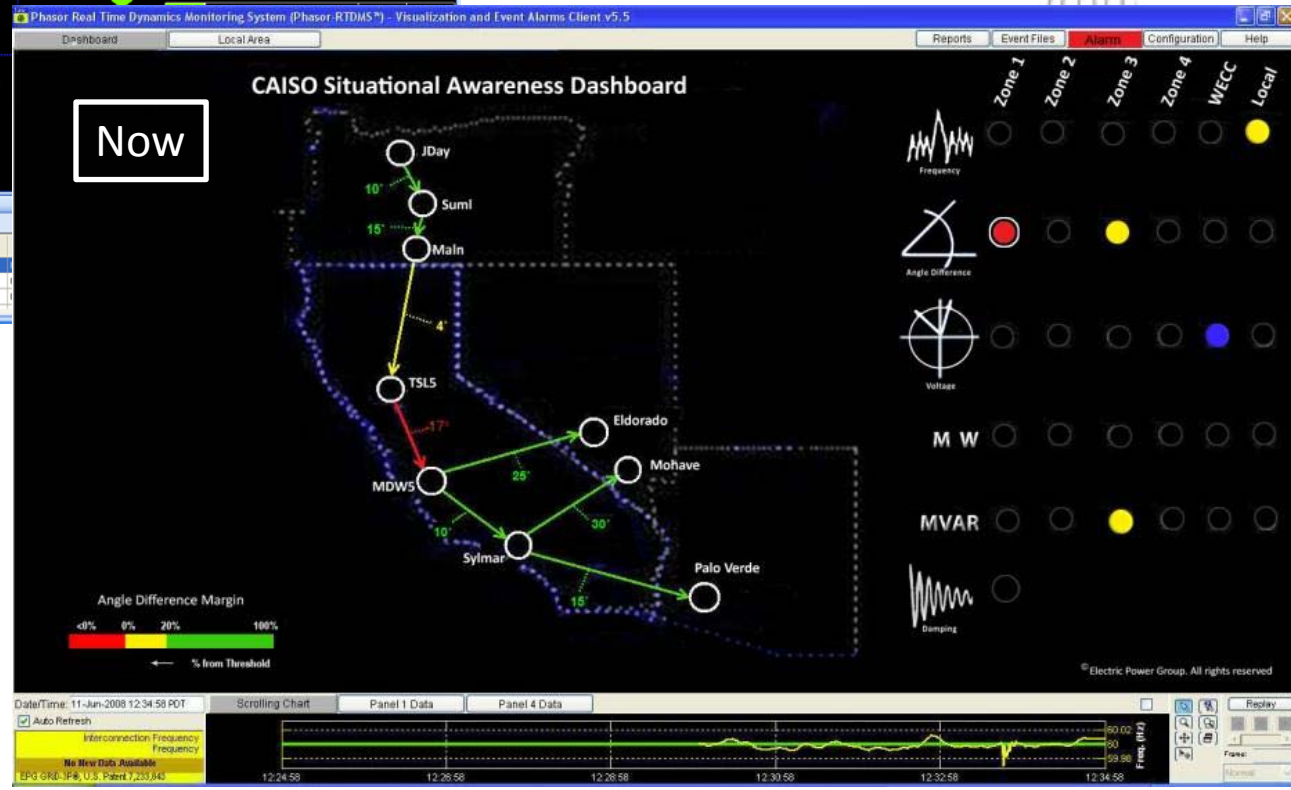
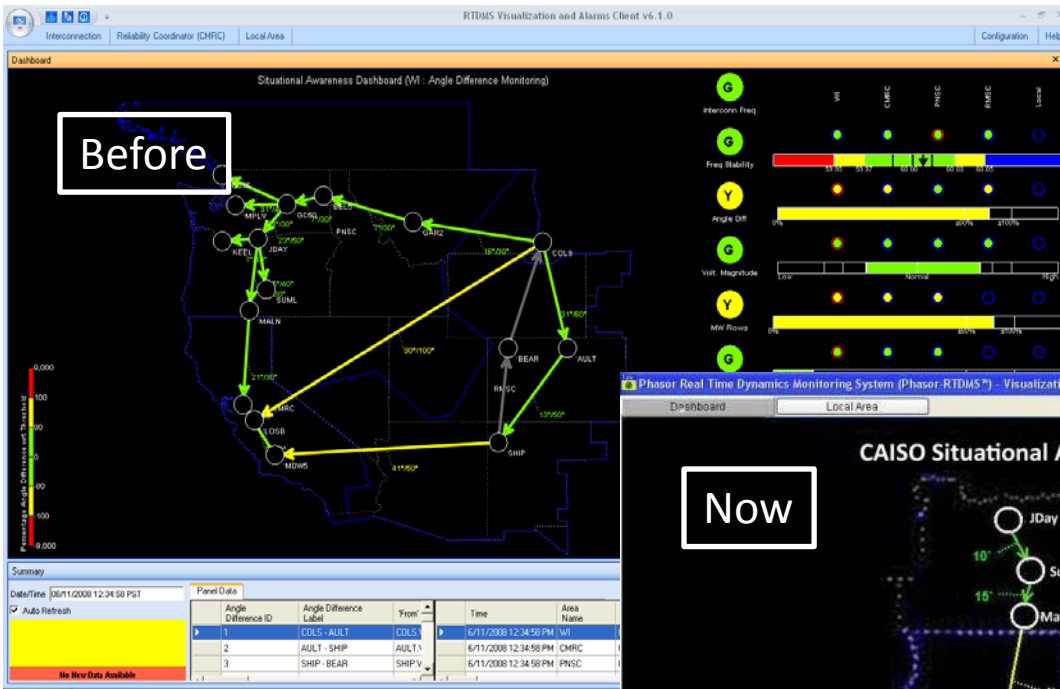


From Concept to Control Center

- Started with a simplistic visualization of the synchrophasor data with RTDMS
- CAISO's phasor application functionality rapidly evolved
 - Event detection & archiving, Alarms, Dynamic Monitoring....
 - Adapted visualization to the requirements of operating staff
 - Dashboard for CAISO centric operations
- RTDMS migrated to control center in 2008

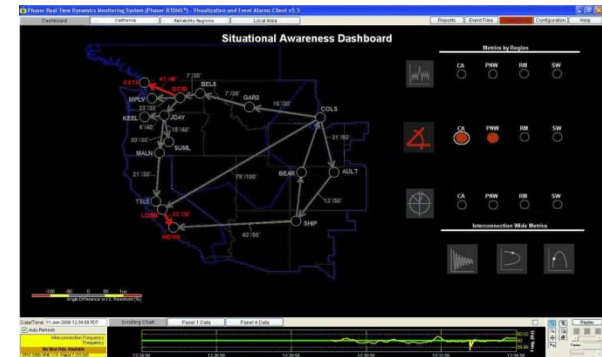


CAISO Centric Adaptation



Today

- 56 PMUs reporting into the CAISO
- Migrated to ePDC in 2010
- RTDMS operating with 14 clients at Folsom & Alhambra
- Fully redundant, failover system by 2012
- Integral to real time operations
 - Provided critical backup intertie information when entire EMS system went down
 - Used by CAISO operators to identify critical events (e.g. Pacific-DC Inter-tie problem) and take preventative action



Q: What Next?



Chapter 2

Taking Synchrophasors Beyond Visualization

Critical & Emerging Issues for System Operators

Critical & Emerging Issues

- **How much margin do I have?**

Voltage Stability and Margins

- **How can we increase asset utilization? (100 MW of increased transfer capability = \$30 M)**

Dynamic Nomograms

- **Will renewables integration result in new grid vulnerabilities?**

Performance Monitoring – Frequency response, oscillations, small signals

- **Can I get a quick diagnostic before taking action?**

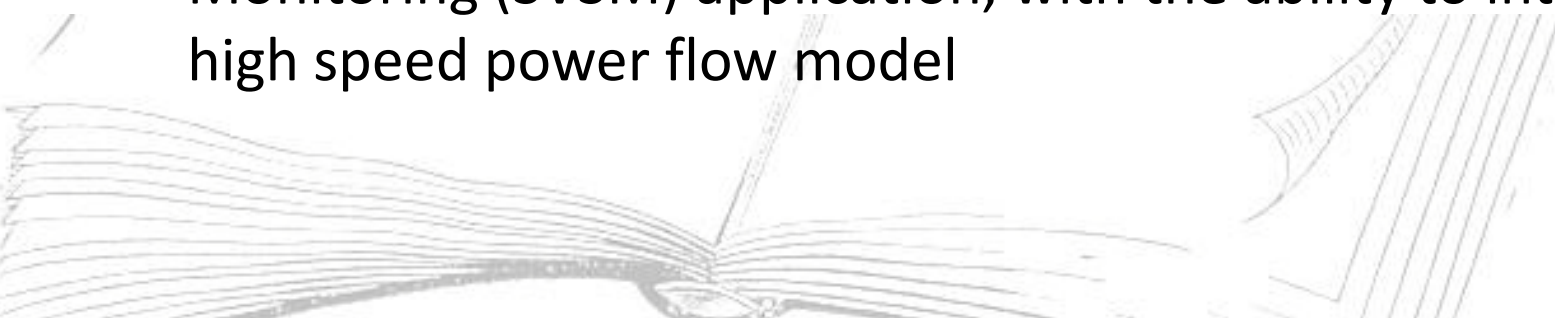
Automatic Event Analysis

Voltage Stability – Challenges & Goals

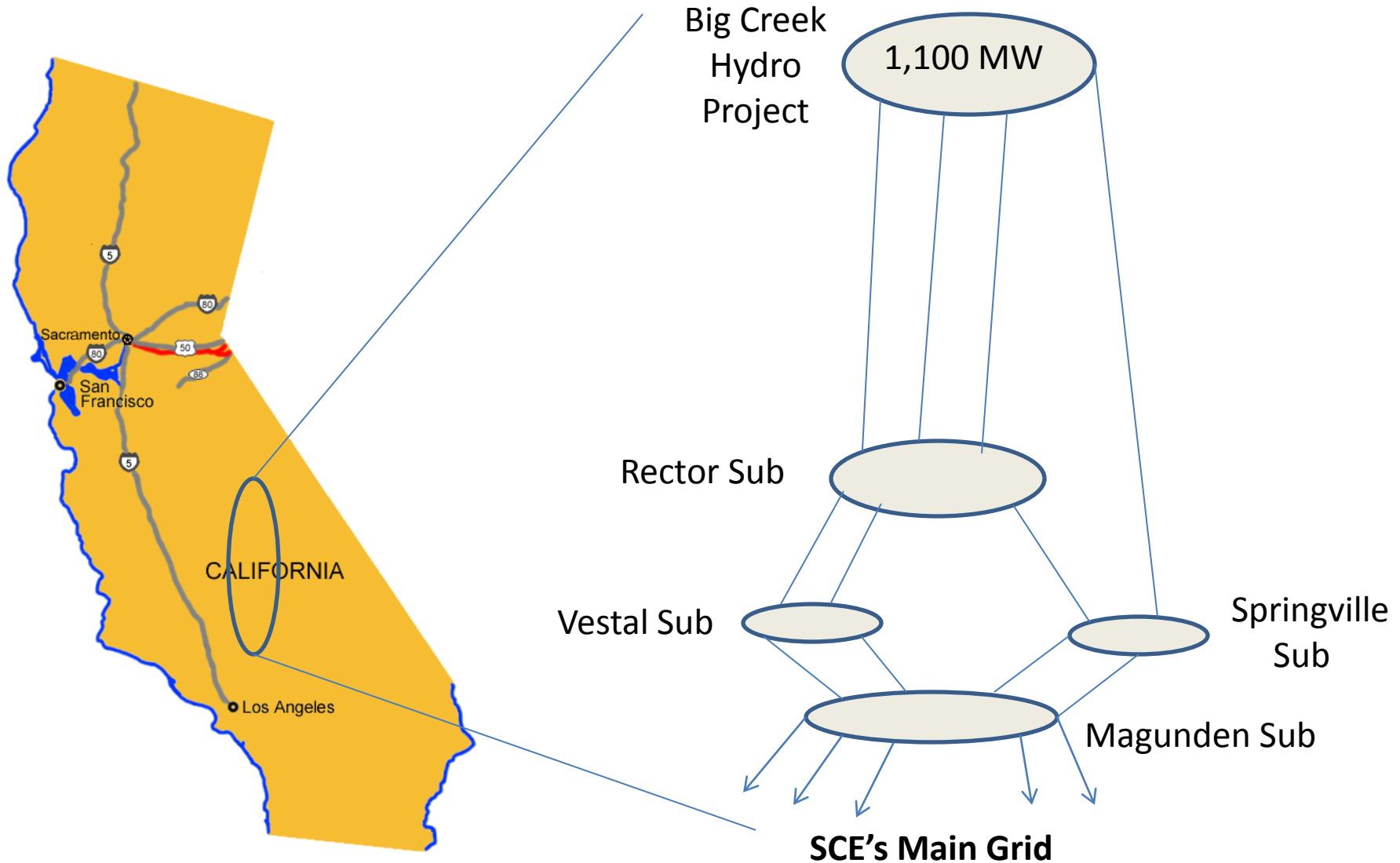
- Based on offline operating studies – not designed for real time monitoring
- Highly dependent on accurate system topology
- Inflexible; Power-voltage relationships are viewed as static and unchanging
- Offline voltage stability analysis under contingency scenarios is limited to those likely $n-1$ and $n-2$ contingencies

Goals

- Expand RTDMS platform for a Synchrophasor Voltage Stability Monitoring (SVSM) application, with the ability to integrate a high speed power flow model

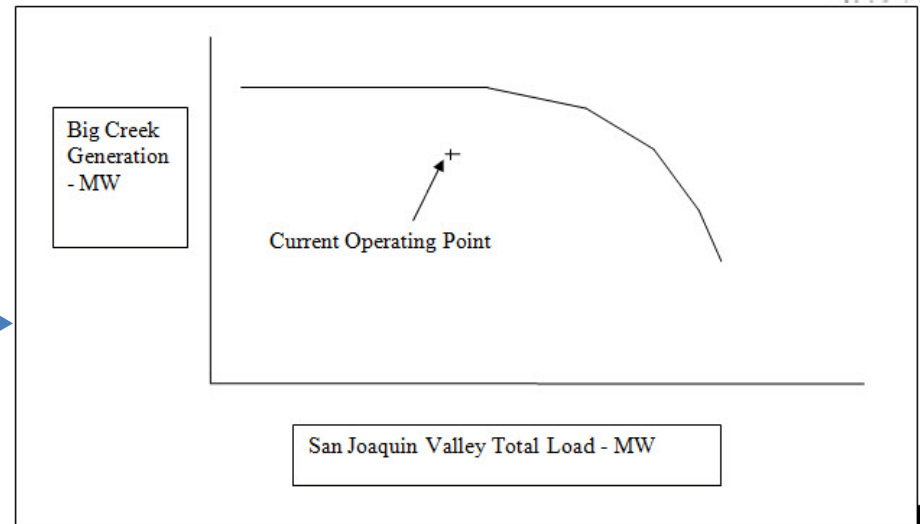


Voltage Stability – SCE's Big Creek System



Voltage Stability – Margin and What If

Real-Time - RTDMS to calculate current operating point and provide the operator with margins (e.g. generation movement or load change)



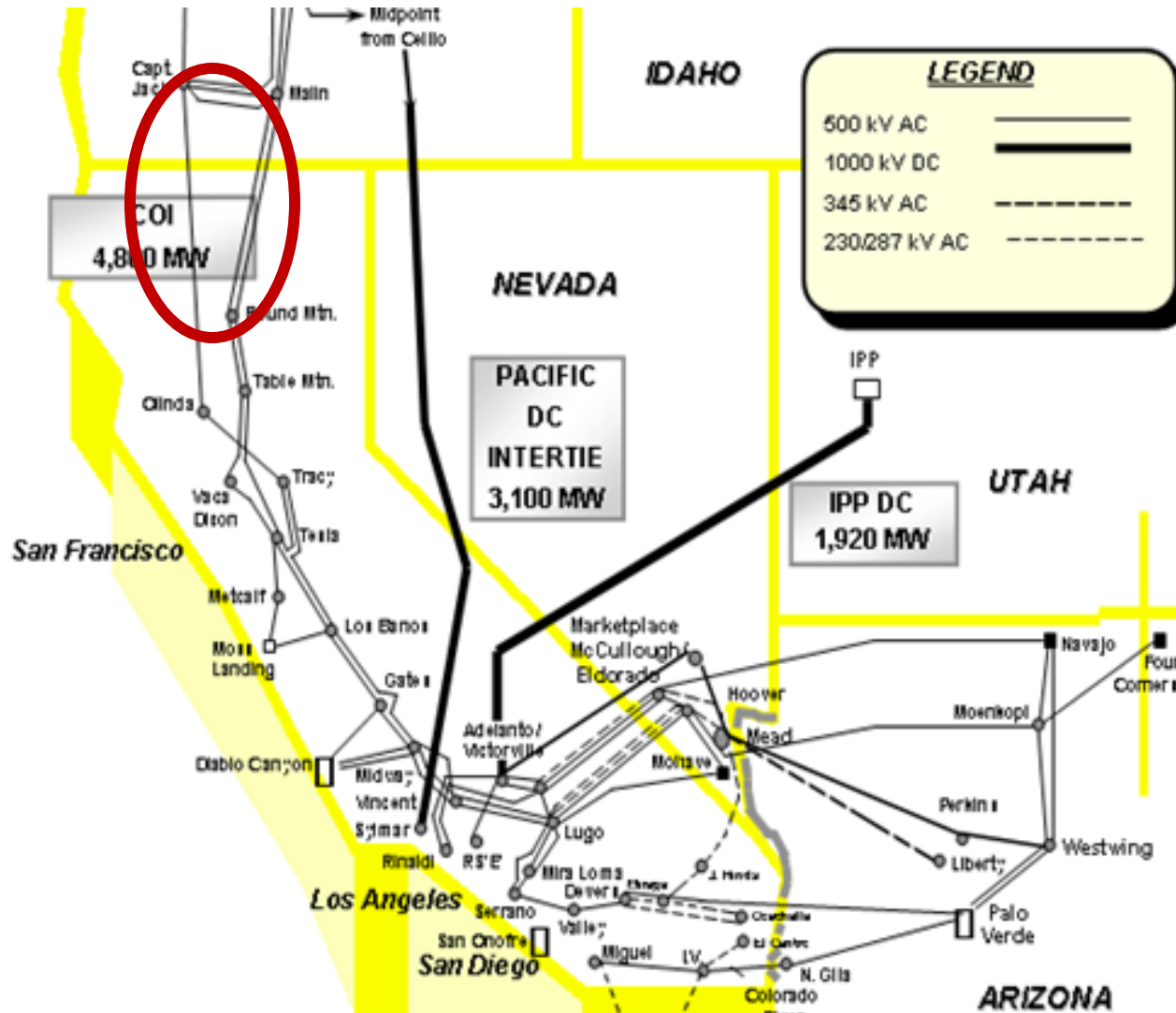
Future Hours and what if Scenarios - RTDMS to be integrated with a high speed power flow model (V&R Energy) to address operator's future needs and concerns

Critical operating answers in near Real Time for:

- Where are you (current position)
- Where are you going (trend)
- What is the margin available?
- What will be the impact of changes in Load, Generation and Topology?

Dynamic Nomogram - Increase Asset Utilization

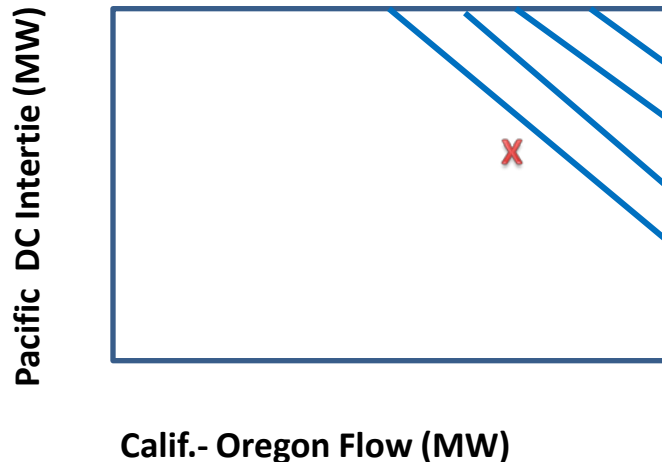
California – Oregon Interconnection



From Static to Dynamic Nomograms

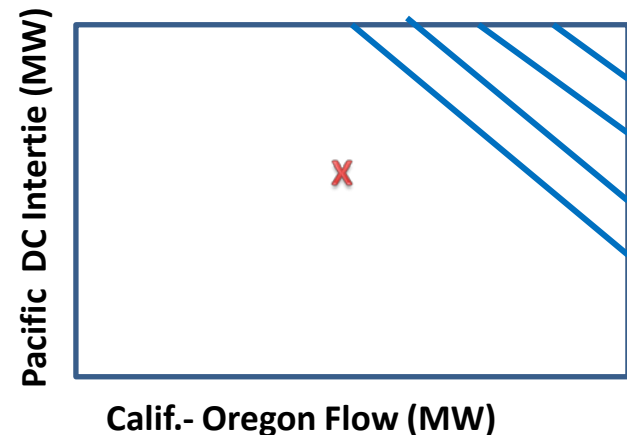
Static Nomograms

- Based on seasonal studies
- Transmission Owners' worst case scenarios; Preserve path ratings
- Assumptions may not reflect reality
- Operating zone is at best a conservative estimate



Dynamic Nomograms

- Validate Static Nomograms
- Monitor and track the actual path capability
- Help define margins accurately or lack of margin
- Dynamic Nomograms will allow operators to work with real margins instead of extra cautious assumptions



Renewable Integration



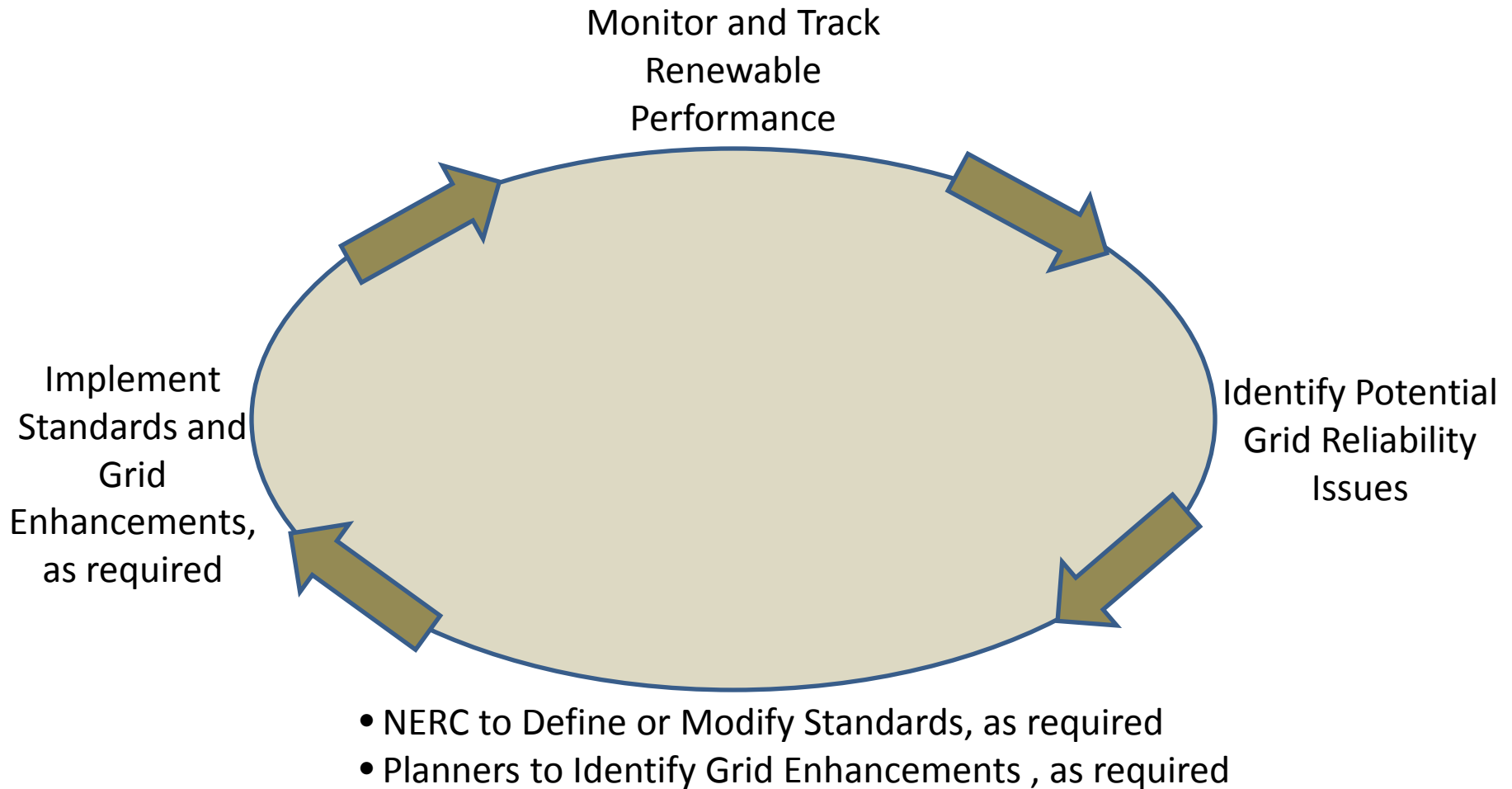
**Interconnected
Grid**

RTDMS to monitor, track and report on performance of renewable resources, looking for potential grid reliability issues, such as:

- Power Oscillation modes
- Frequency oscillations
- Low voltage ride through
- Inertia and Hz response



Renewable Integration (cont.)



Automated Event Reports

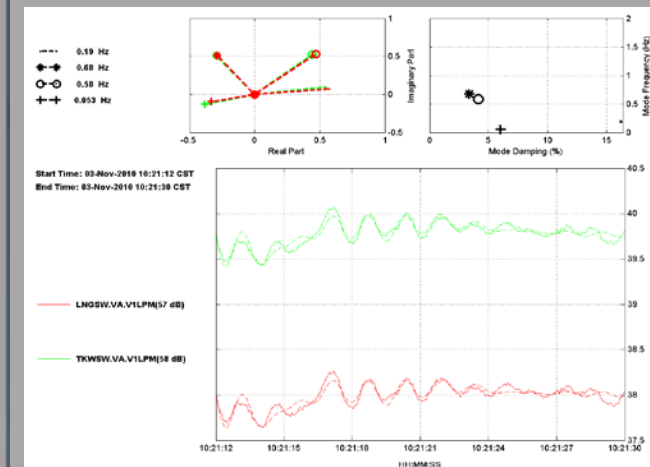
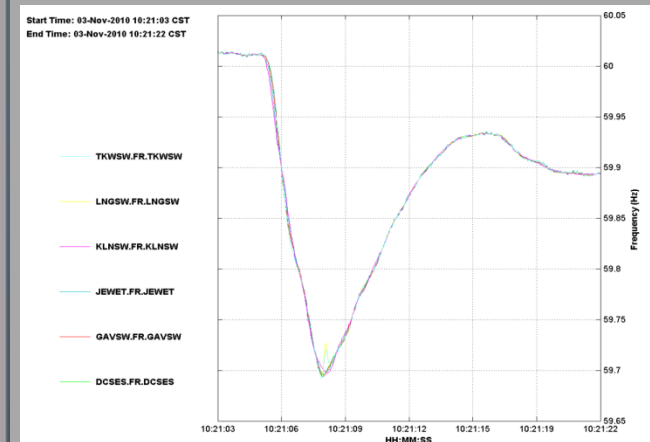
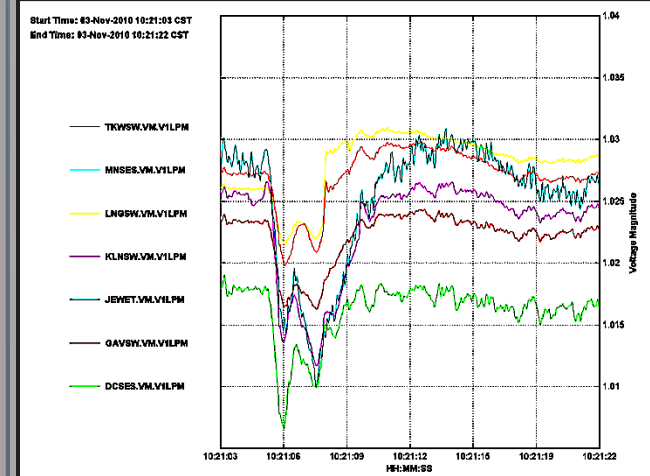
- Arm the operators with the information they need to make on the spot decisions
- Analysis available immediately
- Summarize the key metrics – operator gets a 360° view of all parameters at a glance:
 - Location, status of key metrics (frequency, voltage, damping, power flows)



| | |
|---------------|---|
| Date & Time | 02/01/2011, 15:30:45 – 15:30:53 (8 seconds) |
| BA | CAISO |
| Reporting PMU | Round Mountain 500 kV |
| Description | Malin-Round Mt. #2 500 kV Line Trip |



| | Pre | Max/Min | Δ | Post |
|---|--------------------|-------------|----------|-------|
| Frequency | 60.01 Hz | 59.89 Hz | 0.12 Hz | 60.01 |
| Voltage | 535 | 560/510 | +25/-25 | 520 |
| Wide Area \angle Grand Coulee-Devers | 70 | 75/65 | 5 | 75 |
| MW | 3,700 | 4,400/2,800 | 200 | 3,500 |
| Segment \angle diff Malin-Round Mt. | 40 | 46/40 | 6 | 46 |
| Modes | 0.28 Hz 0.34 Hz | N/A | N/A | N/A |
| Damping | 18% 8% | N/A | N/A | N/A |



Taking RTDMS Beyond Visualization at the CAISO

RTDMS – Will provide a production quality, redundant and reliable system that will integrate with other applications (EMS, third party data e.g. weather, historian)

- Voltage Stability
- Dynamic Nomograms
- Renewable Integration
- Automated Event Reports

Thank You



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