

# Synchro-Phasor Applications at Bonneville Power Administration

i-PCGRID Conference

March 31, 2011

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# Applications

- Engineering Applications
  - Reliability starts with good planning – understanding the system and making the right investment decisions
- Wide-Area Situational Awareness (WASA)
  - Give power system operators and tech staff greater visibility of electric power grid
- Improvements of the existing EMS applications
  - State estimation
- Stability Controls (WACS)
  - Unlock transmission capacity, provide “defense in depth” against blackouts



# Engineering Applications

- BPA is the pioneer of Wide-Area Monitoring Systems (WAMS)
  - Bill Mittelstadt received Federal Engineer of the Year
  - BPA had PMUs for 15+ years, 25 units are in service today, getting data from several other WECC utilities
- BPA developed and deployed engineering application using WAMS technology
  - System performance analysis and testing
  - Model validation
  - Inter-area power oscillation analysis
- BPA today is very effective and efficient in analyzing events **after** they happen



# Power System Models

Power System Models are used:

- Make decisions on the capital investment
- Set system operating limits

Accurate models are essential for reliable and economic grid operations and investment

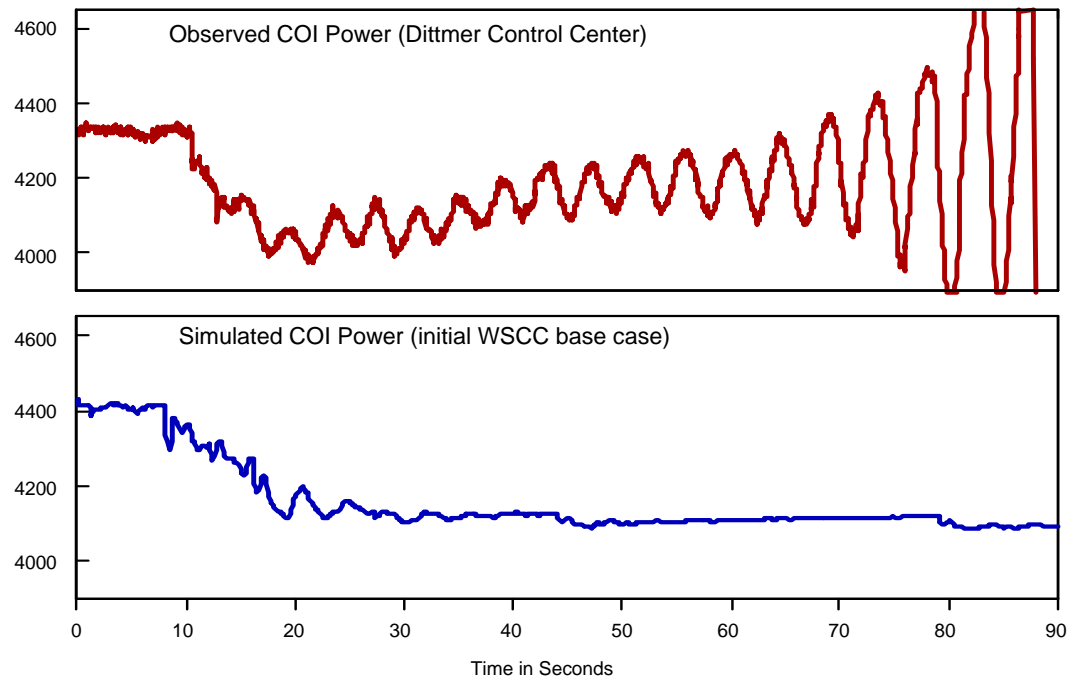
Accurate modeling and model validation are now required by NERC MOD standards



# Why it matters

- Failure of models to predict or reproduce the 1996 disturbances
- Loss of confidence in model's ability to set transfer capability limits
- Operational de-rating of California-Oregon Intertie (from 4,800 to 3,200 MW) and Pacific HVDC Intertie (from 3,100 to 2,000 MW)

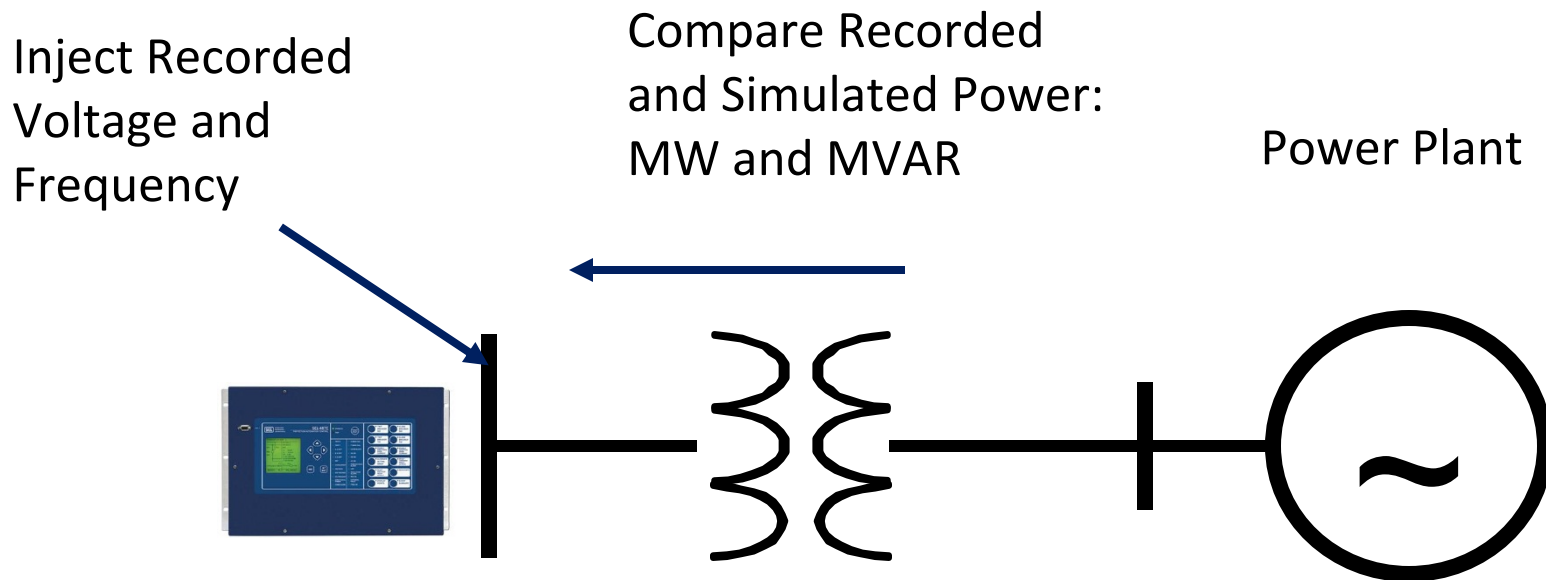
**August 10, 1996**



**Model Validation is one of the deliverables under WISP**



# Power Plant Model Validation



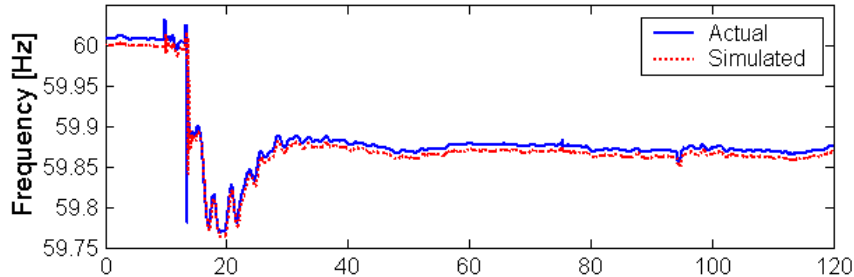
Disturbance “playback” is a standard feature in GE PSLF Tools developed under a Technology Innovation project at BPA starting in 2000



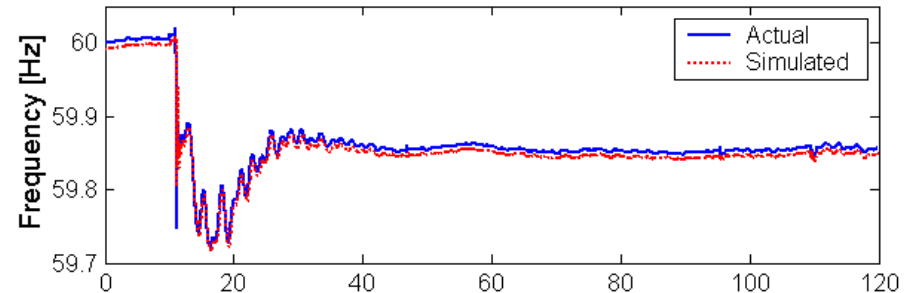
# Power Plant Model Validation

- Power plant model verification by using disturbance data is an acceptable technical approach
- More frequent verification, early detection of abnormalities, much less expensive or risky than staged generator tests

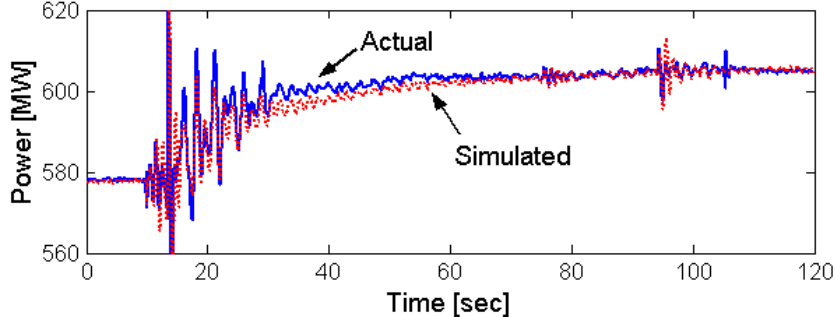
Grand Coulee Frequency, NW RAS event on July 15, 2002



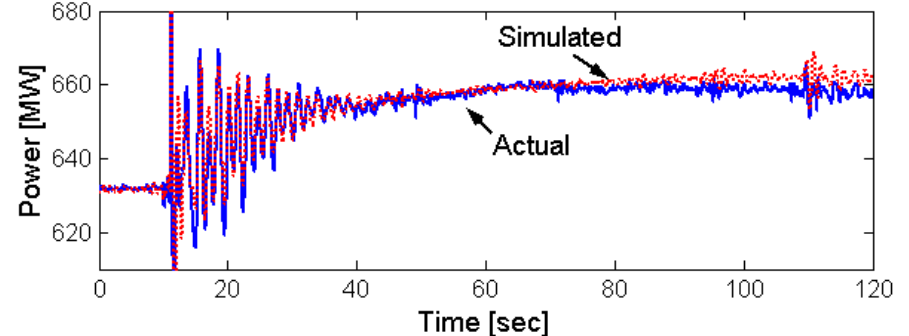
Grand Coulee Frequency, NW RAS event on July 16, 2002



Grand Coulee #20, NW RAS event on July 15, 2002



Grand Coulee #20, NW RAS event on July 16, 2002

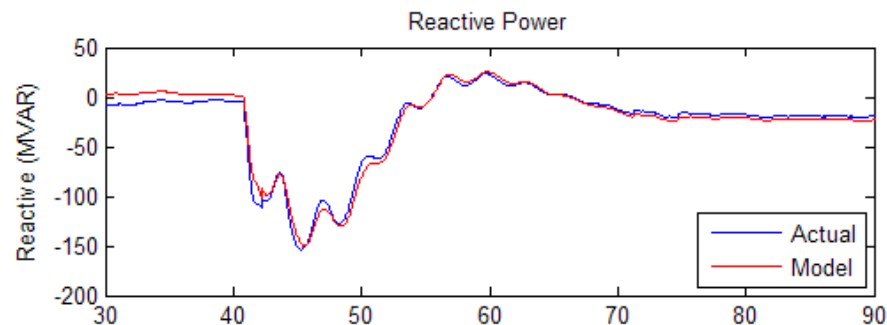
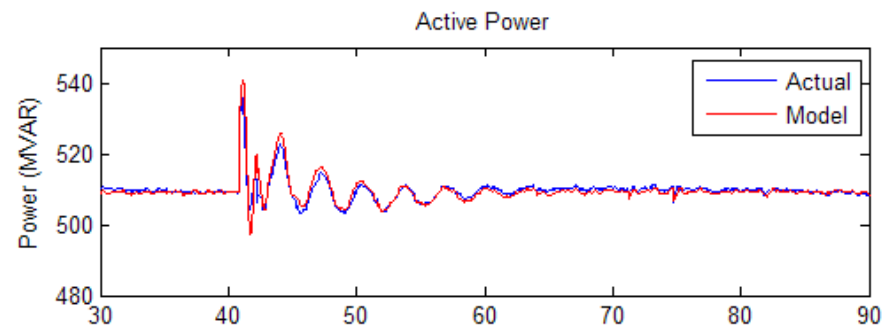
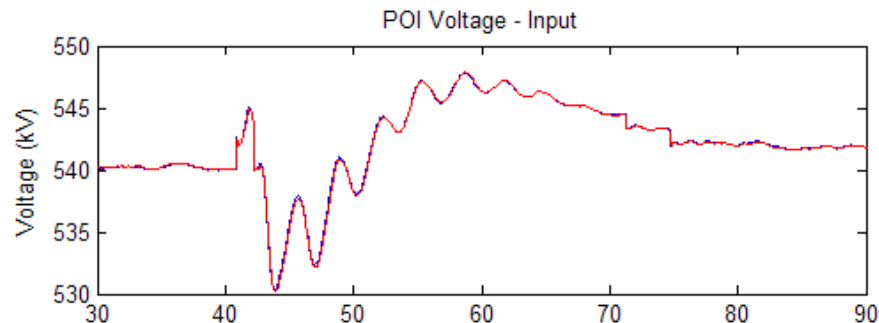
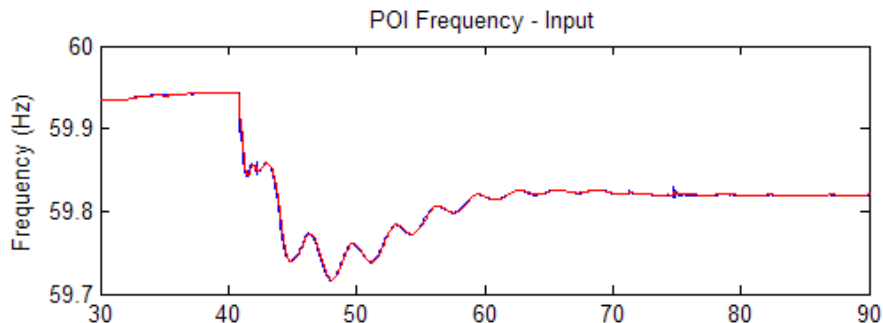


Blue line = actual recording

Red line = model

# Power Plant Model Validation

- Successful model validation for 550 MW combined cycle plant



Voltage and frequency are inputs

Active and reactive power are “measures of success”

Blue line = actual recording

Red line = model

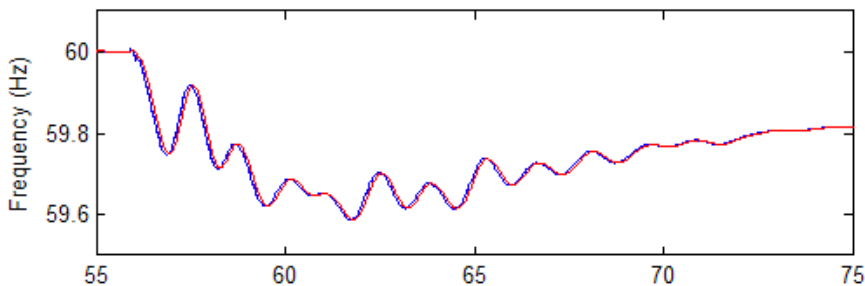




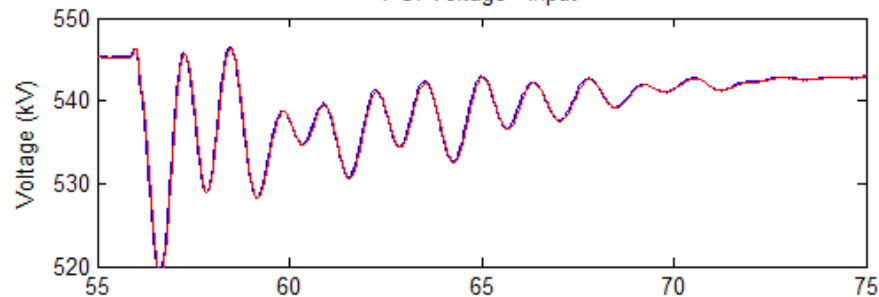
# Power Plant Model Validation

- What a bad model looks like (800 MW steam-turbine unit)

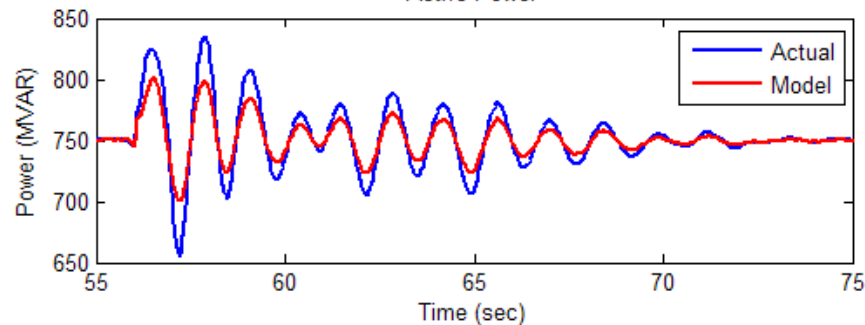
POI Frequency - Input



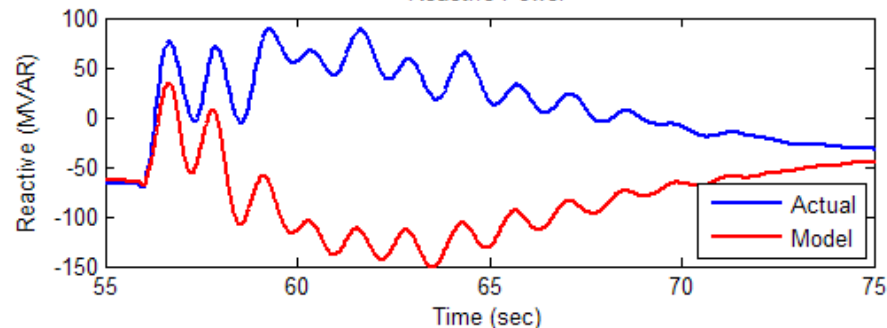
POI Voltage - Input



Active Power



Reactive Power



Voltage and frequency are inputs

Active and reactive power are “measures of success”

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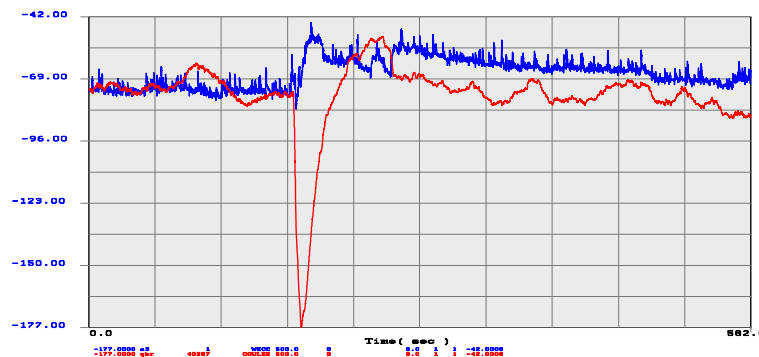
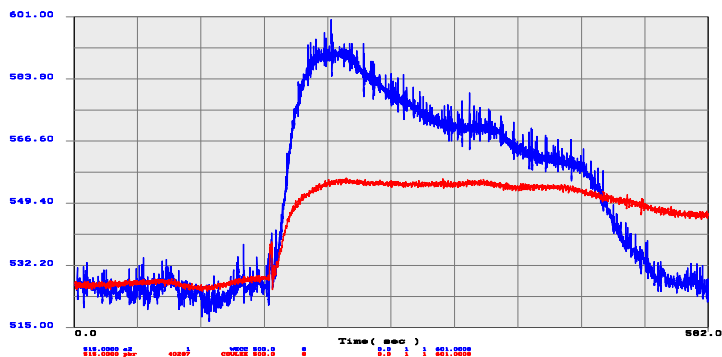


# Power Plant Model Validation

- What a bad model looks like (700 MW hydro-turbine unit)

- active power

- reactive power



TAMMO MODEL, OUTPUT GENERATED 2003-07-16 11:52:08  
 #WZINGMJS 1620 FOR FC-2001-1:2003-07-14:17:43--1-1-0-0

TAMMO MODEL, OUTPUT GENERATED 2003-07-16 11:52:08  
 #WZINGMJS 1620 FOR FC-2001-1:2003-07-14:17:43--1-1-0-0

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Coulee20-2010-06-08-1018.chf

atlas\grand coulee\unit20  
 Mon Jun 21 16:01:17 2010

Coulee20-2010-06-08-1018.chf

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 Mon Jun 21 16:01:17 2010

Active and reactive power are “measures of success”

Blue line = actual recording

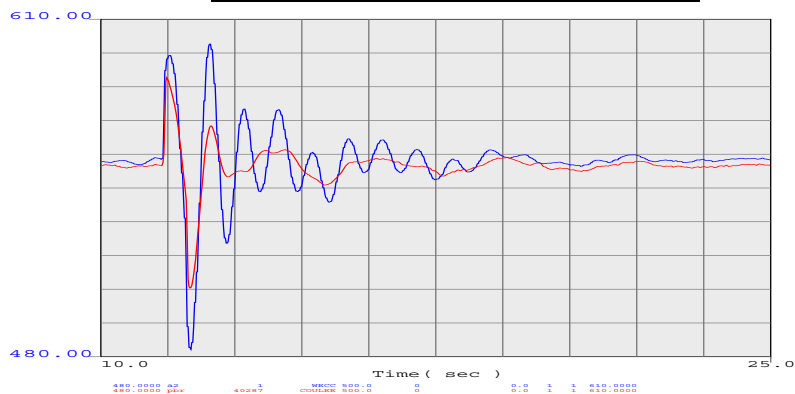
Red line = model



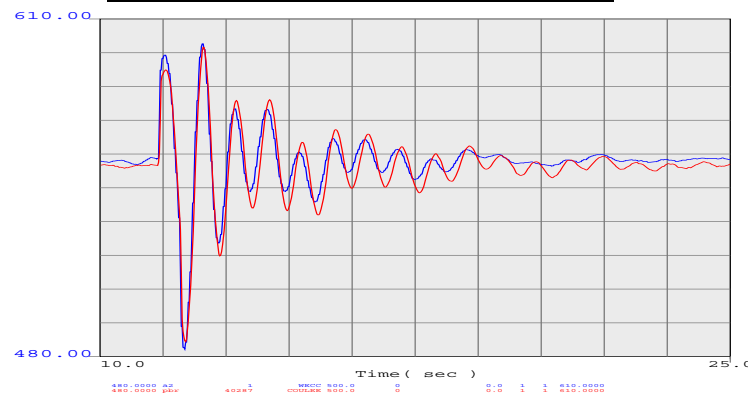
# Early Detection of Control Failures

- Having phasor data available at this 700 MW hydro-power plant allowed to identify Power System Stabilizer failure

PSS is modeled ON



PSS is modeled OFF



Active Power Oscillation  
 Blue = actual recording  
 Red = models



# Resources

- NASPI Planning and Implementation Task team:
  - [www.naspi.org](http://www.naspi.org)
  - Technical session at the upcoming NASPI meeting on June 8-9 in Toronto, ON
  - Presentation at NERC PC meeting on December 7, 2010
  - Power plant disturbance monitoring document
- WECC Modeling Workshop, June 21-22 in Salt Lake City, UT – Register Today !
- Contacts:
  - Dmitry Kosterev, [dnkosterev@bpa.gov](mailto:dnkosterev@bpa.gov)
  - Alison Silverstein, [alison.silverstein@mac.com](mailto:alison.silverstein@mac.com)
  - Donald Davies, [donald@wecc.biz](mailto:donald@wecc.biz)



# Moving Forward

2005

Vickie VanZandt:

It is time to move

from *Wide-Area Monitoring*

to *Wide-Area Controls*

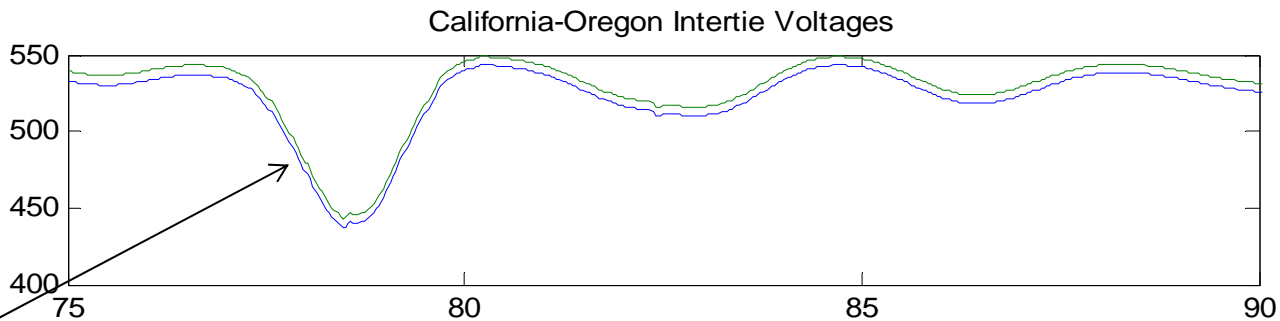


## Response-Based RAS at BPA

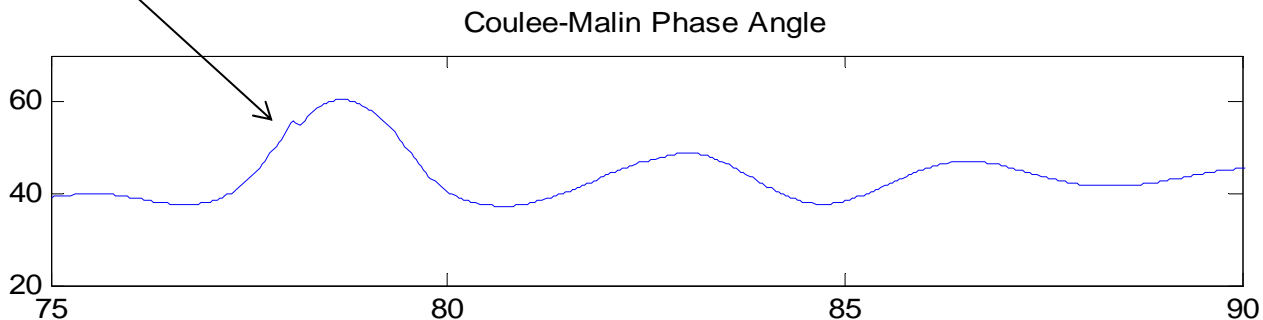
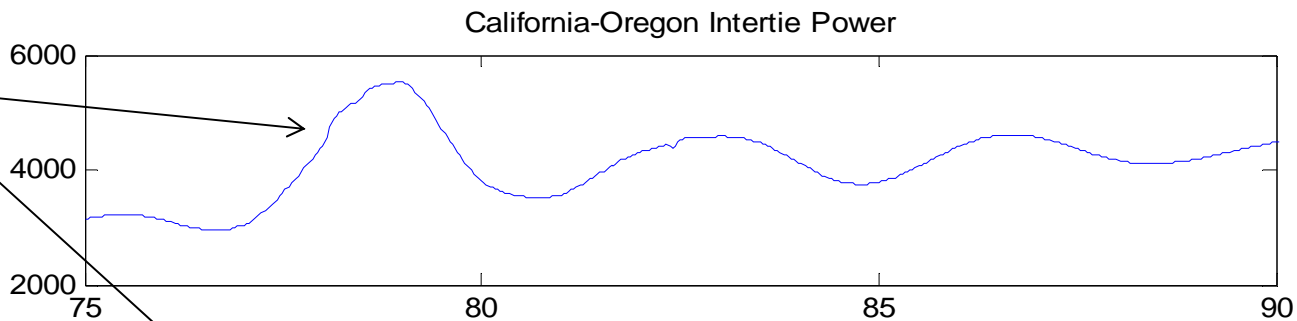
- Fast AC Reactive Insertion
  - Implemented in 1996 in response to the system outages
  - Insertion of series capacitors at Fort Rock for low voltages at California – Oregon Intertie
  - Arguably prevented potential blackouts on
    - June 14 2004 Palo Verde 3-unit outage
    - June 6 2002 sequential DC outage
- Rate of power change relay to initiate Chief Joseph Brake insertion



# June 14 2004 Palo Verde 3-Unit Outage



FACRI



Time (sec)



# Wide Area voltage stability Control Systems (WACS)

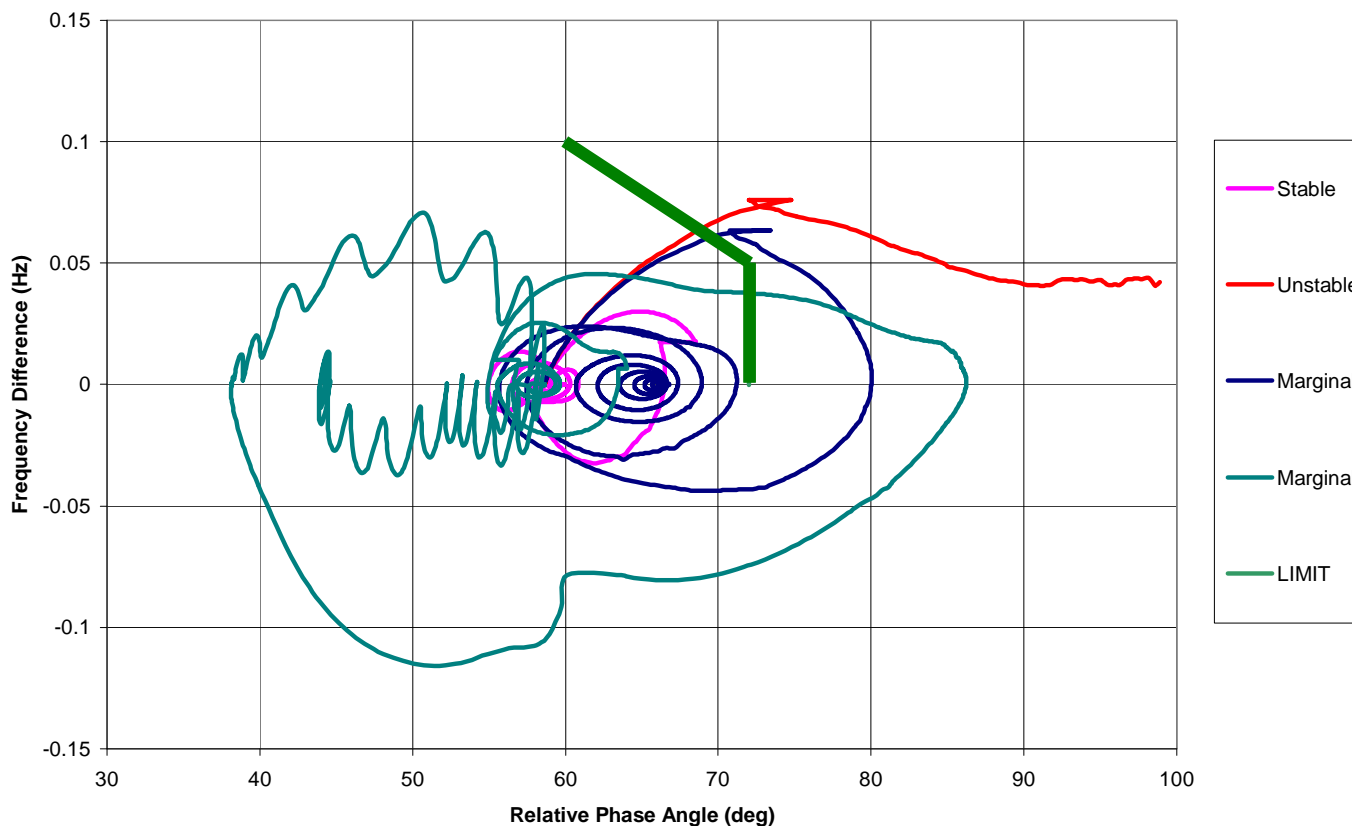
- WACS is response-based RAS using wide-area synchronized measurements
- Initial research was done by Carson Taylor at BPA
- Project refocus in 2009-2010:
  - Do No Harm ! – Brian Silverstein, BPA Tx SVP
  - Keep logic simple and failure tolerant
- Algorithms:
  - Angular stability in phase angle plane
  - Reactive reserve at major power plants



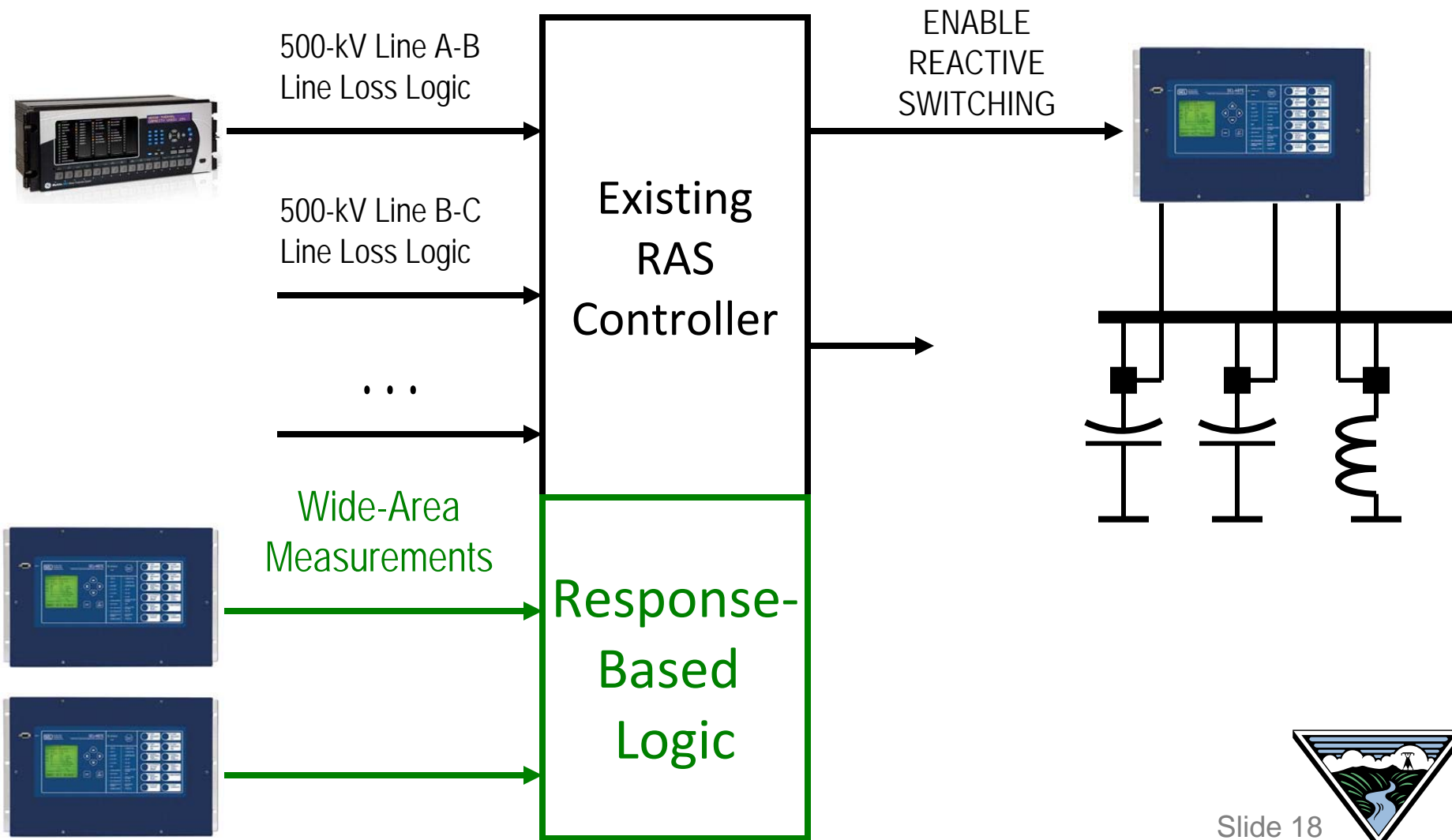


# Wide Area voltage stability Control Systems (WACS)

Phase Plane Algorithm



# Wide Area voltage stability Control Systems (WACS)



# Thank You

