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# Implementation of State Estimation at Tacoma Power

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#### • State Estimation in general

- Background
- o What
- Why

# State Estimation at Tacoma Power Considerations/Challenges Milestones



#### Acronyms

- FEP Front End Processor
- ICCP Inter-control Center Communications Protocol
- LODF Line Outage Distribution Factors
- NERC North American Electric Reliability Corporation
- PLC Programmable Logic Controller
- RC Reliability Coordinator
- RTCA Real-Time Contingency Analysis
- RTU Remote Terminal Unit
- SCADA Supervisory Control And Data Acquisition
- SCED Security Constrained Economic Dispatch
- SE State Estimator, State Estimation
- SOE Sequence Of Events
- TSA Transient Stability Analysis
- VSA Voltage Stability Analysis
- WECC Western Electricity Coordinating Council



- Originated in the aviation industry to estimate location of an aerospace vehicle
- Introduced to the Power System in 1968 by Fred C. Schweppe
- Utilized mostly by large utilities





 Fred Schweppe defined the state estimation as, "a data processing algorithm for converting redundant meter readings and other available information into an estimate of the state of an electric power system".







- Provide an estimate for unmetered quantities
  - Power flows
  - Voltages



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- Provide an estimate for all metered quantities due to imperfections in
  - Current & voltage transformer
  - Transducers
  - Rounding in calculations
  - Communication links/Time skew



- Filter out small errors due to model approximations and measurement inaccuracies
- Detect and identify the bad data



**Data Flow** 



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- Help system operators in decision making
- To get a base case for other analyses
  - Real-time Contingency Analysis
  - Voltage Stability Analysis
- Give warning for any emergency situation



• Power system can be analyzed for different operating conditions



## Why do we need State Estimation?

- Required for Operator Training Simulator (OTS)
- Enhance Dynamic Line Ratings
- Support New Services
  - Frequency Response
  - Spinning Reserve





### Why do we have to have State Estimation now?



- NE Blackout August 2003:
  - Evaluate and adopt better real-time tools for operators

#### SW Blackout Sept 2011:

 Ensure transmission operators, <u>including</u> <u>small ones</u>, have adequate situational awareness

#### NERC Standard April 2017:

 Each Transmission Operator shall ensure that a Real-time Assessment is performed at least once every 30 minutes



#### **State Estimation at Tacoma Power**

- EMS replacement is a good opportunity for SE implementation
- State Estimation is new tool
  - RFP (Specifications)
  - Evaluation (Scoring Bids)
  - Internal support
  - External support



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#### • Considerations

- System representation
- Availability of model/data
- On-going maintenance
- Model Reduction Technique
  - LODF to identify impacting facilities
  - Equivalence or Pseudo
    Injections at the boundary





- CIM/XML conversion challenges
  - Conversion tool sizing
  - Incompatible fields
  - Different naming conventions

#### Helpful resources

- WECC Planning cases
- PEAK RC real-time cases (.csv format)





#### SE at Tacoma Power – Real-time Data

- MW/MVAR instead of AMPS, MVA, PF
- Many MVAR measurements are not available
- Pseudo measurements for non-telemetered data



#### SE at Tacoma Power – External System Data

- ICCP data
  - Telemetered
  - Non-telemetered
- Detailed modeling data
  - Connectivity
  - By-pass devices
  - Emergency connections



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### SE at Tacoma Power – Measurement Mappings

- Breaker flow
  - BKR B-223 3 PHASE MW
- Transformer flow
  - O XFMR #1 3 PHASE MW

□\_\_\_\_\_B-223 <\_\_\_\_



- Voltage measurements
  - BUS A VOLTAGE PHASE A
    - o Phase A LN\*sqrt(3)
    - o Phase A-C LL
    - o Phase A-B LL
    - Phase C LN\*sqrt(3)



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#### SE at Tacoma Power – Model Tuning

- Zero impedance branch(zbr) threshold default value
  - Jumpers
  - o Buses
  - Series capacitors







#### SE at Tacoma Power – Configuration Tuning



- Real-time sequence
- Alarm functionality
  - Last solved time
  - Mismatch
  - Violations
- Archive
  - SE Cases
  - Export cases (.raw, .epc)



#### SE at Tacoma Power – User Profile Tuning

- Administrator
- Engineer
- Dispatcher
- Other





#### Model Maintenance

- Internal changes
- External changes

#### Study

- Real-time Assessment
- Next-day Study
- 24/7 Support





#### SE at Tacoma Power – Milestones



- ✓ October 2017:
- March 2018:
- April/May 2018:
- May/June 2018:

June 2018:

- Factory Acceptance Testing Site Acceptance Testing User Acceptance Testing System Availability Testing (Parallel Testing w/ production) System fully commissioned
- July Sept 2018: Decommission old EMS



- A good vendor is required
- Cooperation between TPWR and others (PEAK, PSE, BPA, & SCL) is important
- Cooperation among groups inside TPWR is very important



• Diligence of modeling engineers is a must

