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# Deployment of Real-time State Estimator and Load Flow in BC Hydro DMS - Challenges and Opportunities

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# Summary

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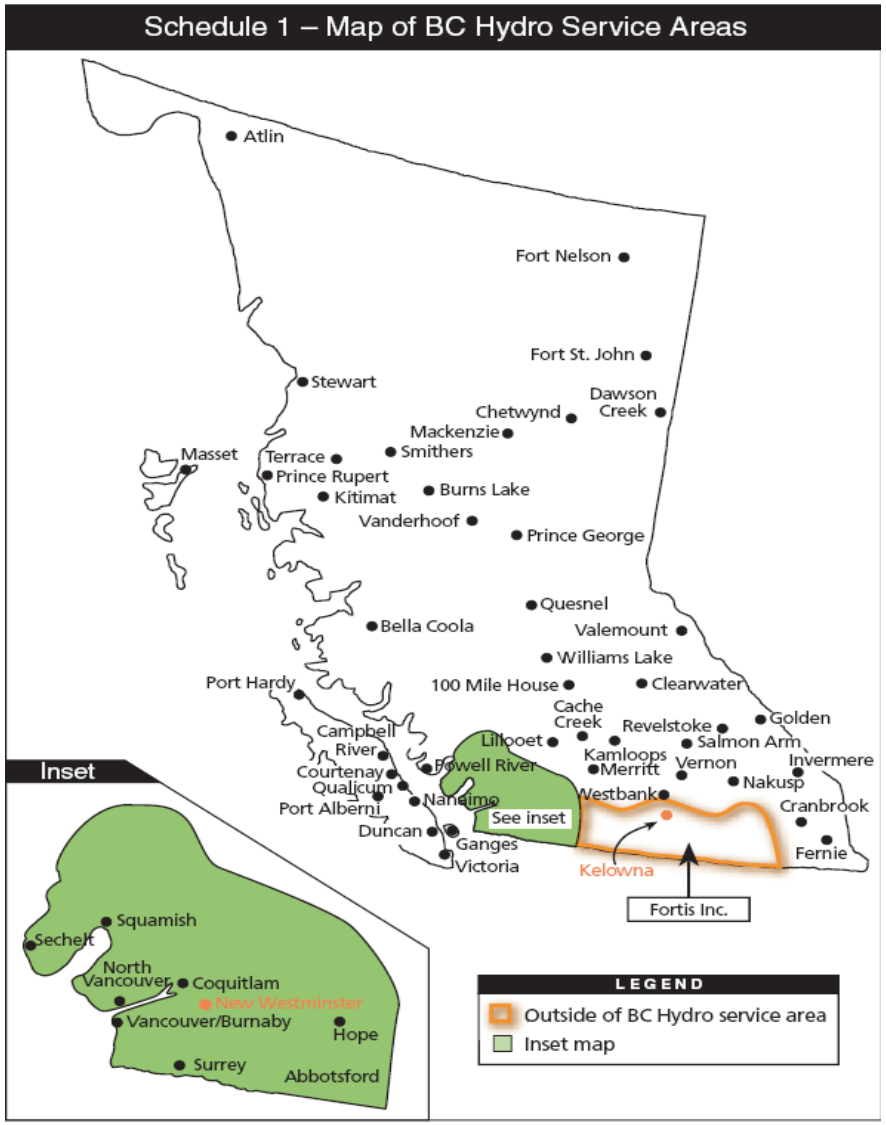
- Overview of BC Hydro distribution system
- DMS model requirements
- Distribution application sequence
- State estimator tuning and commissioning
- Results
- Next steps

# BC Hydro System

- As one of the largest electric utilities in Canada, BC Hydro serves customers in an area containing over 94% of British Columbia's population.
- 1.8 million customers
- Reliable Power, at Low Cost for Generations
- 11.3 GW generating capacity
  - 90.3% hydroelectric
  - remainder diesel or thermal
- Operating Area is 68,201 $km^2$



# BC Hydro Quick Facts

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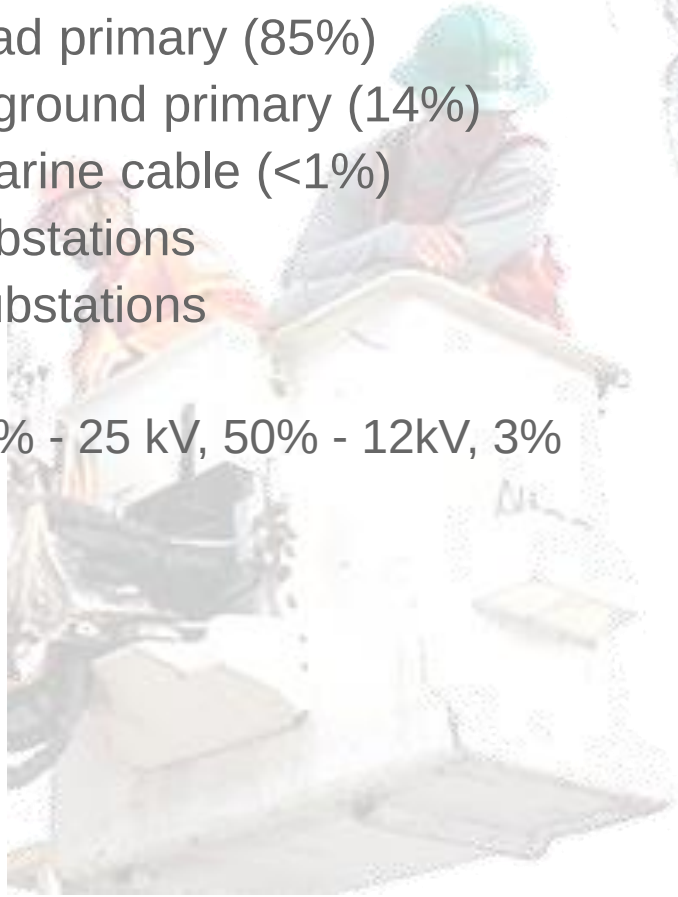
- 18,500 km transmission (500kV to 60kV)
- 1,000,000 poles, 300,000 transformers
- 47,000 km overhead primary (85%)
- 7,600 km of underground primary (14%)
- 400 km of D submarine cable (<1%)
- 212 distribution substations
- 75 transmission substations
- 1500 + feeders
  - <1% - 35 kV, 47% - 25 kV, 50% - 12kV, 3% - 4 kV



# DMS Model Requirements
# Data Sources

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- Distribution substation data – Energy Management system (EMS)
- Distribution network data (outside of substation fence) – Asset Management GIS
- Real-time data (SCADA)
- Load profiles (customer care and conservation)
- Plant alterations and system design - GIS
- Weather data (Environment Canada)
- Supplemental technical information related to distribution equipment

# DMS Model Development

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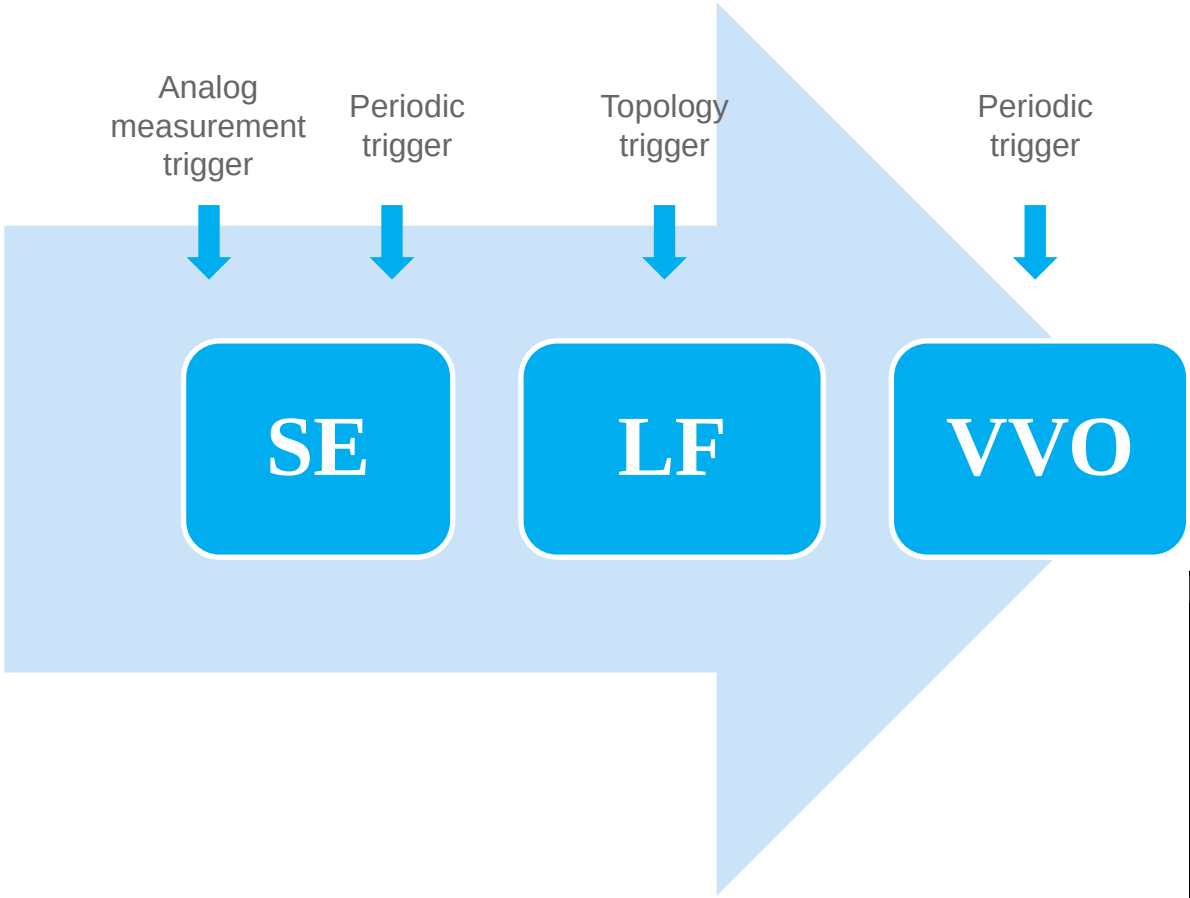
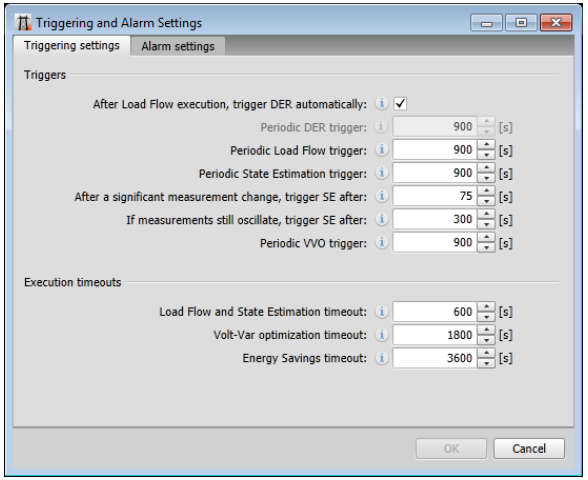
- Conversion of substation model from EMS into CIM format
- Conversion of distribution network model from GIS into CIM format
- Addition of supplemental substation and feeder data during model build including load profiles
- Stitching of EMS and GIS CIM models into a cohesive DMS model in proprietary phase connectivity format
- Export of SCADA model from EMS to cover all substation real-time measurements
- ICCP definition for integration real-time SCADA models of EMS and DMS. All substation controlled via EMS as a conduit
- Creation of SCADA model for measurements and statuses outside of substation fence in DMS SCADA subsystem

# Distribution Applications Sequence



# Distribution State Estimation – BCH Implementation

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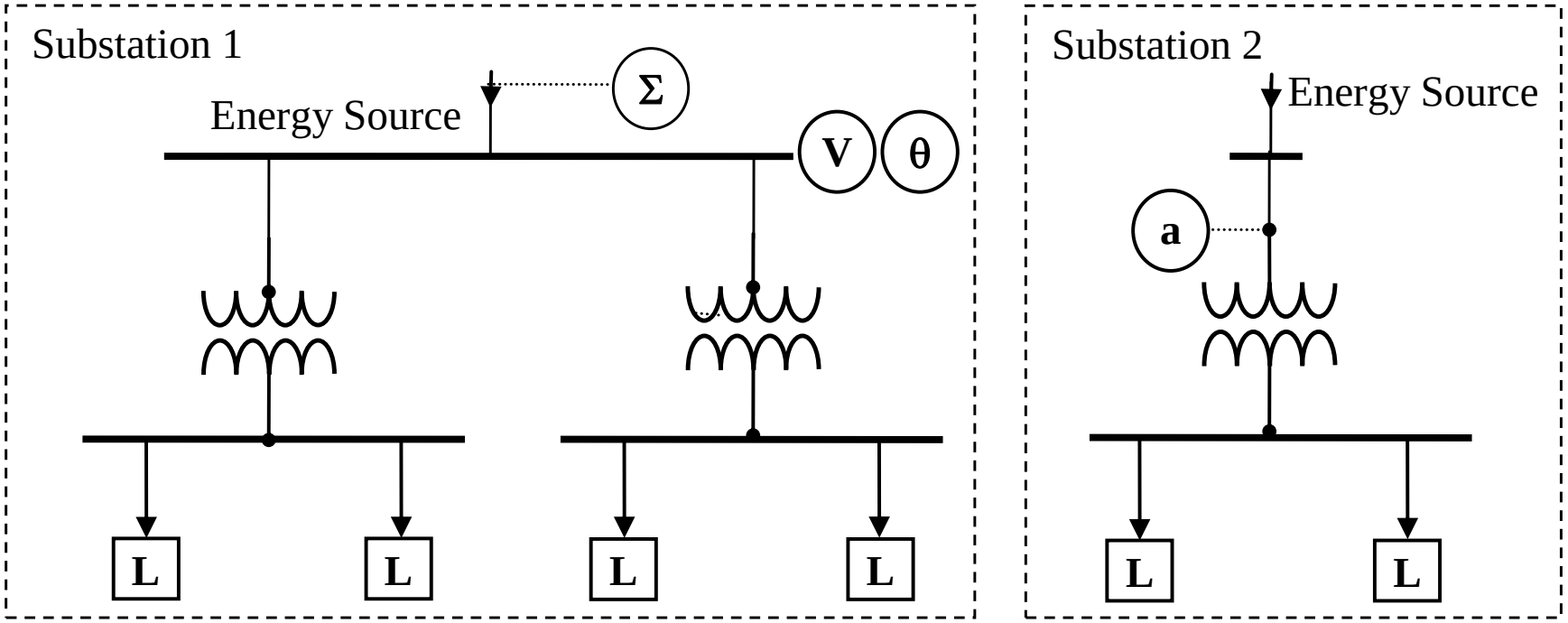
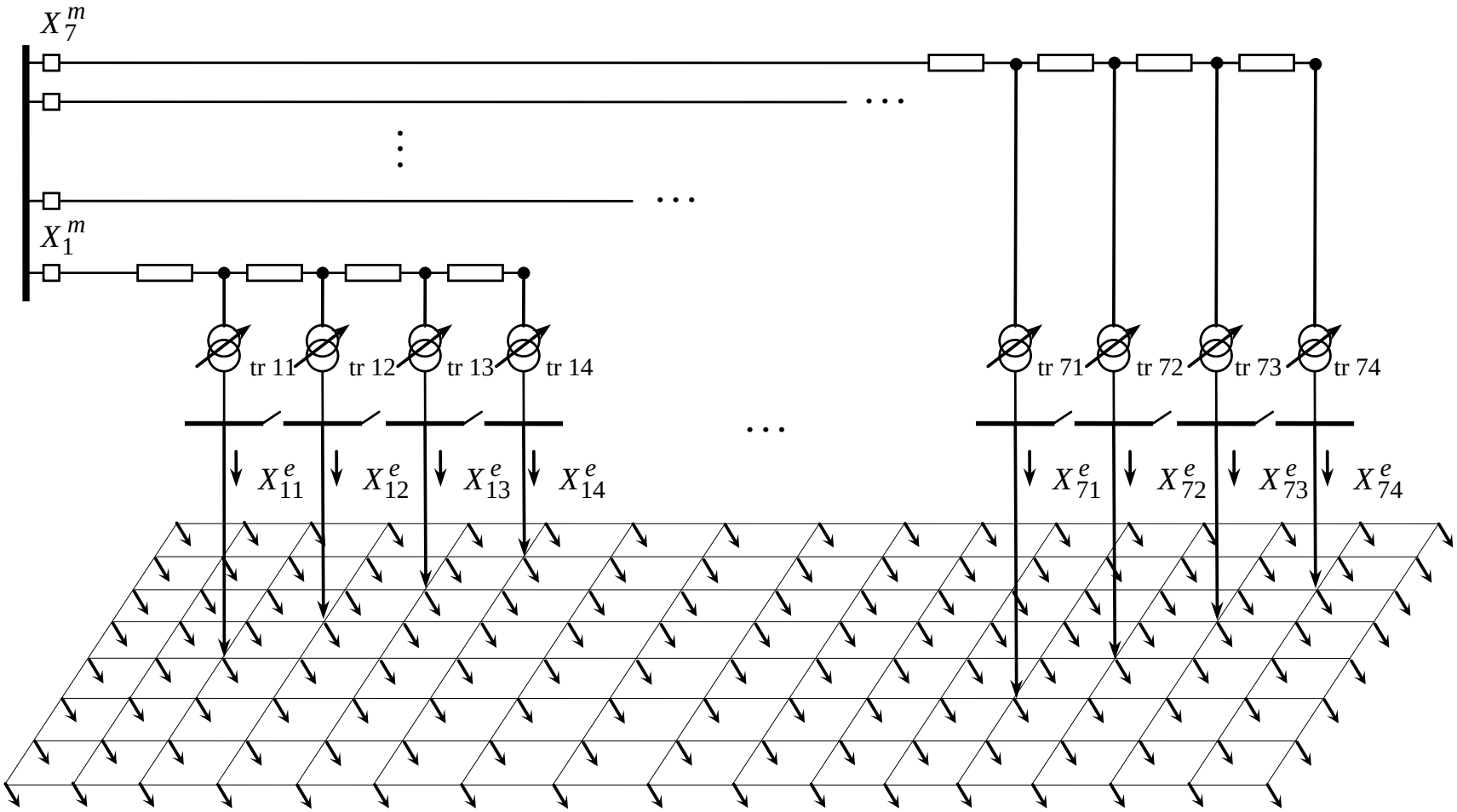
- Integration with EMS – energy source data transferred from EMS state estimator
- Summed measurements representation
- Utilization of field measurements including SMI
- Archiving and tracking of state estimator solution (PI)
- State estimation of meshed distribution networks (includes complete low voltage networks)
- Customized reports – violations and performance indices

# Distribution State Estimation – Integration with EMS



# Distribution State Estimation – Meshed Networks



# Distribution Load Flow – BCH Implementation

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- Two tier algorithm to enable solution for meshed networks including low voltage)
- Customized solution reports for violations and performance indices
- Secondary networks equivalent – to optimize performance for validation purposes

# Distribution Load Flow – Reports

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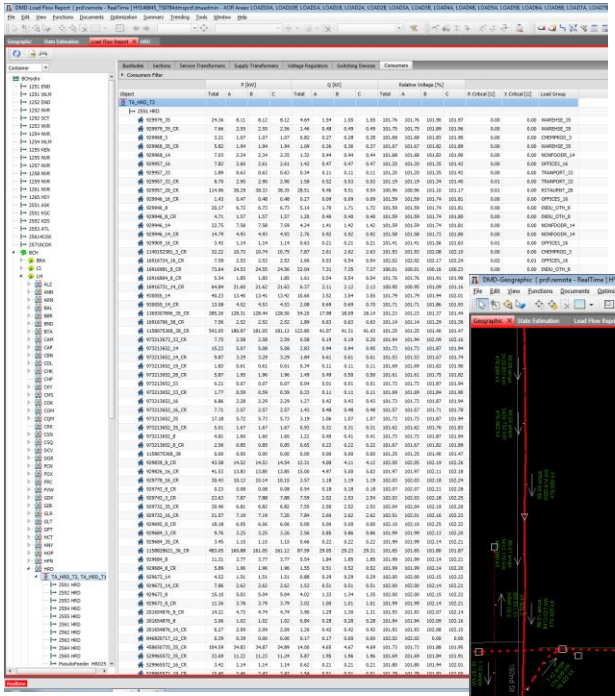
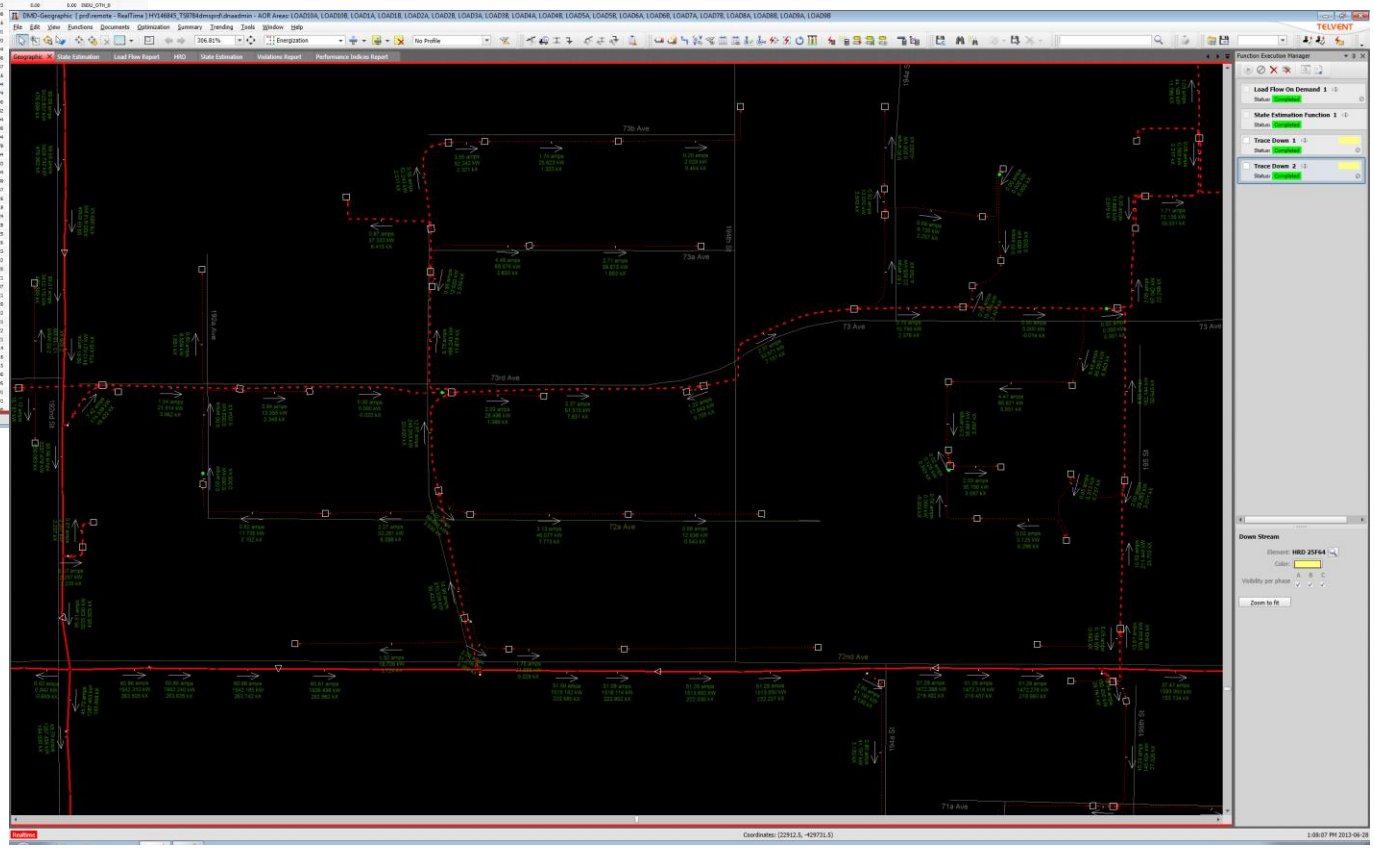


- Tabular reporting of selected LF results
- Graphical presentation of LF flow along distribution network



# State Estimator Tuning

- Tuning performed in five phases
- Phases 1-3 model validations
- Phase 4 measurement error tuning
- Phase 5 Benchmarking against real-time

# Preparatory network tuning for SE Phase 1

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- Topology validation for substations and connected distribution system
- Utilization of Topology reports from DMS and comparison with source data
- Validation of substation transformer attributes
- Validation of LTC controller model
- Validation of substation transformer impedance
- Validation of a proper “stitching” between feeder and feeder head
- Validation of equipment models: capacitor, voltage regulator, generator etc.
- Validation of number of elements imported from source GIS system
- Validation of catalogs assigned to equipment

# Preparatory network tuning for SE Phase 1

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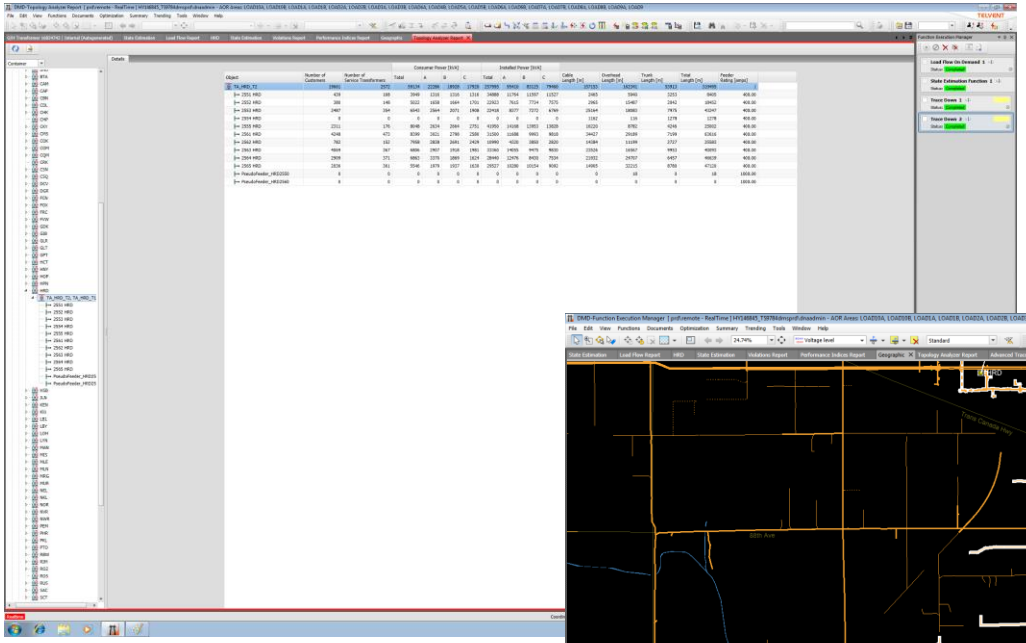

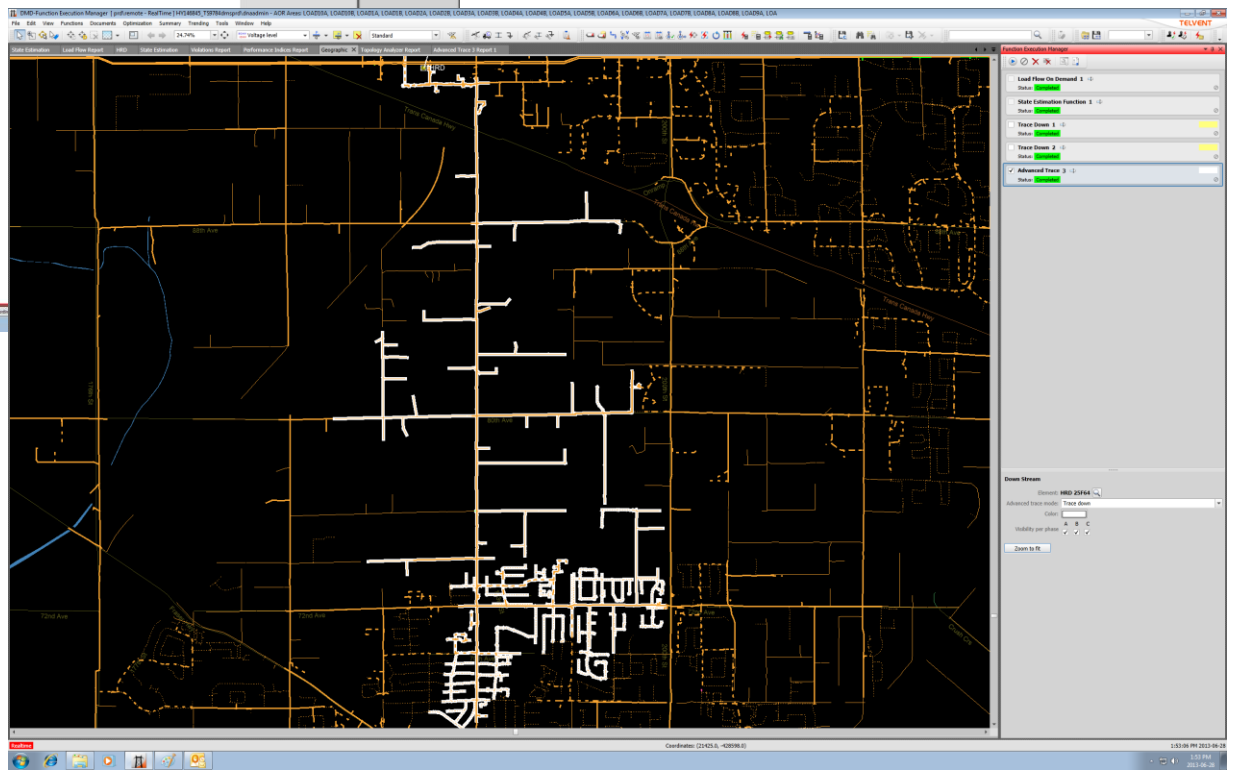

# Preparatory network tuning for SE Phase 2

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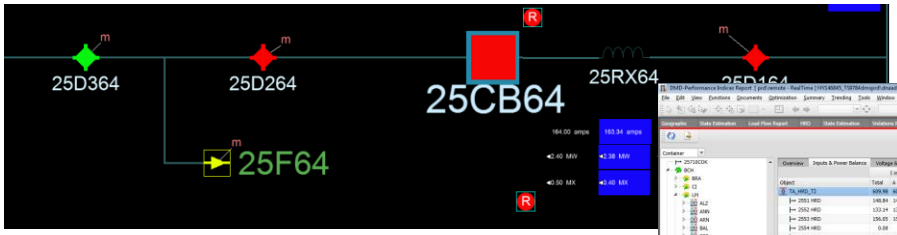
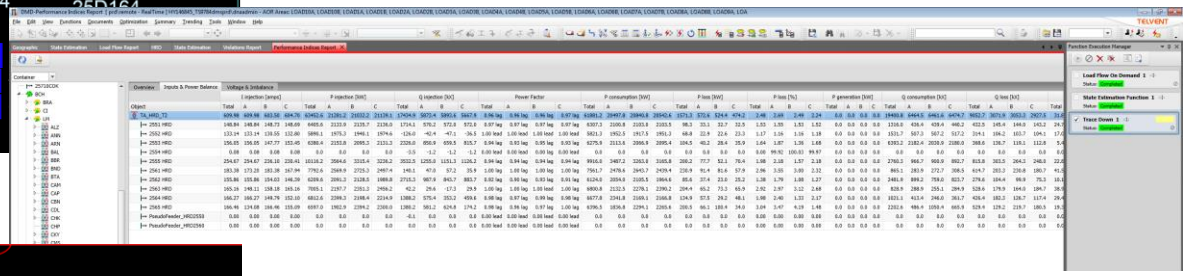
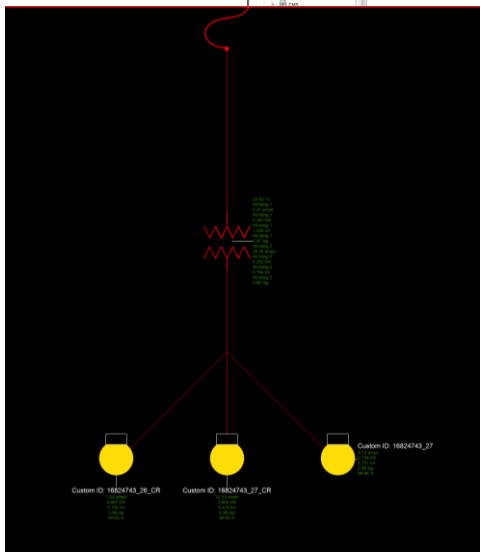
- SCADA model &validation of ICCP points
- Display validation for LF&SE
- Analysis of Load flow and State Estimation results on selected area





# Preparatory network tuning for SE Phase 3

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- Analysis of overloaded service transformers – each individual case was looked to determine source of problem:
  - Connectivity issues – incorrect association of customers and transformers
  - Legitimate overload
  - Incorrect transformer size
  - Incorrect load profile

- Analysis of overloaded sections – determination of probable cause:
- Data issue (e.g. incorrect association of wire/cable catalog)
- Legitimate overload
- Analysis of low voltage problems at customer location – determination of probable cause:
  - Incorrect association of customer to service transformer
  - Undersized transformer and/or service wire for the customer connection
  - Incorrect association of load profile (e.g. customer consumption doesn't follow typical assigned load profile)

# Preparatory network tuning for SE Phase 3

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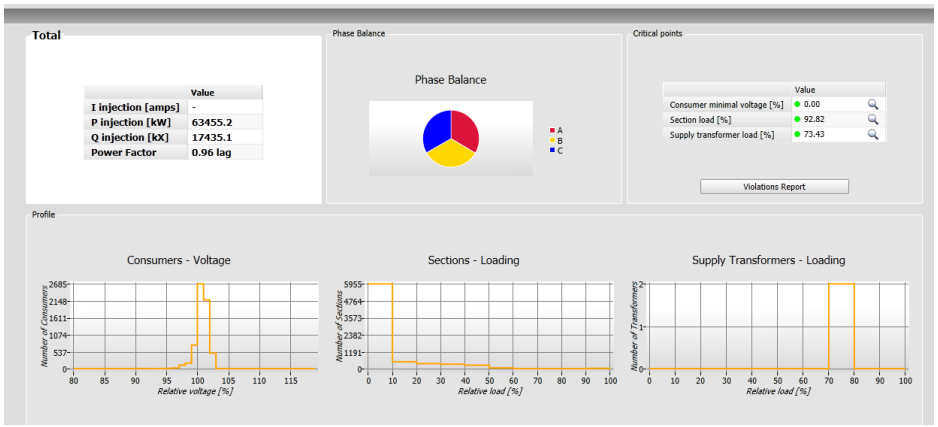
- Violation report –overloaded transformers




- Overall Load Flow distribution on selected domain

# Preparatory network tuning for SE Phase 3

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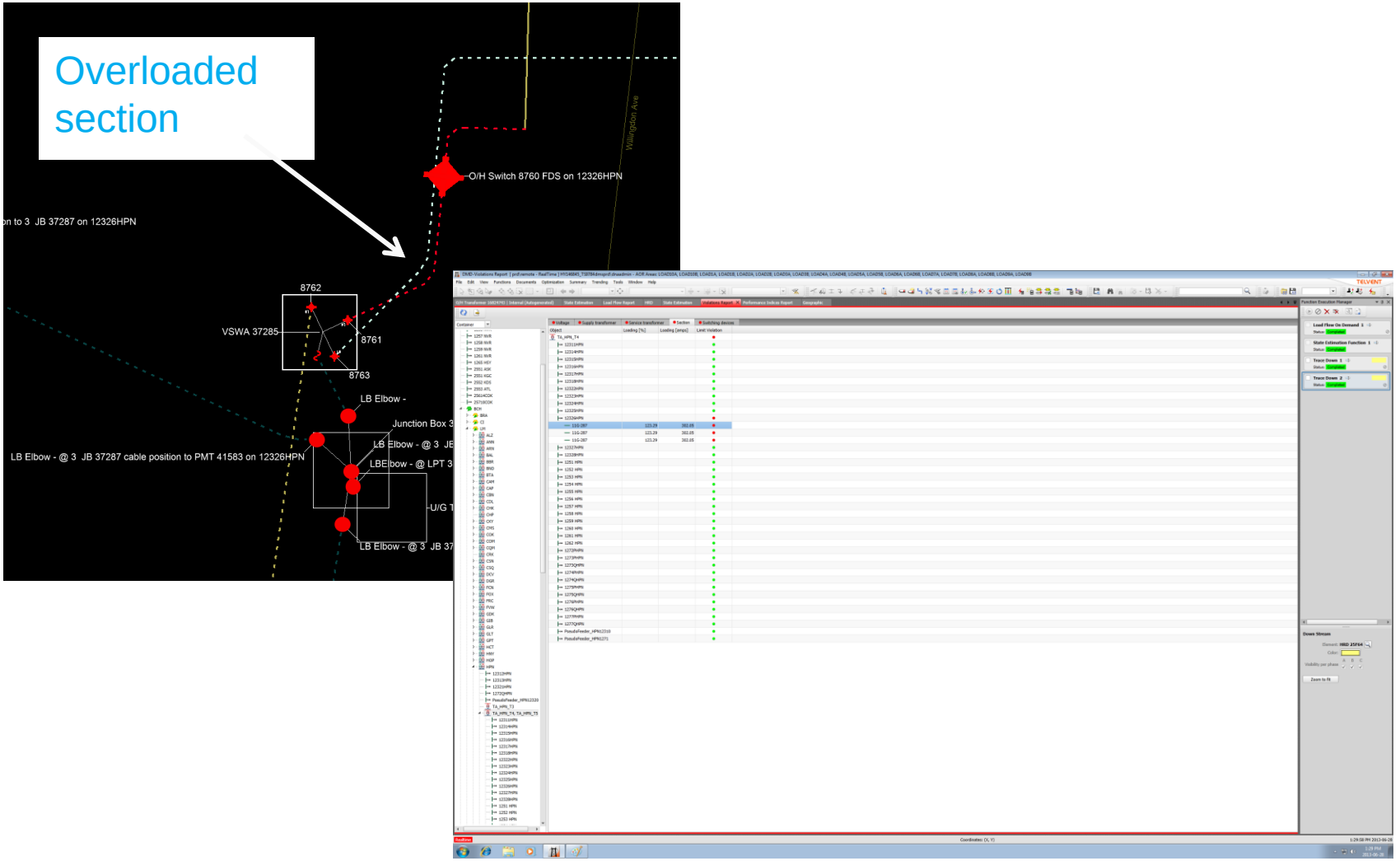

# State Estimator Tuning – phase 4

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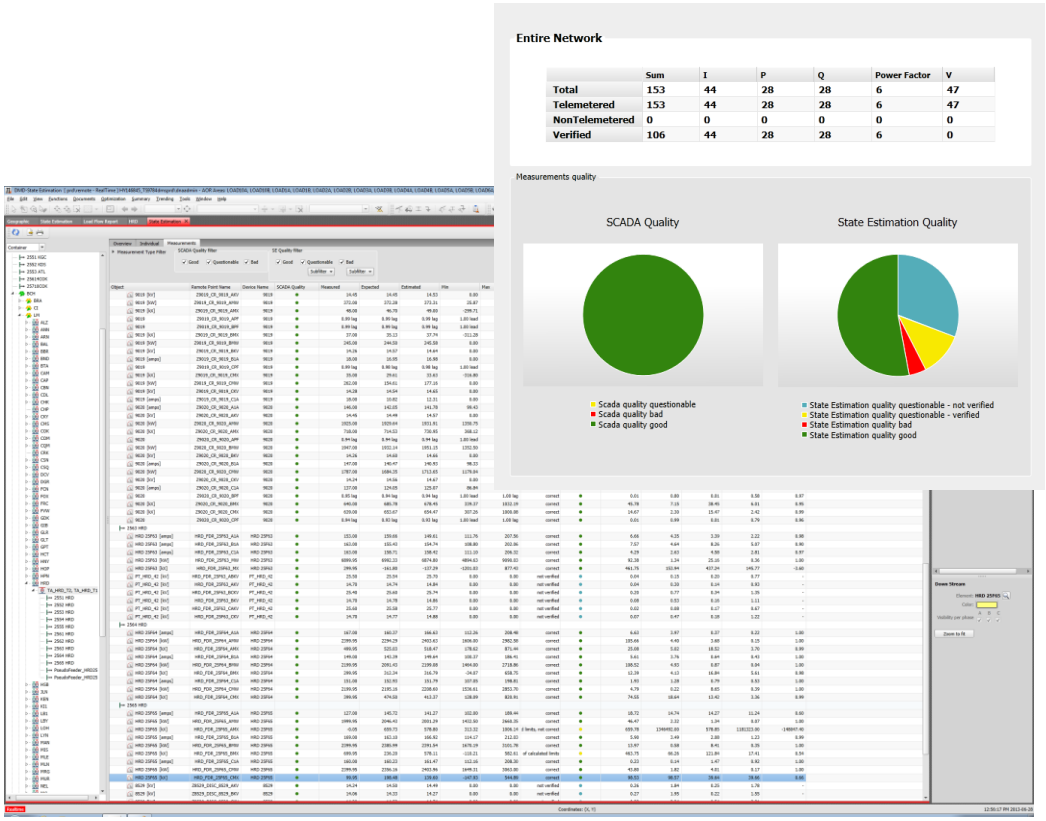
- Validation of SE results quality



**Entire Network**

| | Sum | I | P | Q | Power Factor | V |
|---|---|---|---|---|---|---|
| Total | 153 | 44 | 28 | 28 | 6 | 47 |
| Telemetered | 153 | 44 | 28 | 28 | 6 | 47 |
| NonTelemetered | 0 | 0 | 0 | 0 | 0 | 0 |
| Verified | 106 | 44 | 28 | 28 | 6 | 47 |

Measurements quality

SCADA Quality

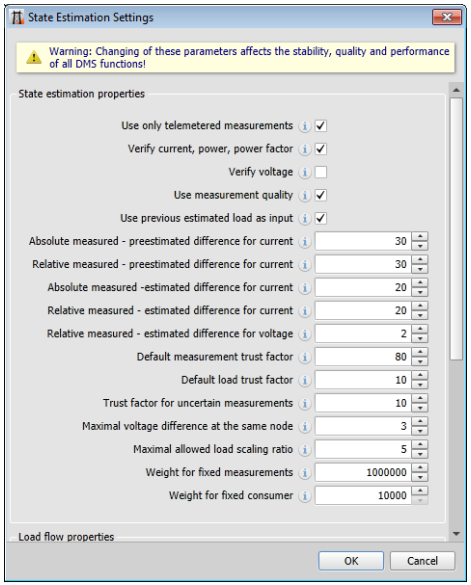


Scada quality questionable
Scada quality bad
Scada quality good

State Estimation Quality



State Estimation quality questionable - not verified
State Estimation quality questionable - verified
State Estimation quality bad
State Estimation quality good



# State Estimator Tuning – phase 4

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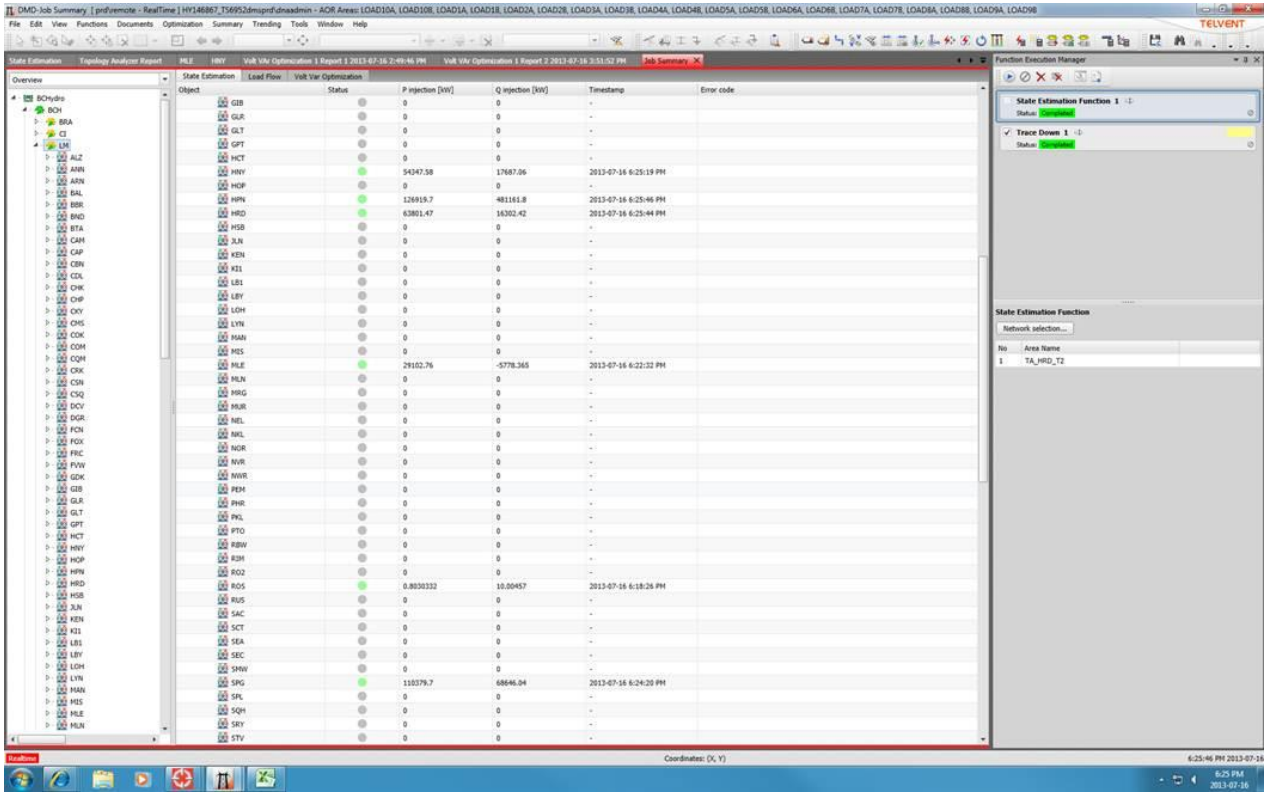
- Job dashboard – monitoring of real time sequence



# Results and experiences

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- PI tracking
- Job dashboard
- State estimator report
- Violation report
- Performance indices
- Benchmarking results

# Next steps

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- Release to production (staged) – large amount of work to tune one station (time it takes, people impact, skill set, relation to data sources etc.)
- Error detection (measurement redundancy, se reports, quality indices etc.)
- Violation report
- Performance indices
- Benchmarking results (against recorded SMI data from real-time)

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# QUESTIONS ?