

Linear State Estimation

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- What is Linear State Estimation (LSE)?
- Observability
- Advantages of LSE
 - Data Expansion
 - Data Correction
- Synchrophasor System Architecture

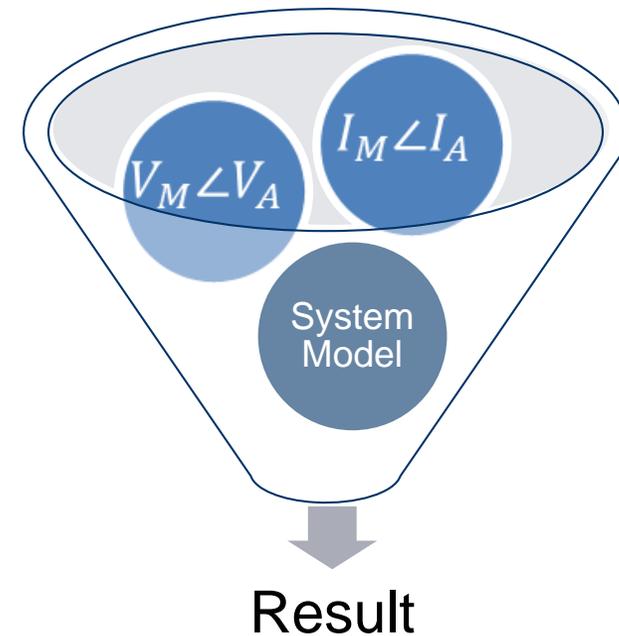
- Linear State Estimation combines:
 - PMU Voltages
 - PMU Currents
 - Topology
 - Model Impedance

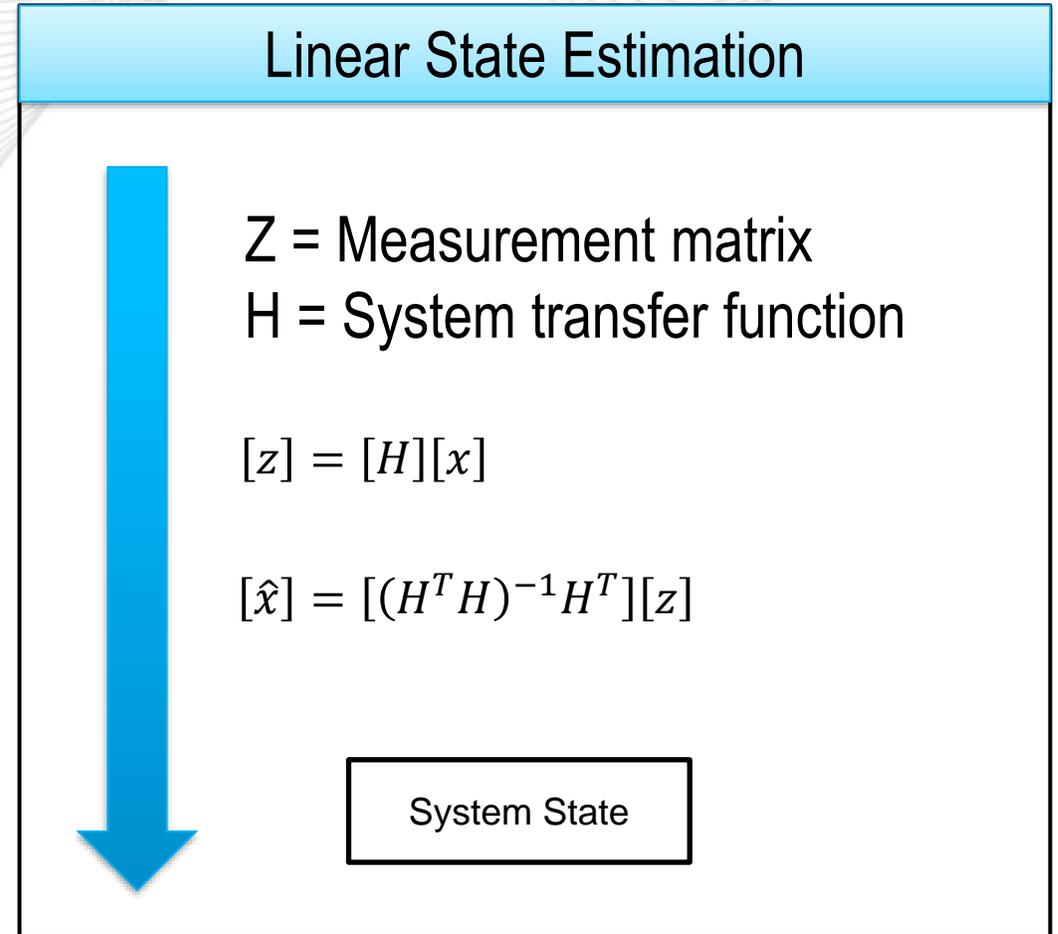
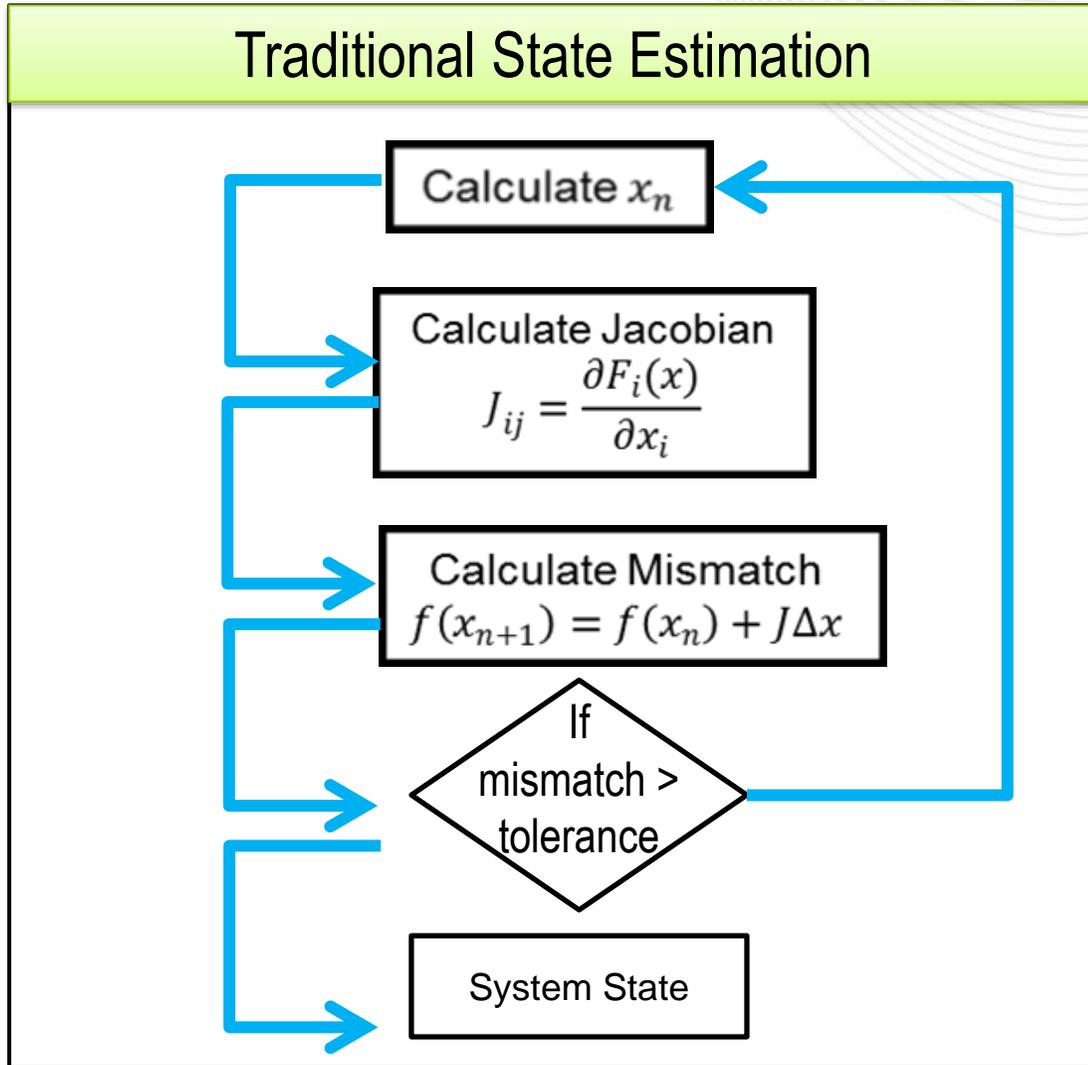
Linear State Estimation

Z=Measurement Matrix

H=System transfer function

$[x] = [(H^T H)^{-1} H^T][z] = [H][z]$

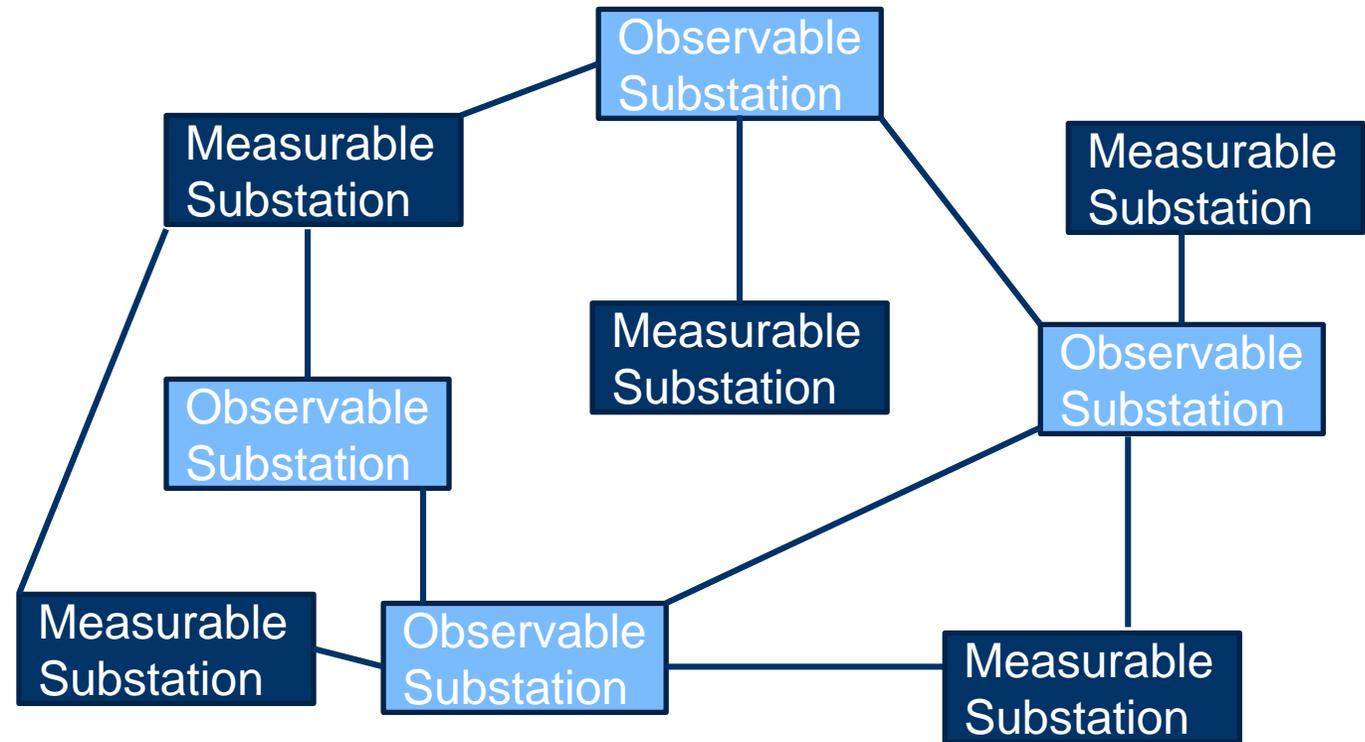




- A Linear State Estimator fills-in the picture of our grid.
- A Linear State Estimator is the first step to improving data quality.
- A substation can be measurable, observable, or **both**.

Measurable Substation Station with one or more PMUs installed

Observable Substation Station with a PMU installed one line away



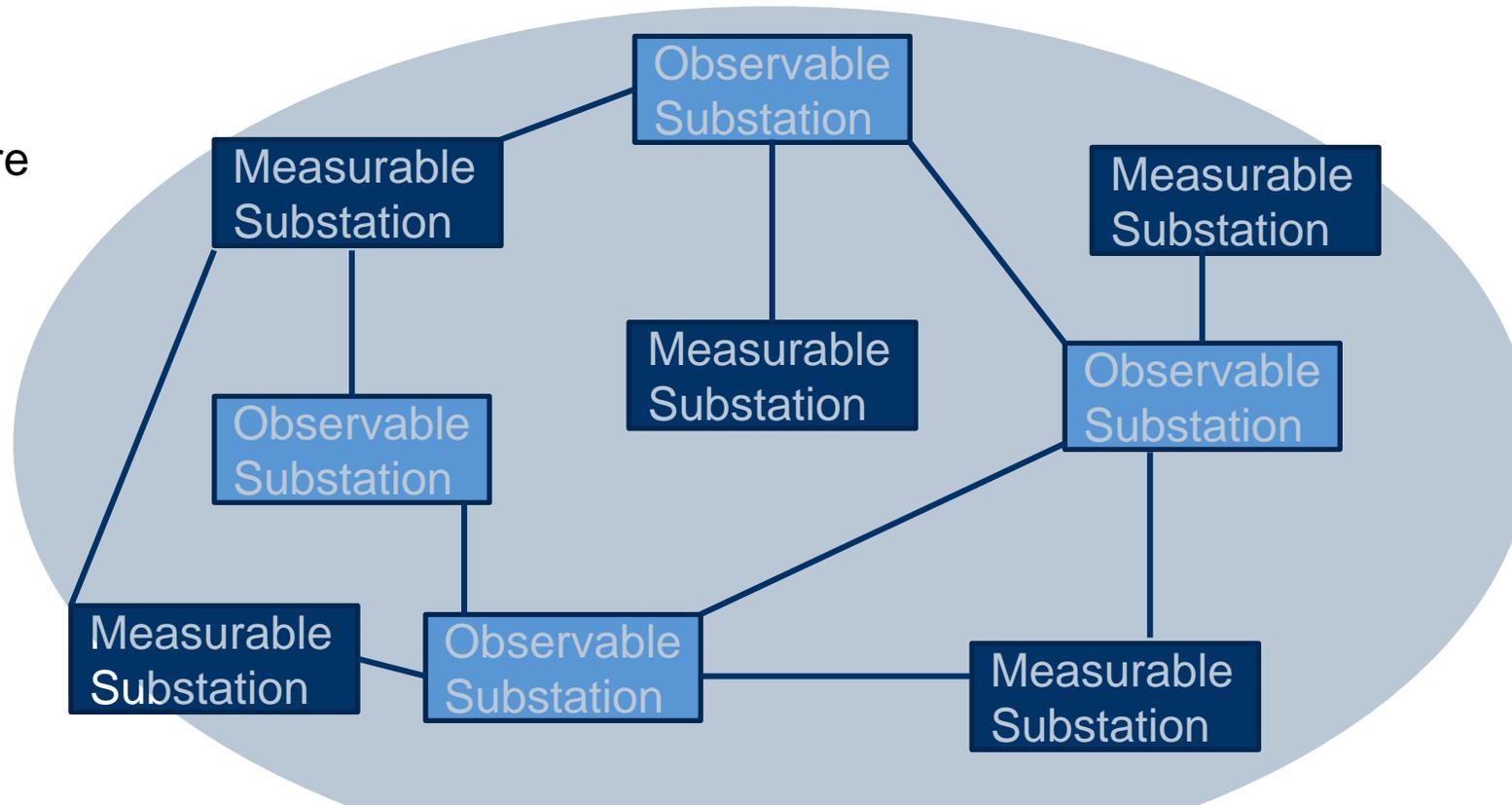
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Measurable Substation

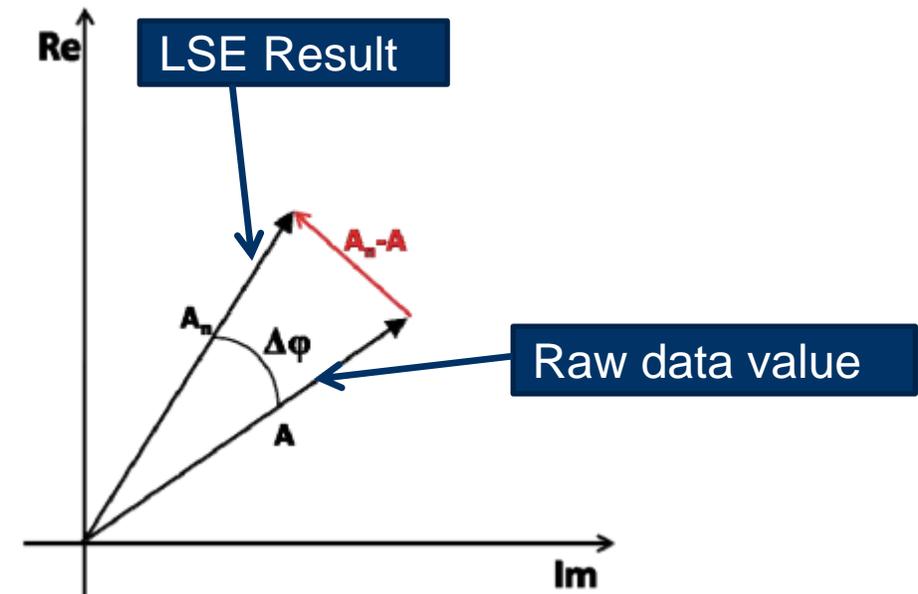
Station with one or more PMUs installed

Observable Substation

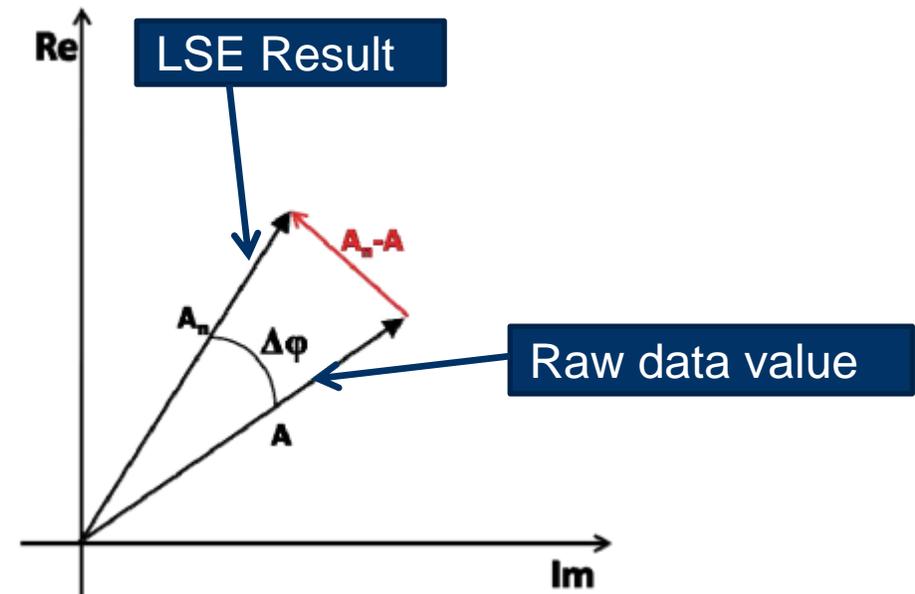
Station with a PMU installed one line away



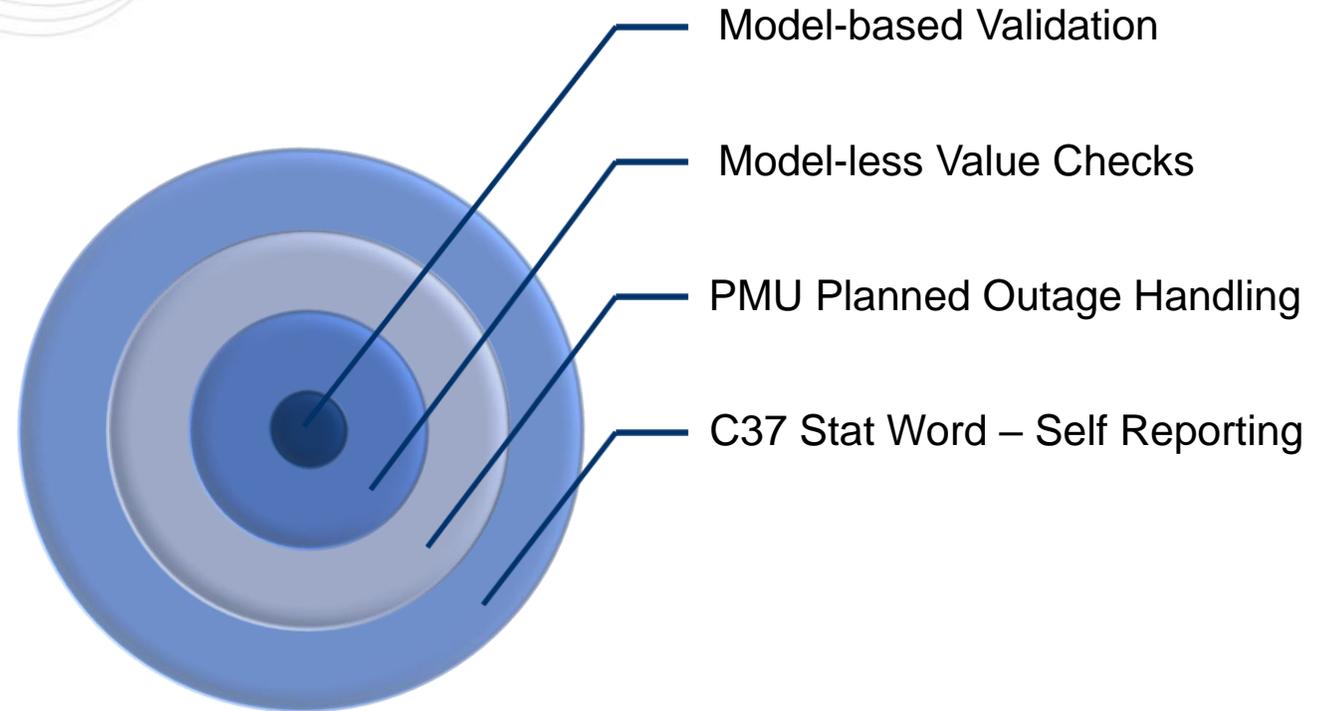
1. Process and arrange input data
2. Calculate State Estimate
3. Calculate residual between raw value and LSE result



1. Process and arrange input data
2. Calculate State Estimate
3. Calculate residual between raw value and LSE result
4. Remove signal with largest residual, return to step 1



- Linear State Estimation output:
 - Model-based state estimate
 - Data quality metrics
- Data from all four categories summarized in a weekly report and sent to the Transmission Owner.
- Data quality availability and accuracy requirements set in M01.



- ✓ Expands PMU Observability
- ✓ Iterative data quality checks remove bad data
- ✓ Fills in bad/missing data points
- ✓ Never diverges

