Distribution State Estimation:

Implementation Challenges and Toolkit

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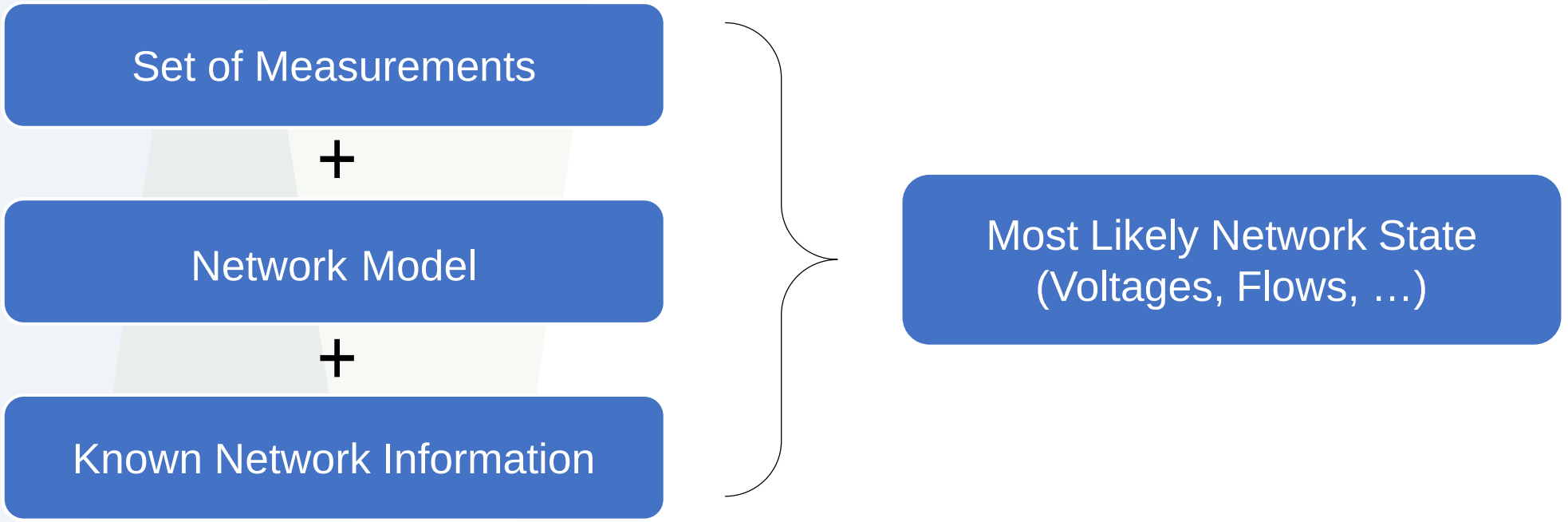
Power System State Estimation

- A mathematical method with which underlying power network behavior can be determined from operating information



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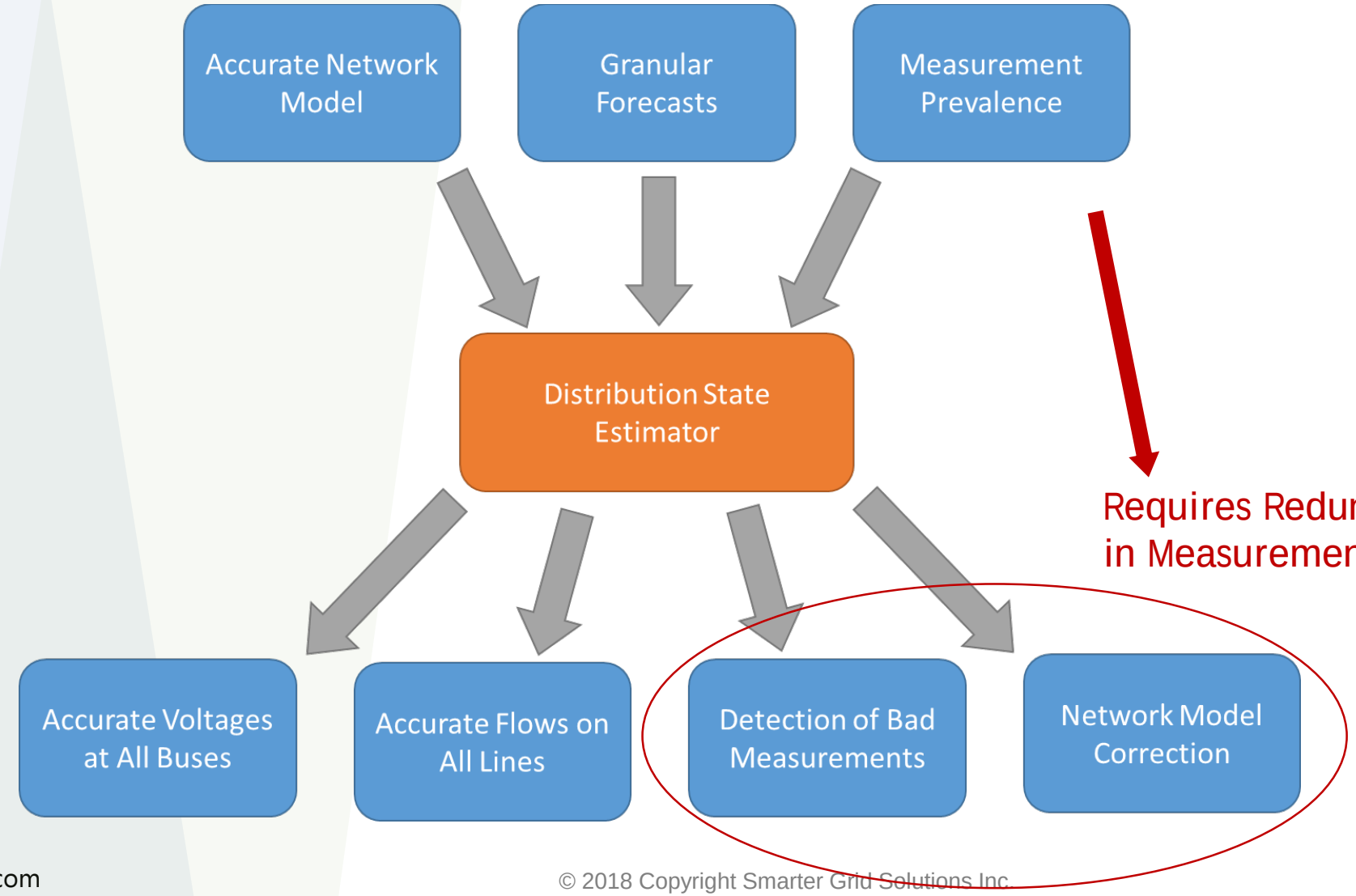
Provided Data versus DSE Benefits

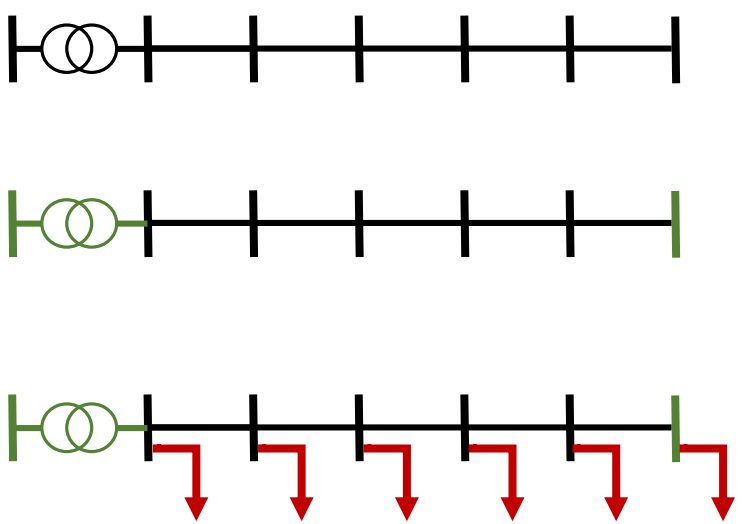


DSE Toolkit

- SGS has prepared a software toolkit for New York utilities and other interested parties:
  - Set up DSE on an example network
  - Explore DSE concepts in a sandbox environment
    - Measurement placement
    - Observability
    - Accuracy of resulting state
- Run test cases:
  1. Determining necessary measurements for an observable network
  2. Identifying and removing bad data with limited measurements
  3. Improving performance with redundant measurements

Example DSE Implementation

- Simple radial network
- Measurements at substation, end of line
- 15-minute P&Q forecasts at each bus (AMI-powered)
- We can use the DSE toolkit to determine:



- This system is observable.
- State estimation improves upon load flow and load allocation methods
- This system cannot detect bad data.
- How performance can improve with more measurements

Best Practices for Distribution State Estimation

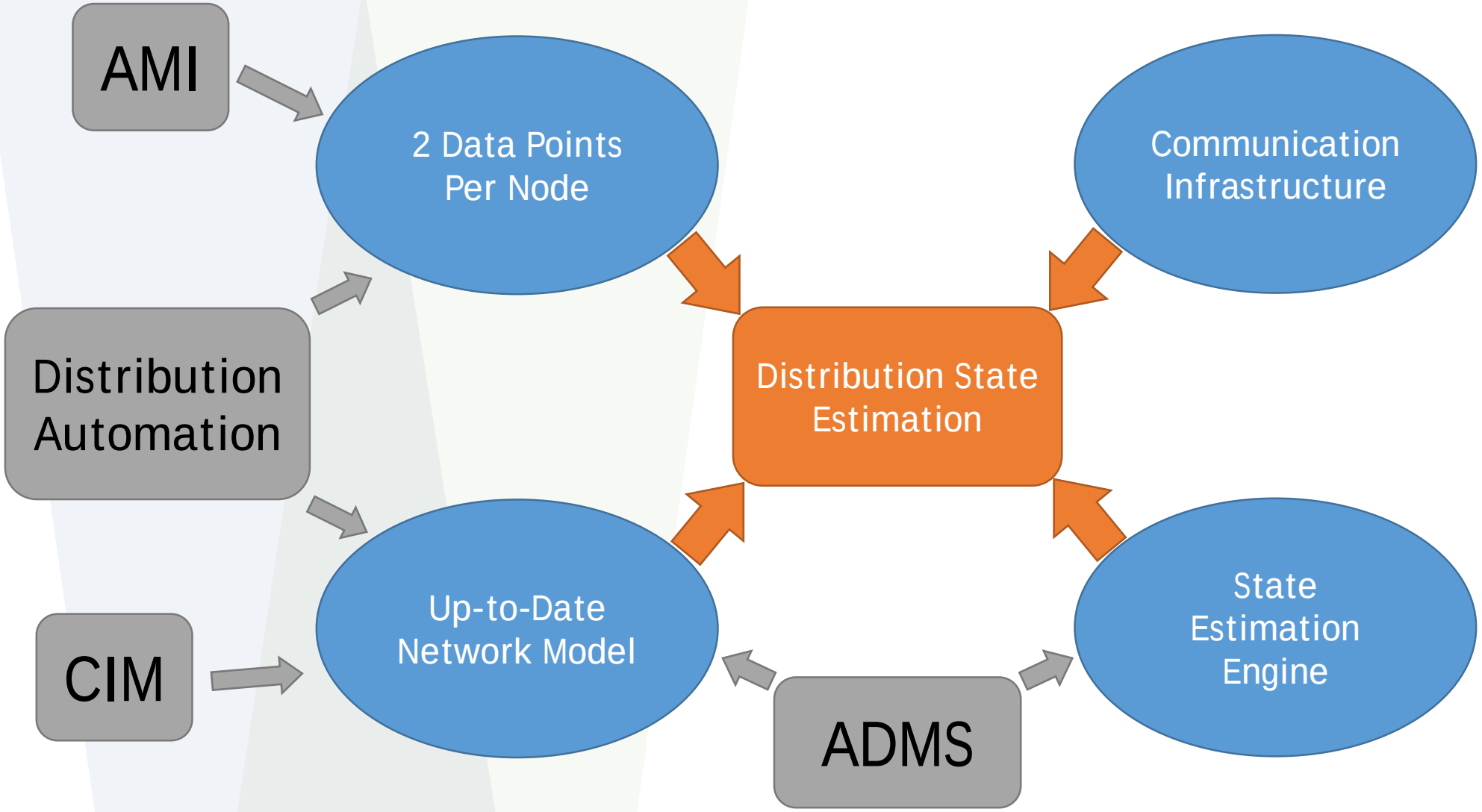
1. Set expectations based on measurement capability
   - Full benefits of DSE require extensive measurement placement.

2. Develop CIM-based on-line network model
   - Update control actions, automation, and manual switches in real time.

3. Use granular forecasts and load allocation
   - Forecasts will usually make up vast majority of measurements.
   - Machine learning with AMI and weather data improves DSE.
   - Feedback loop: DSE can improve forecasts, iterative process.

4. Leverage redundant measurements in the substation
   - Remove erroneous measurement devices
   - Detect incorrect switch positions.

DSE Minimum Requirements



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Questions and Discussion

Project materials will be available on the NYSERDA webpage:

https://www.nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Electric-Power-Transmission-and-Distribution-Reports

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Appendix Material

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Benefits of DSE

1. Real-time visibility
   - Invaluable to many advanced distribution applications
2. Reducing uncertainty
   - Accuracy improvement based on most likely power flow
   - Feeds better data into most other advanced distribution applications
3. Bad data detection
   - Network model calibration

DSE is a powerful tool, but the benefits are entirely dependent on the data that can be provided by the utility.

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Implementation Challenges

1. Not enough measurements
   - Almost no distribution system is observable without the use of load forecasts
2. Communication infrastructure
   - Network model & topology (switch status) must be updated in real time
   - Measurements relayed to control center with minimal delay
     - Considerations for AMI data collection
3. Uncertainty in available information
   - Un-modelled customer connections might preclude use of AMI
   - Over-reliance on load forecasts introduces error

Performance Improves with Redundancy

- Redundancy allows a better estimate of the power system state
  - Enables applications such as bad data detection and model calibration
- Forecasts should not be used to generate redundancy