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Sensor Placement for NASPI 2024

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Andy Reiman
PNNL

U.S. DEPARTMENT OF ENERGY BATTELLE

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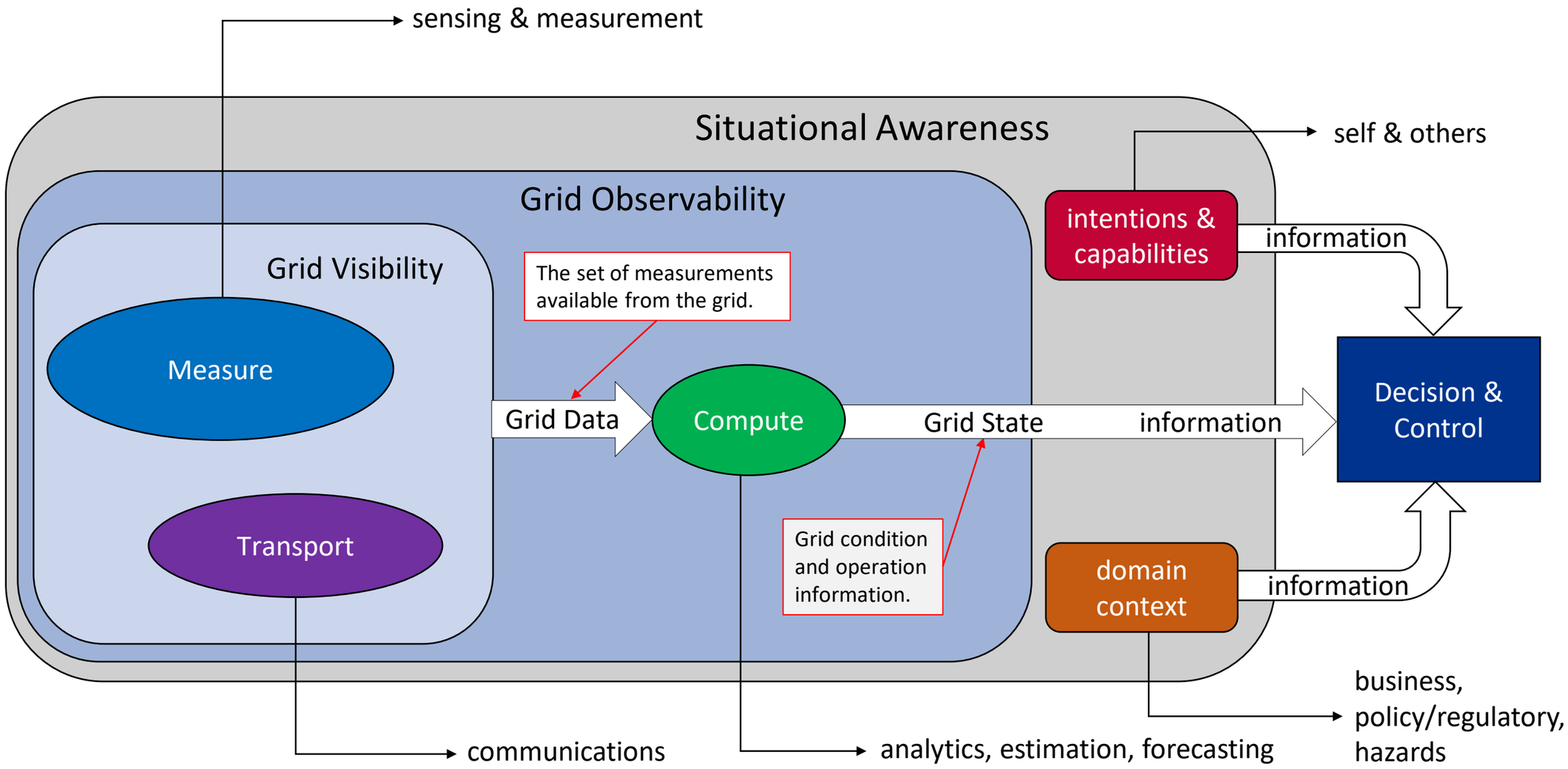
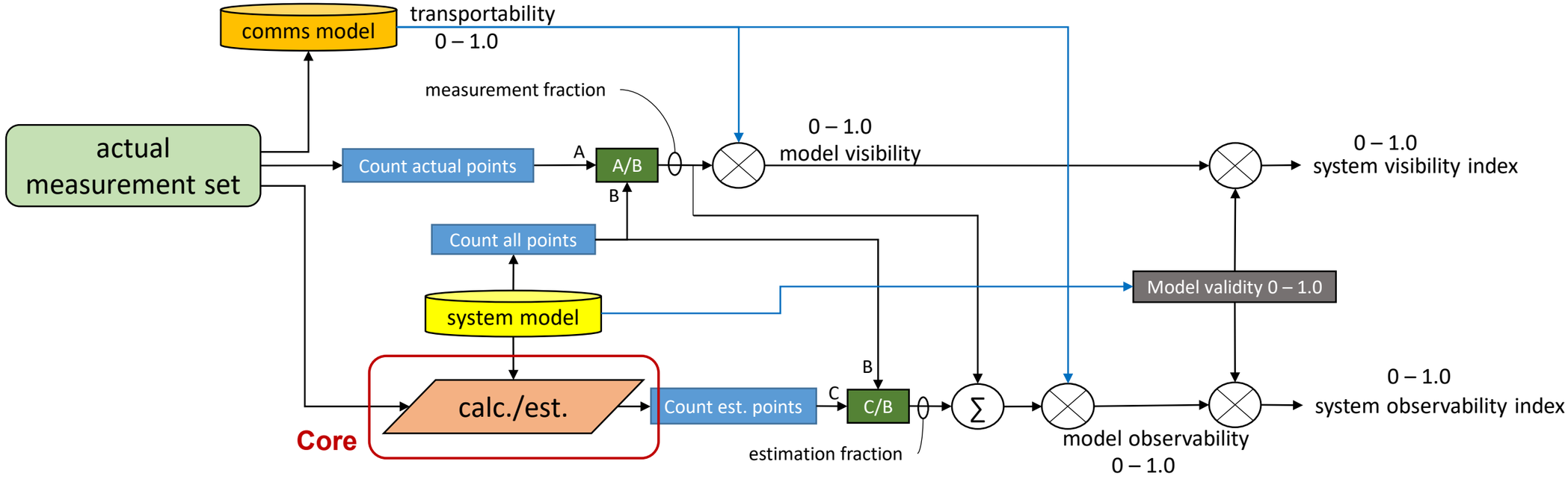
Visibility, Observability, and Situational Awareness



Evaluating Grid Visibility and Observability

- Apply to all or any part of a grid
- For all elements:
  - % of all possible measurements that are actually measured (measurement fraction)
  - modify measurement fraction by transportability (ability to deliver the data) → visibility
  - % of all unmeasured values that can be estimated from measurements (estimation fraction)
  - sum of modified % measured and % estimated but not measured → observability
  - apply model validity as global correction factor



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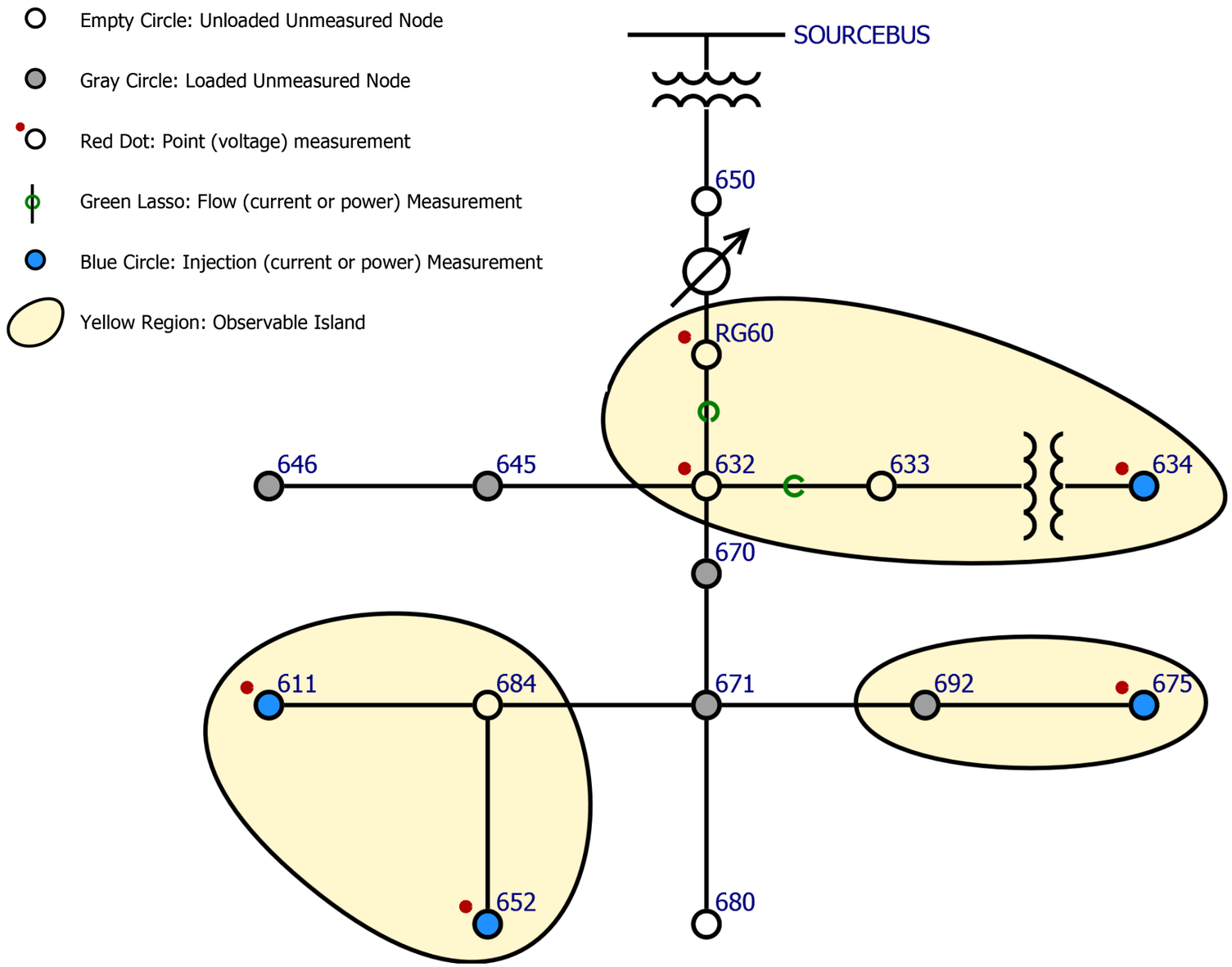
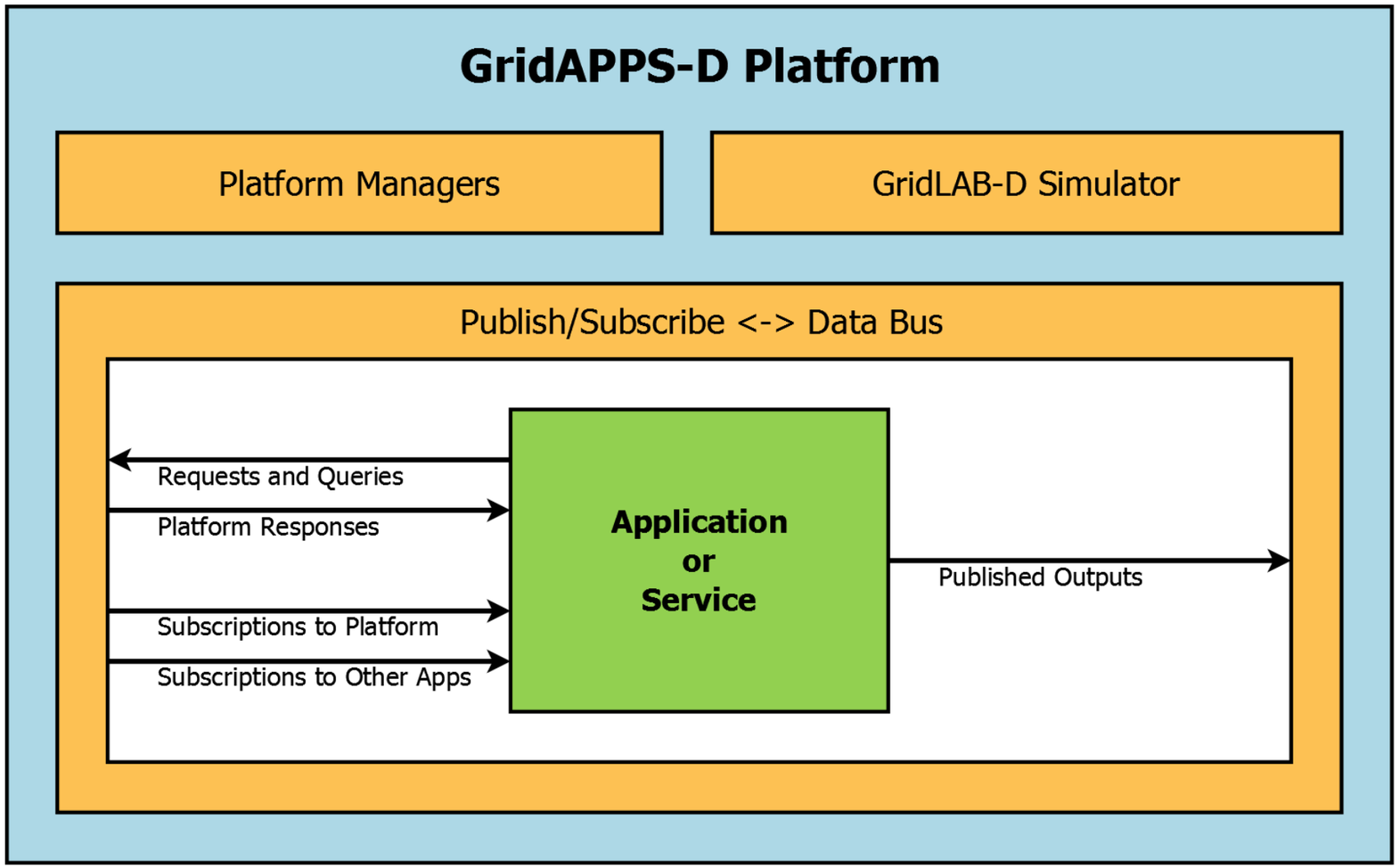
IEEE 13-Bus Example

- Measurements:
  - 6 Point
  - 2 Flow
  - 4 Injection
- System Visibility Index:
  - **0.2374**
- System Observability Index:
  - **0.3957**



Observability Application for GridAPPS-D



Exploring Observability Scenarios

Observability Calculator

Parameters | Indices | Sensor Library | Strategies | Optimal Sensor Placement | Compare

Functional Sensors

Name	V	I	PQ	Cost
Line Sensor - Voltage Magnitude	✓			$1
Line Sensor - Current Magnitude		✓		$1
Line Sensor - Combined Voltage and Current	✓	✓		$1
Line Sensor - PMU				$1
Meter - Power			✓	$1
Meter - Voltage and Power	✓		✓	$1
Meter - Power Quality			✓	$1

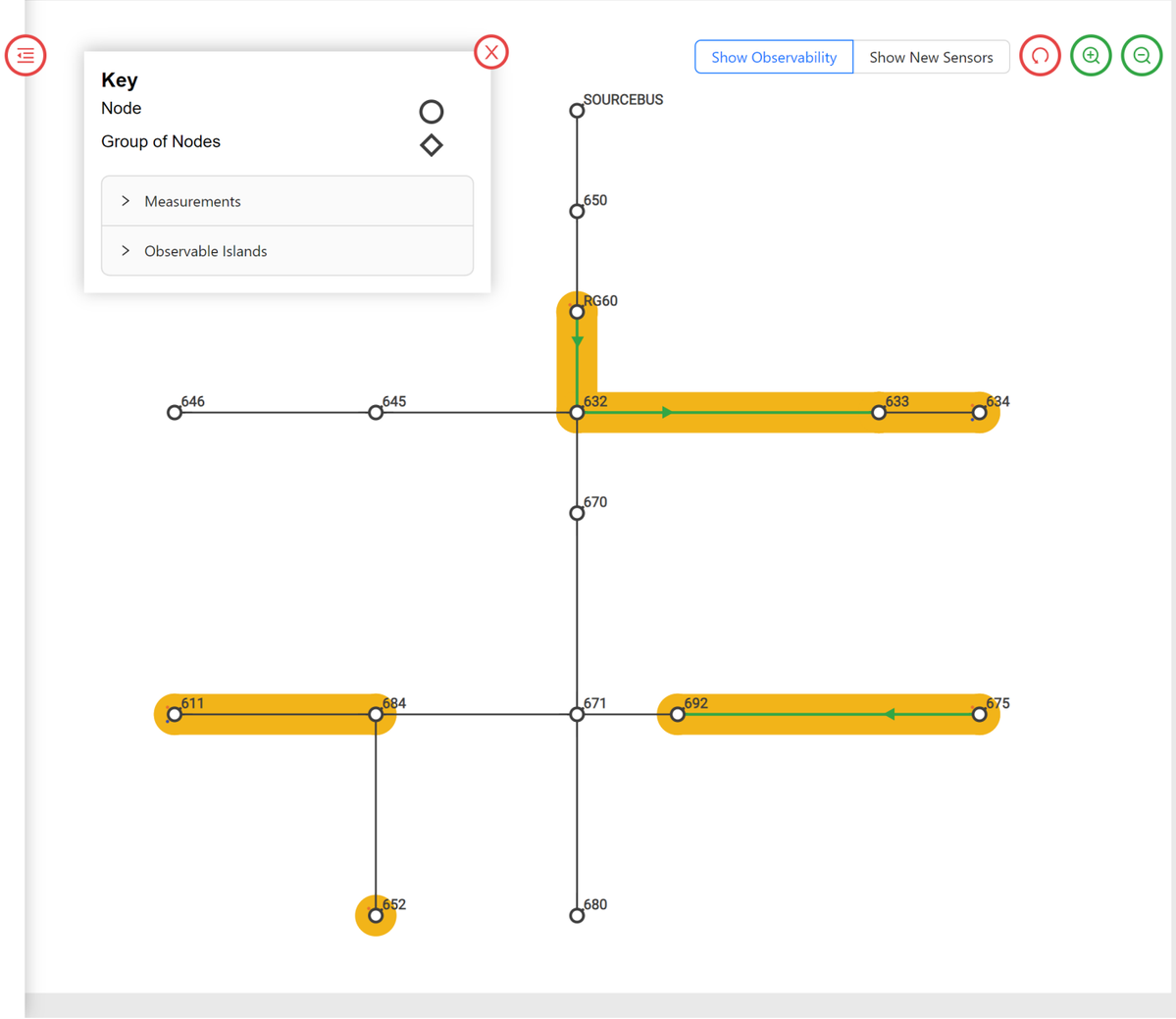
User Defined Sensors

Name	V	I	PQ	Cost	Actions
Test Sensor	✓			$1	
Test New Sensor	✓	✓		$1	

Itemized Sensor Cost

Sensor Name	Sensor Quantity	Total Cost
Meter - Voltage and Power	1	$1
Line Sensor - Current Magnitude	3	$3
Meter - Power Quality	3	$3
Line Sensor - Voltage Magnitude	1	$1

Exit | Export Image | Export JSON | Save | Calc



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Observability Calculator

Parameters | Indices | Sensor Library | Strategies | Optimal Sensor Placement | Compare

Compare Scenarios

Select Baseline Scenario:

10/7/2024, 9:46:00 PM

Select Compare Scenario:

Small Model Demo 2

Reset

Rename a Run Scenario

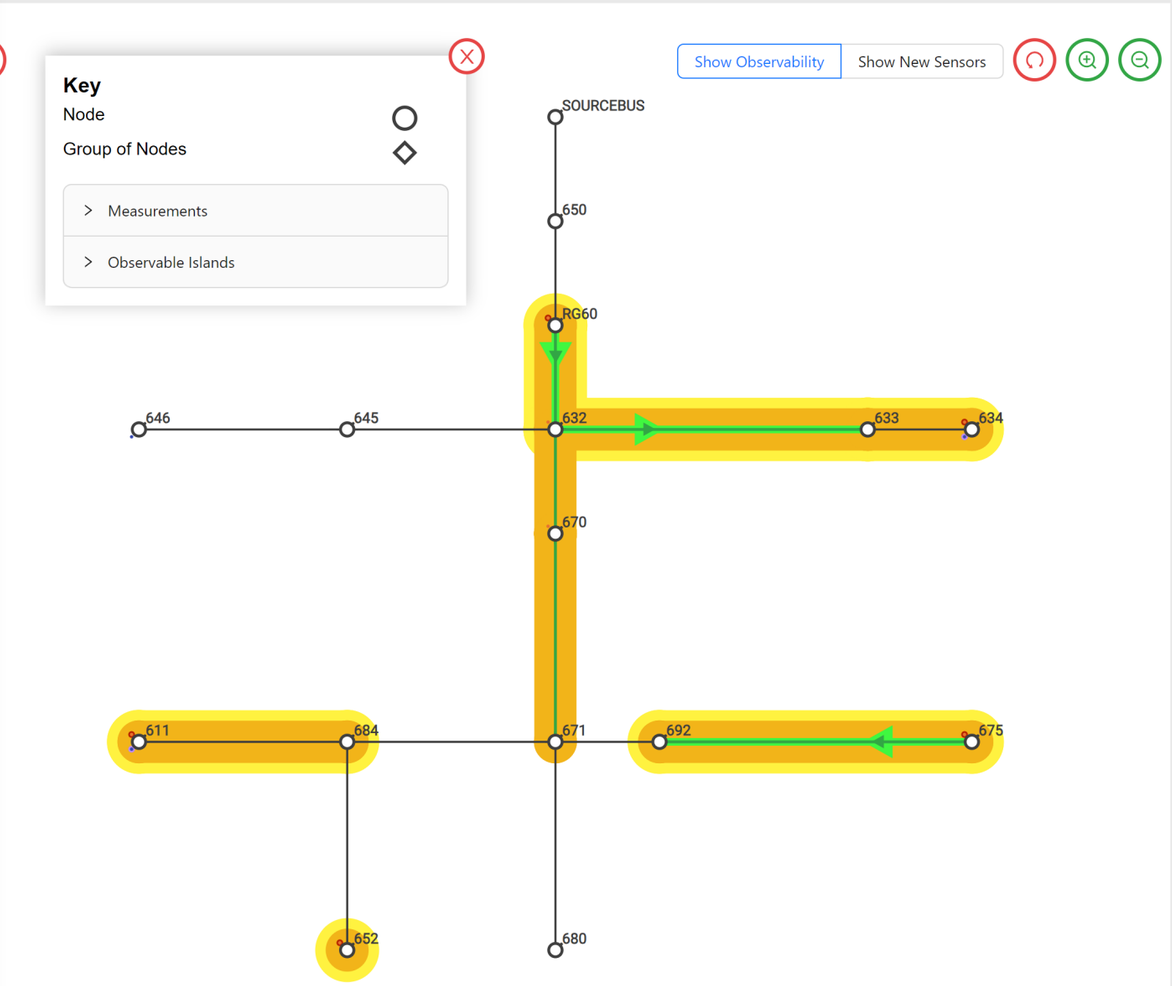
Select Scenario to Rename:

Select

View Compared Indices

Field	Baseline Scenario	Compare Scenario
Sensor Count	14	22
System Visibility Index	0.2128	0.3191
System Observability Index	0.4468	0.6596

Exit | Export Image | Export JSON | Save | Calc



Optimal Sensor Placement

$$\min_{x,y,\varphi} \left(\sum_{i \epsilon V} c_i x_i + \sum_{(i,j) \epsilon E} c_e y_{(i,j)} - c_p \varphi \right)$$

$$\text{s.t.} \quad x_i + \sum_{(i,j)} y_{(i,j)} \leq d_i$$

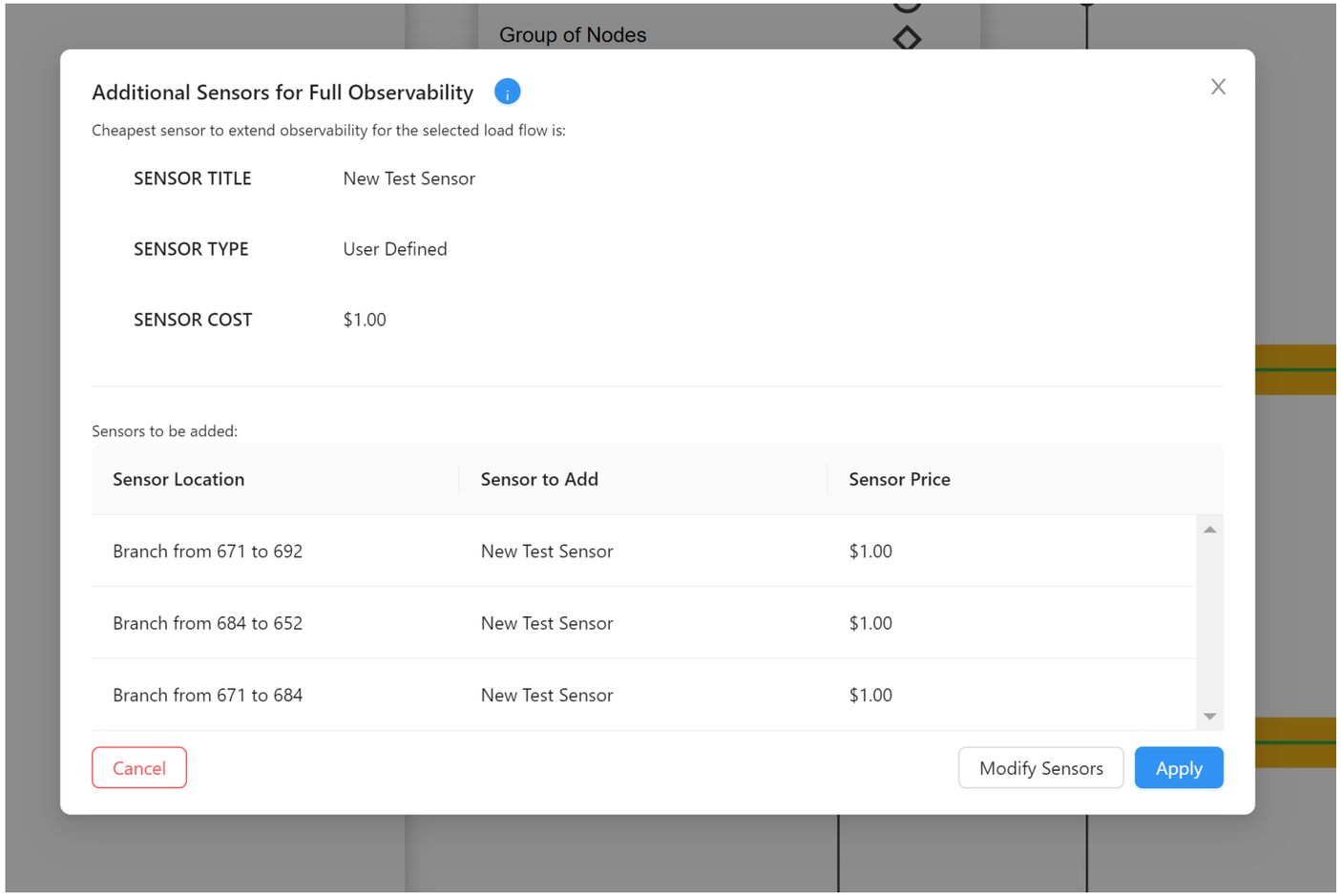
$$\sum_i x_i + \sum_{(i,j)} y_{(i,j)} \geq \varphi$$

$$\sum_i c_i x_i + \sum_{(i,j)} c_e y_{(i,j)} \leq \overline{c}$$

$$0 \leq \varphi \leq A^r$$

$$0 \leq x_i \leq 1$$

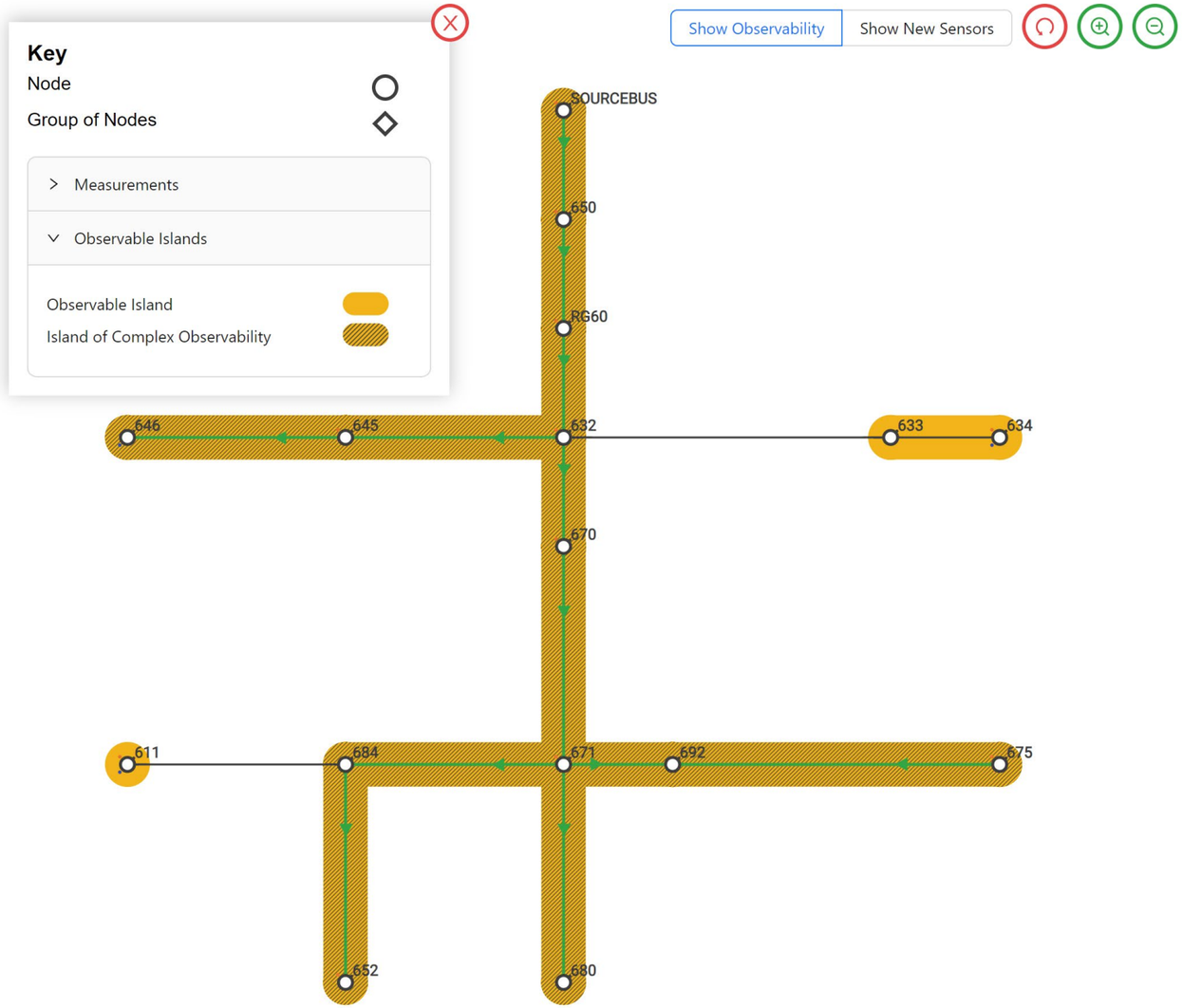
$$0 \leq y_{(i,j)} \leq 1$$



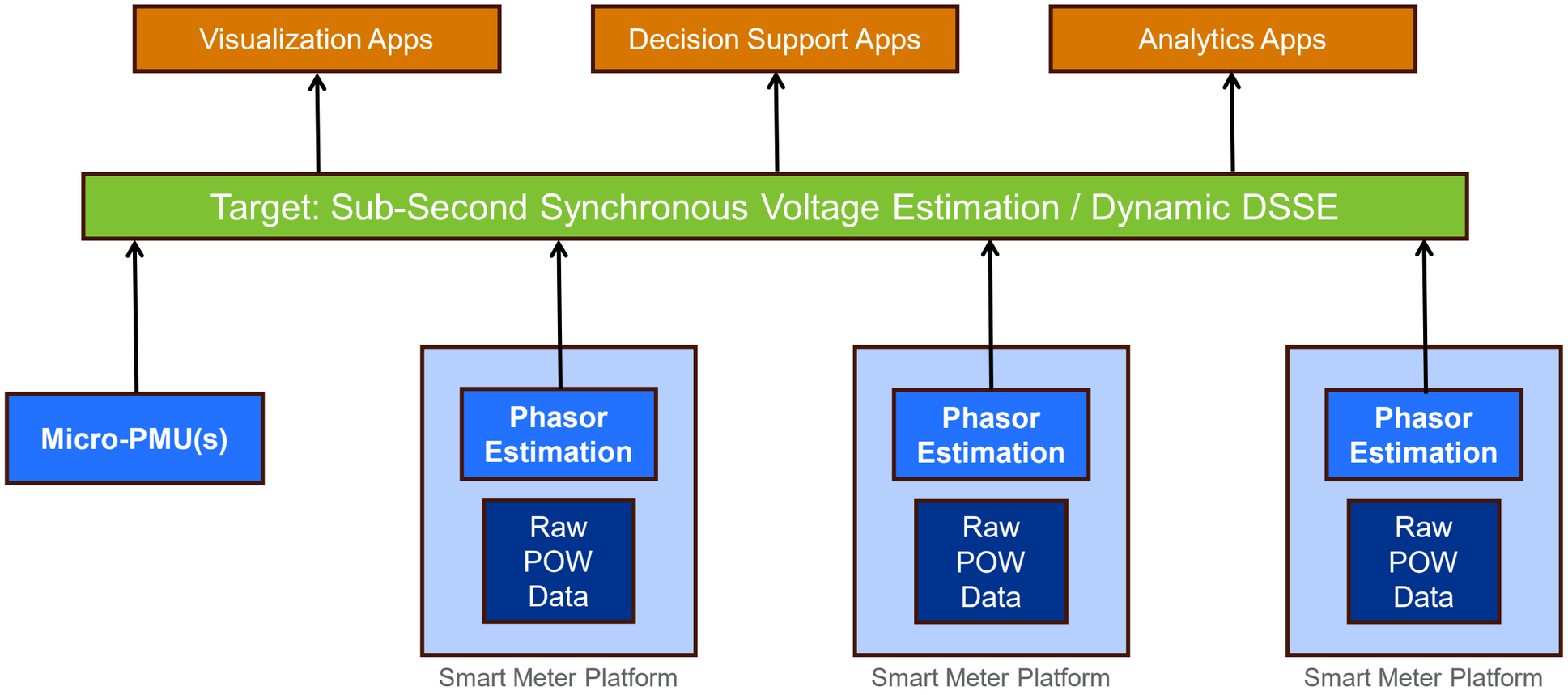
Islands with Synchronous Angle Observability

Synchronous Observable Island + Relative Branch Angle → New Observable Bus

Synchronous Observable Island + Relative Segment Angles → New Observable Segment



FY25 – Distributed Synchronous Observability



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Thank you