

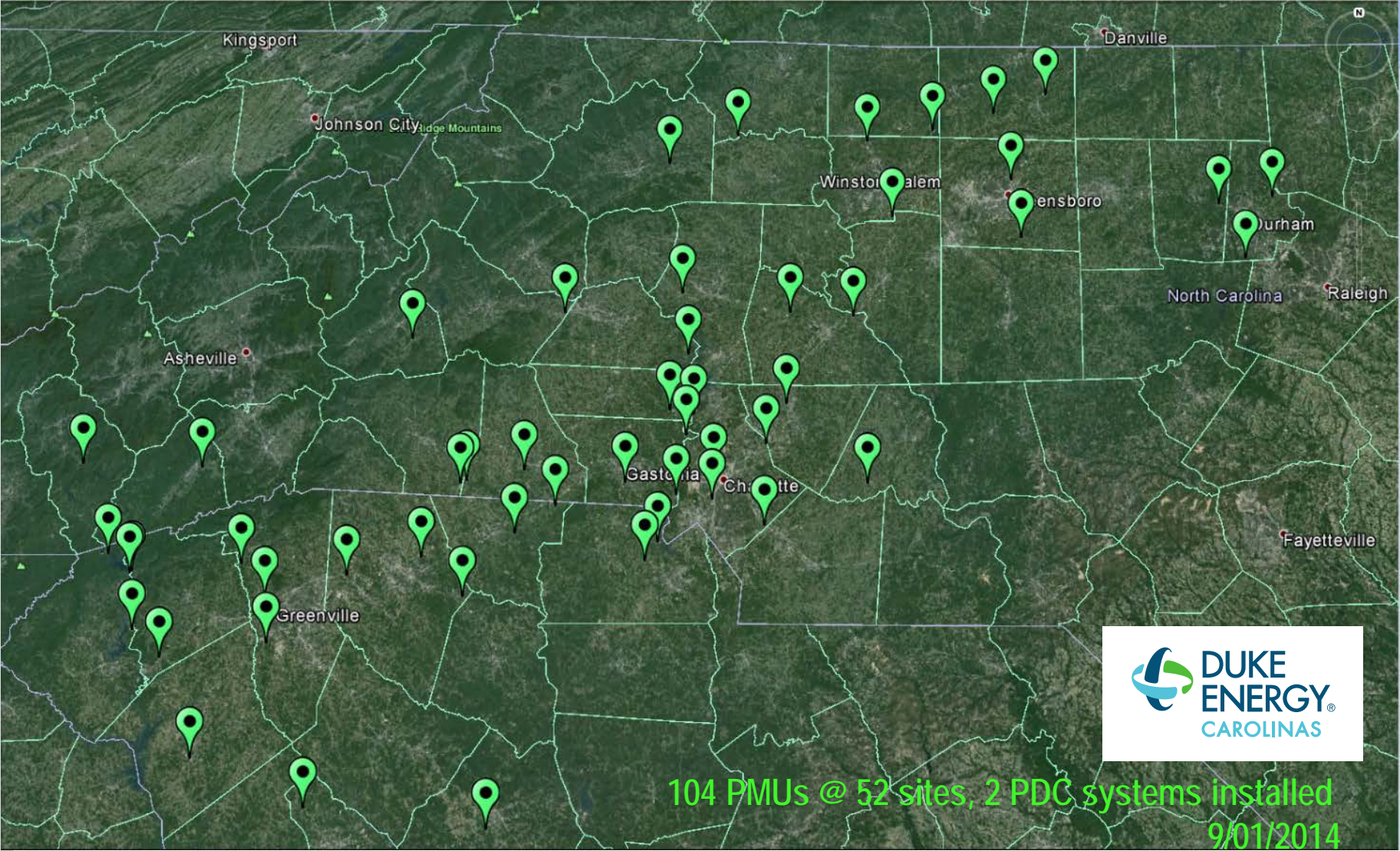
Data content as of August 2014  
NASPI Work Group Meeting  
October 22-24, 2014

**Duke Energy Carolinas - Insights on Operations Solutions**

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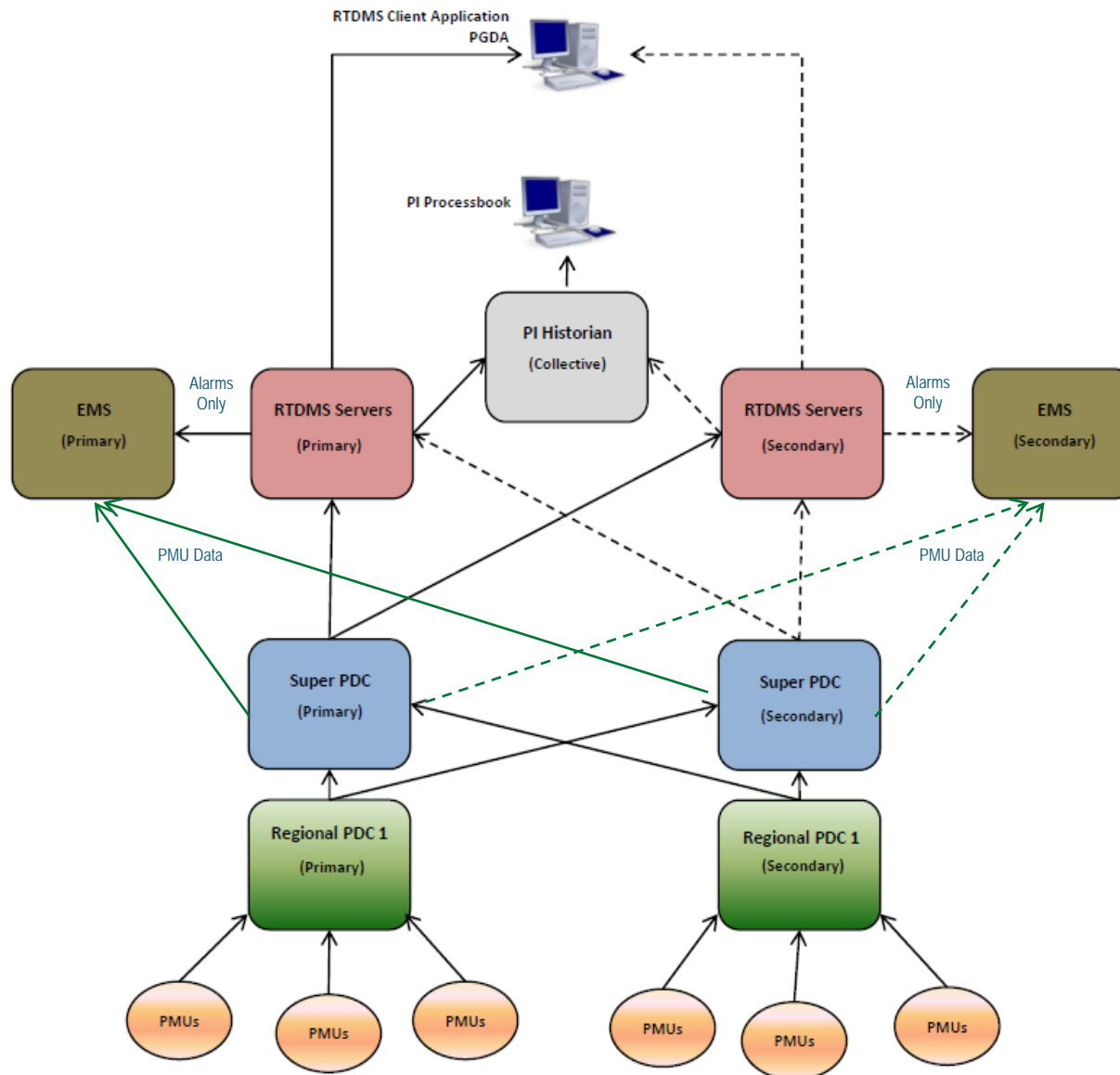
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# Project Map



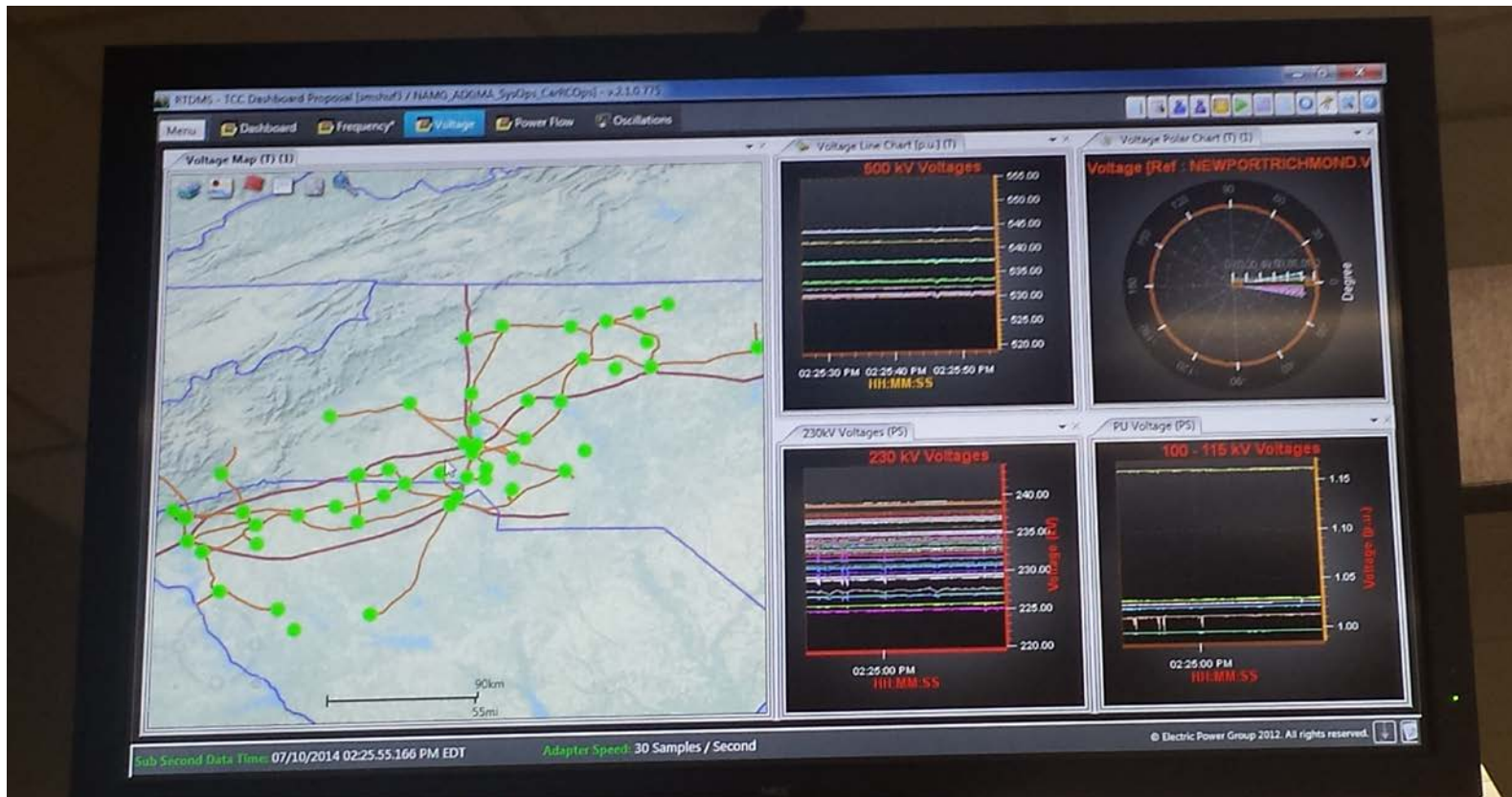
- Control Room Usage
  - Visualization software deployed spring 2014, will include alarms sent to EMS
  - Integration with State Estimator
  - Redundant measurements in SCADA applications
- Planning Usage
  - Event analysis
  - Model tuning (generator parameters, frequency response, etc)
- PMUs installed at one distribution (solar) facility
  - “seeing what we get”

# Carolinas Architecture



- Deployed in Control Room Spring 2014
- No current operating procedures/guides, strictly monitoring currently
- Able to see system behavior not previously observed
  - Not all oscillations are “bad” oscillations
  - Currently operators notify engineers of “abnormal” behavior

- Dedicated monitor





- Targeted 2015, proof of concept complete
- Additional DNP3 input configured to EMS
- ONLY alarms not available via the EMS
  - RTDMS still alarms on all, but only certain selected
  - Want to maximize value to operator
  - Examples: angle differences, oscillations
  - Alarms refer the user back to RTDMS for further analysis

- Pilot project involves combining SCADA and phasor measurements into the traditional WLS estimator
- Solution rate of 99.8% prior to PMU incorporation, don't expect to see significant improvement
- Expect PMUs to provide measured angle values, redundant measurements for SCADA



- Reference bus is currently Allen
  - assumed zero degrees

Network Island Summary				Min Bus Number: <input type="text" value="8"/> for an Island		1 TOPOLOGY ISLANDS										
RTNET Last Solved: 24-Jul-2014 14:24:47										RTNET		REALTIME		LOSSES CALC ED		
#	- Reference Bus - Station	KV	Number	Swing Generator	MW Online Capacity	MW Generation	MW Load	Number of Buses	Number of Branches	MW Losses	MW Mismatch	MW HVDC	Solution Status Converged	IterMax	Div	No
1	ALLEN	16	<a href="#">32</a>	<a href="#">UN_3</a>	309757.94	173119.61	168876.92	7767	11340	4503.19	260.55	0.00	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

### Network Bus Summary

Bus: [32](#)
Island: [1](#)
Solved
16.0 KV
0.999 PU
**0.0 DEG**
Remove
Show Nhood

V Meas Observable
MEAS 16.0 KV 0.999 PU

XF Remove

AUX Remove

Unit [UN\\_3](#)

267.2MW → 77.8MR → G

269.7MW → 77.2MR → MEAS

Diagram showing bus 32 connected to BK3A (252.0MW → 62.6MR →), AUX3 (15.2MW → 15.2MR →), and a generator (G) (267.2MW → 77.8MR →). A measurement point (MEAS) is also shown (269.7MW → 77.2MR →).

# RTNET Solution without PMUs

**Network Bus Summary** | -- Bus Symbolic View -- | Bus List View

RTNET Last Solved: 24-Jul-2014 13:45:47

ANTIOCH IN DUKE | Options | 5517 | Position to Bus

Station Total  
 Generation: 0.0 MW 0.0 MVAR  
 Load: 0.0 MW 0.0 MVAR

500 KV

Bus: 54 | Island: 1 | Solved | 535.2 KV | 1.070 PU | **-3.7 DEG** | Remove | Show Nhood

V Meas Observable | MEAS 531.4 KV | 1.063 PU | -1.6 DEG

XF	418.3 AMP	Remove	0	AT1H	To Station: ANTIOCH
	412.8 AMP			387.7MW → 6.0MR →	XF2: AT1H
				391.3MW → 6.5MR →	MEAS
XF	418.9 AMP	Remove	0	AT2H	To Station: ANTIOCH
	415.0 AMP			388.3MW → 3.6MR →	XF2: AT2H
				379.4MW → 7.6MR →	MEAS
LN	398.4 AMP	Remove		ROCK_SPRNG-2	To Station: MCGUIRE
	398.7 AMP			369.2MW ← 11.3MR ←	LN2: ROCK_SPRNG-2
				375.1MW ← 14.1MR ←	MEAS
LN	438.9 AMP	Remove		JKSN_FERRY-1	To Station: JKSN_FY
	369.5 AMP			406.9MW ← 1.8MR →	LN2: JKSN_FERRY-1
				380.5MW ← 2.2MR →	MEAS

$$\Delta = 1.6^\circ$$

**Network Bus Summary** | -- Bus Symbolic View -- | Bus List View

RTNET Last Solved: 24-Jul-2014 13:45:47

JKSN\_FY IN PJM | Options | 5517 | Position to Bus

Station Total  
 Generation: 0.0 MW 0.0 MVAR  
 Load: 0.0 MW 0.0 MVAR

Bus: 5782 | Island: 1 | Solved | 533.4 KV | 1.067 PU | **-1.1 DEG** | Remove | Show Nhood

V Meas Observable | MEAS 527.3 KV | 1.055 PU

LN	452.0 AMP	Remove		JKSN_FERRY-1	To Station: ANTIOCH
	434.4 AMP			407.6MW → 90.7MR ←	LN2: JKSN_FERRY-1
				393.3MW → 100.0MR ←	MEAS



- Reference bus is still Allen
  - Since there are measured angles now, no angle is assumed for the reference.
  - PMU reference is configured in the ISD adapter in the PDC

Network Island Summary				Min Bus Number: <input type="text" value="8"/> for an Island		1 TOPOLOGY ISLANDS										
RTNET Last Solved: 24-Jul-2014 14:26:47				RTNET		REALTIME		LOSSES CALC ED								
#	- Reference Bus - Station	KV	Number	Swing Generator	MW Online Capacity	MW Generation	MW Load	Number of Buses	Number of Branches	MW Losses	MW Mismatch	MW HVDC	Solution Status	Converged	IterMax	DI
1	ALLEN	16	<a href="#">32</a>	<a href="#">UN_3</a>	309757.94	173358.20	169167.94	7767	11340	4480.77	290.55	0.00	<input checked="" type="checkbox"/>			

### Network Bus Summary

RTNET Last Solved: 24-Jul-2014 14:26:47

RTNET REALTIME LOSSES CALC ED

Bus: [32](#) Island: [1](#) Solved 16.0 KV 0.999 PU **-161.4 DEG** Remove Show Nhood

A-V Meas Observable MEAS 16.0 KV 1.000 PU

XF Remove 0

AUX Remove

Unit UN\_3 267.4MW → 78.2MR → G 270.2MW → 77.2MR → MEAS

To Station: ALLEN  
XF2: BK3A

# RTNET Solution with PMUs

**Network Bus Summary** | - Bus Symbolic View - | Bus List View

RTNET Last Solved: 24-Jul-2014 13:47:47

ANTIOCH IN DUKE | Options | 5517 | Position to Bus

RTNET	REALTIME	LOSSES CALC ED
Station Total		
Generation:	0.0 MW	0.0 MVAR
Load:	0.0 MW	0.0 MVAR

500 KV

Bus: 54 | Island: 1 | Solved | 535.1 KV | 1.070 PU | **-163.7 DEG** | Remove | Show Nhood

A-V Meas Observable | MEAS 531.4 KV | 1.063 PU | **-163.7 DEG**

Device	Value	Action	Station	LN2
XF	420.1 AMP 418.2 AMP	Remove	ANTIOCH	AT1H
XF	420.8 AMP 421.5 AMP	Remove	ANTIOCH	AT2H
LN	396.6 AMP 379.2 AMP	Remove	MCGUIRE	ROCK_SPRNG-2
LN	444.5 AMP 398.7 AMP	Remove	JKSN_FY	JKSN_FERRY-1

AT1H: 389.4MW → 6.0MR →  
397.8MW → 6.5MR →

AT2H: 390.0MW → 3.6MR →  
384.8MW → 7.6MR →

ROCK\_SPRNG-2: 367.4MW ← 12.0MR ←  
359.9MW ← 13.0MR ←

JKSN\_FERRY-1: 411.9MW ← 2.4MR →  
406.5MW ← 2.2MR →

$$\Delta = 1.7^\circ$$

**Network Bus Summary** | - Bus Symbolic View - | Bus List View

RTNET Last Solved: 24-Jul-2014 13:47:47

JKSN\_FY IN PJM | Options | 5517 | Position to Bus

RTNET	REALTIME	LOSSES CALC ED
Station Total		
Generation:	0.0 MW	0.0 MVAR
Load:	0.0 MW	0.0 MVAR

Bus: 5782 | Island: 1 | Solved | 533.3 KV | 1.067 PU | **-161.0 DEG** | Remove | Show Nhood

A-V Meas Observable | MEAS 526.7 KV | 1.053 PU

Device	Value	Action	Station	LN2
LN	457.5 AMP 460.0 AMP	Remove	ANTIOCH	JKSN_FERRY-1

JKSN\_FERRY-1: 412.7MW → 90.8MR ←  
415.6MW → 101.1MR ←



- Delta Angles stay the same, though individual angle values are “skewed”
- Cost (Error) remains the same before and after PMU measurements are enabled
- Not giving phasors higher accuracy weight



