NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Reliability Standards – Disturbance Monitoring Conference

July 30 - 31, 2013 – Tempe, AZ
August 6 - 7, 2013 – Atlanta, GA
Day 1

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Standards Development Process Participant Conduct Policy

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Introduction

Barb Nutter
NERC Standard Developer

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Disturbance Monitoring Standards Drafting Team (DMSDT) Membership

Member	Registered Entity
Lee Pedowicz, Chair	Northeast Power Coordinating Council
Frank Ashrafi	Southern California Edison
Alan Baker	Florida Power & Light Co.
Dan Hansen	NRG Energy
Tim Kucey	PSEG Fossil LLC
Steve Myers	ERCOT
Ryan Quint	Bonneville Power Administration
Jack Soehren	ITC Holdings Corp.
Vladimir Stanisic	AESI Inc.

Additional Participants

- Chuck Jensen
- Juan Villar
- Bob Cummings
- Neil Burbure
- Natara Bierria
- Barb Nutter
- Bill Edwards

- Seminole Electric Cooperative
- FERC - Office of Electric Reliability
- NERC - Reliability Initiatives & Events Analysis
- NERC - Reliability Initiatives & Events Analysis
- NERC - Standards Development
- NERC - Standards Development
- NERC - Legal and Regulatory

Day 1 - Agenda

- Introduction – Barb Nutter
- Background – Bob Cummings
- FERC Staff Perspective – Juan Villar
- PRC-002-2 Disturbance Monitoring & Reporting Requirements
  - History, Purpose, Applicability, Definitions – Lee Pedowicz
  - Requirements R1 and R2 – Chuck Jenson/Alan Baker
- Break – 15 minutes
  - Requirements R3 thru R8 – Jack Soehren
- Questions & Answers – Team
- Summary – Neil Burbure/Natara Bierria
- Wrap Up – Lee Pedowicz

Day 2 - Agenda

- Kick-off – Lee Pedowicz
- PRC-002-2 Disturbance Monitoring & Reporting Requirements
  - Requirements R9 thru R17 – Ryan Quint
- Break – 15 minutes
  - Requirements R18 thru R21 – Tim Kucey
- Implementation Plan – Lee Pedowicz
- Questions & Answers – Team
- Summary – Neil Burbure/Natara Bierria
- Wrap Up – Lee Pedowicz

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Background

Bob Cummings
Reliability Initiatives & Events Analysis

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FERC Staff Perspective

Juan Villar
Office of Electric Reliability, FERC

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DMSDT Working Draft

PRC-002-2 Disturbance Monitoring and Reporting Requirements

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History, Purpose, Applicability, Definitions

Lee Pedowicz, NPCC

History

Purpose Statement

- To have adequate data available to facilitate event analysis of Bulk Electric System (BES) disturbances.

Applicability

4.1. Functional Entities:

The Responsible Entity to establish a list of monitored BES bus locations and the Elements for Dynamic Disturbance Recording and triggers for the Transmission Owner and Generator Owner, where applicable, is either the:

4.1.1 Planning Coordinator

4.1.2 Reliability Coordinator

4.2. Transmission Owner establishes the bus locations for Fault Recording and Sequence of Events Recording, and is responsible for Sequence of Events Recording, Fault Recording, ~~or~~ and Dynamic Disturbance Recording data for each of the Elements they own connected to the established bus locations.

4.3. Generator Owner is responsible for Sequence of Events Recording, Fault Recording, ~~or~~ and Dynamic Disturbance Recording data for each of the Elements they own connected to the established bus locations.

Definitions

- Dynamic Disturbance Recording (DDR)
  - The action of recording time sequenced data for dynamic ~~events~~ characteristics such as power swings, frequency variations, and abnormal voltage problems.
- Fault Recording (FR)
  - The action of recording time sequenced waveform data for short circuit or failure of Elements resulting in abnormal voltage(s) and/or current(s).
- Sequence of Events Recording (SOER)
  - The action of recording time sequenced data to capture change of status of Elements, which may include protection and control devices.
- Generating Plant
  - One or more generators at a single physical location whereby any single contingency can affect all the generators at that location.

Discussion

History, Purpose, Applicability, Definitions

Requirements R1 and R2

Chuck Jensen, Seminole Electric Cooperative - Tempe

Alan Baker, Florida Power & Light - Atlanta

Requirements R1 and R2 SOER & FR - Locations

- R1. Each **Transmission Owner** shall establish a list of monitored BES bus locations for **Sequence of Events Recording** and **Fault Recording**. The list shall be established by following the selection procedure contained in *PRC-002-2 Attachment 1 – SOER and FR Locations Selection Procedure*.
- R2. The **Transmission Owner** shall review the list established in Requirement R1 at least every five calendar years.

FR and SOER - Goals and Objectives

- FR and SOER data used for after the “Event” analysis, reconstructing complex “Events”
- Location criteria = “Equivalent” across all NERC Registered Entities (REs)
- Location criteria = based on DATA, not opinion
- Receive industry feedback on the location criteria and modify as needed

Historical Location Criteria Development

- In the absence of a "good BES definition" – proposed a 200 kV bright line with 3 lines or more at a substation – generated a plethora of questions; from Industry, FERC and NERC
  - Why > 200kV? (Is this kV a good choice?)
  - Why 3 lines or more at a substation? (Why not 4 or 5, or even 2?)
  - What is the definition of a substation? Substations are not alike and they differ greatly. Electrical infrastructure enclosed by a fence – just doesn't capture the full definition meaning of a substation.
- How can we answer these questions?

Historical Location Criteria Development (cont'd)

- DMSDT Monitored Value Analysis Team to use a method to answer these questions – so where do we start?
- One idea - Top 100 Low Impedance busses (Short Circuit MVA or SCMVA) for a Region and determine what KV percentages were best represented from this analysis
- In the FRCC Region 10,000 MVA includes more than 100 busses, 148 busses are included at 88 substations

MVA Short Circuit Advantages

- Voltage Level Independent, includes all voltage levels
- More likely to select busses which are electrically close to large generating centers
- More likely to select busses where delayed clearing can cause electric system cascading outages
- Selected busses directly correlate to the Universal Power Transfer equation
  - Lower Impedance – increased power flows – greater system impact
- Data is readily available from short circuit studies associated directly with the busses modeled

Test Cases: Three Phase Short Circuit Level = 10,000 MVA and 15,000 MVA

- Look at the short circuit data from multiple regions and try to answer the question of > 200 kV
- DMSDT - Team members supplied first set of short circuit data, then analysis was completed and presented to others
- Let's review some results from multiple regions…

200 kV Criteria - FRCC Data

FRCC Entire Region					
	kV level	Total	In top 100	> 15,000 MVA	> 10,000 MVA
	500	22	9	7	13
	230	442	88	34	129
	138 &115	937	3	0	6
	<100	1332	0	0	0
	Total	2733	100	41	148
MVA Highest	25,433				
>15M at Bus	41				
>10M at Bus	148				
MVA at Bus 100	10,793				

200 kV Criteria – ITC-Michigan Data

ITC - Michigan					
	kV level	**Total**	**In Top 100**	**> 15,000 MVA**	**> 10,000 MVA**
	345	50	48	26	48
	200	15	6	1	6
	100	97	3	0	3
	Total	162	57	27	57
MVA Highest	25,846				
>15M at Bus	27				
>10M at Bus	57				
MVA at Bus 100	10,103				

200 kV Criteria – New York Data

New York System					
	kV level	**Total**	**In Top 100**	**> 15,000 MVA**	**> 10,000 MVA**
	765	3	2	0	2
	500	13	9	9	9
	345	125	49	38	49
	230	101	17	10	17
	138	954	23	4	23
	Total	1196	100	61	100
MVA Highest	34,131				
>15M at Bus	61				
>10M at Bus	100				
MVA at Bus 100	10,072				

200 kV Criteria – ERCOT Region

ERCOT (Texas) System Summary					
	kV level	**Total**	**In top 100**	**> 15,000 MVA**	**> 10,000 MVA**
	345	406	100	223	318
	138	3389	0	11	294
	<100	3511	0	3	7
	total	7306	100	237	619
MVA Highest	53,875				
>15M at Bus	237				
>10M at Bus	619				
MVA at Bus 100	19,978				

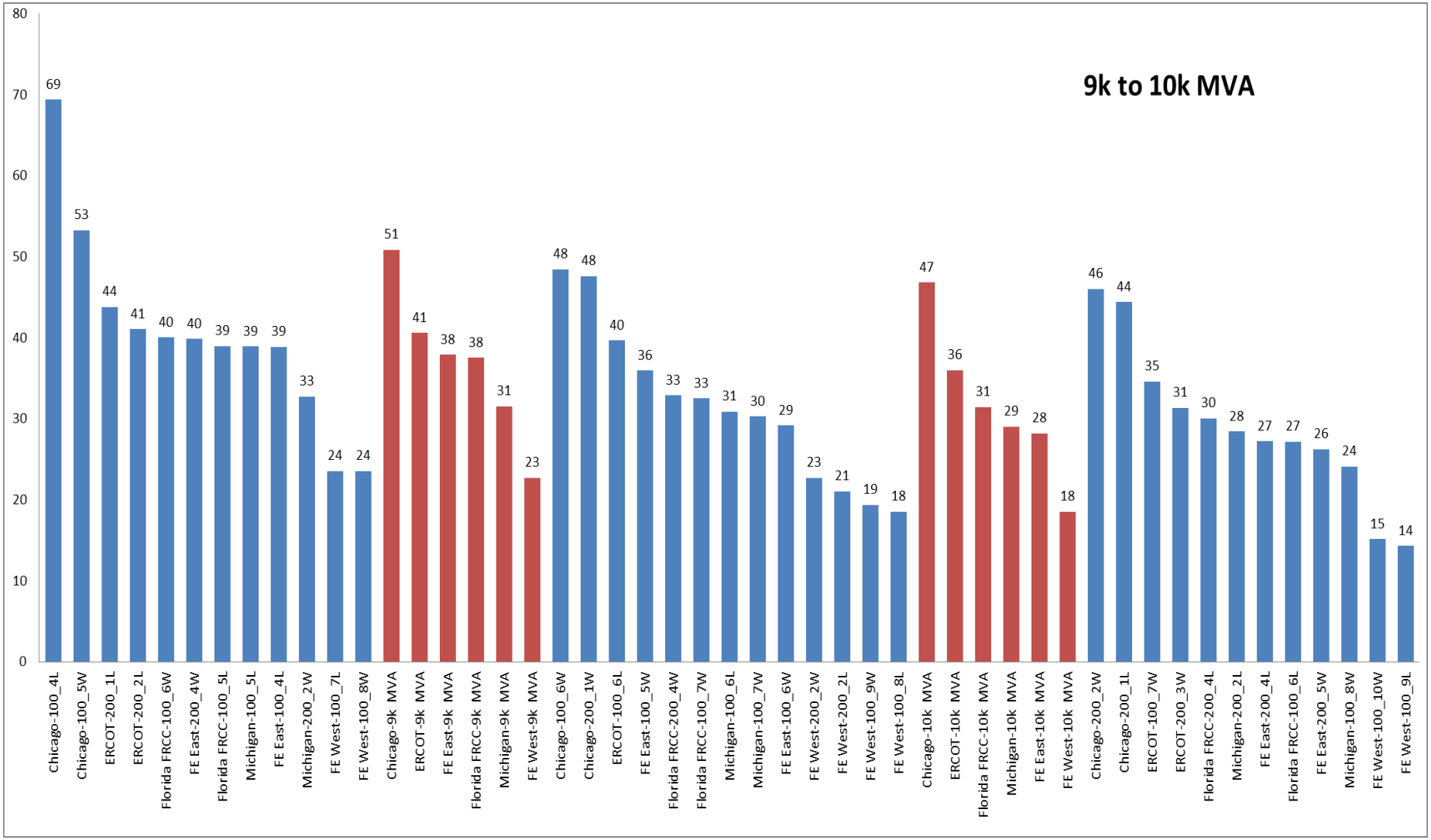
>200kV Correlations by System

• Upper Great Plains	100%	Good
• Rocky Mountain Region	100%	Good
• Desert South West	99%	Good
• FRCC – Florida	96%	Good
• ITC – Michigan	95%	Good
• Sierra Nevada Region	94%	Okay
• PJM	93%	Okay
• New York	77%	← Some concern here
• North East	66%	← Some more concern here
• ERCOT (Texas)	51%	← Real Concern here

Looks like we are going to have to include >100kV

How do we include 100kV?

9k to 10k MVA


9k to 10k MVA
80
70
60
50
40
30
20
10
0
69
53
44
41
40
40
39
39
39
33
24
24
51
41
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31
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30
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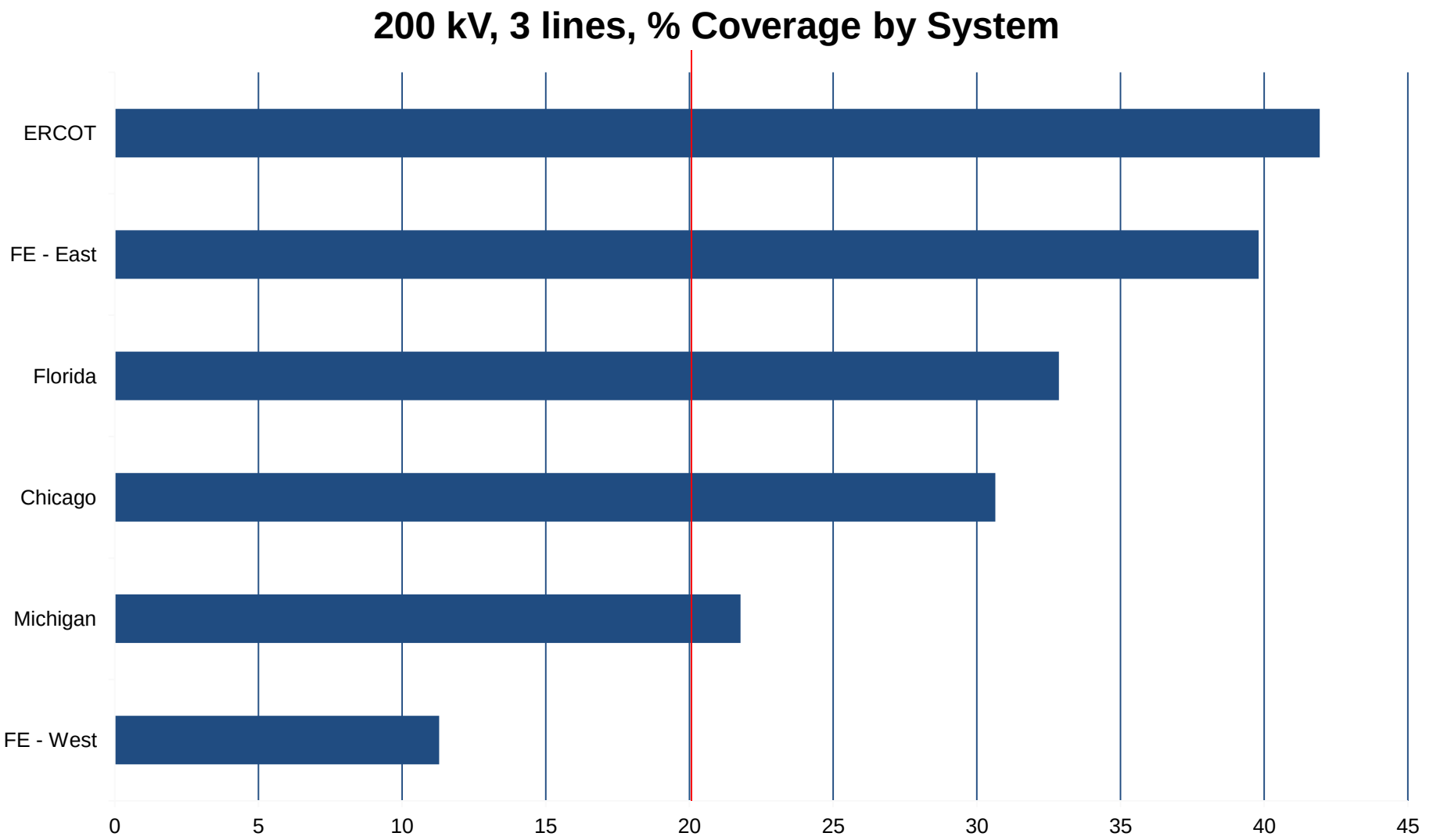
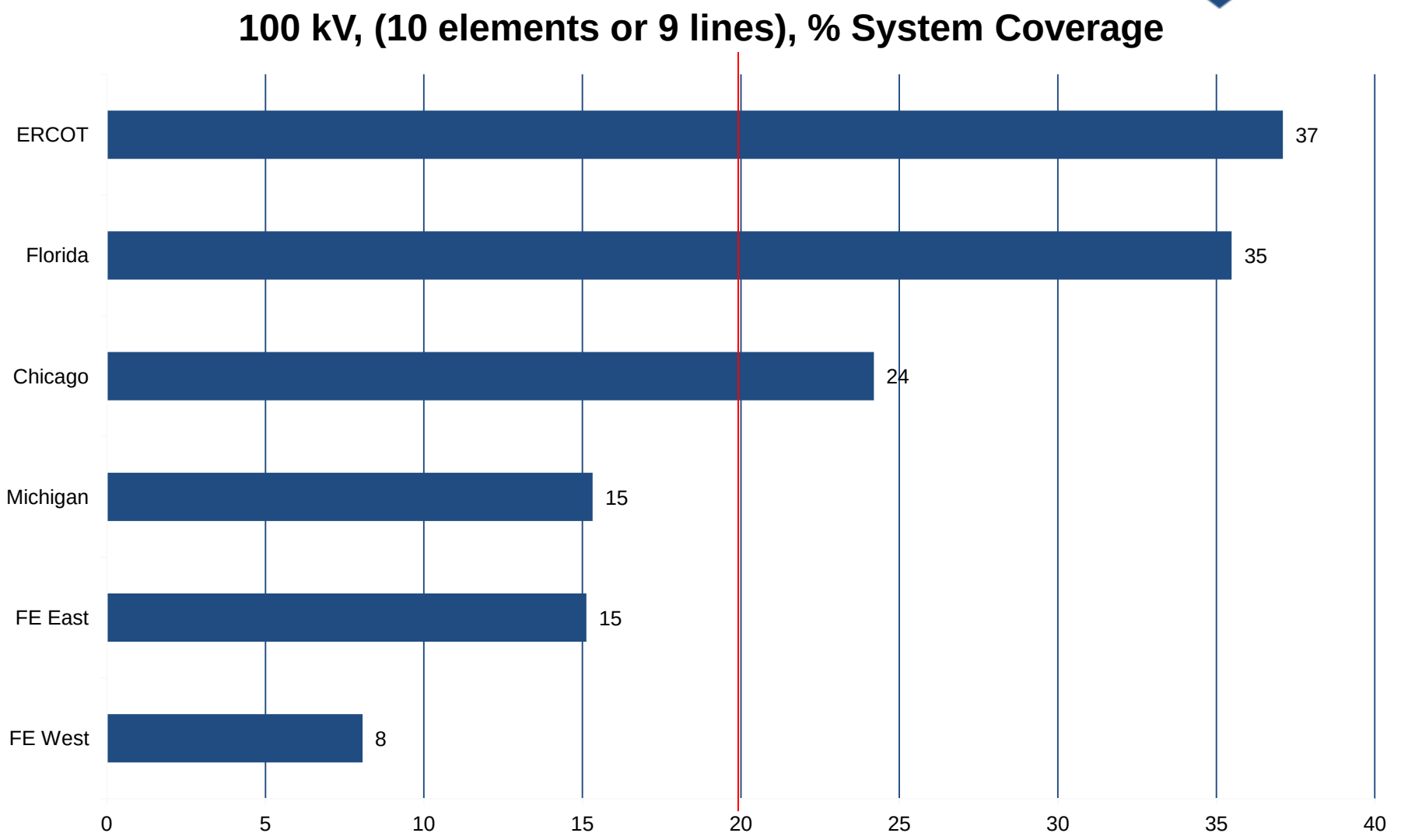
27
27
26
24
15
14
Chicago-100_4L
Chicago-100_5W
ERCOT-200_1L
ERCOT-200_2L
Florida FRCC-100_6W
FE East-200_4W
Florida FRCC-100_5L
Michigan-100_5L
FE East-100_4L
Michigan-200_2W
FE West-100_7L
FE West-100_8W
Chicago-9k MVA
ERCOT-9k MVA
FE East-9k MVA
Florida FRCC-9k MVA
Michigan-9k MVA
FE West-9k MVA
Chicago-100_6W
Chicago-200_1W
ERCOT-100_6L
FE East-100_5W
Florida FRCC-200_4W
Florida FRCC-100_7W
Michigan-100_6L
Michigan-100_7W
FE East-100_6W
FE West-200_2W
FE West-200_2L
FE West-100_9W
FE West-100_8L
Chicago-10k MVA
ERCOT-10k MVA
Florida FRCC-10k MVA
Michigan-10k MVA
FE East-10k MVA
FE West-10k MVA
Chicago-200_2W
Chicago-200_1L
ERCOT-100_7W
ERCOT-200_3W
Florida FRCC-200_4L
Michigan-200_2L
FE East-200_4L
Florida FRCC-100_6L
FE East-200_5W
Michigan-100_8W
FE West-100_10W
FE West-100_9L

200 kV, 3 lines, % Coverage by System



100 kV, (10 elements or 9 lines), % System Coverage



Use, or Not to Use Bifurcated Criteria?

- Bifurcated Criteria:
  - > 200 kV for substations with 3 or more lines or 4 elements,
  - > 100 kV for substations with 9 or more lines or 10 elements
- But, this still is not an “Equivalent” across all NERC Res.
- So what can be done to make the criteria more equivalent across all NERC REs?

Using SCMVA Methodology

- What about Short Circuit MVA?
- Observations - If we can account for one system with low SCMVA and another system with high SCMVA, then we can set up a criteria that is equal across NERC.

Using SCMVA Methodology (cont'd)

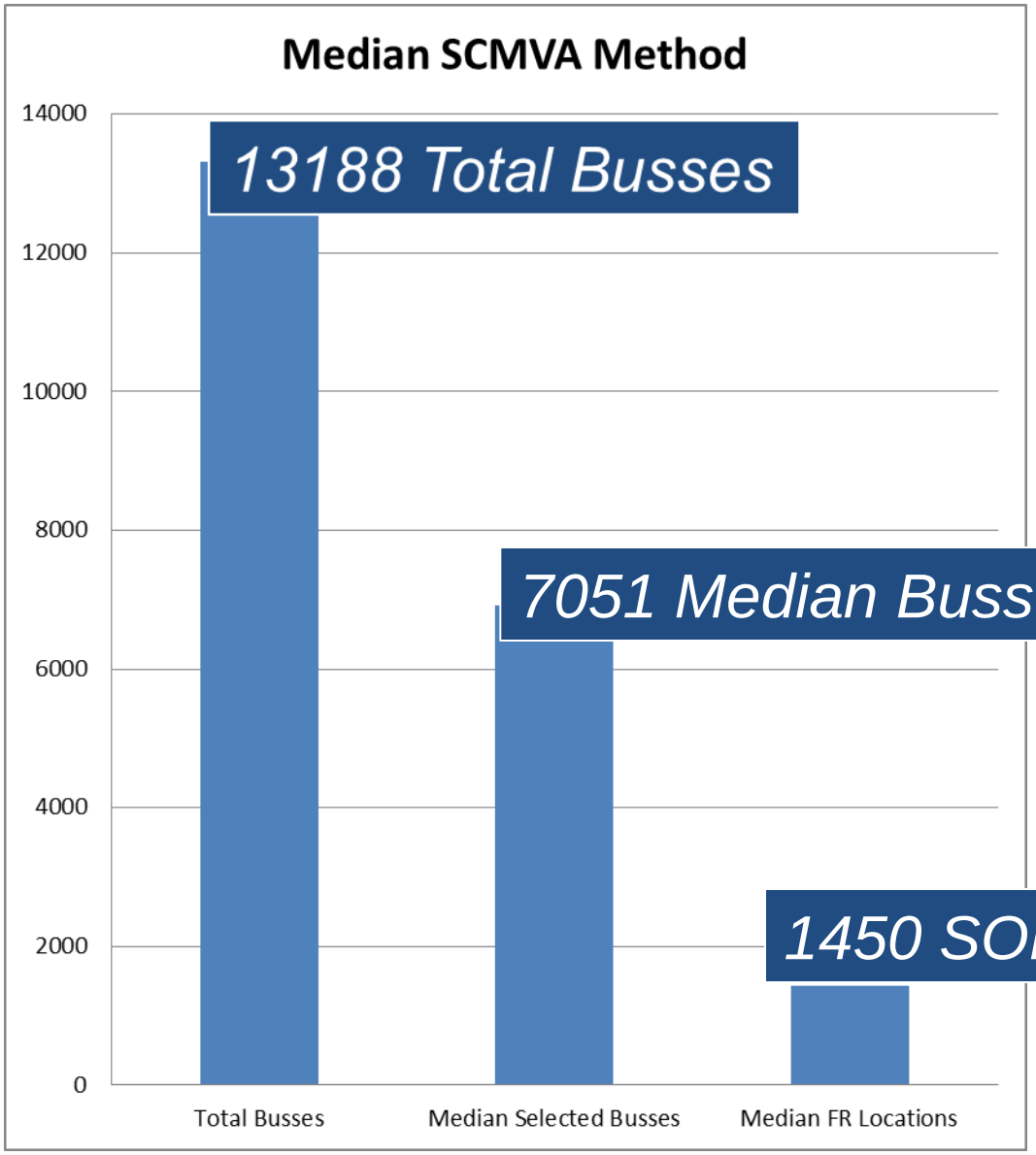
- Apply the 20% System Coverage to SCMVA listings and derive busses to include for FR / SOER
- Use SCMVA listing ordered by highest to lowest SCMVA
- But for high SCMVA systems, the 1500 MVA bottom cut-off value is too low
- Use a Median value method to adjust the lowest MVA value in the SCMVA listing to raise the 1500 MVA to a much higher value based on the system

Example – Median Method

Example RE	Total Bus Count	Total DFR Bus count	Top 10% Bus Count	10% Distributed Bus Count	Median MVA (6th Bus from Top)	New Lowest Median Calc. MVA (20% of Median Value)	Average MVA (Top 11 Buses)	New Lowest Avg. Calc. MVA (20% of Avg. Value)
Base Values	**36**	**8**	**4**	**4**	**12871**	**2574**	**15550**	**3110**
Median Method	**29**	**6**	**3**	**3**		**2574**		
Average Method	**26**	**6**	**3**	**3**				**3110**
Zero Busses	**0**	**0**	**0**	**0**				

Bus Coded Number	NCR-ID Number	Region	Bus kV (L-L)	Bus 3 Phase Fault--Current (amps)	Bus 3 Phase Fault MVA	Row #
244	NCR	WECC	525.00	32,480	29,535	1
238	NCR	WECC	525.00	24,768	22,522	2
245	NCR	WECC	230.00	53,843	21,449	3
235	NCR	WECC	525.00	16,590	15,086	4
218	NCR	WECC	230.00	34,130	13,596	5
230	NCR	WECC	525.00	14,155	12,871	6
231	NCR	WECC	525.00	13,920	12,658	7
239	NCR	WECC	230.00	29,872	11,900	8
236	NCR	WECC	230.00	29,841	11,888	9
224	NCR	WECC	230.00	25,709	10,242	10

Results of 20% Median Method – Number of SOER / FR Locations



Requirement R1, Attachment 1 Examples

Tim Kucey, PSEG Fossil, LLC

Attachment 1 - SOER and FR Locations Selection Procedure

To establish lists of monitored BES bus locations for Sequence of Events Recording and Fault Recording as per Requirement 1 of PRC-002-2, each Transmission Owner shall follow the steps listed below:

Step 1. Determine a complete list of BES bus locations[1] that it owns.

Step 2. Reduce the BES bus locations on the list to only those that have a maximum available calculated three phase short circuit MVA greater than 1500 MVA. If there are no buses on the resulting list, proceed to Step 7.

Step 3. Determine the 11 BES bus locations on the list with the highest maximum available calculated three phase short circuit MVA level. If the list has fewer than 11 bus locations, proceed to Step 7.

1 A single bus location ~~may be considered as~~ includes any bus Elements at the same voltage level within the same physical location. As an example, ring bus or breaker-and-a-half bus configurations ~~may be considered as a~~ are single bus locations.

Attachment 1 - SOER and FR Locations Selection Procedure (cont'd)

Step 4. Select the median MVA level of the 11 bus locations determined in Step 3.

Step 5. Multiply the median MVA level determined in Step 4 by 20%.

Step 6. Reduce the BES bus locations on the list to only those that have a maximum available calculated three phase short circuit MVA higher than the greater of:

a. 1500 MVA or

b. 20% of median MVA level determined in Step 5.

Attachment 1 - SOER and FR Locations Selection Procedure (cont'd)

Step 7. If there are no bus locations on the list: the procedure is complete and no Fault Recording and Sequence of Events Recording will be required. Procedure completed.

If the list has fewer than 11 locations: Fault Recording and Sequence of Events Recording is required at the BES bus location with the highest maximum available calculated three phase short circuit MVA. Proceed to Step 9.

If the list has more than 11 bus locations: Fault Recording and Sequence of Events Recording is required on at least the 10% of the BES bus locations, determined in Step 6, with the highest maximum available calculated three phase short circuit MVA. Proceed to Step 8.

Attachment 1 - SOER and FR Locations Selection Procedure (cont'd)

Step 8. Fault Recording and Sequence of Events Recording is required at additional BES bus locations on the list determined in Step 6. The aggregate of the number of bus locations determined in Step 7 and this step will be at least 20% of the bus locations determined in Step 6.

The additional bus locations are selected, at the Transmission Owner's discretion, to provide maximum wide-area coverage for Fault Recording and Sequence of Events Recording, therefore the following types of BES locations are recommended:

a. Bus locations electrically distant or from other DME devices.

b. Voltage sensitive areas.

c. Cohesive load and generation zones.

d. Bus locations with a relatively high number of incident transmission circuits.

e. Bus locations with reactive power devices.

f. Major facilities interconnecting outside the Transmission Owner area.

Attachment 1 - SOER and FR Locations Selection Procedure (cont'd)

Step 9. The list of monitored locations for Sequence of Events Recording and Fault Recording for PRC-002-2 Requirement R1 is the aggregate of the bus locations determined in Steps 7 and 8.

Example 1

- **Scenario:** TO has 15 buses, of which **none** (0, zero) have a Short-Circuit Fault MVA (SCMVA) > 1500 MVA.

  - **Step 1** produces the TO's list of buses. The list will include all 15 of the TO's buses.
  - Because none of the TO's buses are >1500 MVA **Step 2** reduces the TO's list to 0 (zero) buses. The TO skips Steps 3-6 and proceeds to Step 7.
  - **Step 7** clarifies that no Fault Recording and Sequence of Events Recording will be required from the TO because none of the TO's buses are >1500 MVA. Also, the TO skips Step 8 and proceeds to Step 9.
  - **Step 9** clarifies that the resulting list, *which is a "null" list for this TO*, is the list of buses which the TO must have SOER and FR for to meet PRC-002-2 Requirement R1.

Example 2

- **Scenario:** TO has 18 buses, with **11 (eleven)** @ SCMVA > 1500 MVA

  - **Step 1** produces the TO's list of buses. All 18 of the TO's buses are on the list.
  - **Step 2** reduces the TO's list to its 11 (eleven) buses that have SCMVA >1500 MVA.
  - **Step 3** directs the TO to Step 7, because the TO's list has no more than 11 buses with SCMVA > 1500 MVA.
  - Because the TO has 11 or fewer buses with SCMVA > 1500 MVA **Step 7** directs the TO to select its largest bus, by MVA, from its bus list. Also, the TO skips Step 8 and proceeds to Step 9.
  - **Step 9** clarifies that the resulting list, *which includes only the TO's largest bus by SCMVA*, is the list of buses which the TO must have SOER and FR for to meet PRC-002-2 Requirement R1.

Example 3

- **Scenario:**
  - TO has 48 buses, with 31 @ SCMVA > 1500 MVA.
  - The SCMVA of the median bus of the TO's largest 11 buses, when all 48 of the TO's buses are ranked by SCMVA, is **18000** MVA.
  - 10 of the TO's buses have SCMVA < 3600 MVA.

- **Step 1** produces the TO's list of buses. All 48 of the TO's buses are on the list.
- **Step 2** reduces the TO's list to its 31 buses that have SCMVA >1500 MVA.
- **Step 3** directs the TO to select its largest 11 buses, ranked by SCMVA, of these 31 buses.
- **Step 4** directs the TO to select the median bus, by SCMVA, of those 11 buses. It will be the 6th largest bus of the 11.
- **Step 5** directs the TO to calculate 20% of the median bus's SCMVA. In this case that value will be 3600 MVA (**18000** MVA * 20%)

PRC-002-2 R1 Procedure – Example 3

- **Scenario (continued):**
  - TO has 48 buses, with **31** @ SCMVA > 1500 MVA
  - The SCMVA of the median bus of the TO's largest 11 buses, when all 48 of the TO's buses are ranked by SCMVA, is 18000 MVA.
  - **10** of the TO's 48 buses have SCMVA < 3600 MVA

- The value calculated in Step 5 is 3600 MVA. Since this value is >1500 MVA **Step 6** directs the TO to reduce its list of 31 buses, from Step 2, to only those buses which have SCMVA greater than that value (3600 MVA). The TO's resulting list includes **21** buses.
  - **21** = **31** @>1500 MVA – **10** @<3600 MVA
- Where the TO has >11 buses with SCMVA > 1500 MVA, SOER and FR is required on at least 10% of the TO's largest buses on the list determined in Step 6. In this example **Step 7** therefore directs TO to select its **3** largest buses.
  - 3/**21** > 10% whereas 2/**21** < 10%

Example 3

- **Scenario (continued):**
  - TO has 48 buses, with 31 @ SCMVA > 1500 MVA
  - The SCMVA of the median bus of the TO's largest 11 buses, when all 48 of the TO's buses are ranked by SCMVA, is 18000 MVA
  - 10 of the TO's 48 buses have SCMVA < 3600 MVA

- Where the TO has >11 buses with SCMVA > 1500 MVA, SOER and FR is required on at least 20% of the TO's buses on the list determined in Step 6. In Step 7 of this example the TO selected its 3 largest buses and Step 6 produced a list of 21 buses; **Step 8** therefore directs the TO to select **2 more** of its buses, considering recording coverage over the TO's footprint.
  - (3+2)/21 > 20% whereas (3+1)/21 < 20%
- **Step 9** clarifies that the resulting list, *which includes the 3 TO's largest buses by SCMVA selected in Step 7* ***and*** *the 2 buses selected in Step 8*, is the list of buses which the TO must have SOER and FR for to meet PRC-002-2 Requirement R1.

Discussion

Requirements R1 & R2

BREAK

15 minutes

Requirements R3 through R8

Jack Soehren, ITC Holdings

Requirement R3
SOER - Circuit Breaker Status

- R3. Each **Transmission Owner** and **Generator Owner** shall have **Sequence of Events Recording** for changes in circuit breaker position (open/close) for each of the circuit breakers they own connected to the bus locations established in Requirement R1.

Requirement R4
FR - Locations

- ~~R4. Each **Transmission Owner** and **Generator Owner** shall have **Fault Recording** for each of the Elements they own connected to the bus locations established in Requirement R1.~~

Discussion

Requirements R3 & R4

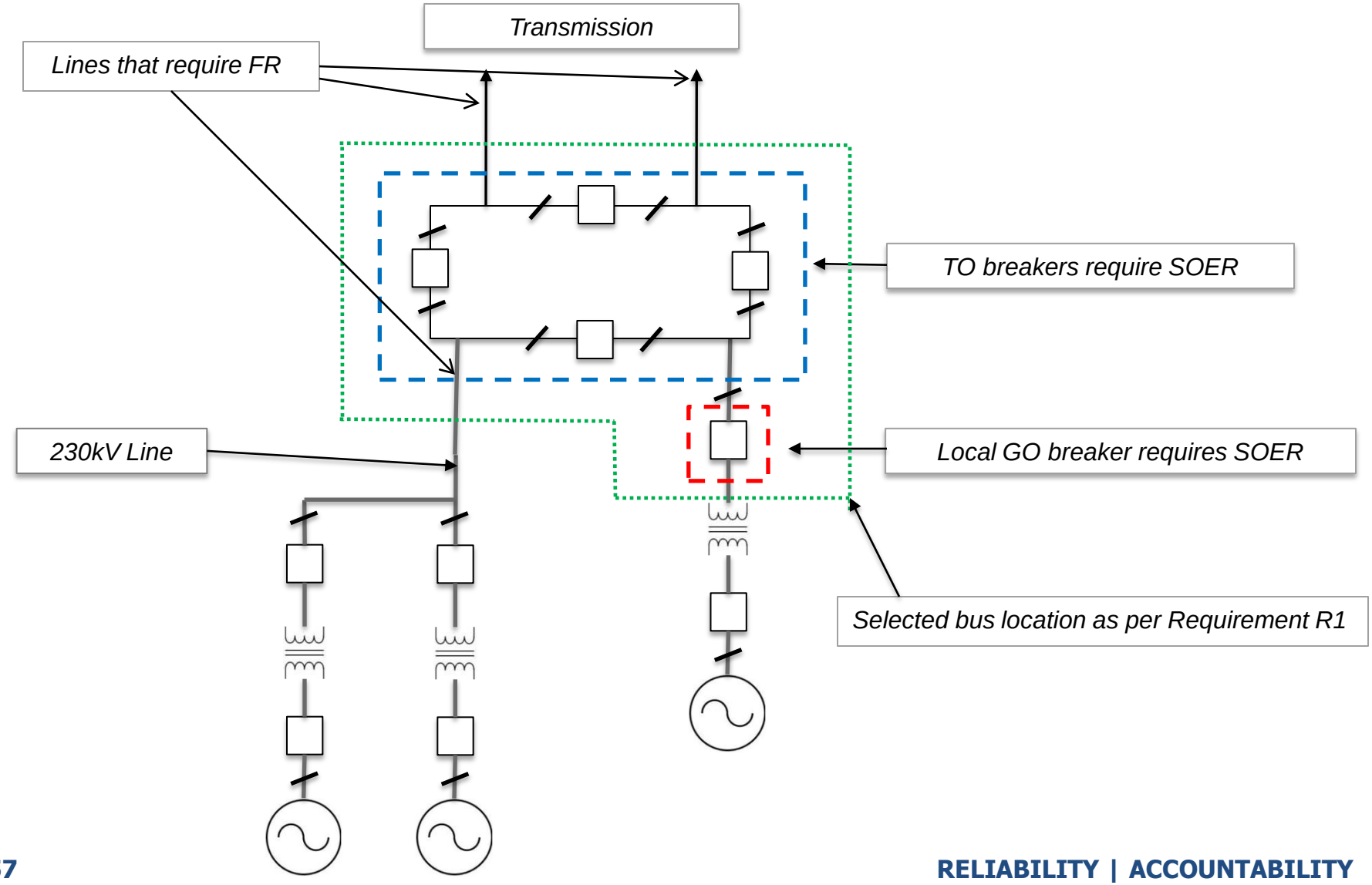
Requirement R5
FR - Voltage

- R5. Each **Transmission Owner** and **Generator Owner** shall record **electrical quantities** in order to determine phase-to-neutral voltages for each phase of either each line or common bus they own connected to the bus locations established in Requirement R1.

Requirement R6 FR - Current

- R6. Each **Transmission Owner** and **Generator Owner** shall record **electrical quantities** in order to determine each phase current and the residual or neutral current for the following BES Elements they own connected to the bus locations established in Requirement R1:
  - 6.1 Transformers that have a low-side operating voltage of 100 kV or above.
  - 6.2 Transmission Lines.

SOER / FR – Example Diagram



Discussion

Requirements R5 & R6

Requirement R7
FR - Data

- R7. Each **Transmission Owner** and **Generator Owner** shall have **Fault Recording** as specified in Requirements ~~R4~~ R5 and R6 that meets the following:

  7.1 A single record or multiple records that include either:

  - A pre-trigger record length of at least two cycles and a post-trigger record length of at least 50 cycles for the same trigger point.
  - At least two cycles of the pre-trigger data, the first three cycles of the fault, and the final cycle of the fault.

  7.2 A minimum recording rate of 16 samples per cycle.

Discussion

Requirement R7

Requirement R8 FR - Triggers

- R8. Each **Transmission Owner** and **Generator Owner** shall have Fault Recording as specified in Requirements ~~R4~~ R5 and R6 that triggers for at least the following:

  8.1 Neutral (residual) overcurrent set at 40% or less of CT secondary rating.

  8.2 Monitored phase under-voltage set no lower than 85% of normal operating voltage.

Discussion

Requirement R8

Questions and Answers

Summary

Neil Burbure, NERC - Tempe

Natara Bierria, NERC - Atlanta

Day 1 Wrap up

Day 1

- Background
- FERC Staff Perspective
- PRC-002-2 Disturbance Monitoring & Reporting Requirements
  - History, Purpose, Applicability, Definitions
  - Requirements R1 thru R8

Day 2

- Kick Off
- PRC-002-2 Disturbance Monitoring & Reporting Requirements
  - Requirements R9 thru R21
- Implementation Plan
- Summary
- Next Steps
- Wrap Up

Questions?