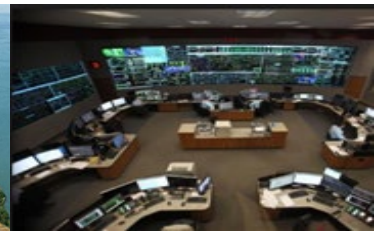


PUBLIC



# PRC-027-1 (Coordination of Protection Systems for Performance During Faults) Overview

Stephen Whaite – Technical Auditor, RF  
Technical Talk with RF  
July 19, 2021



# Agenda

## PRC-027-1 Overview

- Purpose
- Applicability
- Implementation Plan

## Requirements R1 and R3

- Applicability Discussion
- Lessons Learned from PRC-004-6
- R3 Sampling: Attachment C

## Requirement R2

- Options, Applicability and Example Timelines
- Possible Approaches to Sampling



# **PRC-027-1 (Coordination of Protection Systems for Performance During Faults) Overview**

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# PRC-027-1 Purpose

**Purpose:** To maintain the coordination of Protection Systems installed to detect and isolate Faults on Bulk Electric System (BES) Elements, such that those Protection Systems operate in the intended sequence during Faults.

- The purpose is to **maintain** coordination.
- Two sets of risks to existing Protection System coordination are addressed:

## R1 & R3

The risk that new or revised Protection System settings will not be properly coordinated.

## R2

The risk changing fault current levels over time will degrade existing coordination.



# PRC-027-1 Applicability

**Functional Entities:** Transmission Owners, Generator Owners, and Distribution Providers (for Distribution Providers that own Protection Systems identified in the Facilities section)

**Facilities:** Protection Systems installed to detect and isolate Faults on BES Elements.

**Note:** Attachment A of PRC-027-1 is referenced in Requirement R2 but is not relevant for the overall applicability of the standard or for R1/R3.

## Attachment A

The following Protection System functions<sup>2</sup> are applicable to Requirement R2 if: (1) available Fault current levels are used to develop the settings for those Protection System functions; and (2) those Protection System functions require coordination with other Protection Systems.



# PRC-027-1 Implementation Plan

**Standard effective date: April 01, 2021**

**Required on the effective date:**

- R1 – a documented process
- R2 – an initial Fault current baseline for all BES Elements using Option 2
- R3 – utilization of the process for all new or revised Protection System settings for BES elements

**Required by December 31, 2027 (the end of the first six calendar year interval for R2):**

- Protection System Coordination Studies for all BES Elements Using R2 Option 1
- Fault current comparisons and any resulting required Protection System Coordination Studies for all BES Elements Using R2 Option 2



# REQUIREMENTS R1 AND R3

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# PRC-027-1 – Requirements R1 and R3

## **R1 - Establish a process for developing new and revised Protection System settings for BES Elements, including:**

- Review and update of short-circuit model data (1.1)
- Review of the developed settings (1.2)
- Communication with neighboring entities for Protection Systems on BES Elements that electrically join Facilities owned by separate functional entities (1.3)
  - *Replaces requirements previously in PRC-001-1(ii).*

## **R3 - Utilize the process established in Requirement R1**

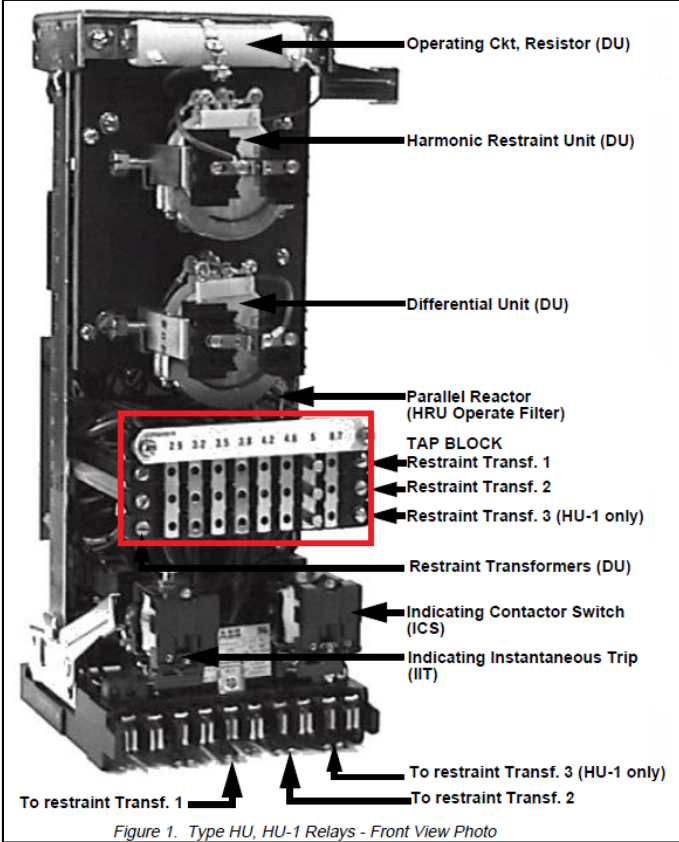
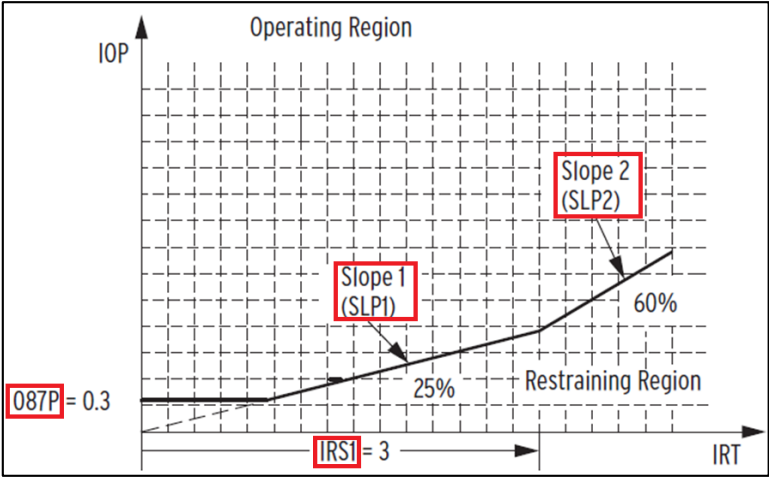
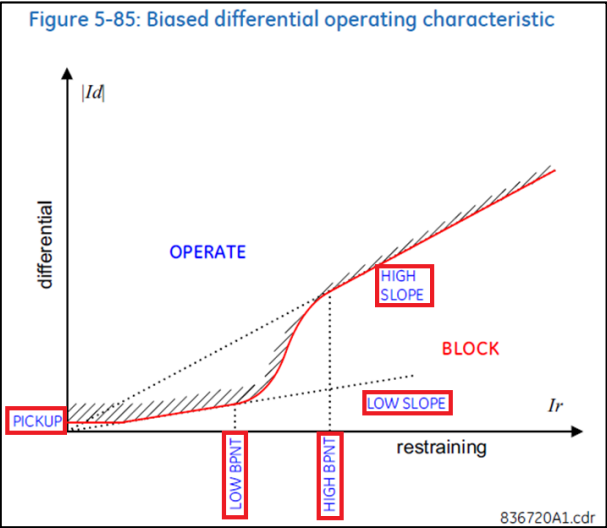




# Requirements R1 and R3 Applicability Examples

## Bus and Transformer Differential Schemes

- A short-circuit study with reviewed/updated model data (1.1) helps to verify security for maximum external faults (despite current transformer saturation) and sensitivity for minimum internal faults.
- A review of developed numerical or logic settings (1.2) helps to prevent human performance errors (calculation or documentation).
- Differential Relays **do** have settings!



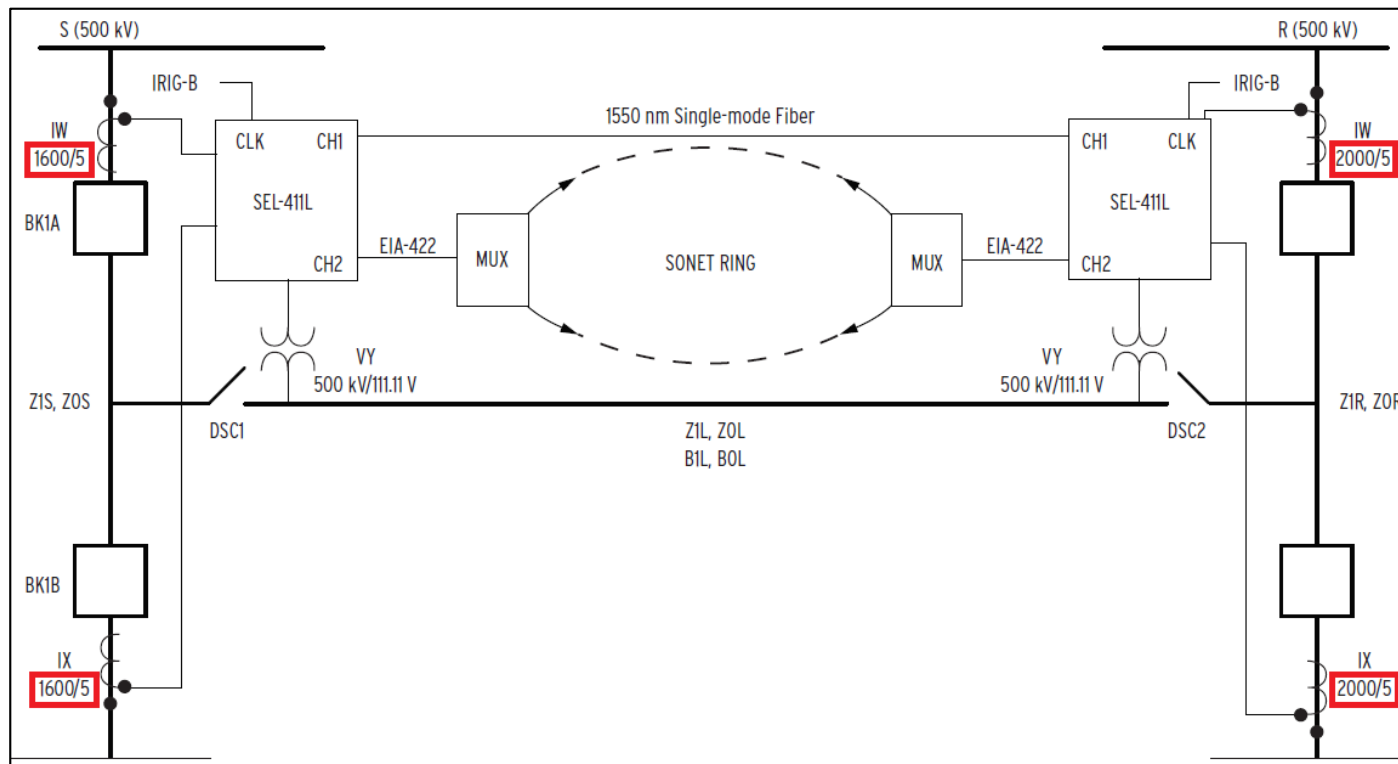
**Differential Settings Pictures:**  
 Left: GE B90 Manual Figure 5-85  
 Center: SEL-387 Manual Figure 3.1  
 Right: ABB/Westinghouse Type HU/HU-1 Instruction Leaflet Figure 1



# Requirements R1 and R3 Applicability Examples

## Line Current Differential Schemes

- Coordination of new or revised settings for tie line protection must involve the owners of the electrically joined Facilities (1.3).
- For example, a CT ratio change at the local end of a tie line protected by a line current differential schemes may require CT ratio settings to be changed in relays at the remote end of the line.



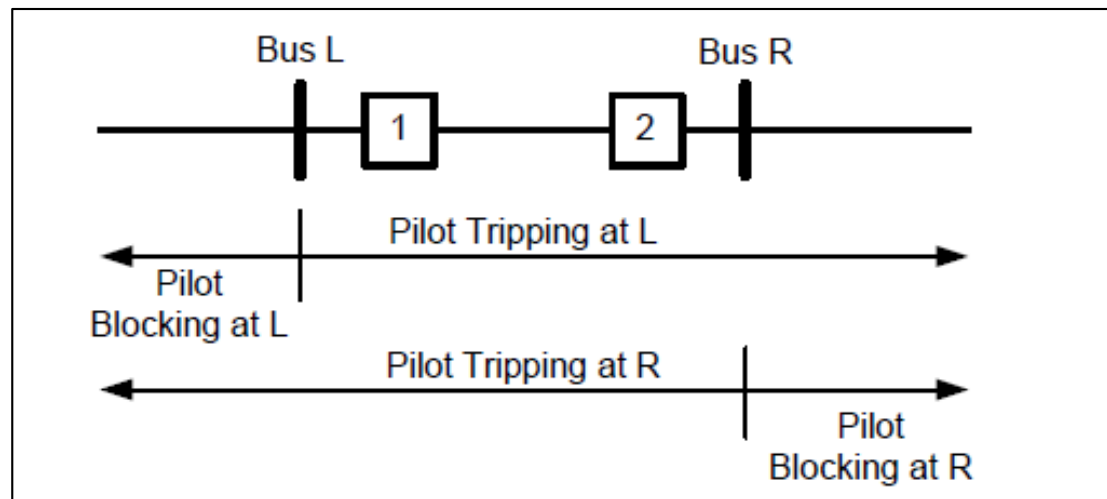
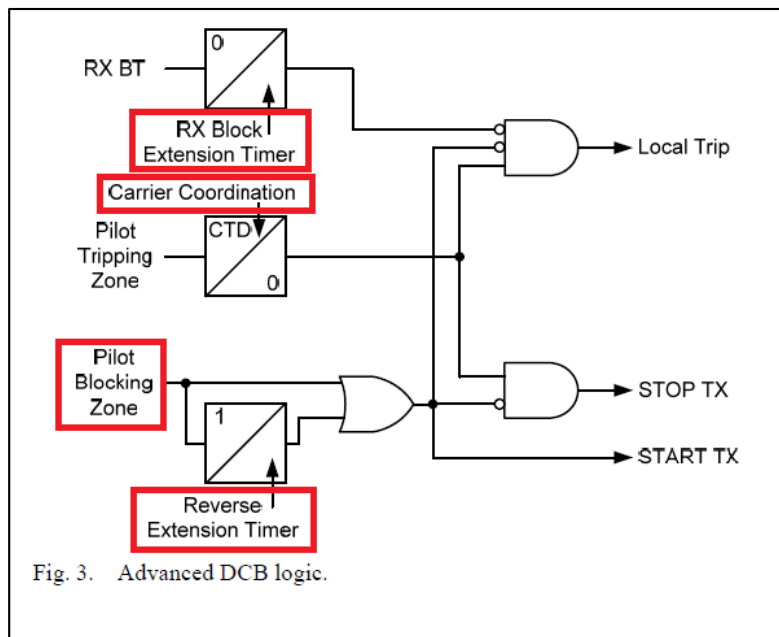
Line Current Differential Picture:  
SEL-411L Manual Figure 6.1



# Requirements R1 and R3 Applicability Examples

## Other communication-aided line protection schemes

- Coordination of new or revised settings for tie line protection must involve the owners of the electrically joined Facilities (1.3).
- For example, coordination of Directional Comparison Blocking (DCB) protection on a tie line should involve communication between owners of the terminals regarding settings philosophy items such as the use of nondirectional carrier start, the length of the carrier coordination pickup time delay, and the use of RX block extension timers and/or reverse extension timers.



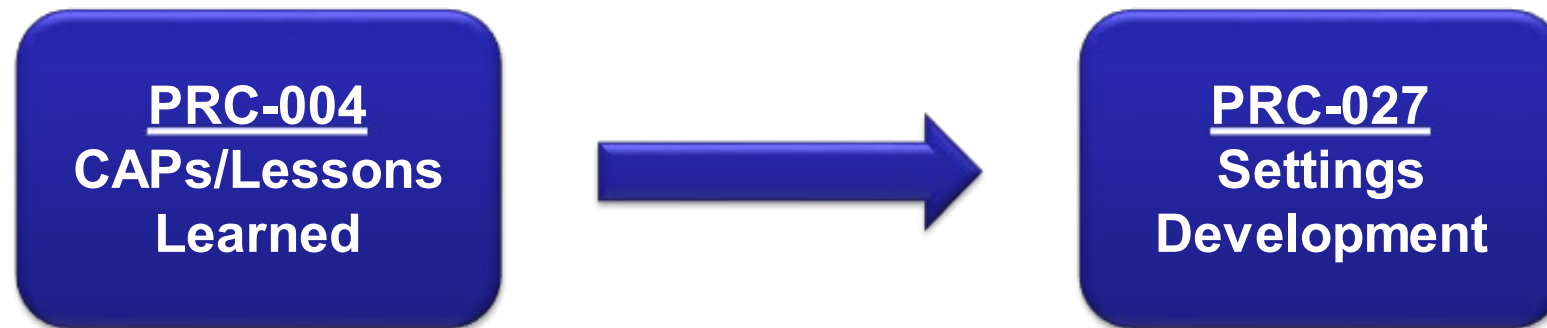
Source: Tucker et al., "Coordinating Dissimilar Line Relays in a Communications-Assisted Scheme."

Left: Fig. 3

Right: Fig. 2

# Lessons Learned from PRC-004-6

- The 2021 ERO Enterprise Compliance Monitoring and Enforcement Program (CMEP) Implementation Plan groups PRC-027 R1 and R3 with PRC-004-6 R1 and R5 as areas of focus to address the risk element Determination and Prevention of Misoperations.
- Lessons learned from PRC-004-6 (Protection System Misoperation Identification and Correction) should be applied to the development of new and revised Protection System settings.



# PRC-027-1 R3 Sampling: Attachment C



**Contains Confidential Information Including Privileged and Critical Energy Infrastructure Information. Do Not Distribute.**

Attachment C - Data Sampling Request

Standard Number	Requirement Number	Data List	Data List returned to ReliabilityFirst	Evidence Requested	Evidence Returned to ReliabilityFirst
PRC-027-1	R3.	Provide a list of new and revised Protection System settings developed for BES Elements (since 4/1/2021 or the last audit, whichever is later).  <b>Use Attached Template</b>	Return Data List to ReliabilityFirst no later than the deadline indicated in the Notification Letter for "Submittal of Attachment C - Data Sampling".	Acceptable evidence may include, but is not limited to, dated electronic or hard copy documentation to demonstrate that the responsible entity utilized its settings development process established in Requirement R1, as specified in Requirement R3	Return evidence to ReliabilityFirst no later than the deadline indicated in the Notification Letter for "Submittal of Attachment B, the RSAWs, Data Sampling Evidence, and all evidence of compliance".



# PRC-027-1 R3 Sampling: Attachment C

Index Number (RF use only)	Date (For changes after 4/1/2021)	New or Revised Protection System Settings (Note 1)	BES Element kV	Other Owner(s) of Electrically Joined Facilities	Comments
	xx/xx/xxxx	Line XYZ Upgrade	161	NA	
	xx/xx/xxxx	Bus X	161	ABC Electric	
	xx/xx/xxxx	Primary Bus Relay Upgrade	345	NA	
	xx/xx/xxxx	New Substation	230	NA	
	xx/xx/xxxx	Individual Relay Change	161	NA	
	xx/xx/xxxx	New Line	161	NA	

Note 1: Protection System settings changes may be listed by individual relays, packages containing multiple relays, or new projects such as new substation or line.



# REQUIREMENT R2

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## **R2 - For each BES Element with Protection System functions identified in Attachment A of the standard:**

- Option 1: Perform a Protection System Coordination Study (PSCS) within a six-calendar year time interval; or
- Option 2: Compare present Fault current values to an established Fault current baseline and perform a PSCS when the comparison identifies at least a 15% deviation, all within a six-calendar year time interval; or,
  - Note: The initial baseline must have been established by the effective date of this Reliability Standard to use Option 2 for the initial performance of R2. A baseline may be established for a new BES element or a BES element previously under Option 1 by performing a Protection System Coordination Study.
- Option 3: Use a combination of the above.





# Requirement R2 Applicability: Attachment A

## **Protection System functions applicable to Requirement R2:**

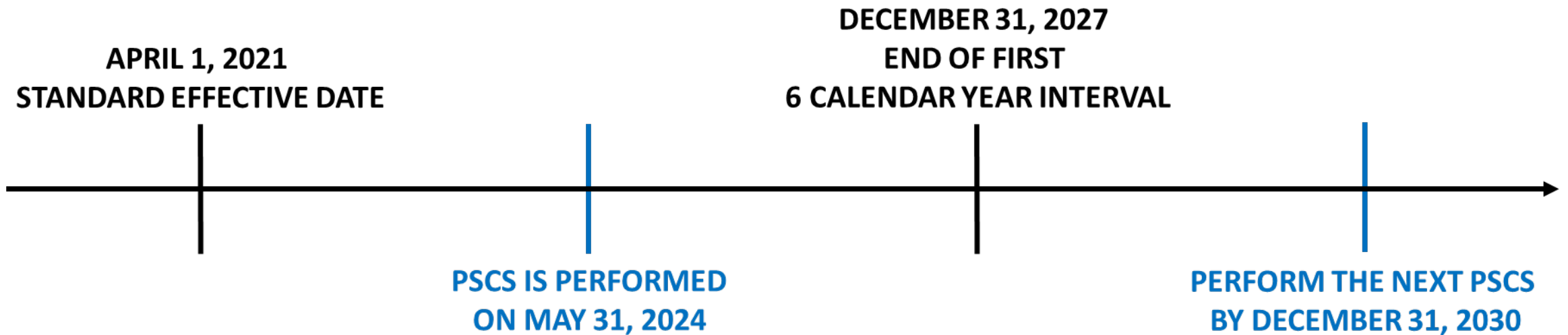
- 21 – Distance (if infeed or zero-sequence mutual coupling are used in determining reach)
- 50 – Instantaneous overcurrent
- 51 – AC inverse time overcurrent
- 67 – AC directional overcurrent (if used in a non-communication-aided protection scheme)

**The Protection System functions above are applicable if available Fault current levels are used to develop the settings and those Protection System functions require coordination with other Protection Systems.**

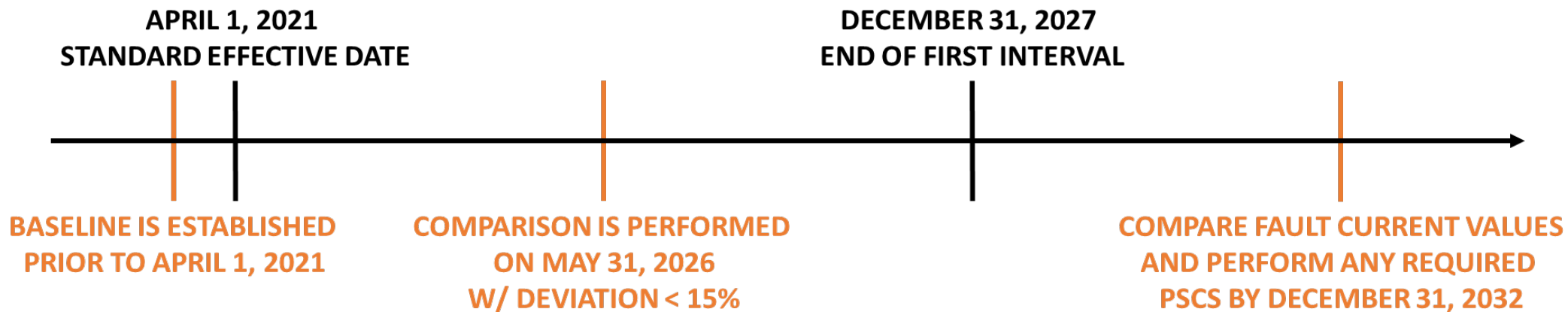


# Requirement R2 Example Timelines: Option 1

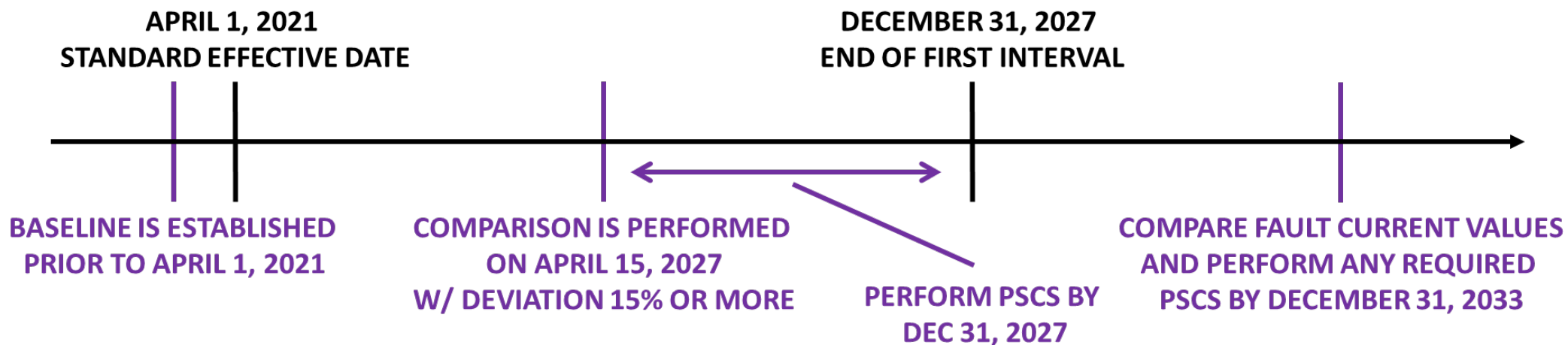
## PRC-027-1 R2 OPTION 1 EXAMPLE



# Requirement R2 Example Timelines: Option 2

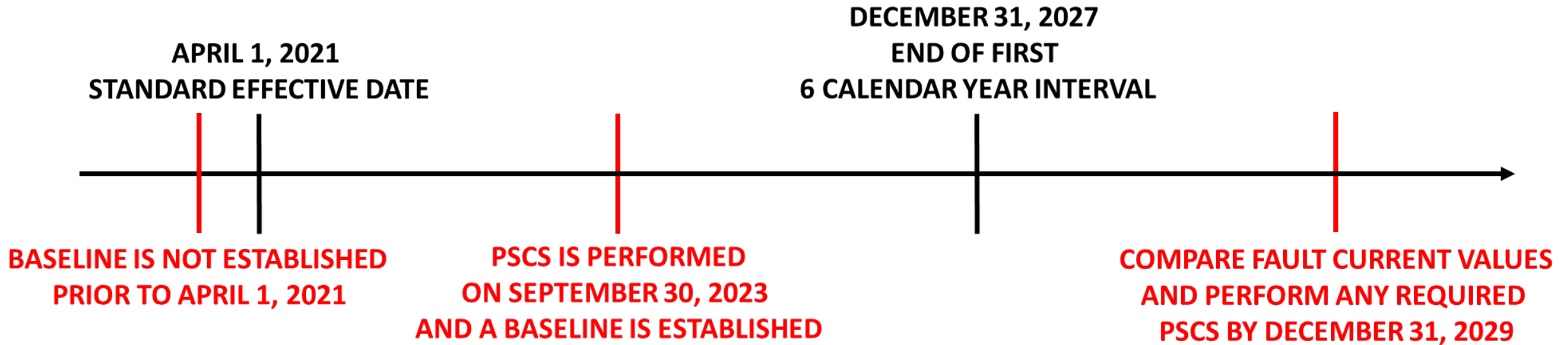


## PRC-027-1 R2 OPTION 2 EXAMPLES



# Requirement R2 Example Timelines: Option Change

## PRC-027-1 R2 OPTION 1 TO OPTION 2 CHANGE EXAMPLE



# Performing a PSCS With R3

**PRC-027-1 does not require the R1/R3 process to include performance of a Protection System Coordination Study (PSCS), however...**

**Performing a PSCS when developing new or revised settings may be an efficient use of resources.**

- For a BES Element under R2 Option 1, the performance of a PSCS can be used to reset the 6 calendar year interval.
- For a BES Element under R2 Option 2, the performance of a PSCS can be used to establish a new Fault current baseline and to reset the 6 calendar year interval.



# R2 Discussion: Possible Approaches to Sampling

**There are at least two options for identifying a population for sampling:**

- A separate Attachment C – Data Sampling Request may be issued for a list of BES Elements with Protection System functions identified in Attachment A.
- Alternately, the full population of BES Facilities (e.g. from a FAC-008 list) may be used for sampling in order to test that the appropriate BES Elements were identified for R2 in accordance with PRC-027-1 Attachment A.



# PRC-027-1 R2 Sampling: Draft Attachment C



**Contains Confidential Information Including Privileged and Critical Energy Infrastructure Information. Do Not Distribute.**

Attachment C - Data Sampling Request

Standard Number	Requirement Number	Data List	Data List returned to ReliabilityFirst	Evidence Requested	Evidence Returned to ReliabilityFirst
PRC-027-1	R2.	<p>Provide a list of BES Elements with Protection System functions identified in Attachment A of PRC-027-1.</p> <p><b>Use Attached Template</b></p>	<p>Return Data List to ReliabilityFirst no later than the deadline indicated in the Notification Letter for "Submittal of Attachment C - Data Sampling".</p>	<p>Acceptable evidence may include, but is not limited to, dated electronic or hard copy documentation to demonstrate that the responsible entity performed Protection System Coordination Study(ies) and/or Fault current comparisons in accordance with Requirement R2.</p>	<p>Return evidence to ReliabilityFirst no later than the deadline indicated in the Notification Letter for "Submittal of Attachment B, the RSAWs, Data Sampling Evidence, and all evidence of compliance".</p>

**HOLD - DRAFT - May use FAC-008 list or judgmental selection of buses from one-line diagram.**

**NOTE - Entities have until December 31, 2027 (6 calendar years) to complete the initial performance of R2.**



# PRC-027-1 R2 Sampling: Draft Attachment C

Index Number (RF use only)	BES Elements with Protection System functions identified in Attachment A	R2 Compliance Method (Option 1 or Option 2)	Populate These Columns for BES Elements Using Option 1 During any Portion of the Audit Period		Populate These Columns for BES Elements Using Option 2 During any Portion of the Audit Period				Comments
			Date of the most recent Protection System Coordination Study (if any) performed after April 1, 2021 but prior to the audit period	Dates of any Protection System Coordination Studies performed during the audit period	Date the initial Fault current baseline was established	Date of the most recent Fault current comparison (if any) performed after April 1, 2021 but prior to the audit period	Date of any Fault current comparisons performed during the audit period	Did any Fault current comparisons performed during the audit period identify a 15 percent or greater deviation in Fault current values from the Fault current Baseline?	
	HOLD - DRAFT - May use FAC-008 list or judgmental selection of buses from one-line diagram.								
	NOTE - Entities have until December 31, 2027 (6 calendar years) to complete the initial performance of R2.								





# Questions & Answers

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# **APPENDIX: ADDITIONAL SLIDES FOR REFERENCE**

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# What is a Protection System Coordination Study?

## NERC Glossary of Terms Definition

- An analysis to determine whether Protection Systems operate in the intended sequence during Faults.

## Which Protection Systems should be included in a Protection System Coordination Study (PSCS)?

- For a given BES element, a PSCS should include Protection System functions identified in Attachment A that could operate for faults on the BES element, including remote backup functions.
- For a given BES element, there may also be Protection Systems functions excluded by Attachment A that impact coordination.
  - It is prudent for any required PSCS to include these additional functions.



# What Fault Current Values Should be Compared?

**From the Supplemental Material:** The Fault current values used in the percent change calculation, whether three-phase or phase-to-ground Fault currents, **are typically determined with all generation in service and all transmission BES Elements in their normal operating state.**

## Notes:

- It may be reasonable to use multiple system configurations for SC studies
  - For example a case representing minimum expected SC current with some generation offline or certain transmission facilities out of service may make sense
- However, modeling the normal network operating state with all generation in service supports consistency in Option 2 comparisons.

