TPL-007-1

Transmission System Planned Performance for Geomagnetic Disturbance Events

Stan Sliwa
Transmission Planning

RSCS Meeting

May 18, 2017

PJM©2017

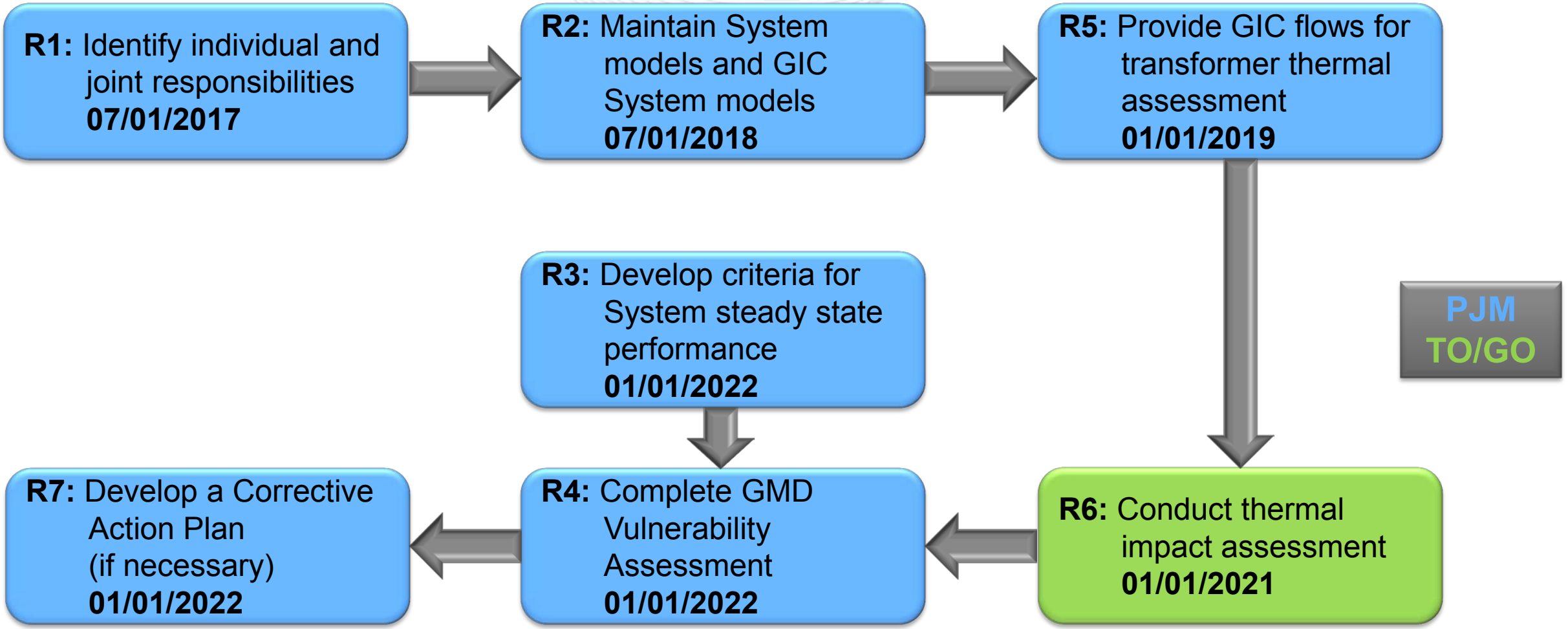
- **Purpose:**
  - Establish requirements for Transmission system planned performance during geomagnetic disturbance (GMD) events.

- **Applicable to:**
  - Planning Coordinator
  - Transmission Planner
  - Transmission Owner
  - Generator Owner

  With Facilities that include power transformer(s) with a high side, wye-grounded winding with terminal voltage greater than 200 kV

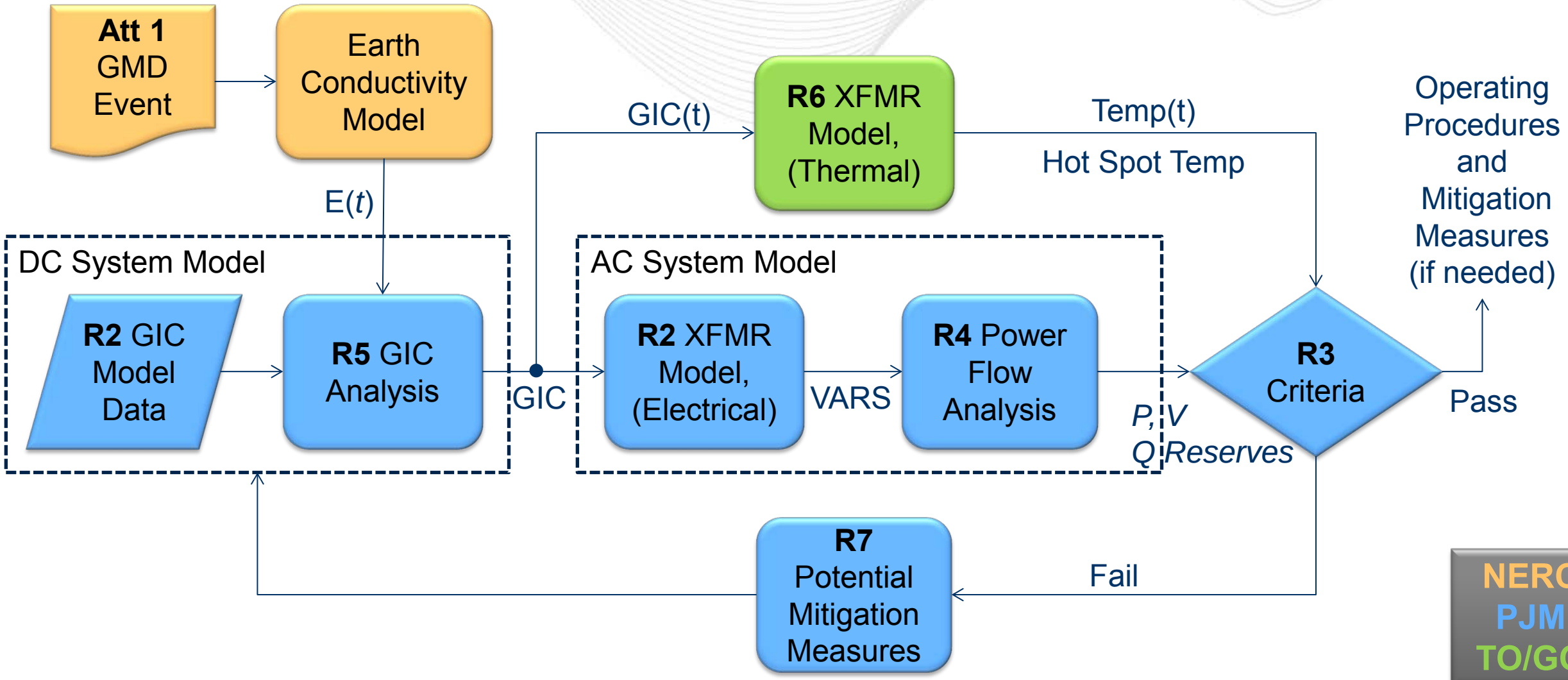
PJM©2017

Implementation Schedule



PJM©2017

TPL-007-1 GMD Vulnerability Assessment Process



PJM©2017

Requirement R2

R2: Maintain System models and GIC System models
07/01/2018

- Transmission Owner data request sent May 10th
- Modeling information to be submitted via Excel spreadsheet
- Transmission Owners are only responsible for providing the requested information for the equipment that they own
- It would be helpful (but not required) for a Transmission Owner to assist us with GO mapping where possible (substation/bus)
- Spreadsheet contains both TO & GO information
  - Not easy to separate who owns what in loadflow case

PJM©2017

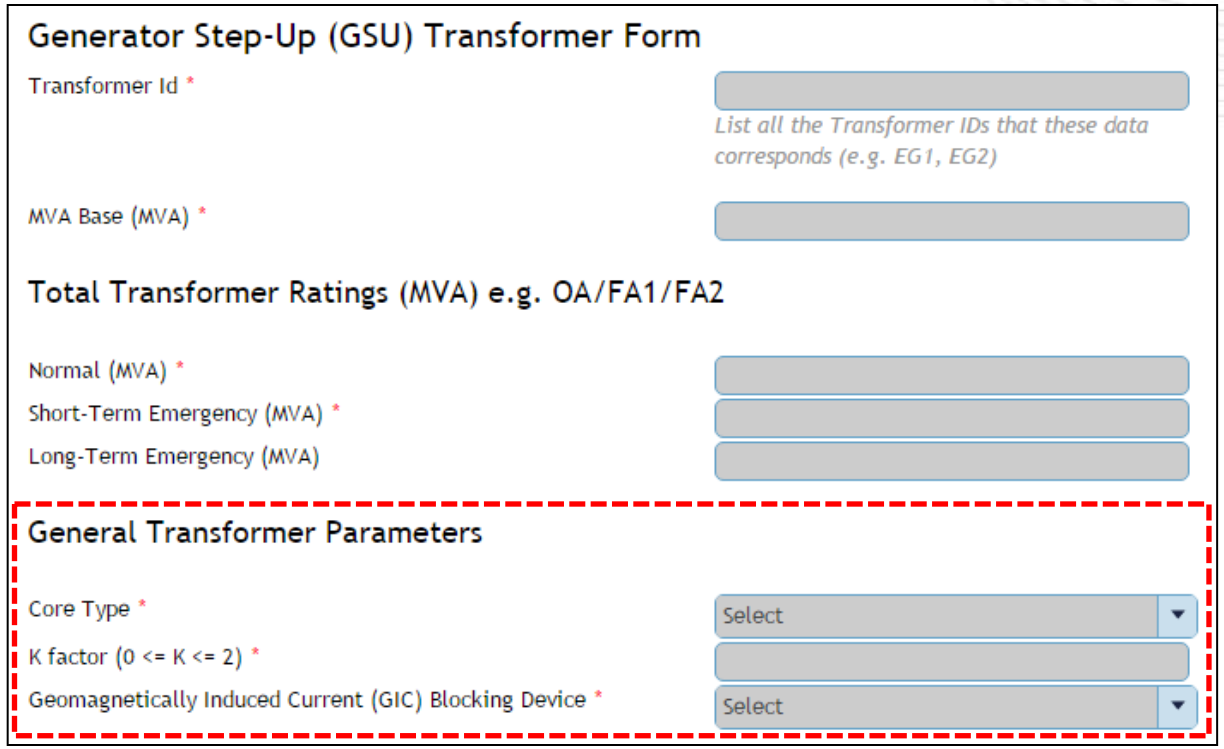
Requirement R2

R2: Maintain System models and GIC System models
07/01/2018

- Generator Owner data request to be sent latter part of June
- Modeling information to be submitted through GenModel
- Generator Owners are only responsible for providing the requested information for the equipment that they own

PJM©2017

New GenModel Fields Added for TPL-007-1



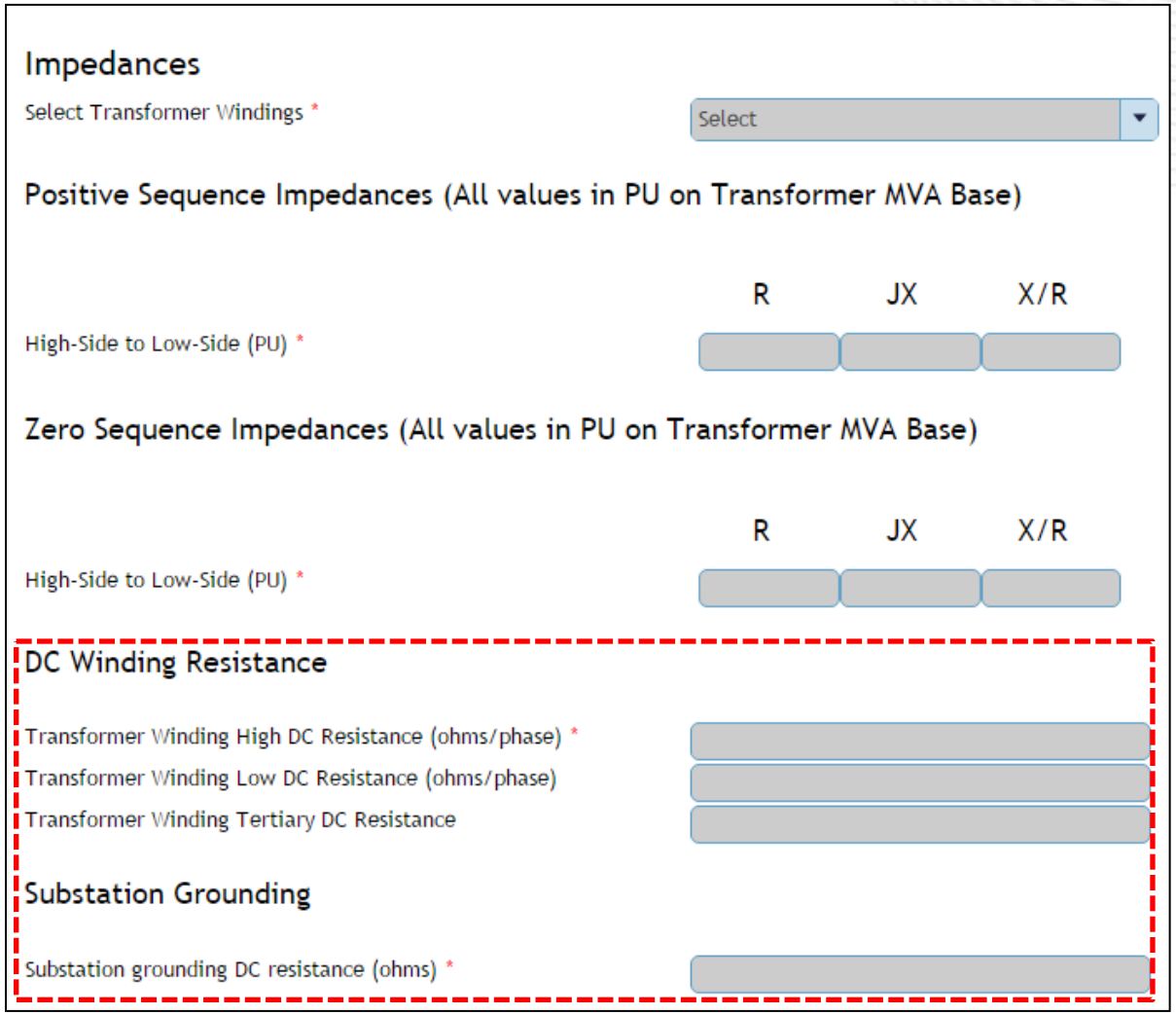
Parameter: Core Type
Description: Number of cores in transformer core design.
Bounds: Available core options are as follows:
Other -> Use Comment box to provide additional information
Single Phase
Three Phase Shell
3-Legged, Three Phase
5-Legged, Three Phase
7-Legged, Three Phase
Core, Three Phase Generic

Parameter: K factor
Description: A factor to calculate transformer reactive power loss from GIC flowing in its winding (MVAR/Amp).
Bounds: $0 \leq K \leq 2$

Parameter: Geomagnetically Induced Current (GIC) Blocking Device
Description: Indicates whether a GIC Blocking Device is installed to block DC neutral current.
Bounds: Yes/No

PJM©2017

New GenModel Fields Added for TPL-007-1



Parameter: Transformer Winding High DC Resistance
Description: DC resistance of Transformer Winding High in ohms/phase.
Bounds: 0.01 Ω ≤ DC Resistance ≤ 3.0 Ω

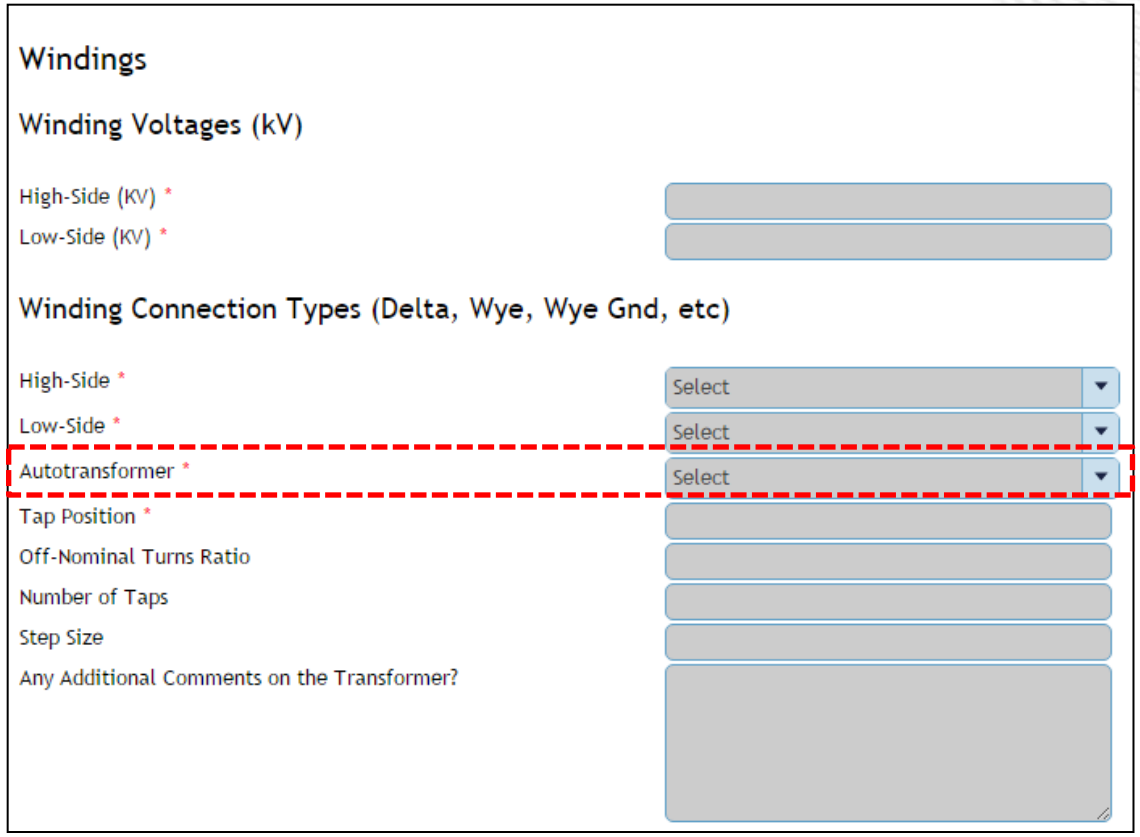
Parameter: Transformer Winding Low DC Resistance
Description: DC resistance of Transformer Winding Low in ohms/phase.
Bounds: 0.01 Ω ≤ DC Resistance ≤ 3.0 Ω

Parameter: Transformer Winding Tertiary DC Resistance
Description: DC resistance of Transformer Winding Tertiary in ohms/phase.
Bounds: 0.01 Ω ≤ DC Resistance ≤ 3.0 Ω

Parameter: Substation Grounding DC Resistance
Description: GSU/Substation grounding DC resistance in ohms.
Bounds: N/A

PJM©2017

New GenModel Fields Added for TPL-007-1



Parameter: Autotransformer
Description: Indicates whether the transformer should be modeled as an autotransformer.
Bounds: Yes/No

Note: Grounding configuration is covered under Winding Connection Types.

PJM©2017

Requirement R2 Continued

R2: Maintain System models and GIC System models
07/01/2018

- 2016 RTEP (2021 5-year case) is the data source
  - Only known data is being requested at the present time (i.e. substations and equipment already in service)
  - PJM will request future updates as data becomes available (i.e. when new substations and equipment are placed into service)
- TO & GO data to be returned by October 1, 2017
- Data to be submitted to NERC.Transmission.Planner@pjm.com

PJM©2017

GIC System Model Data

- Transformer Data (high-side wye-grounded winding ≥ 200kV)
  - Conventional transformers
    - DC winding resistance of each winding on a per phase basis
  - Autotransformers
    - DC winding resistance of common & series winding on a per phase basis
  - Number of cores and core type
  - Grounding configuration
  - Whether a GIC blocking device is enabled
  - K-Factor (only if known)

PJM©2017

GIC System Model Data Continued

- Substation Data
  - Substation-bus mapping (buses ≥ 200kV)
  - Substation geographic latitude and longitude coordinates
  - GSU/Substation grounding DC resistance
- Shunt Reactor Data
  - NOT required at this time
- Branch Data
  - NOT required at this time: PJM will use AC resistance (R_{ac}) from power flow

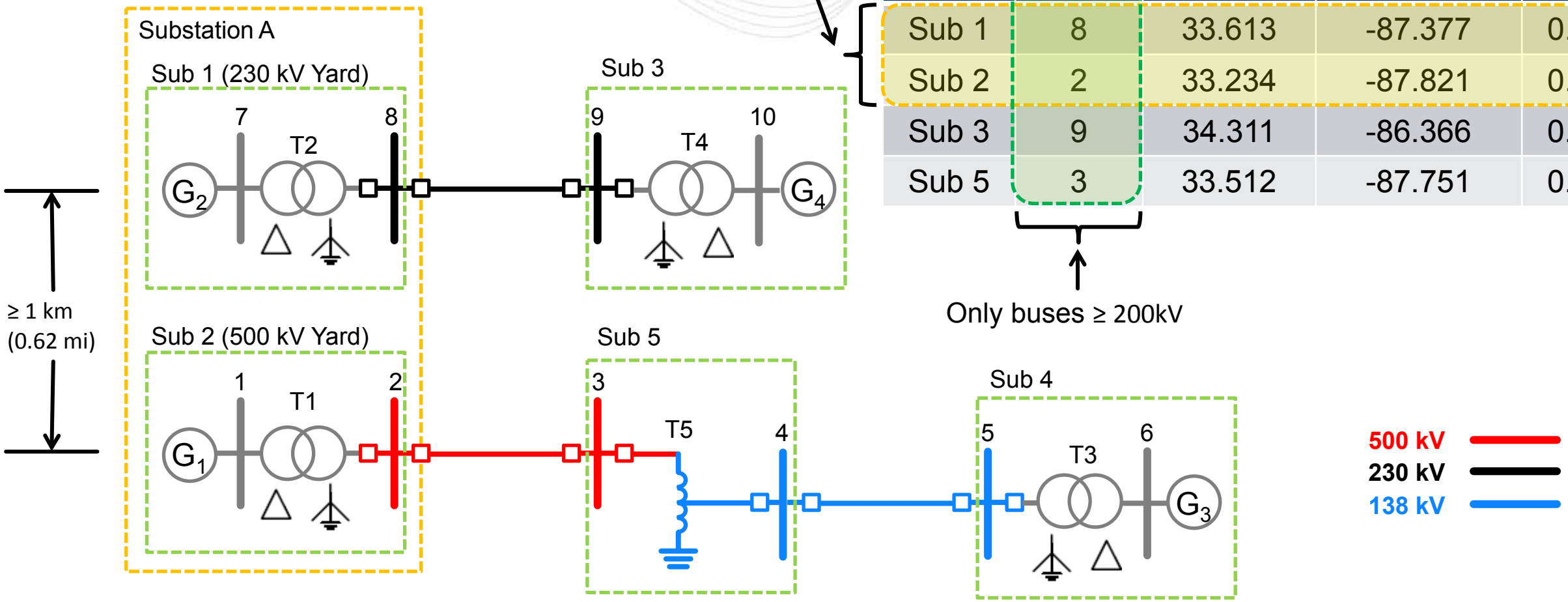
PJM©2017

Substation-Bus Mapping Sample One-Line

Separate geographic latitude and longitude coordinates used for Sub 1 and Sub 2 of **Substation A** since they are more than 1 km away.

Name	Buses	Latitude	Longitude	Ω
Sub 1	8	33.613	-87.377	0.2
Sub 2	2	33.234	-87.821	0.1
Sub 3	9	34.311	-86.366	0.2
Sub 5	3	33.512	-87.751	0.2

Only buses ≥ 200kV



PJM©2017

Requirement R2: GIC System Model Data Continued

- Guidance for developing the GIC System model is provided in NERC's GIC Application Guide:
  - GIC Application Guide 2013_approved – NERC
  - Provides good coverage on each network component
  - Identifies most appropriate data for accurate modeling
  - Identifies best alternative estimate when data is not available
  - Identifies sources for the data

PJM©2017

NERC GIC Application Guide – Table 2 Excerpt

- PJM is requesting this level of accuracy
- If not possible, PJM is requesting specifics on what model data is being provided

Table 2: Summary of network component and associated resistive data for a one-phase GIC network model

Network Component	Most Appropriate Data For Accurate Modeling	Best Alternative Estimate - When Desired Model Data Is Not Available	Data Sources and Comments
Grounded wye winding of conventional transformer	Measured dc resistance of the winding at nominal tap and adjusted to 75 °C and divided by 3 (see note)	50% of the total per-unit copper loss resistance converted to actual ohms at winding base values and divided by 3	dc resistance and copper loss resistance are obtained from transformer test records. Transformer copper loss resistance from power flow model data base.
Autotransformer series windings	Measured dc resistance of each winding at nominal tap and adjusted to 75 °C and divided by 3 (see note)	50% of the total per-unit copper loss resistance converted to actual ohms at full winding base values and divided by 3	dc resistance and copper loss resistance are obtained from transformer test records. Transformer copper loss resistance from power flow model data base.
Autotransformer common winding	Measured dc resistance of each winding at nominal tap and adjusted to 75 °C and divided by 3 (see note)	50% of the total per-unit copper loss resistance converted to actual ohms at V_H winding base values and divided by $(V_H/V_X-1)^2$ and divided by 3	dc resistance and copper loss resistance are obtained from transformer test records. Transformer copper loss resistance from power flow model data base.

PJM©2017

Questions?

PJM©2017