PowerWorld's Experience Using Real-Time Power System Models

Presented by:

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PowerWorld's History of Full-Topology Models

- PowerWorld Simulator – 1996
  - Planning software focused on Bus-Branch Models
- PowerWorld Retriever – 2000
  - Real-time visualization software
  - Many pilot projects with this worked by exporting a bus/branch model from the EMS (RAW file)
    - This was not a sustainable model for customers
- PowerWorld Retriever – 2006
  - ISO-New England started work on using the data already managed in their Areva EMS tool
    - Cases only initially, but progressed to reading their EMS one-lines
  - This was clearly the better approach and other real-time customers followed

PowerWorld's History of Full-Topology Models

- PowerWorld Simulator Integrated Topology Processing – 2010
  - BPA real time operations started using the direct export from their EMS
- Expanding data imports with Peak Reliability – 2016
- This is all data that was already *maintained* at Peak so we are just plugging into their existing processes
  - Direct read of the Contingency record
  - Direct read of the Remedial Action Scheme definitions
  - Direct import of 1000s of maintained substation topology oneline diagrams
  - Direct import of various overview diagrams
  - Direct import of 1000s of scheduled outages as well

Full Topology Models exist today: EMS System Models

- Industry has spent 30 years building the models
  - More importantly: *maintaining* these models
- Maintained by an existing large staff of engineers (dozens)
- More than just the models
  - Oneline diagrams
  - Contingency definitions
  - Remedial Action Scheme definitions
  - SCADA measurements
- Much more frequent updates than power system planners realize
  - Often done weekly
  - At most every few weeks
- Large financial commitment is already being made to keep these models up to date
  - Staff Staff Staff ($ $ $)

For Presentation on 2/28/2018, we skip until slide 21, as listeners understand motivation

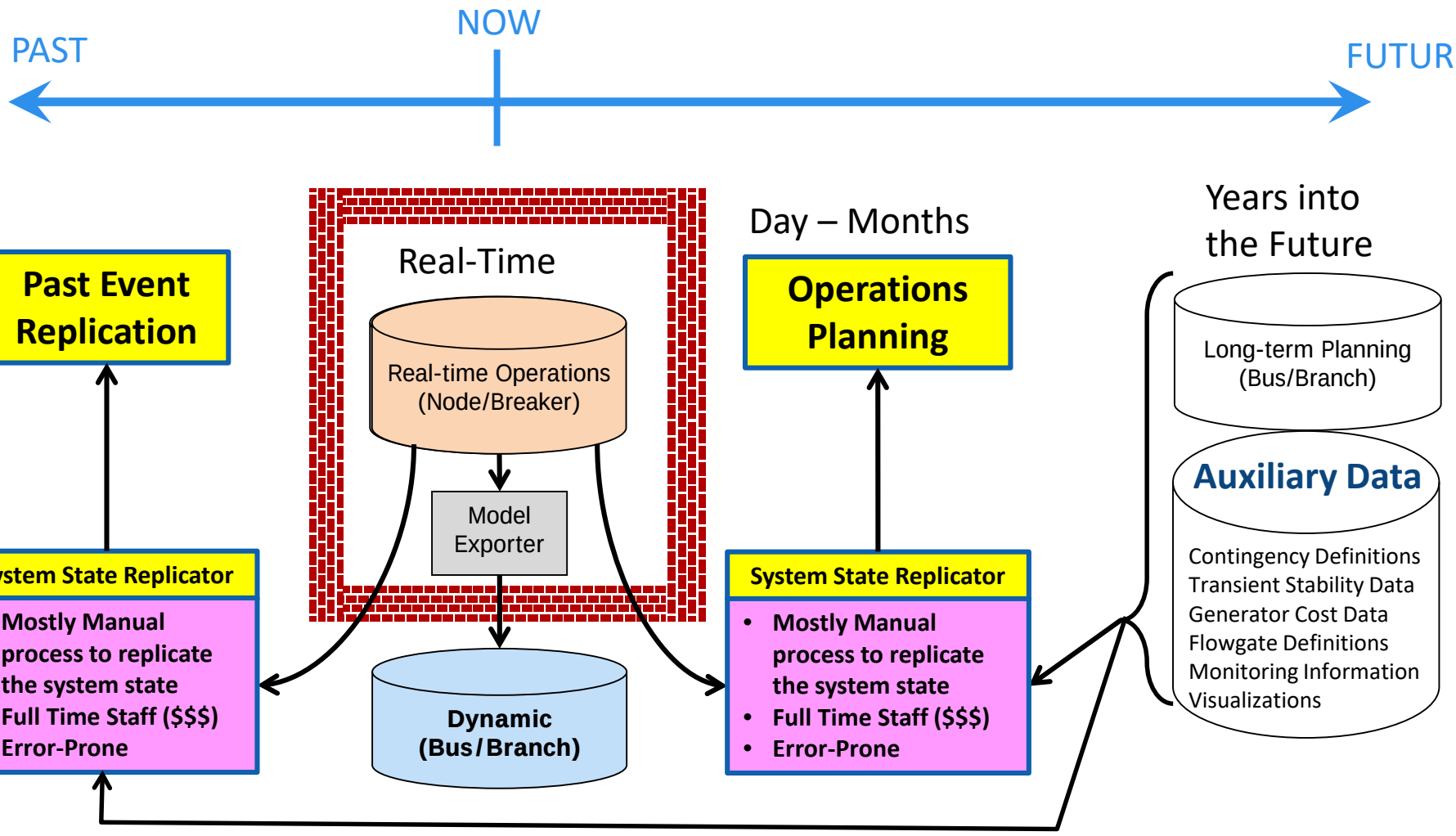
Our Experience: Four Types of Issues

- Data Definitions
  - How are objects uniquely identified
  - How is data structured
- Tools to Manage Increased Model Size
  - Previously simple concepts getting more complicated
    - When is a line open?
    - Single Line Contingency
- Human Interaction
  - My model is huge
  - Data viewing
  - Data reporting
- Data Formats
  - Need to read information directly from the sources that manage the full topology models

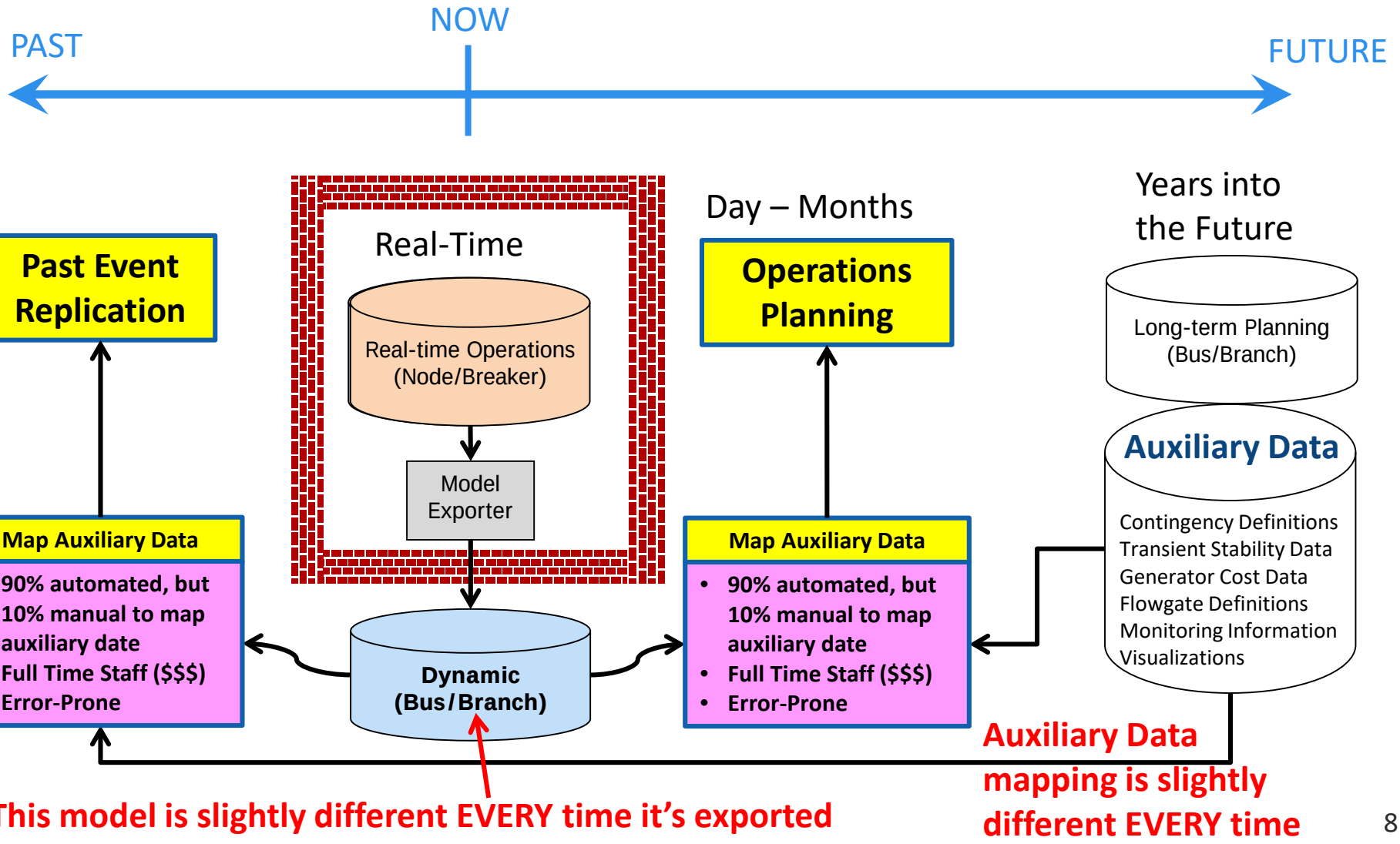
Node-Breaker vs. Bus-Branch Which models are used?

- Depends on the time frame of your analysis
  - Past Event Replication Studies
  - Real-Time Studies
  - "Operations Planning"
    - Looking at the next 24 hours
    - Looking at outage schedule coordination over the next several months
  - "Long-Term Planning"
    - Looking at next several years

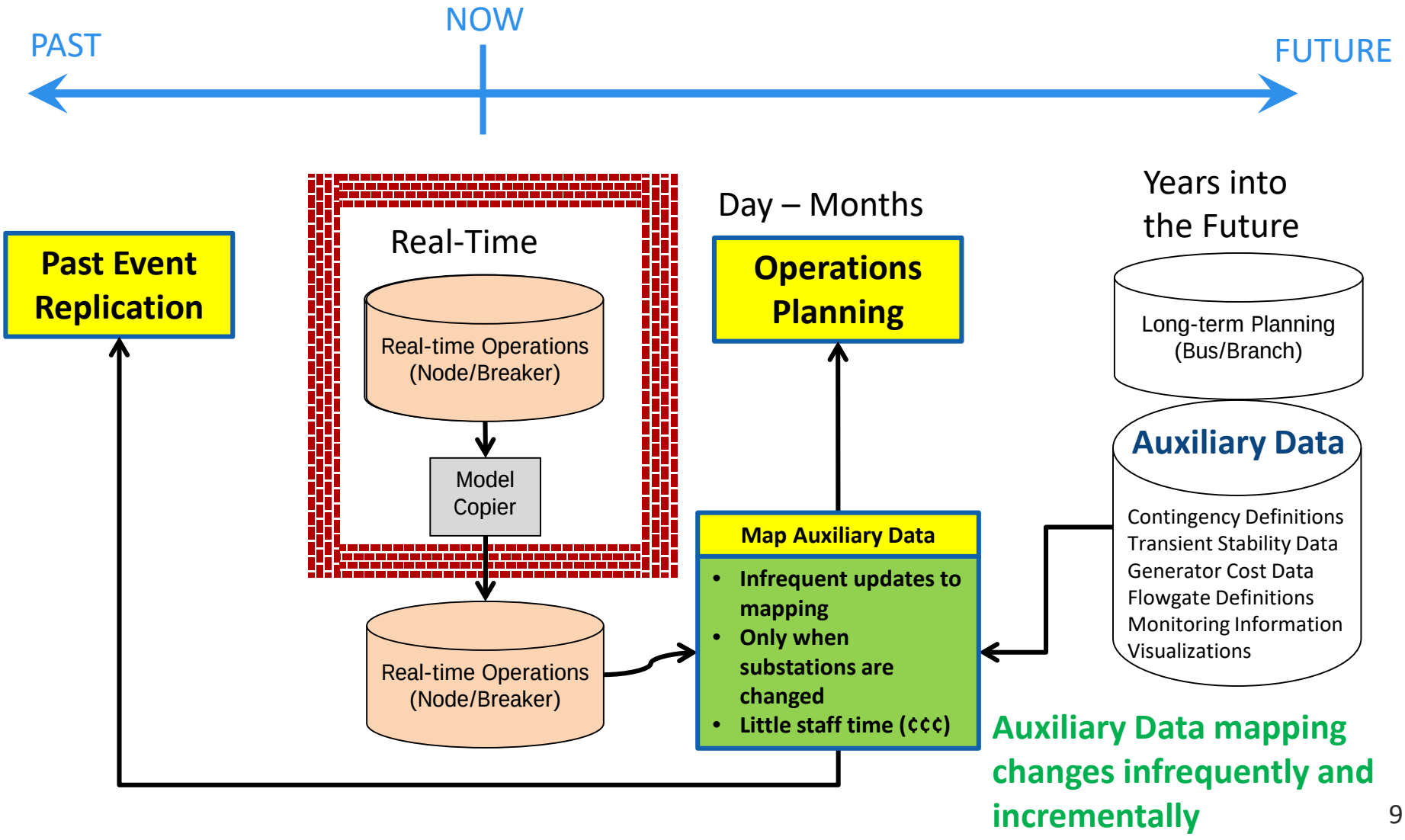
Typical Existing Power Business Stages "State Mapping"



Typical Existing Power Business Stages "Auxiliary Data Mapping"



A Better Choice for Operations Planning



Near Real-Time Analysis of the Power System

- The starting point for this is the system state stored in an EMS system model
  - Or you must match another model to this
  - The model with the disturbance state is the full-topology real-time model
- To use this model for studies, there is a lot more than just the model to maintain

“Model” maintenance: It is more than just the model

- Large amount of Auxiliary Information to maintain
  - Contingency Definitions
  - Interface/Flowgate/Path/Cutplane definitions
  - Limit Monitoring information
    - What to monitor, dynamic limits, etc.
  - Market cost/bid information
  - Transient Stability Models
  - Various other groupings
    - Injection Groups/Subsystems
    - Substations
  - Graphical Visualization Descriptions

Use Alphanumeric Identifiers: *Labels*

- Unique identifiers for all power system objects
- Change infrequently or not at all
- Independent of topology changes
  - Bus numbers can change with each model export even if the only change is a breaker status
  - System upgrades may change where a line is connected, but its identifier should not have to change (it might, but should not be required)
- Can be used with all auxiliary data: contingency definitions, interfaces, etc.
- Created automatically from Real-Time Model object identifiers
  - Typically with a real-time system there will be some unique identifier Substation$RecordType$EMS_ID

  - **BrownsFerryUNUnit2 → Generator**
  - **Johnsville$500$1928 → 500 kV node**

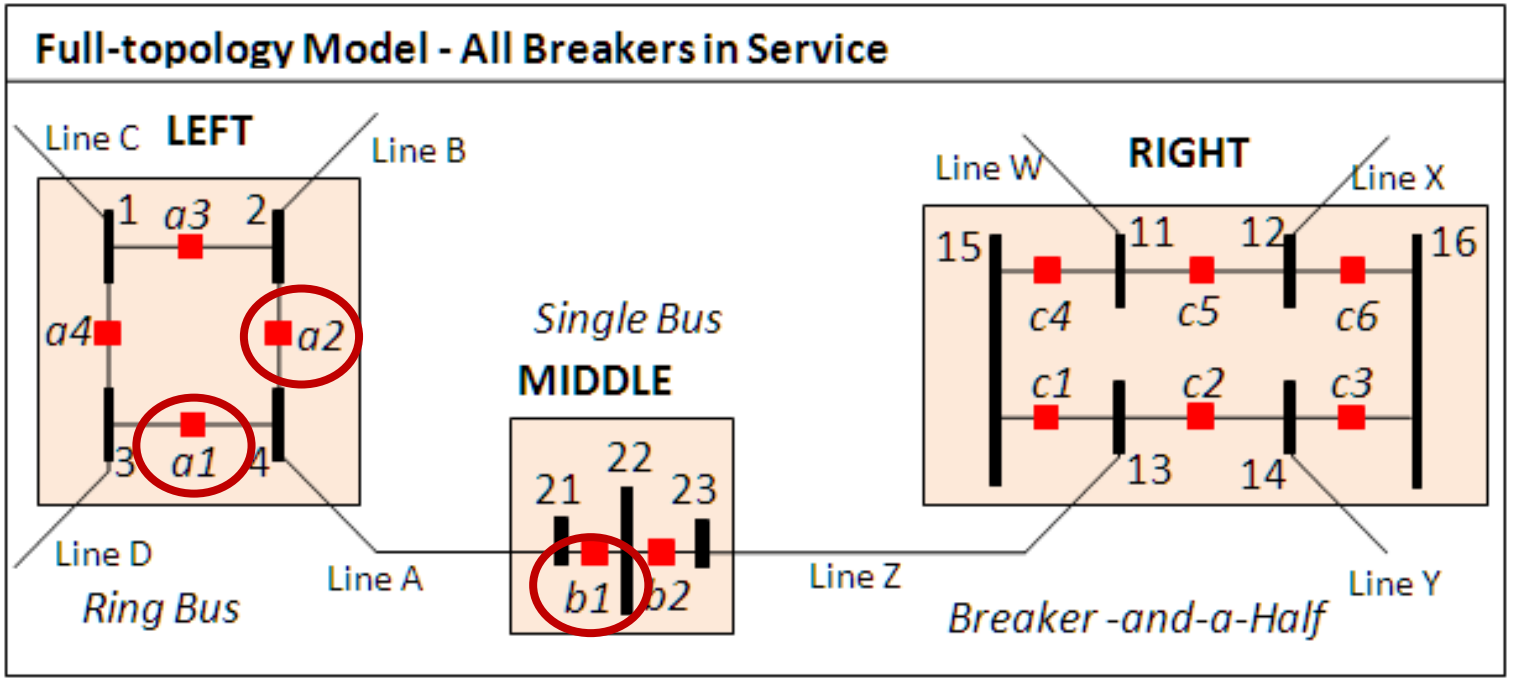
More about labels

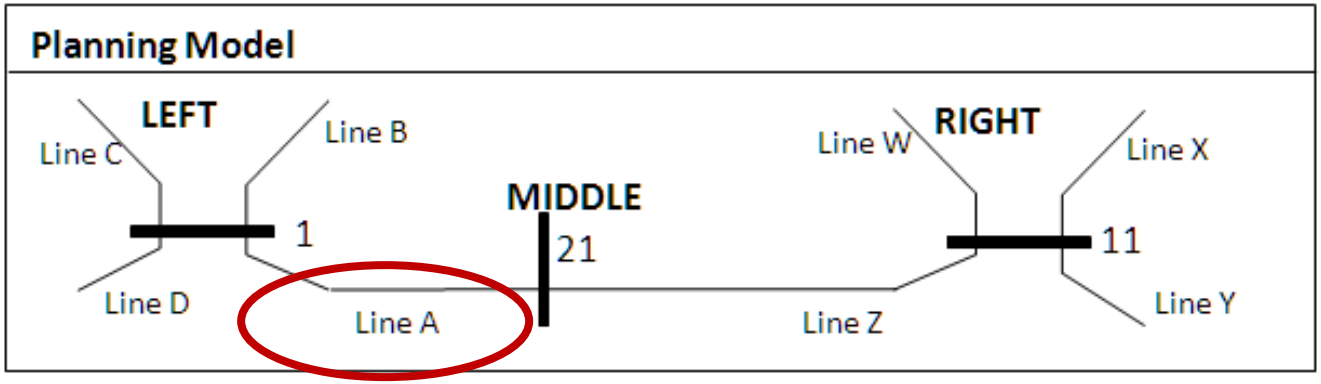
- Even in the EMS model data space we see inconsistencies with labels
  - Labels must be unique across all devices of a type
  - But, PowerWorld Simulator allows you to have multiple labels for each device (unlimited number)
    - SCADA information referring to model information using different naming conventions sometimes
    - Different organizations using different naming (DOE-EIA cost information for example)
- There is no limit to the number of characters in a label

Are Labels enough? NO! Models are Different

- First instinct → this is only a "naming" issue
  - Just build an "*Automated Conversion Tool*" that links the names from the full-topology model to the names in the planning model
  - In other words: Use Labels
- This instinct is not correct. It is more than this.
  - The models are different
  - Breaker topologies matter
  - Can not assume that all breakers are in their normal status
  - Taking a line out of service depends on the present system state

Invalid Contingency Simulations Example 1

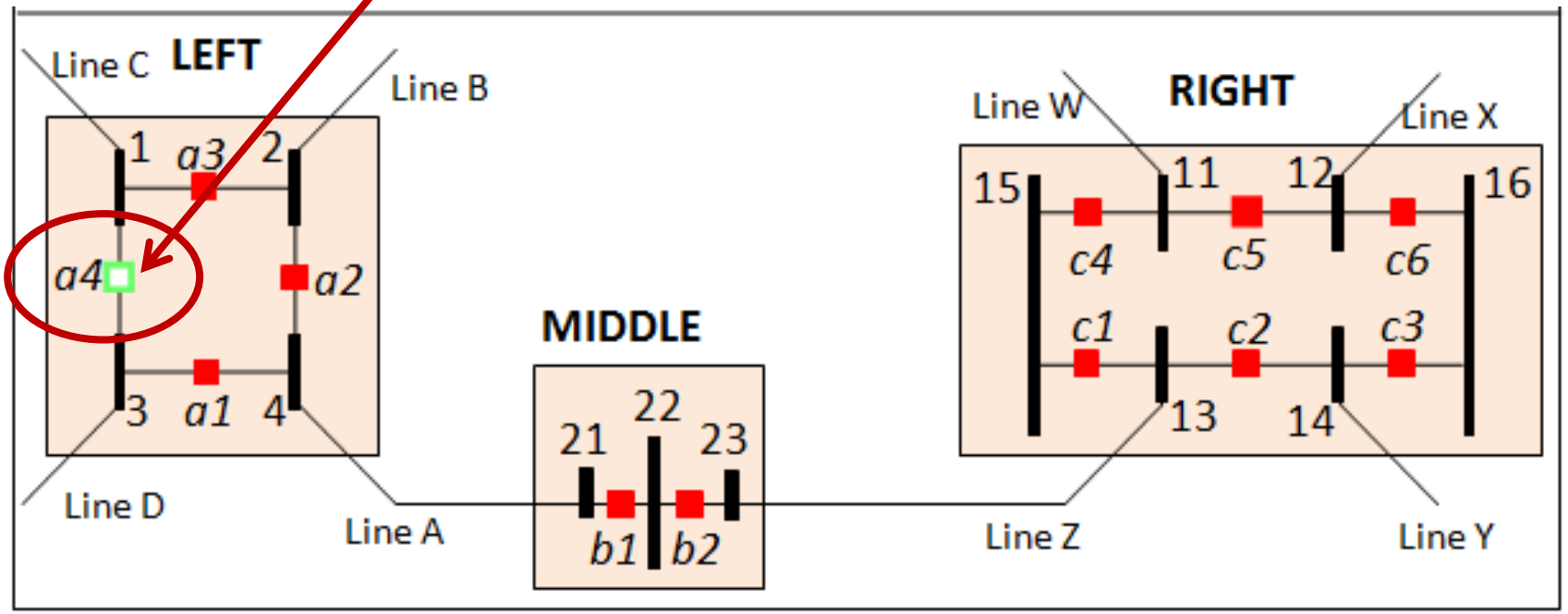




Invalid Contingency Simulations Example 1

- How is outage of Line A modeled on following slide?
  - Planning Model
    - Open Line A
  - Actual System
    - Open breakers *a1*, *a2*, and *b1*
  - Assuming all breakers have same status as original configuration from which planning case was created, then this is a correct simulation in planning case

Breaker ***a4*** Out for Maintenance



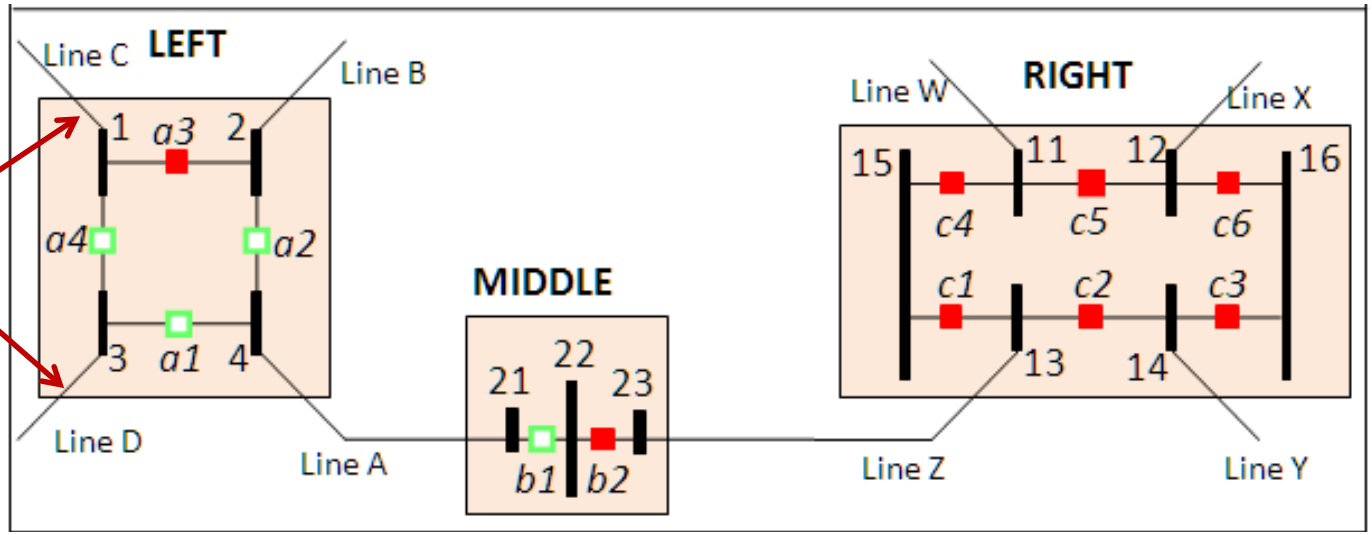
- Now what happens when Line A is taken out of service?

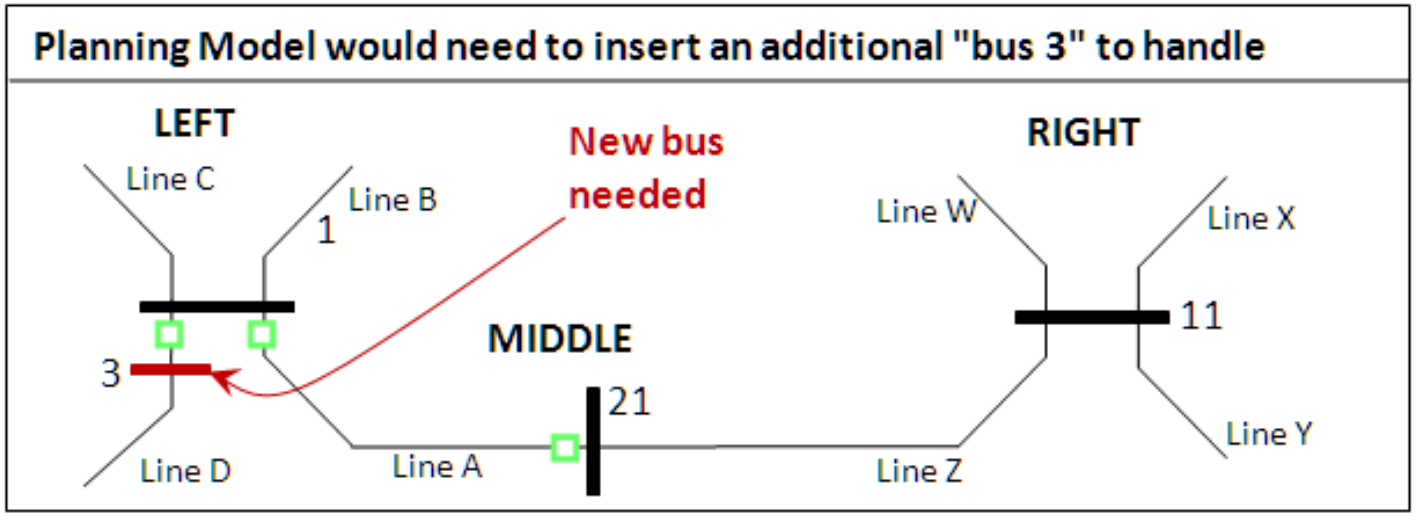
Invalid Contingency Simulations Example 2

- How is outage of Line A modeled along with open breaker *a4*?
  - Planning Model
    - Open Line A
    - No other lines are isolated
    - Bus split not captured
  - Actual System
    - Open breakers *a1*, *a2*, and *b1*
    - Line D isolated from Line B and Line C
  - Modification of planning model is required to correctly model this condition

Invalid Contingency Simulations Example 2

Line D isolated from Line B and Line C





Breaker Failure Outages Example 3

- Problem
  - How to you model a breaker failure if you have consolidated the breaker in the process of creating the planning model?
- Solution
  - Do not consolidate your data, let the software do that as needed
  - To make contingency definitions more familiar, add a new action called *Open with Breakers*

Can you make an Automated Conversion Tool?

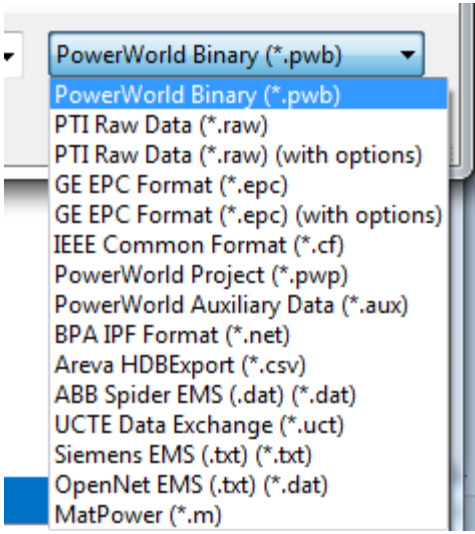
- Answer: No!
- A bus-branch model is inherently an "equivalent" representation of the breaker-node model
  - You have *lost* information by creating the bus-branch model
  - You can't just convert back to something that's not in the model now

What do you need to do?

- Get the data directly from the EMS
- An enormous amount of staff time is spent building and *maintaining* the EMS models
- Read it directly

PowerWorld's Experience with other Data Formats

- EPC and RAW files: Historically represent "bus-branch" models, though that is evolving
- HDBExport command from Areva EMS
  - A lot of experience reading from this EMS data structure for many customers for a decade
  - Data structures are very similar to those used in Bus/Branch models
  - Fundamental object is the Node (ND)
- ABB Spider EMS
  - Experience reading full cases for use in running contingency analysis, but only with 1 customer
- Siemens EMS
  - Small amount of experience loading only the topology definition so that measurements could be mapped
- OpenNet EMS
  - Very small amount of experience

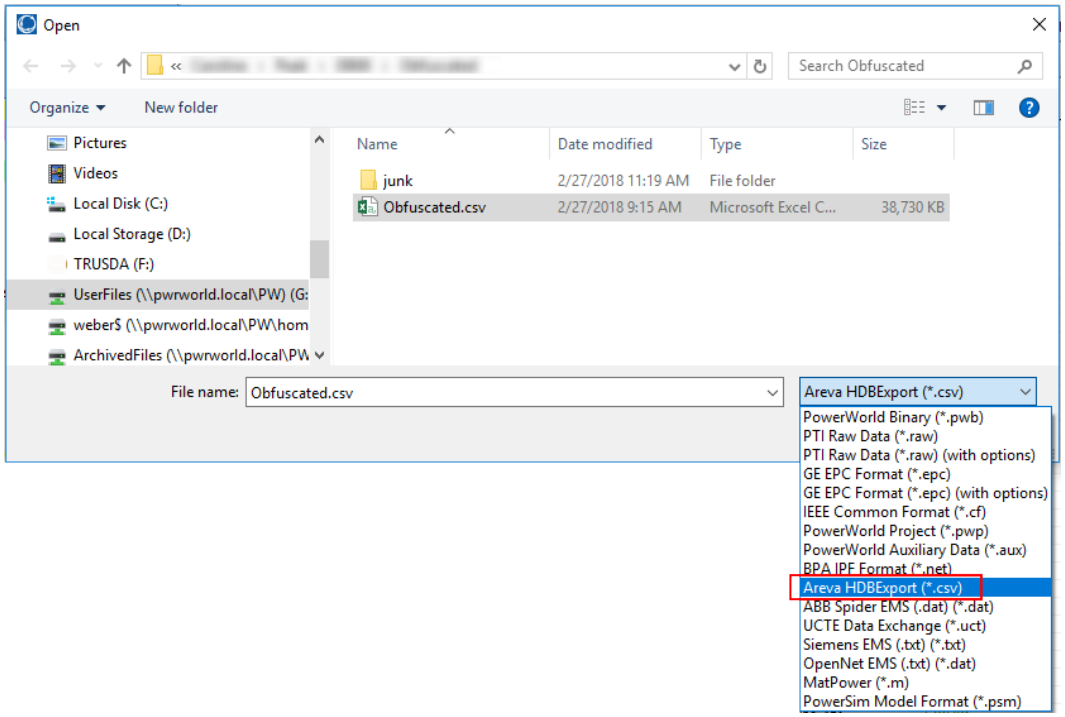


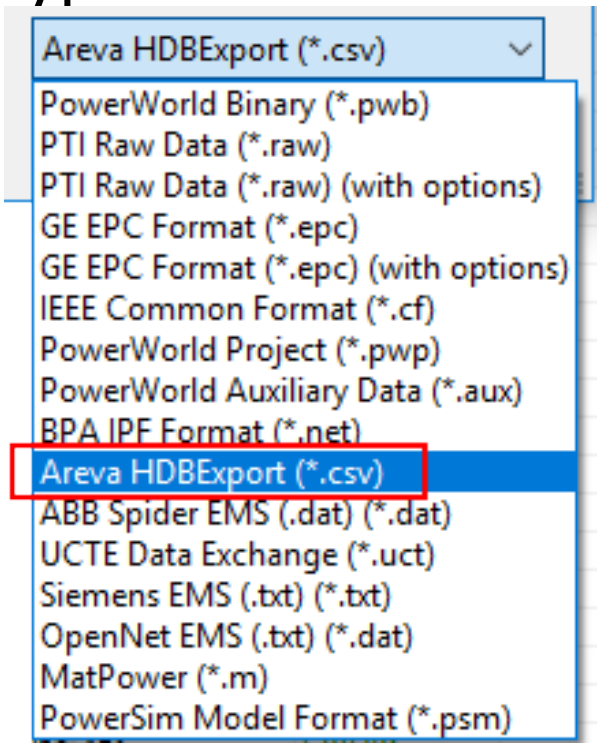
Experience with Areva EMS

- Hdbexport command gives users of this EMS the ability to export data
  - We have 10 years of experience reading the network model
  - Also have experience exporting the Contingency and RAS definitions using similar methodology
- Oneline diagrams format is also text-based and links to these case
  - We can read these diagrams into PowerWorld as well
  - Some work up-front to translate how things are drawn as this is custom for every Areva customer

PowerWorld Demonstration

- How to open a full-topology model
  - Chose File, Open Case
  - Change to the appropriate file type



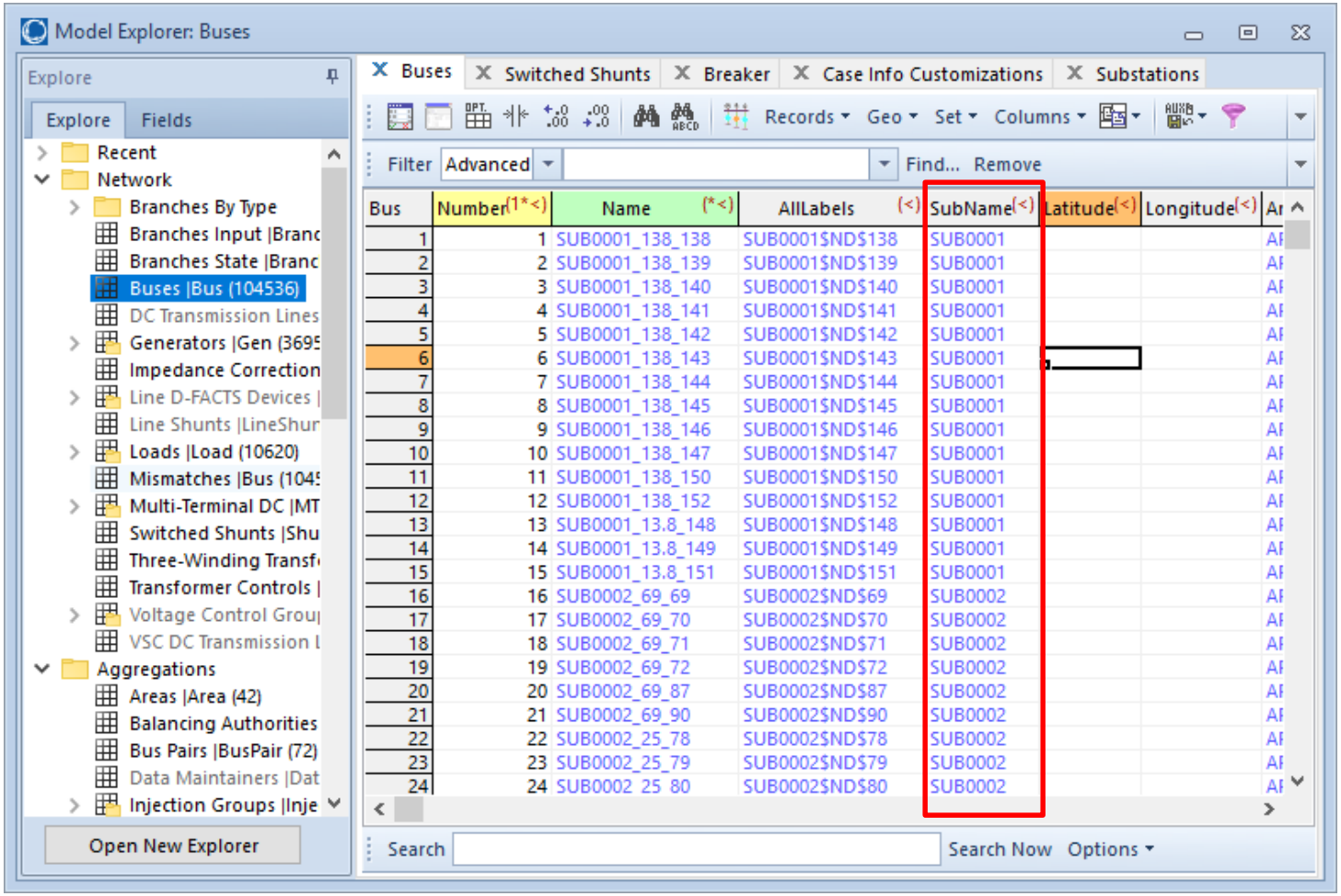


Important Data Structure Parts: Substations

- Substation Definitions
  - The fundamental data structure in a real-time model
  - Part of the unique identifier of a device
  - You must have this to make interaction with the full-topology model easier
    - Define a list of substations
    - Assign each “bus” to a substation
  - Natural place to define geography (Latitude, Longitude)

Bus Display:
each node from EMS becomes a bus

- Each bus is assigned to a Substation

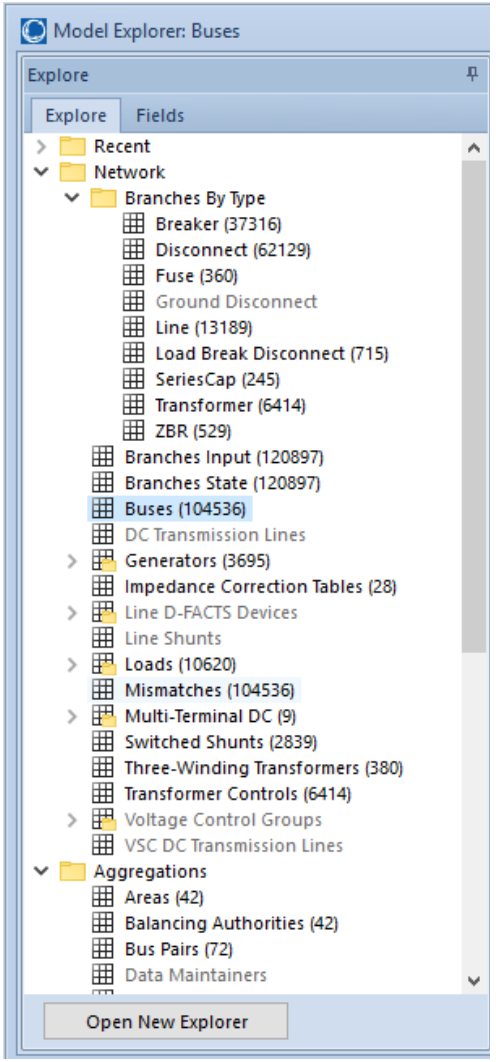


No limitation on device counts
No limitation on characters in names

- No limit on number of substations
- No limit on the number of characters in the name of any device (nor on labels)
- No limit on the Label string length (can also have multiple labels for each device and no limit on the number of labels)
- No limit on number of nodes in a substation
- No limit on the devices in a substation

What do Full Topology Models Look Like

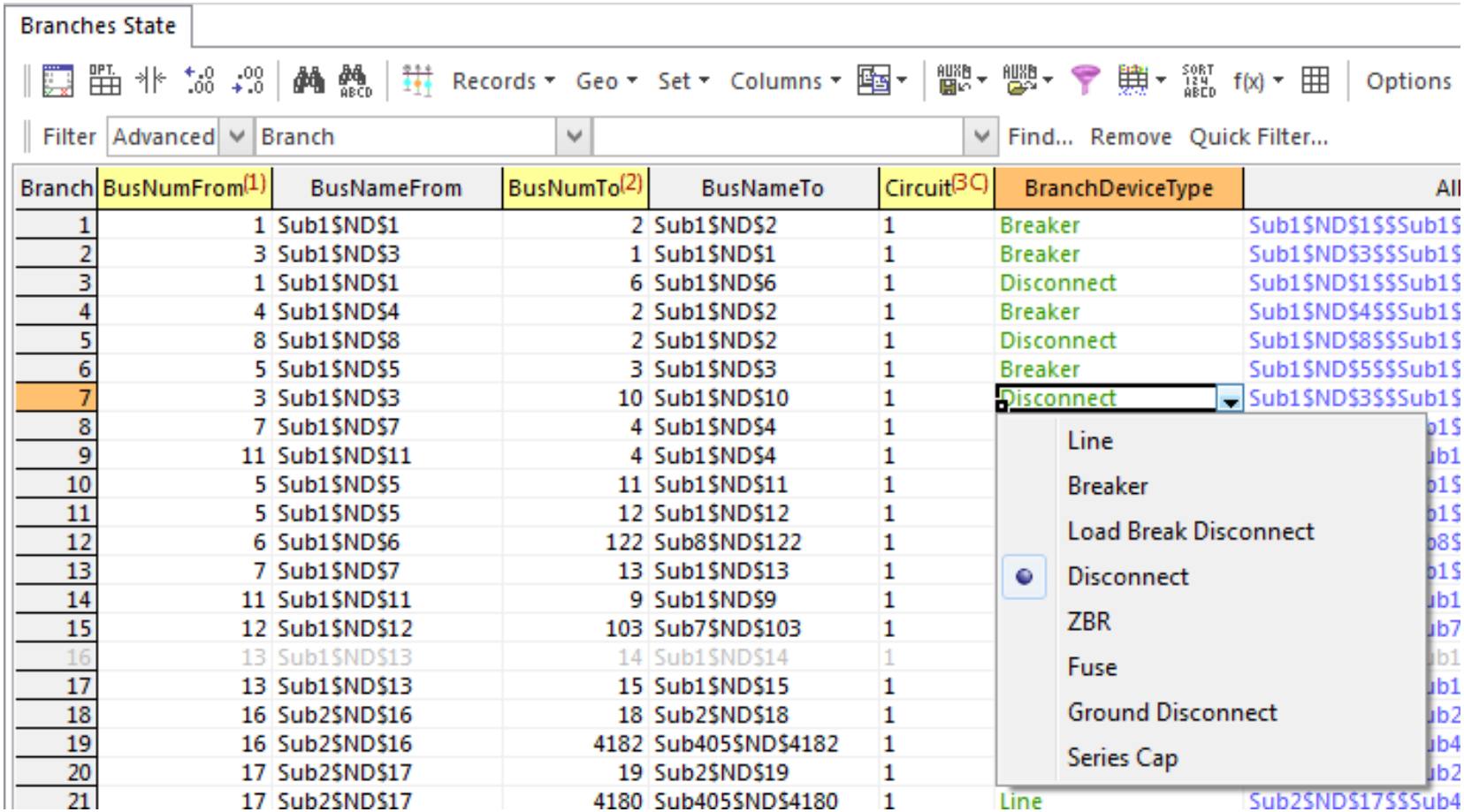
- More nodes (about 4-6 times more)
- More branches (the switching devices)
- Similar Gens, Load, Shunts, Transmission Lines
  - 6,414 transformer
  - 13,189 lines
  - 245 series devices
  - 529 ZBRs
  - 37,316 breakers
  - 62,129 disconnects
  - 715 load-break disconnect
  - 360 fuses



Important Data Structure Parts: More Branch Types

- Planning models already have the concept of distinct types of branches
  - *Line*, *Transformer, Series Cap*
- BranchDeviceTypes that represent switching devices that have very little impedance
  - At a minimum add *Breaker*, *Load Break Disconnect*, and *Disconnect*
    - Used in “Open or Close with Breakers” features discussed shortly
    - Used in “Derived Status” concepts discussed shortly
  - Also add *Fuse*, *Ground Disconnect* and *ZBR* for informational purposes as well

BranchDeviceType



Branch	BusNumFrom(1)	BusNameFrom	BusNumTo(2)	BusNameTo	Circuit(3C)	BranchDeviceType	All
1	1	Sub1ND1	2	Sub1ND2	1	Breaker	Sub1ND1$$Sub1$
2	3	Sub1ND3	1	Sub1ND1	1	Breaker	Sub1ND3$$Sub1$
3	1	Sub1ND1	6	Sub1ND6	1	Disconnect	Sub1ND1$$Sub1$
4	4	Sub1ND4	2	Sub1ND2	1	Breaker	Sub1ND4$$Sub1$
5	8	Sub1ND8	2	Sub1ND2	1	Disconnect	Sub1ND8$$Sub1$
6	5	Sub1ND5	3	Sub1ND3	1	Breaker	Sub1ND5$$Sub1$
7	3	Sub1ND3	10	Sub1ND10	1	Disconnect	Sub1ND3$$Sub1$
8	7	Sub1ND7	4	Sub1ND4	1		
9	11	Sub1ND11	4	Sub1ND4	1		
10	5	Sub1ND5	11	Sub1ND11	1		
11	5	Sub1ND5	12	Sub1ND12	1		
12	6	Sub1ND6	122	Sub8ND122	1		
13	7	Sub1ND7	13	Sub1ND13	1		
14	11	Sub1ND11	9	Sub1ND9	1		
15	12	Sub1ND12	103	Sub7ND103	1		
16	13	Sub1ND13	14	Sub1ND14	1		
17	13	Sub1ND13	15	Sub1ND15	1		
18	16	Sub2ND16	18	Sub2ND18	1		
19	16	Sub2ND16	4182	Sub405ND4182	1		
20	17	Sub2ND17	19	Sub2ND19	1		
21	17	Sub2ND17	4180	Sub405ND4180	1	Line	Sub2ND17$$Sub4

What do Branch Device Types Physically Represent

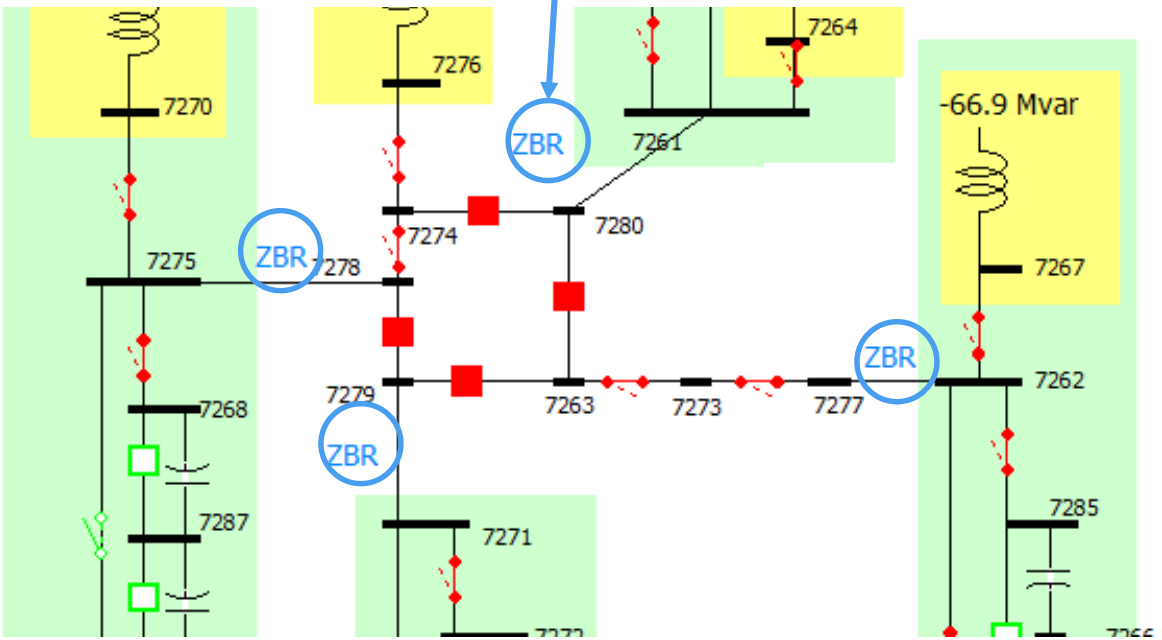
- Transformers, Lines, Series Devices
  - We know these
- Breakers
  - Switching device that can interrupt very high currents such as *during a fault*
- Load-Break Disconnect
  - Switching device that can be opened during normal loading conditions, but NOT during a fault
  - Often associated with a capacitor bank
- Disconnects
  - Switching device can not be opened when under load

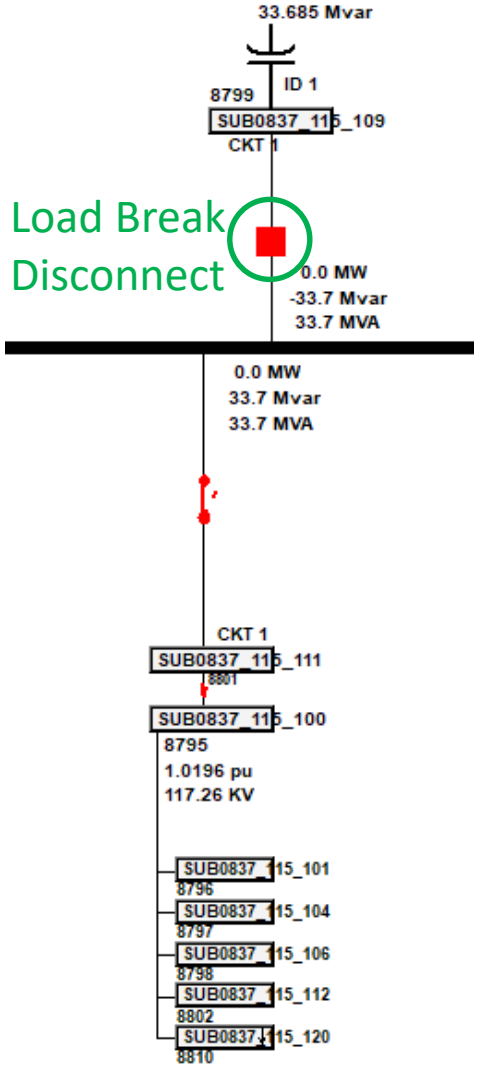
Other BranchDeviceTypes

- ZBR
  - Wire that connects two points.
  - Might be there so a measurement can be taken
  - Might just be a jumper
- Ground Disconnect
  - Switching device connects to ground. Some EMS models actually include nodes that represent the ground and then an associated disconnect.
  - Obviously these should NEVER be closed in for purposes of planning activities
    - System operators however are focused on status and worker safety, so it is useful for them to know if a line is actually grounded properly
- Fuses
  - A fuse

Example ZBR and Load Break Disconnect

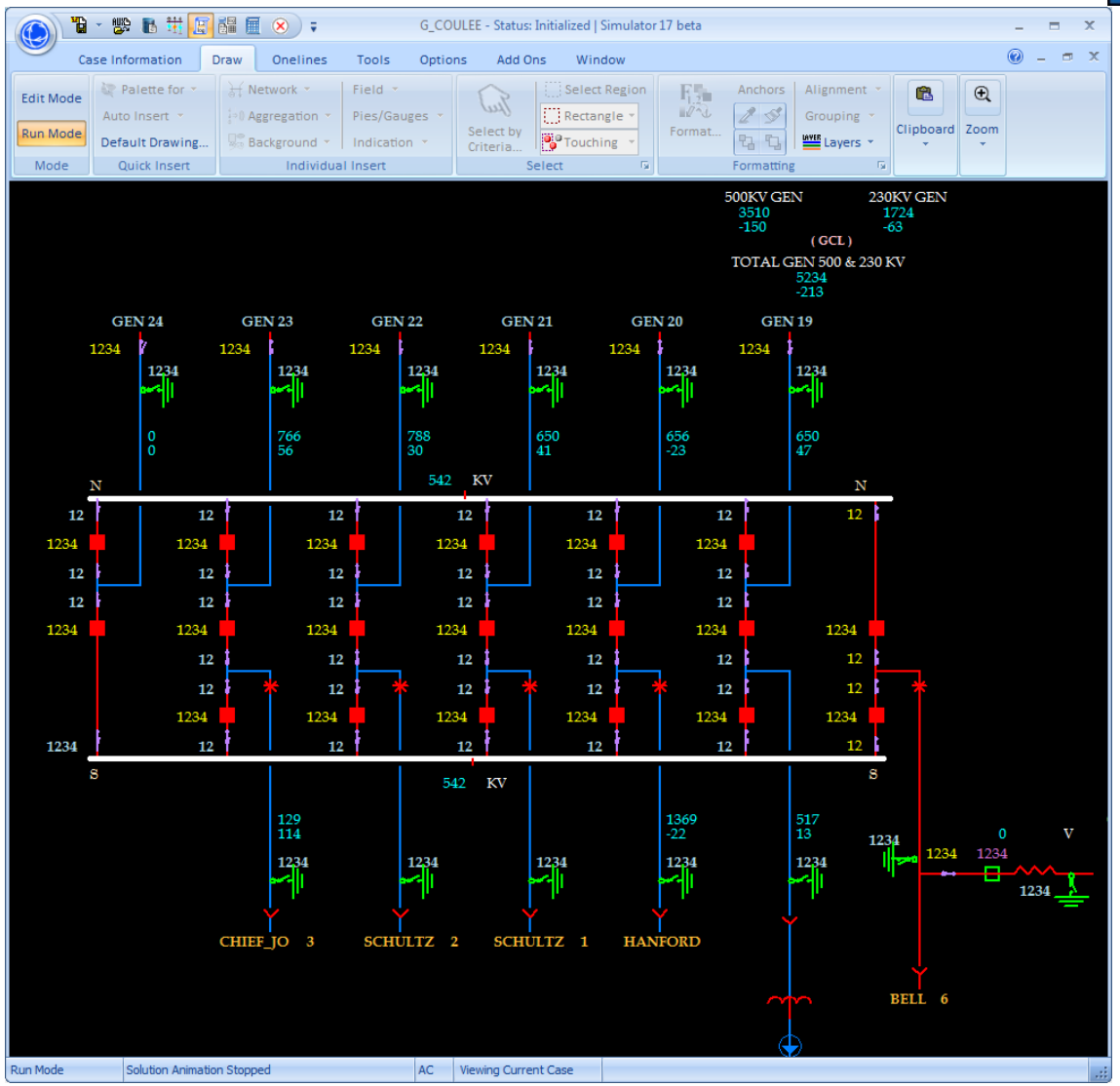
ZBR probably there so that one measurement gets flow on line





Model Detail

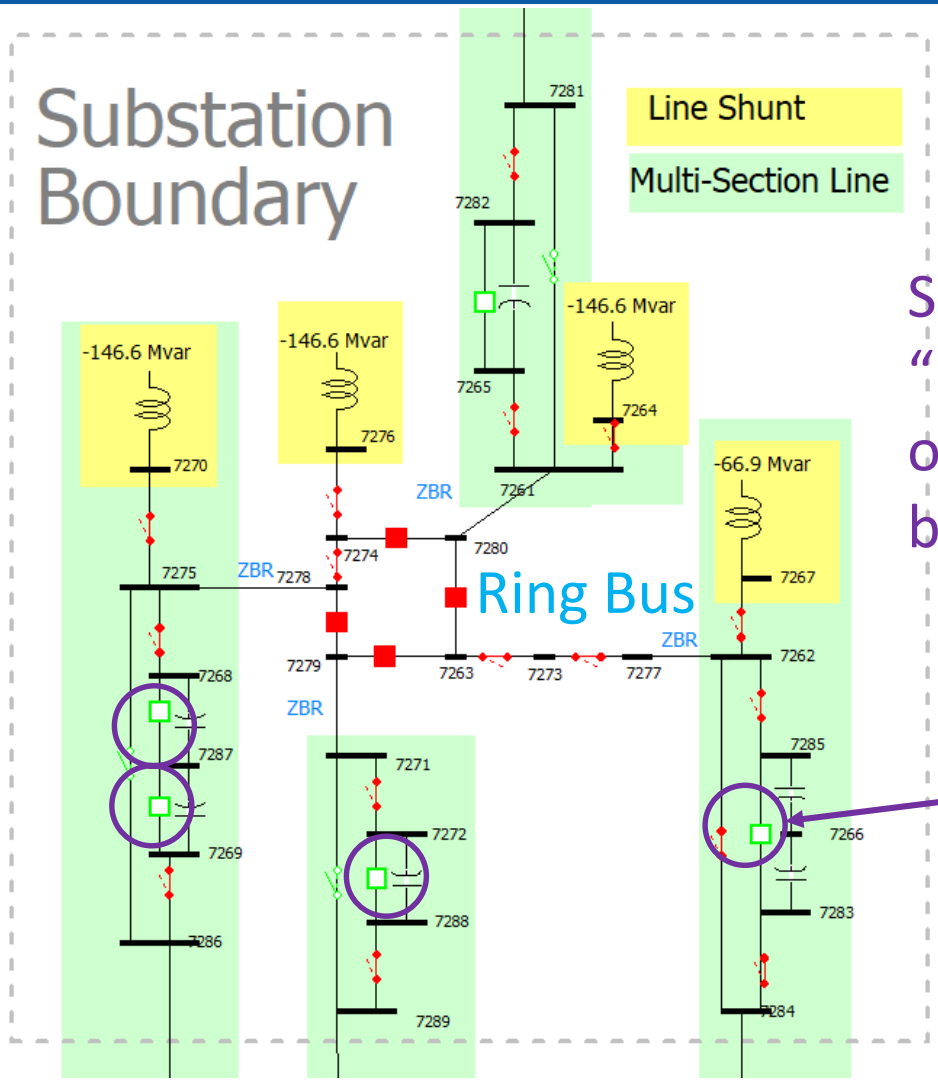
- To the right is a redacted detail of what the topology of a 500 kV bus
- It's a Breaker and a Half configuration
- This would be a single bus in a "planning case"



Good News:

- Some data definitions go away
  - Idea of a “Line Shunt” as compared to a “Bus Shunt” is unnecessary
    - All shunts are modeled with a connection to a bus
    - Line vs. Bus Shunt just depends on which side of the line breaker it is connected
  - Idea of a “Multi-Section Line” is unnecessary
    - Software can automatically traverse the topology to determine which branches get isolated by the same set of breakers
    - “Open with Breakers” option discussed next
  - Concept of a “Bypassed” series cap goes away
    - There will be a separate breaker to model the bypass

Capacitor/Reactors all the same Multi-Section Line concept gone



Shunts are all the same. "LineShunt" just means its on the other side of the breakers

Bypass Breakers

Integrated Topology Processing

- Completely *integrate* the concept of topology processing inside each software algorithm
- Each algorithm consolidates in a manner appropriate to it
  - Power flow → solve directly on the full-topology model (internally consolidate the power system model as necessary)
  - Contingency analysis (only consolidate as necessary)
  - PV Curve and QV Curve behave differently
  - MW Linearized Tools (ATC, Sensitivity tools, etc.) behave differently

Full-Topology Power Flow Solution

- PowerWorld knows when it needs to make a consolidated case and takes care of that
- User only interacts with the full-topology model
  - Power Flow Solution returns flows on *all devices*
  - Contingency analysis limit monitoring looks at all devices including switching devices (*assuming limits are assigned!*)
    - Option to filter bus voltage reporting so only one node inside a Superbus reports as a violation

MW and Mvar flow arrows on all devices on oneline diagrams

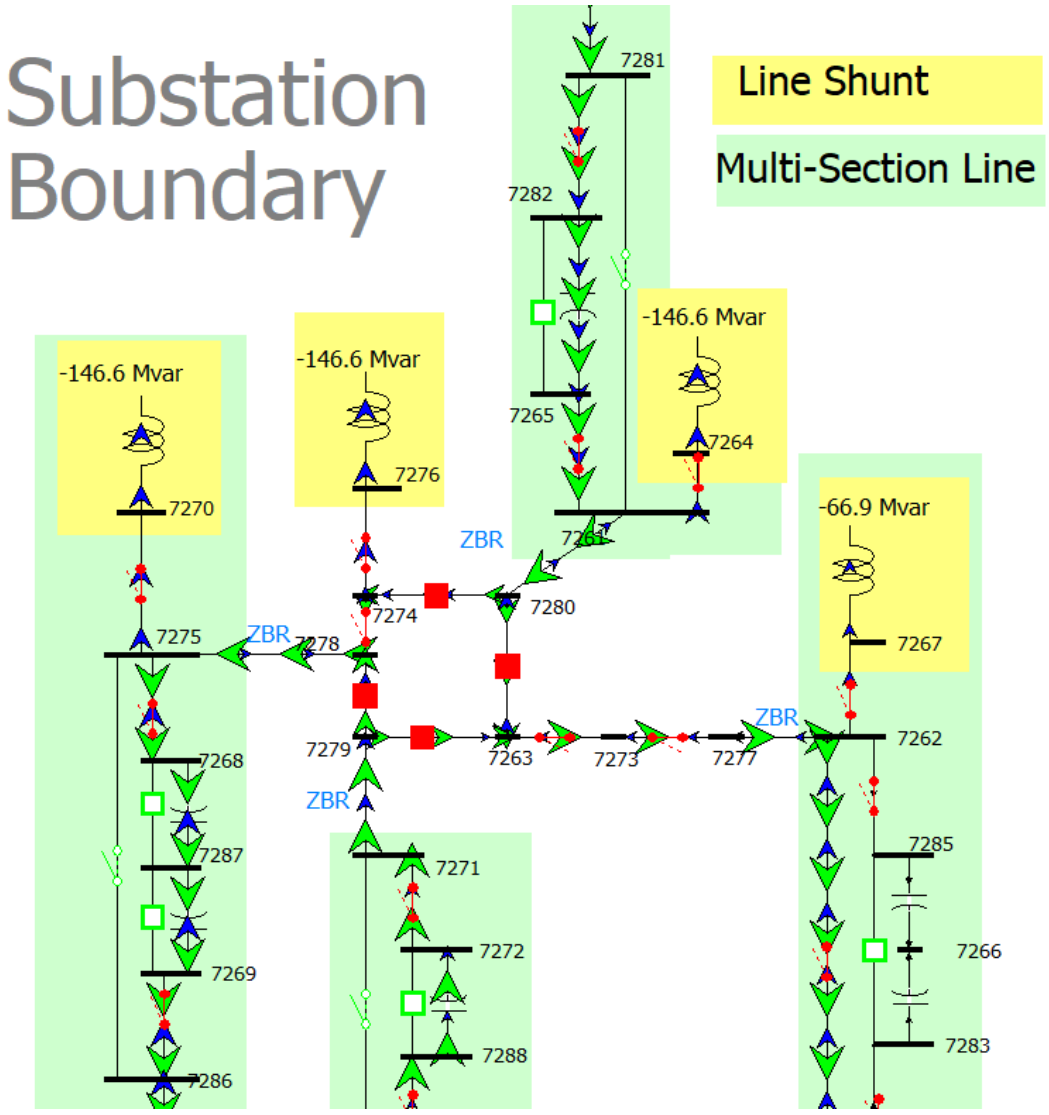
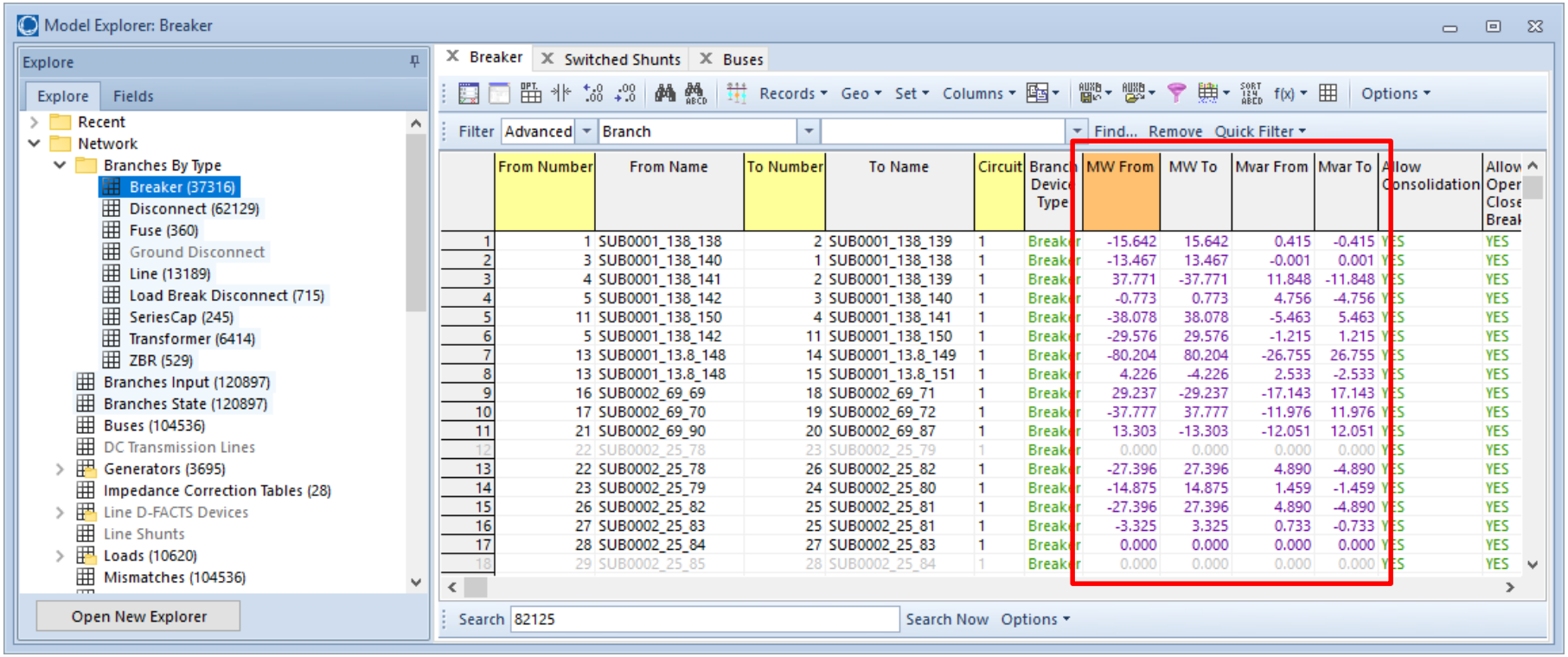
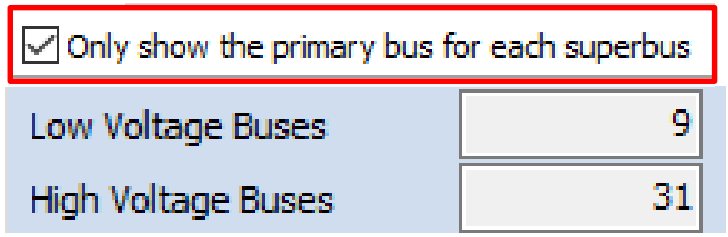
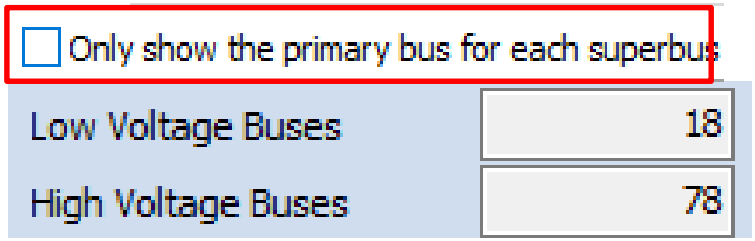


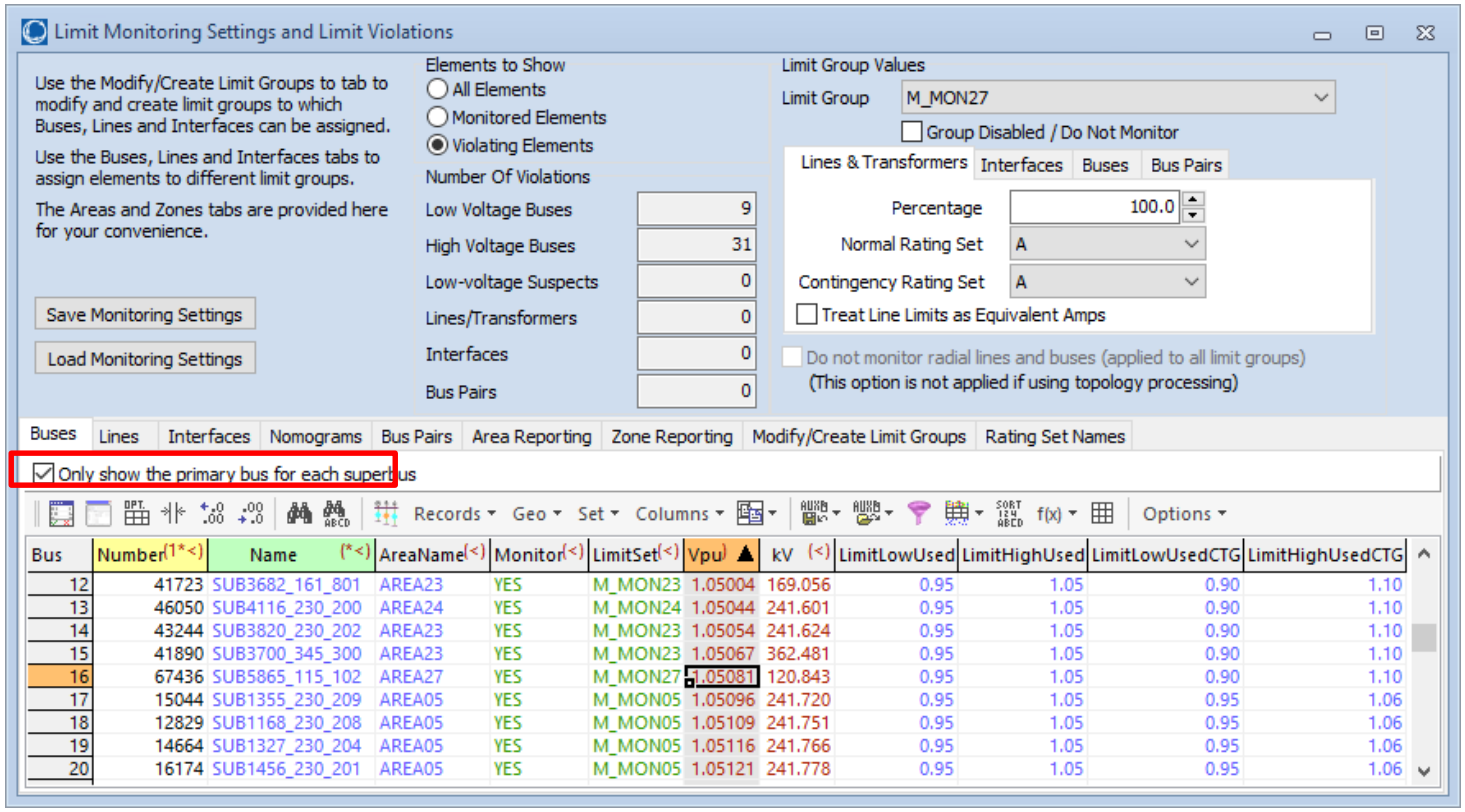
Table of Breakers showing MW and Mvar flows



Limit Monitoring in the Power Flow







PowerWorld Software Features where BranchDeviceTypes Matter

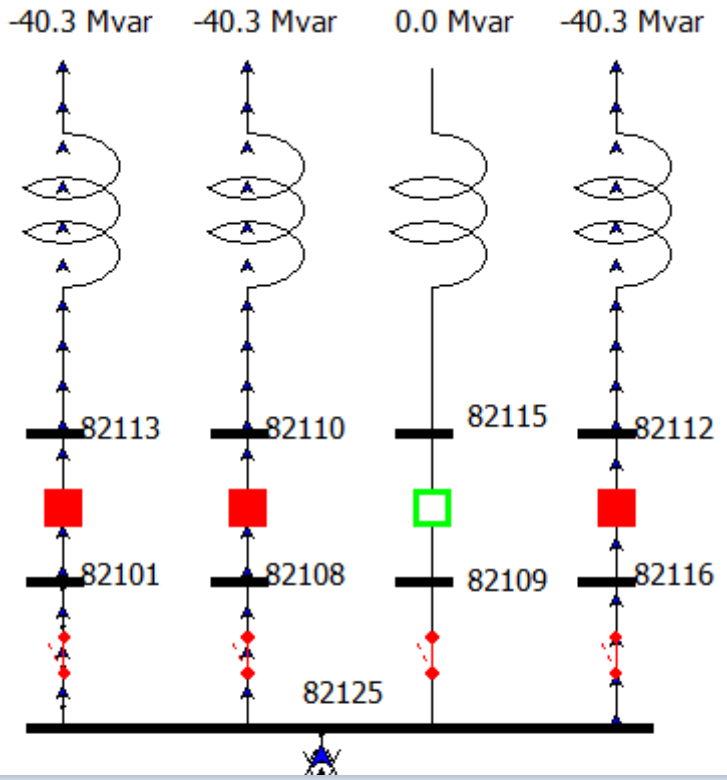
- Software has many automated features that use the BranchDeviceType Information
  - Full Topology Automatic Coordinated Switched Shunt Control
  - User Interaction features “Open Breakers to Isolate” and “Close Breakers to energize”
  - Contingency Analysis “Open with Breakers”
    - These features will only open the Breakers

Full Topology Automatic Coordinated Switched Shunt Control

- PowerWorld automatically detects a group of Switched Shunts that regulate the voltage at the same point
  - By “point” we mean a group of buses connected by very low impedance branches
  - Don’t have to regulate the exact same node, just be connected
- Shunt will automatically close breakers *and load break disconnects* in series with shunt to perform shunt control
- No additional input data: PowerWorld just detects

Full Topology Automatic Coordinated Switched Shunt Control

- Example: 4 shunts all regulate “82125”
- Initial solution has regulate voltage inside High/Low Range
- Change Volt High to 0.94



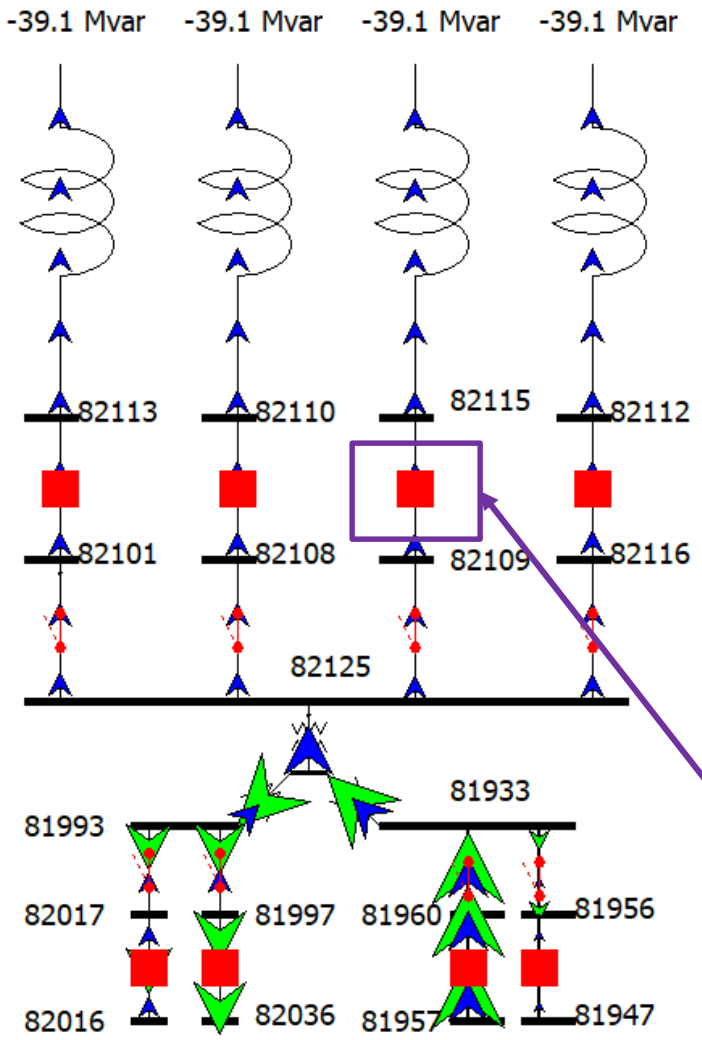
Switched Shunts (Filter:Quick) | Buses

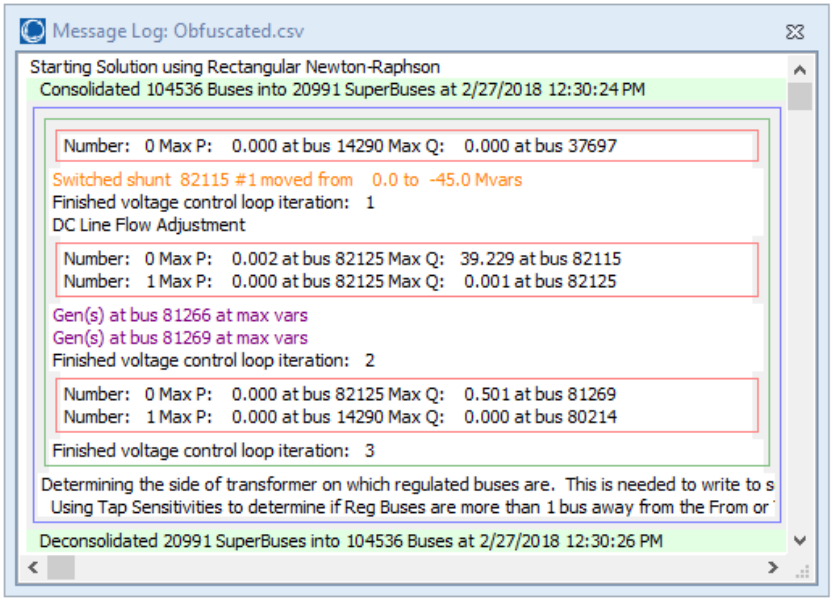
Records | Geo | Set | Columns | f(x) | Options

Filter: Advanced | Switched Shunt | Quick | Find... | Remove | Quick Filter

	Number of Bus	Name of Bus	ID	Reg Bus N	Status	Status Branch	Control Mode	Regulates	Actual Mvar	Volt High	Volt Low	Reg Volt	Deviation	Nominal Mvar	Max Mvar	Min Mvar
1	82110	SUB6984_13.8_1021	1	82125	Closed		Discrete	Volt	-39.10	0.9400	0.9300	0.9321	0.0000	-45.00	0.00	-45.00
2	82112	SUB6984_13.8_1023	1	82125	Closed		Discrete	Volt	-39.10	0.9400	0.9300	0.9321	0.0000	-45.00	0.00	-45.00
3	82113	SUB6984_13.8_1024	1	82125	Closed		Discrete	Volt	-39.10	0.9400	0.9300	0.9321	0.0000	-45.00	0.00	-45.00
4	82115	SUB6984_13.8_1026	1	82125	Closed		Discrete	Volt	-39.10	0.9400	0.9300	0.9321	0.0000	-45.00	0.00	-45.00

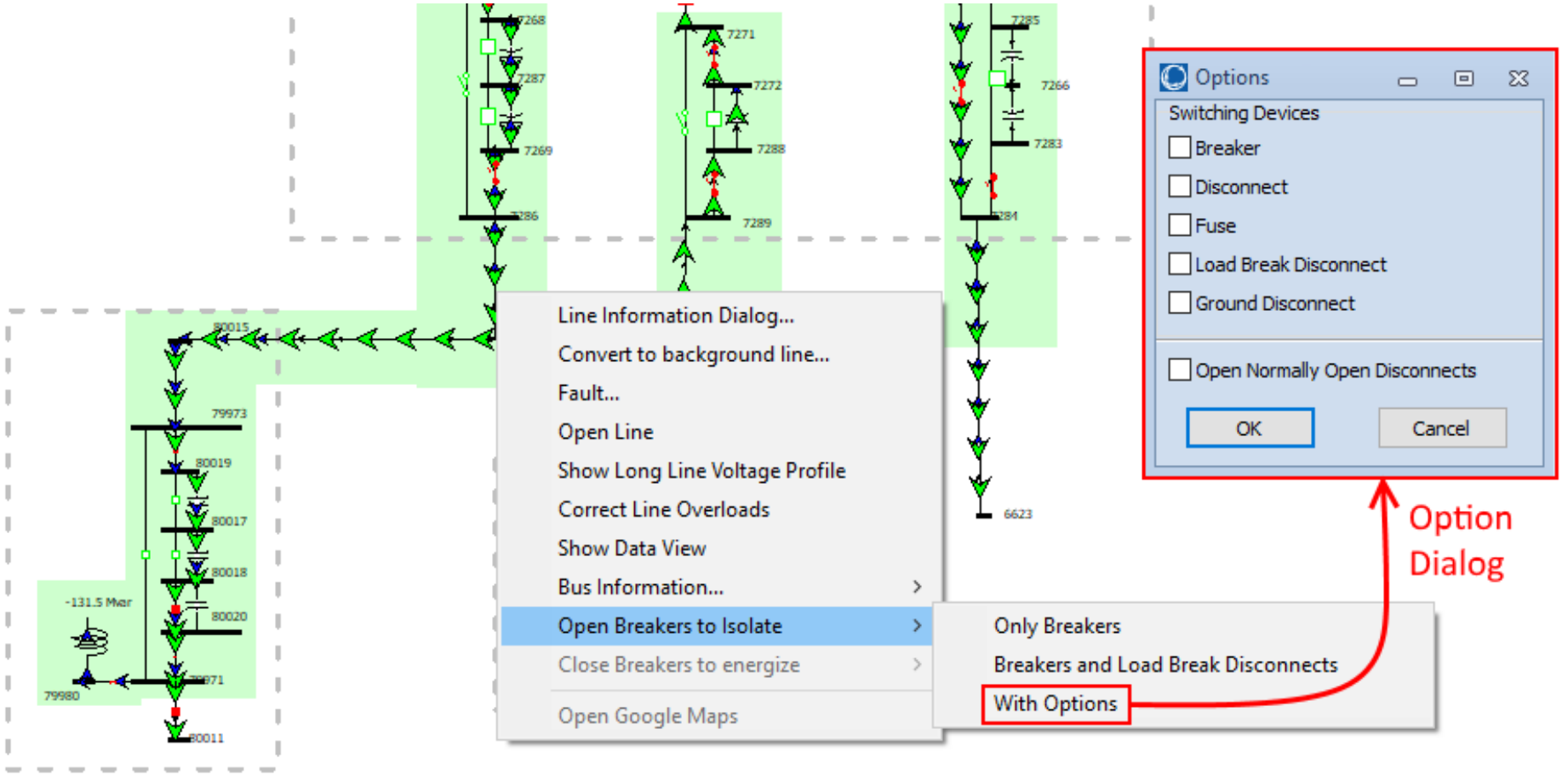
Power Flow Solution automatically closes in the breaker





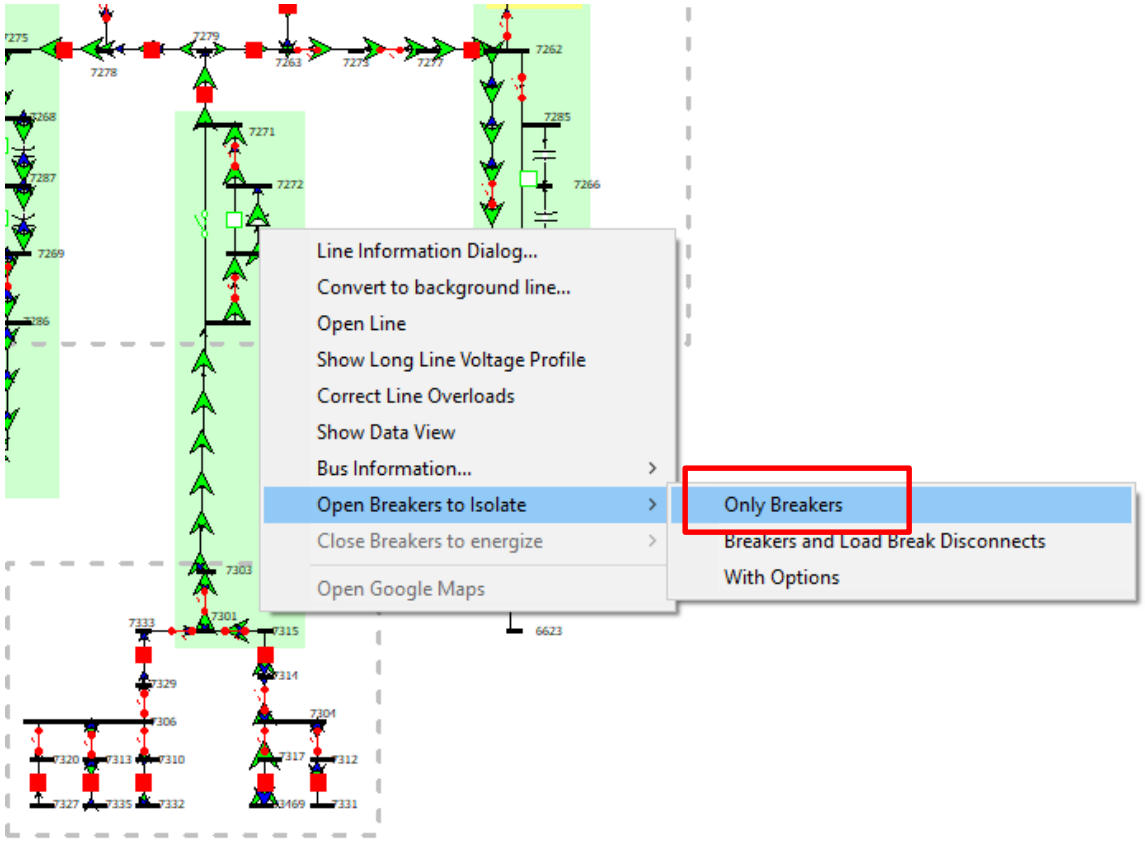
Automatically closed in Breaker (would also close in a Load Break Disconnect)

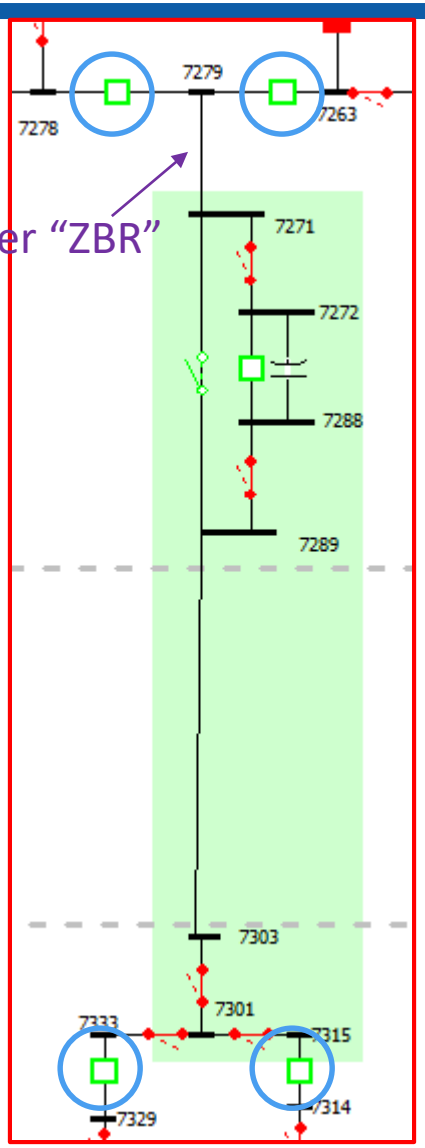
User Interaction features: Open Breakers to Isolate



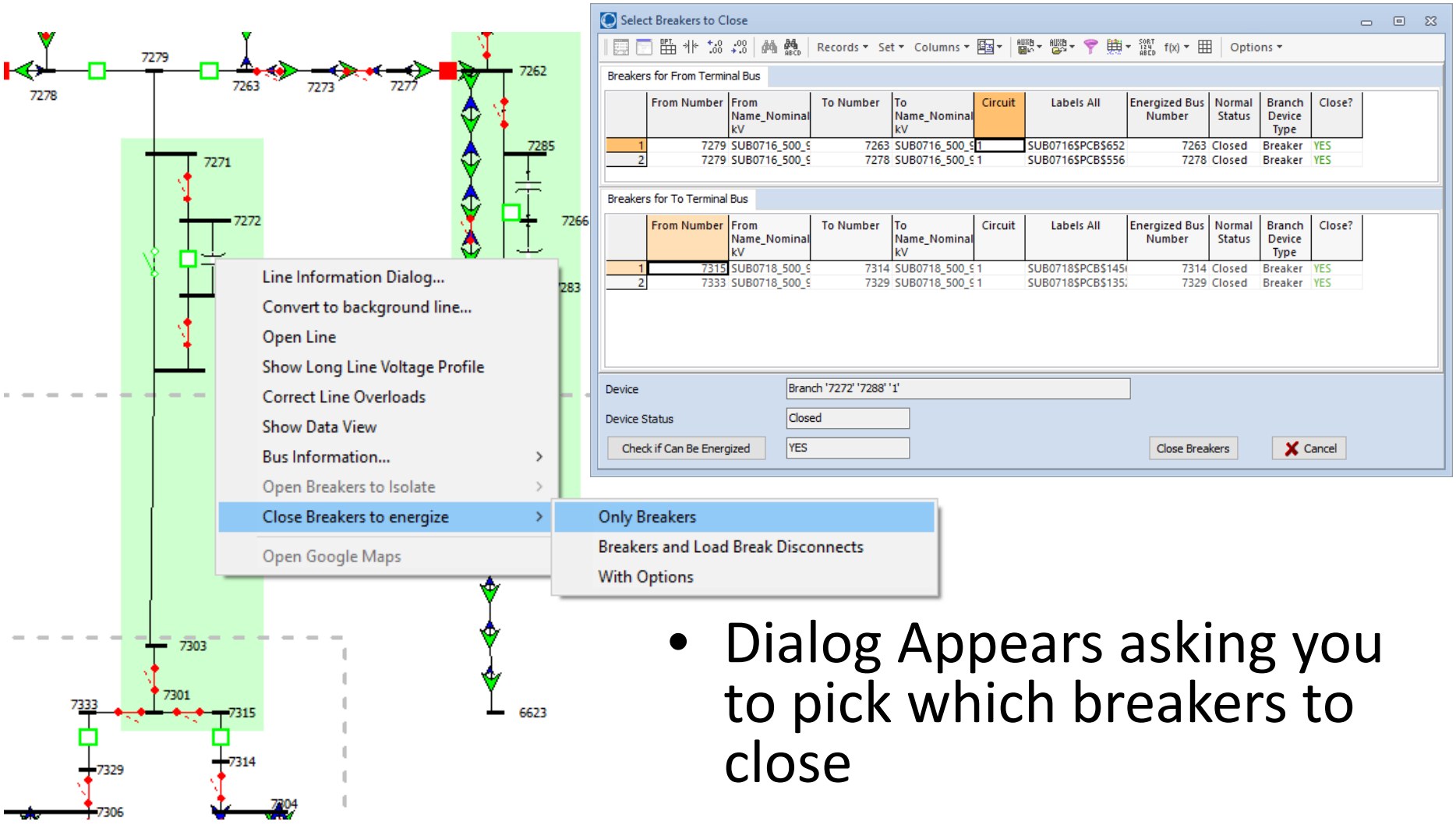
User Interaction features: Open Breakers to Isolate

- Automatically Finds Breakers





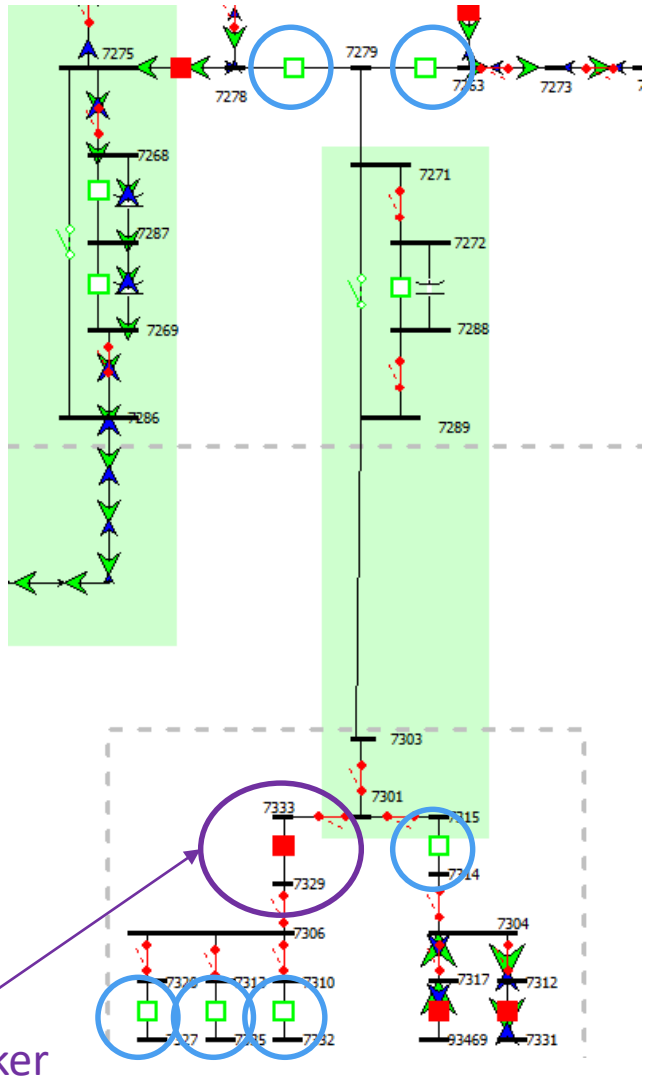
User Interaction features: Close Breakers to Energize



- Dialog Appears asking you to pick which breakers to close

Model a Breaker Failure

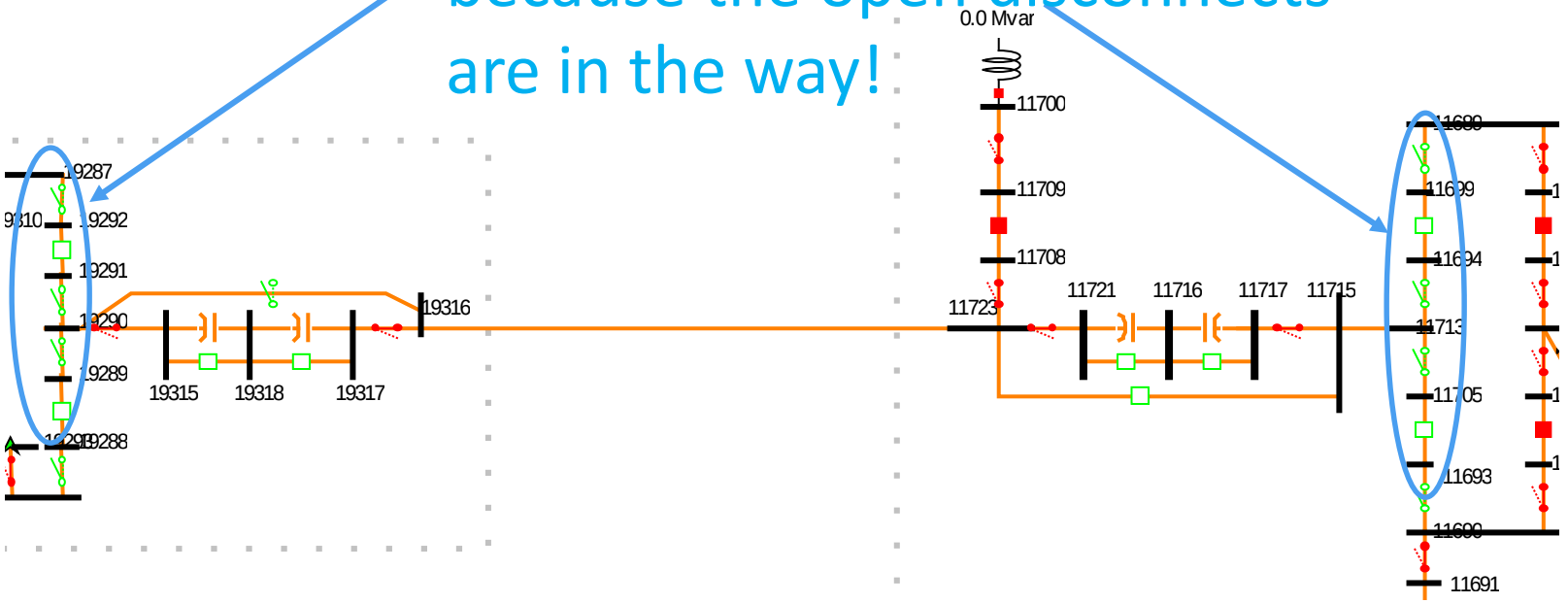
- Perform “Open with Breakers” on a device that is a Breaker
  - PowerWorld assumes that you want to find breakers that surround the breaker
  - Assumption is that the breaker will not open (otherwise you’d just open it!)



Using a Full-Topology Export that includes out-of-service lines

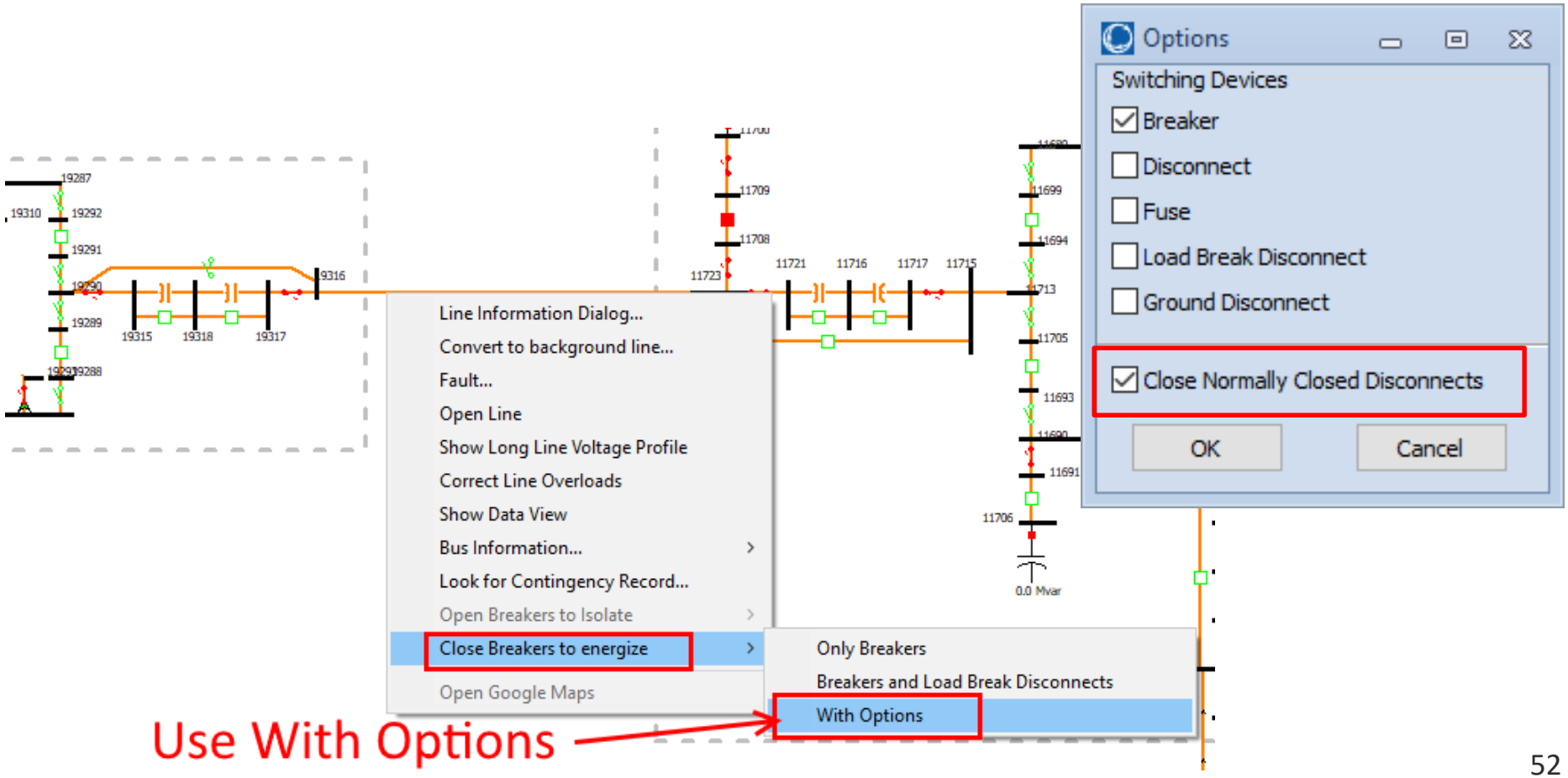
- Open with breakers always works fine
- Close Breakers to Energize can be troublesome
  - Out-of-service line may also have disconnects open

"Close Breakers" won't work because the open disconnects are in the way!



Yet more options to automatically fix this trouble

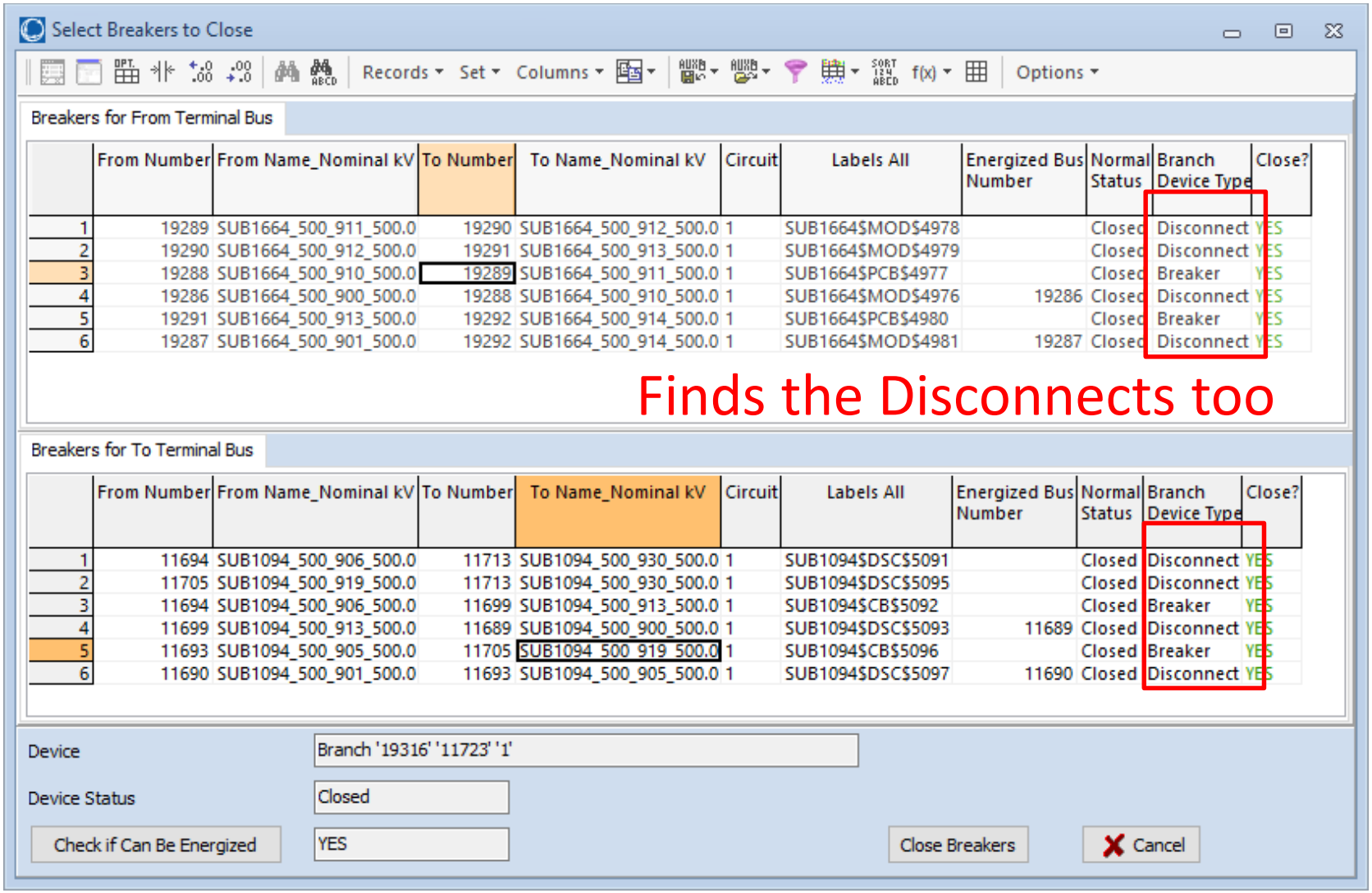
- Use Close Breakers to energize “with Options”



Close Normally Closed Disconnects

- This option will look across normally closed disconnects searching for breakers
- Option will also look *in series* past breakers for disconnects
- Treats a series combination of disconnects with a single breaker as though it is “one switching decision”

Close Normally Closed Disconnects



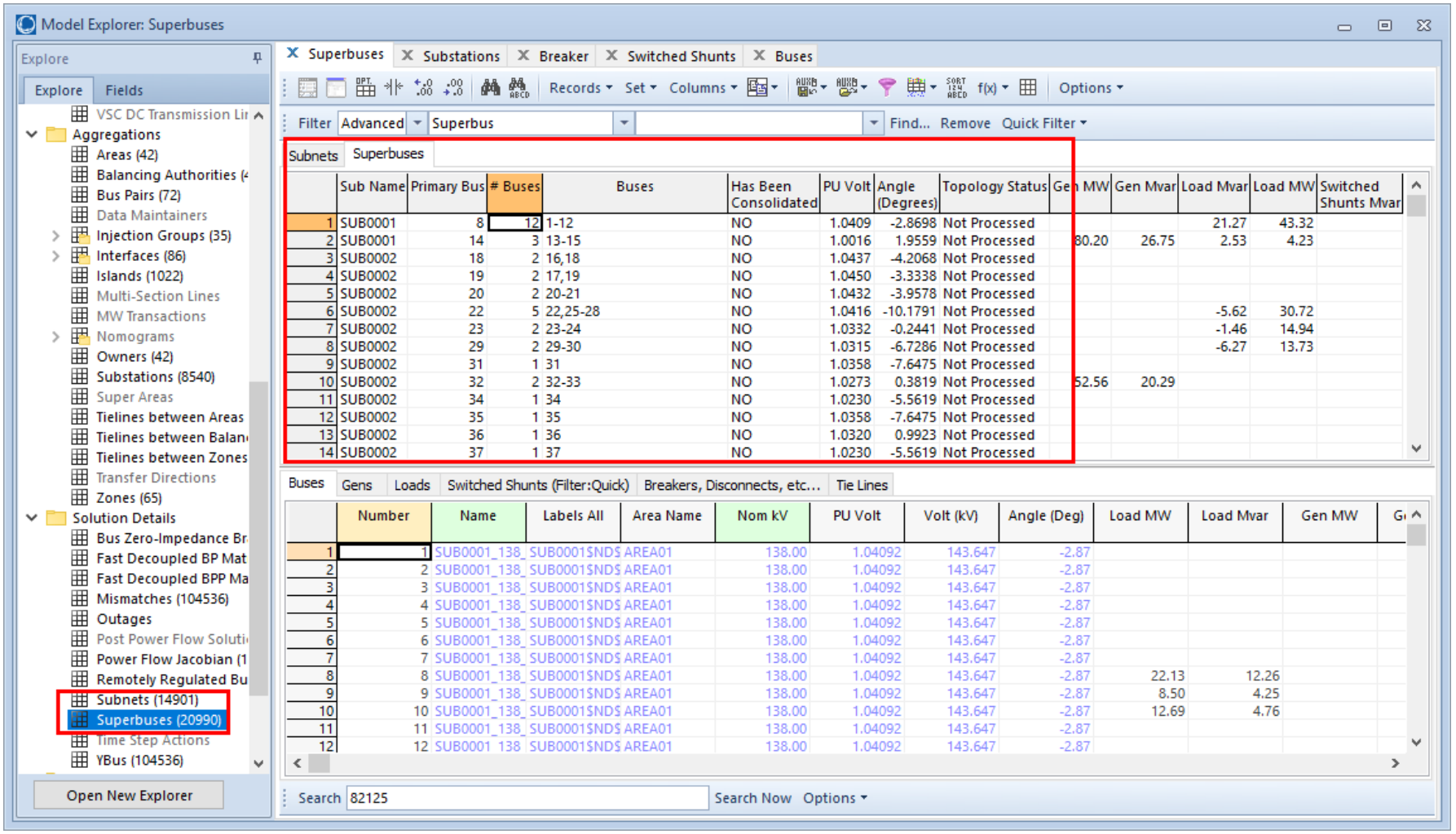
Bus table and Superbus

- PowerWorld treats all “nodes” as additions to the bus table
  - Represent a point where devices connect
- Superbus table (user does not create – software figures it out)
  - Superbus = group of buses connected by closed switching devices
  - It is similar in concept to an electrical island
    - Islands are added and removed in the software as branches change status
    - Island = group of buses connected by closed branches of any type
- Subnet table (user does not create – software figures out)
  - Subnet = group of buses connected by open or closed switching devices

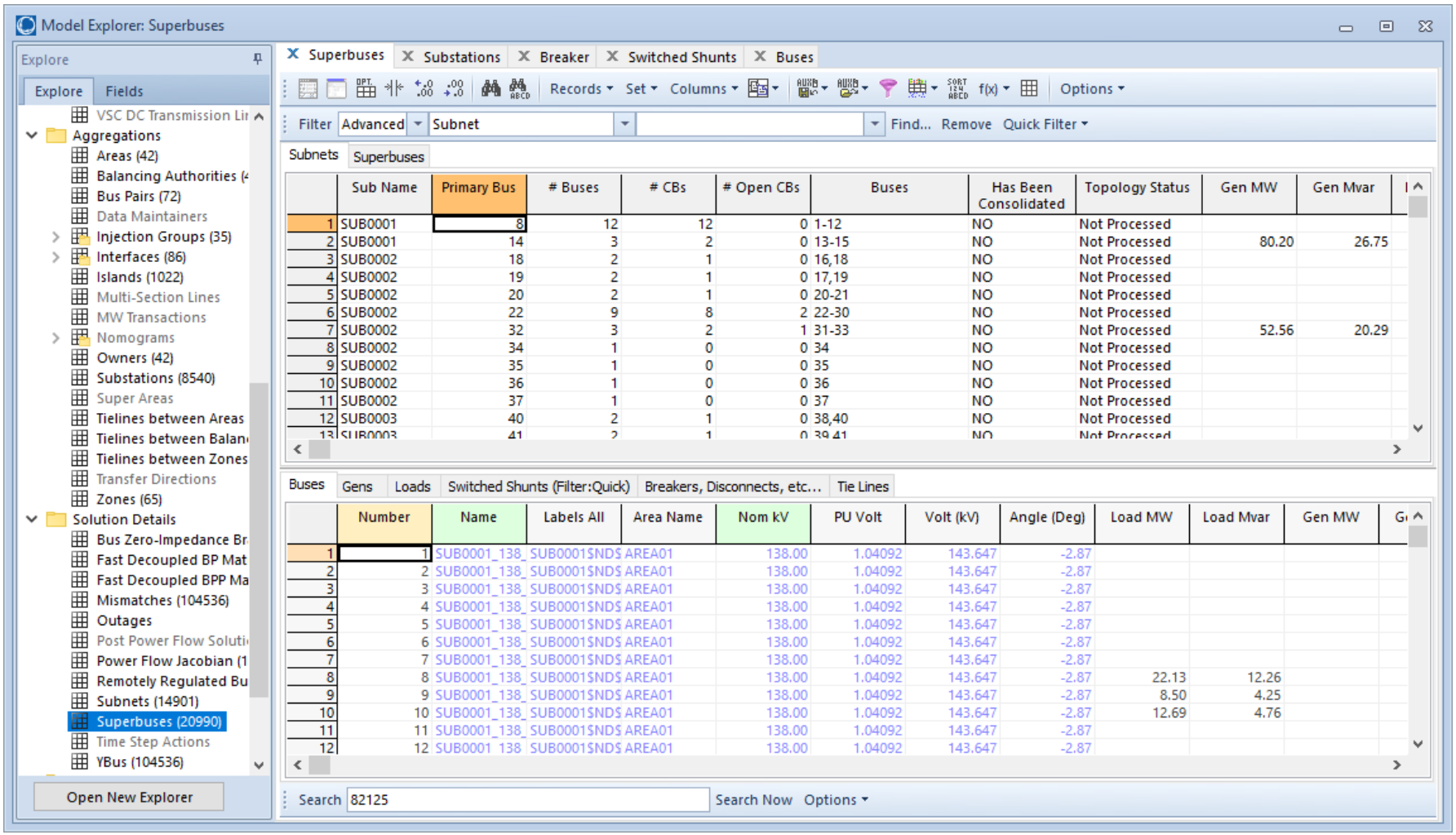
Bus table and Superbus

- Typically as a user you will not interact with either the Superbus or the Subnet table
  - They are available to see
  - Each Superbus and Subnet also chooses “primary node”
    - This affects features that report only one bus violation inside a Superbus
    - Also possible for the user to bias the choice of the super bus by assigning a priority to the bus object

Superbus table



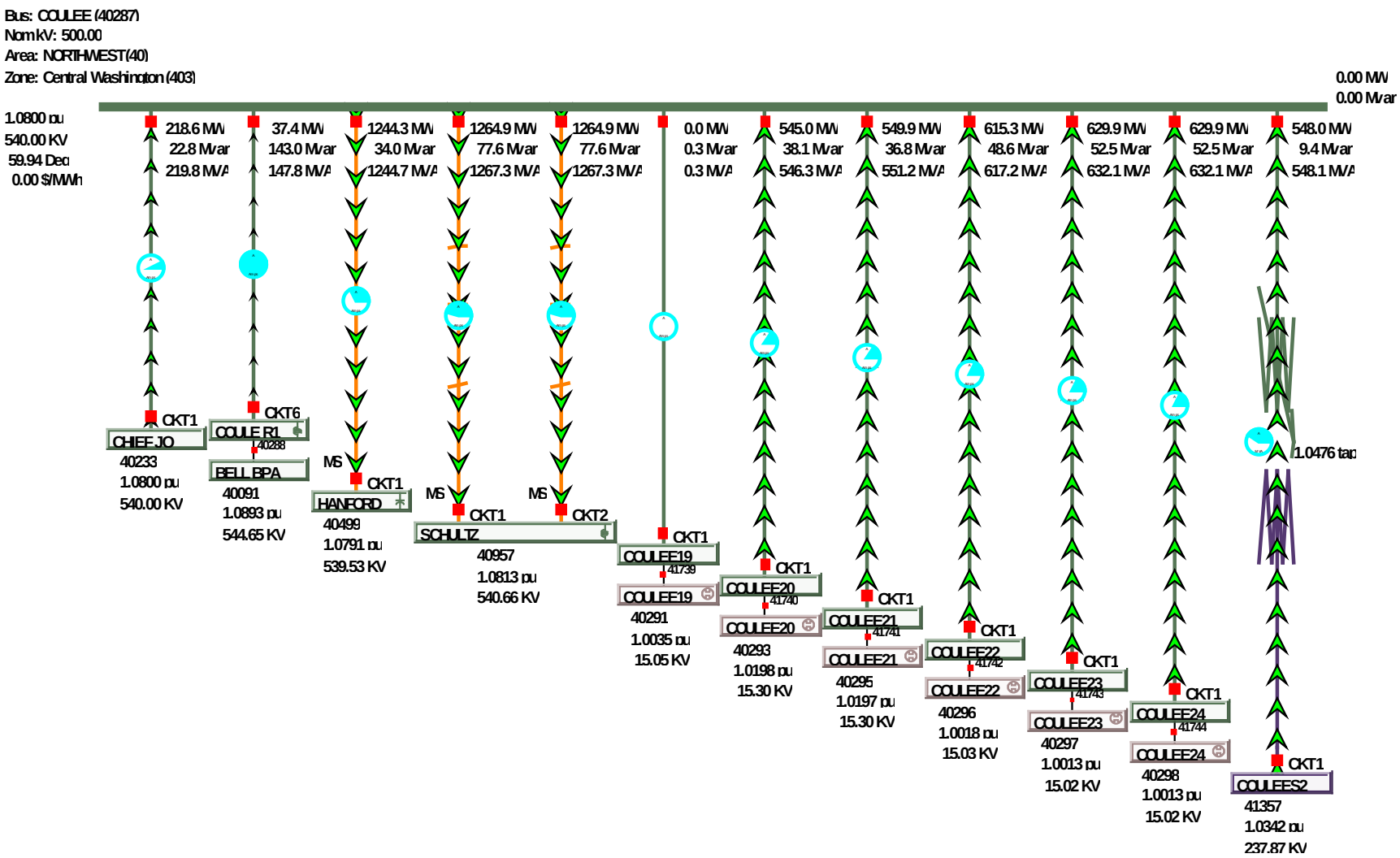
Subnet Table



Human Interaction

- Model Navigation Obstacle
  - Can be confusing to navigate full-topology models
- Tools that graphically show bus-to-bus connections in the model can get very complicated
  - You can get stuck inside all the disconnects and breakers
  - Makes finding more important devices difficult (lines, transformers, generators, loads)
  - PowerWorld's Bus View has features to help

Planning Case Bus View

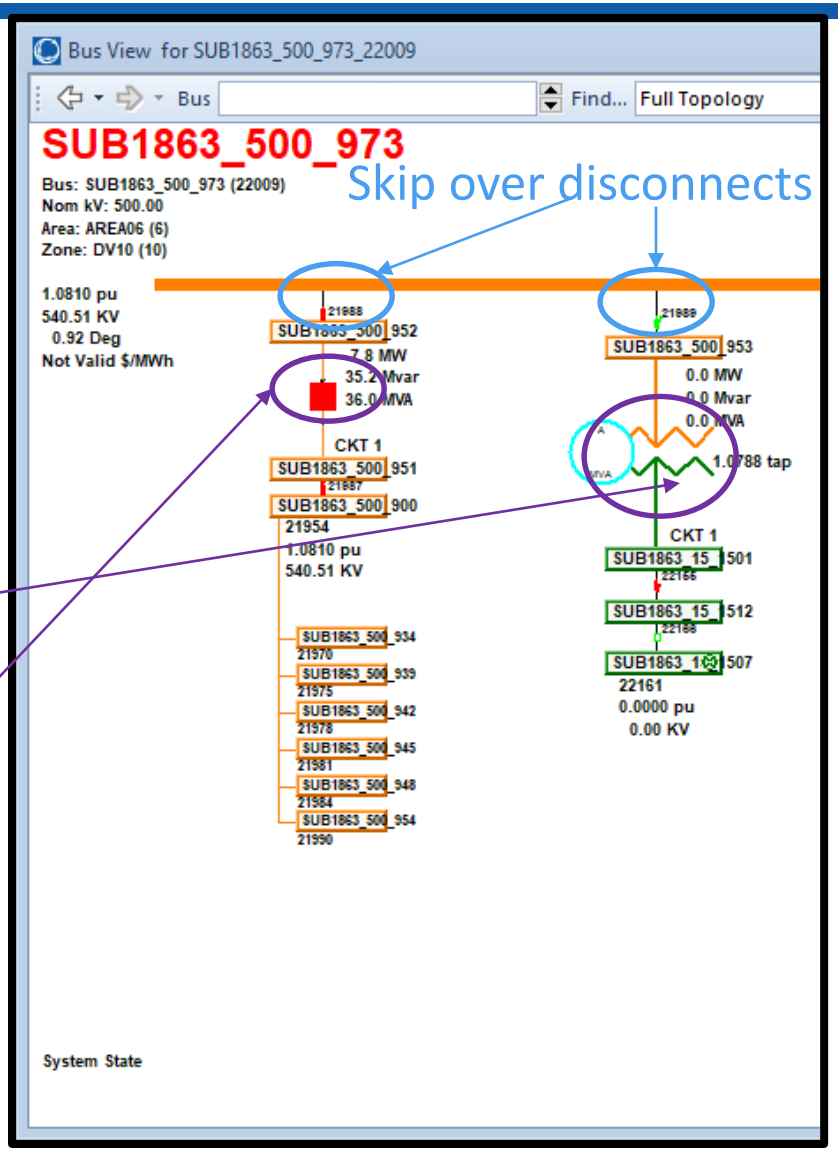


Full Topology Bus View

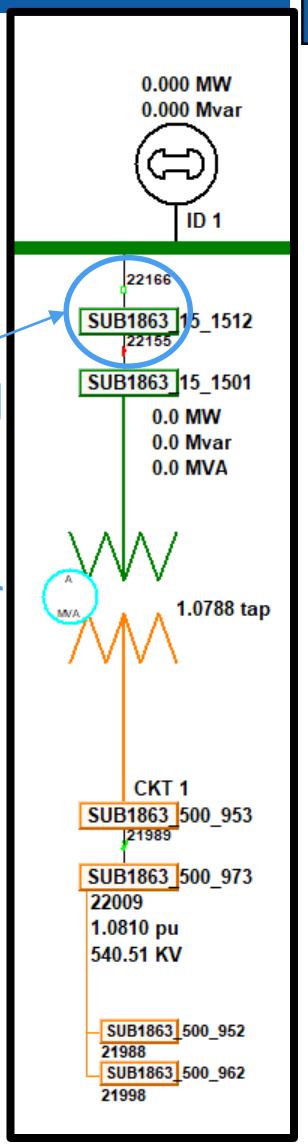
Shows stack of serially connected nodes

Bias to show lines, transformer, or series cap prominently

If those not available, then biases to show breaker

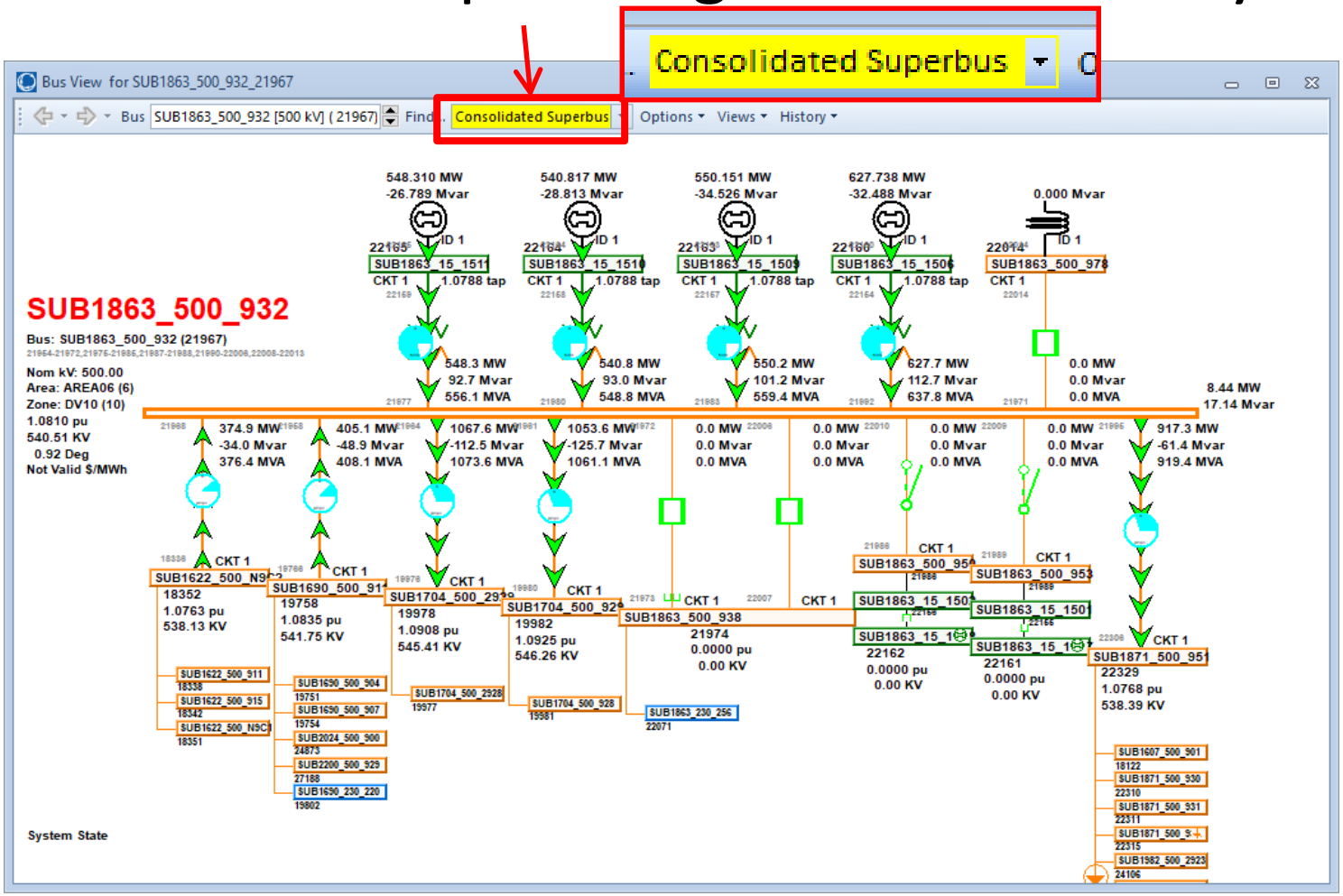


Skip over breaker and disconnect to get to transformer

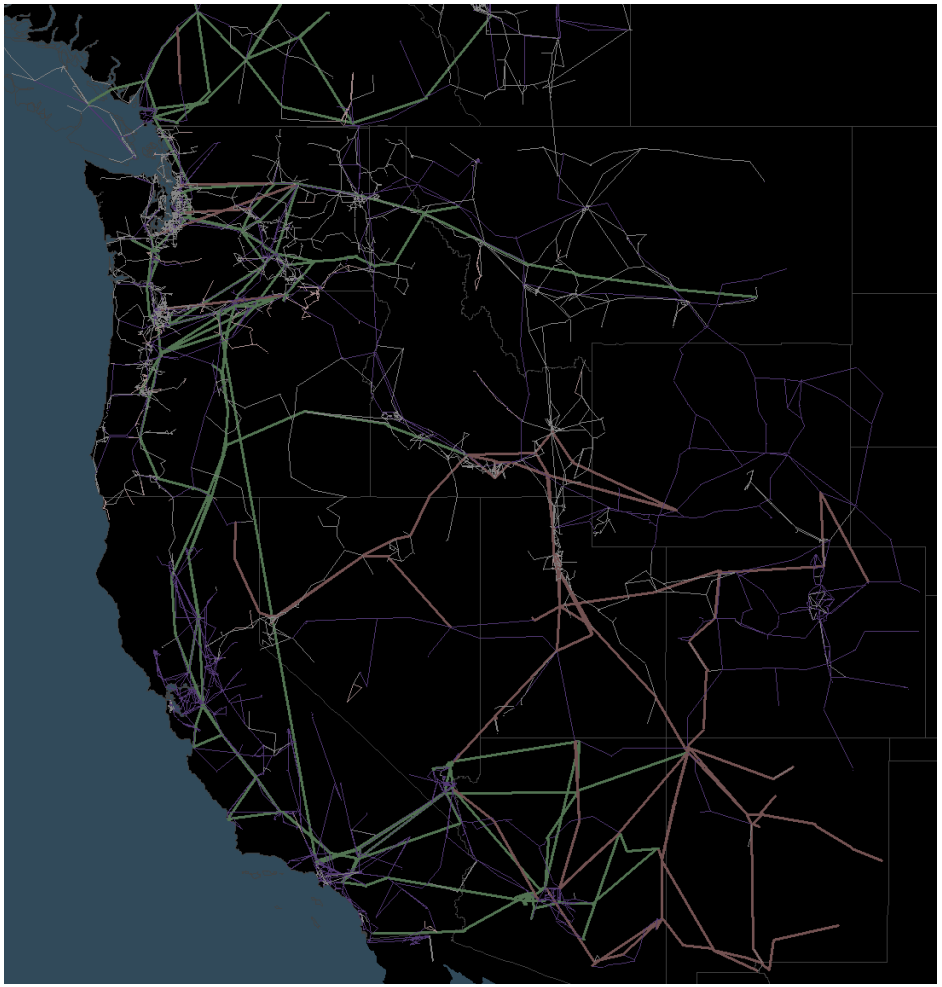


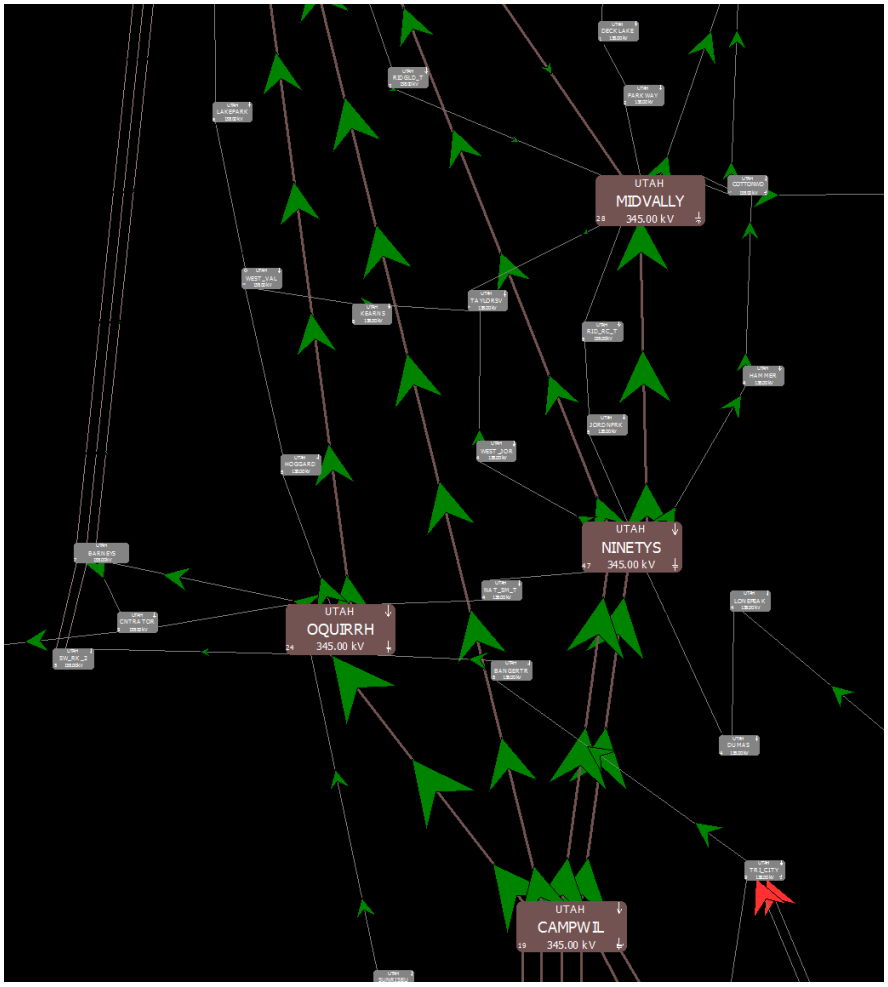
Consolidated Superbus View

- Looks like the “planning case” essentially



Overview Oneline Visualizations will likely be Substation Based

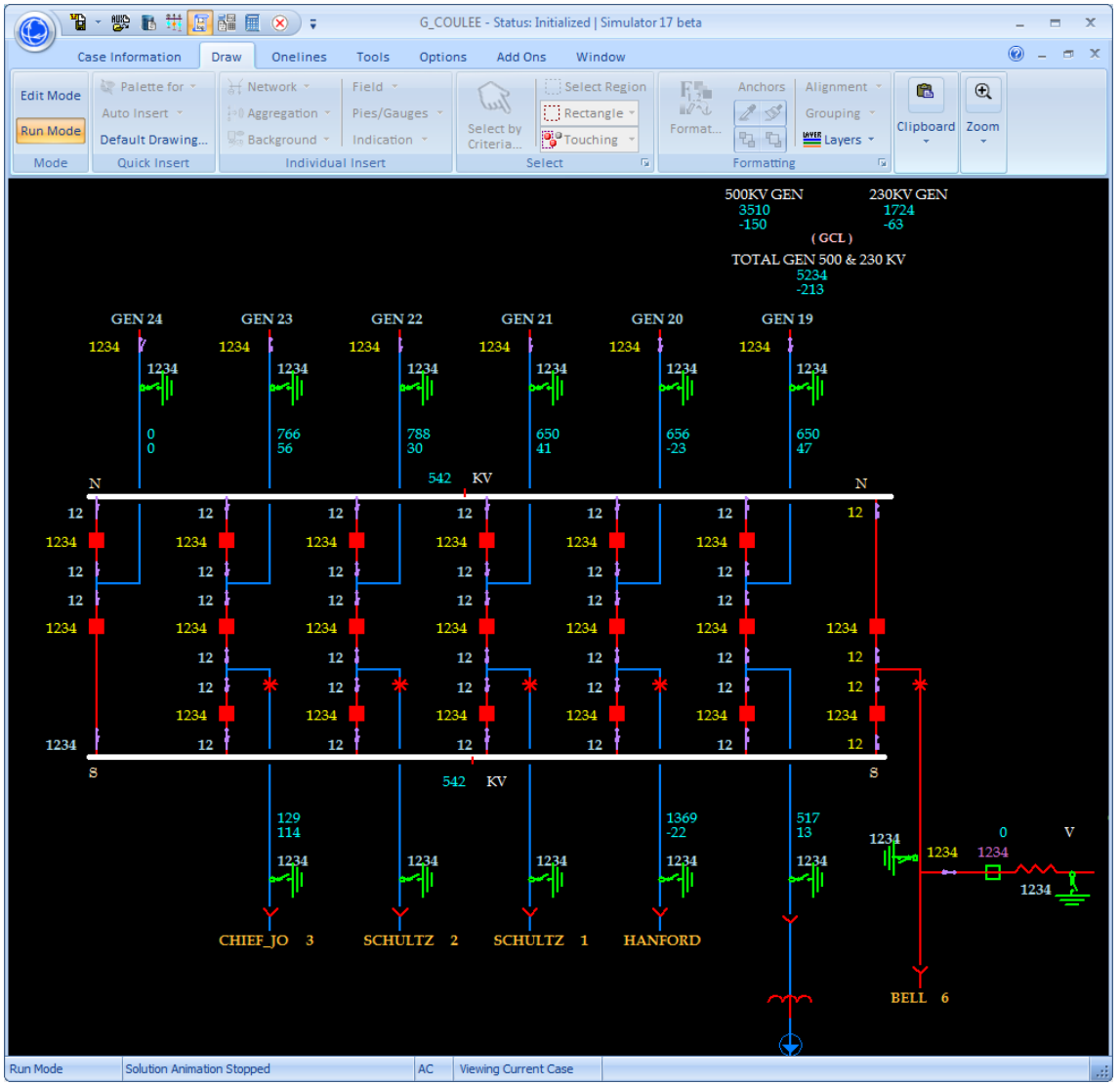




EMS Oneline Diagrams

- Peak Reliability has *a lot* of custom-built substation topology diagrams
  - Our most recent set from them for testing had 4,494 diagrams
  - Clearly not something that they are going to draw a second time
- After a short project (about 1 person-month of effort), we built a translation file that describes how the various symbols on their onelines are drawn
  - Areva onelines are all built around user-customized symbols, so we had to translate a few hundred symbols
  - Once Peak Reliability's symbols are translated, PowerWorld can directly read in all 4,494 of these online diagrams
  - Still working on a mechanism to keep this up-to-date
    - They add new kinds of symbols to the diagrams
    - Peak will share these with other companies
- Have done same work with ISO – New England and BPA

Build Tools to Load Substation Topology Onelines

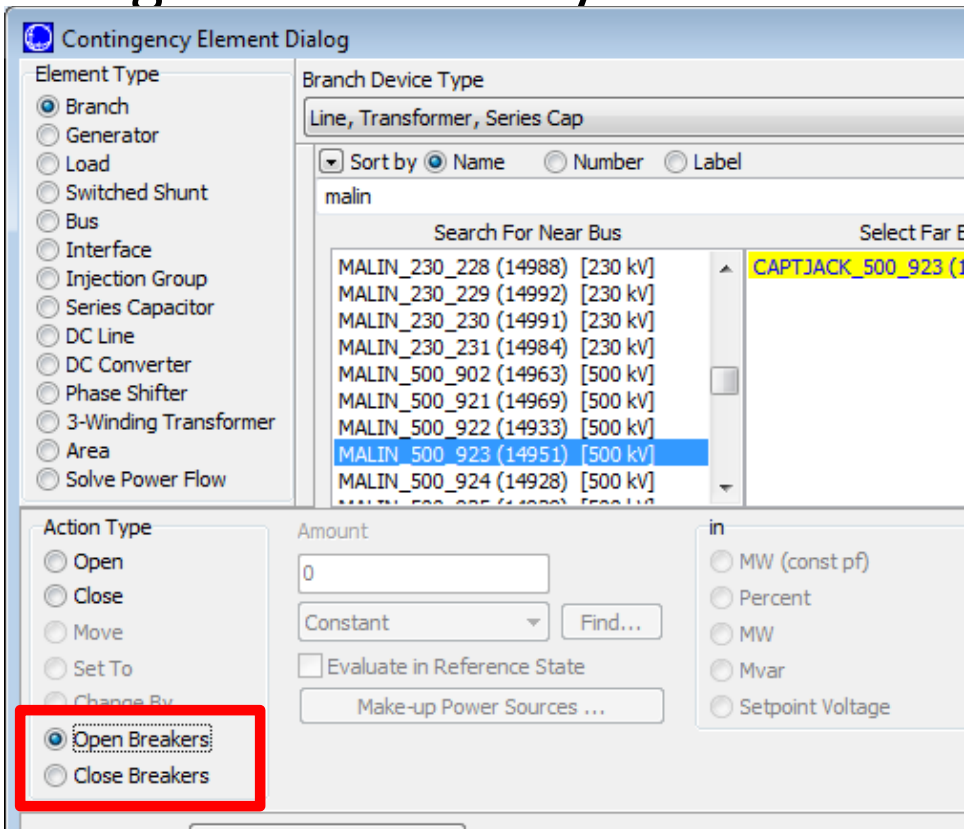


Contingency Definitions

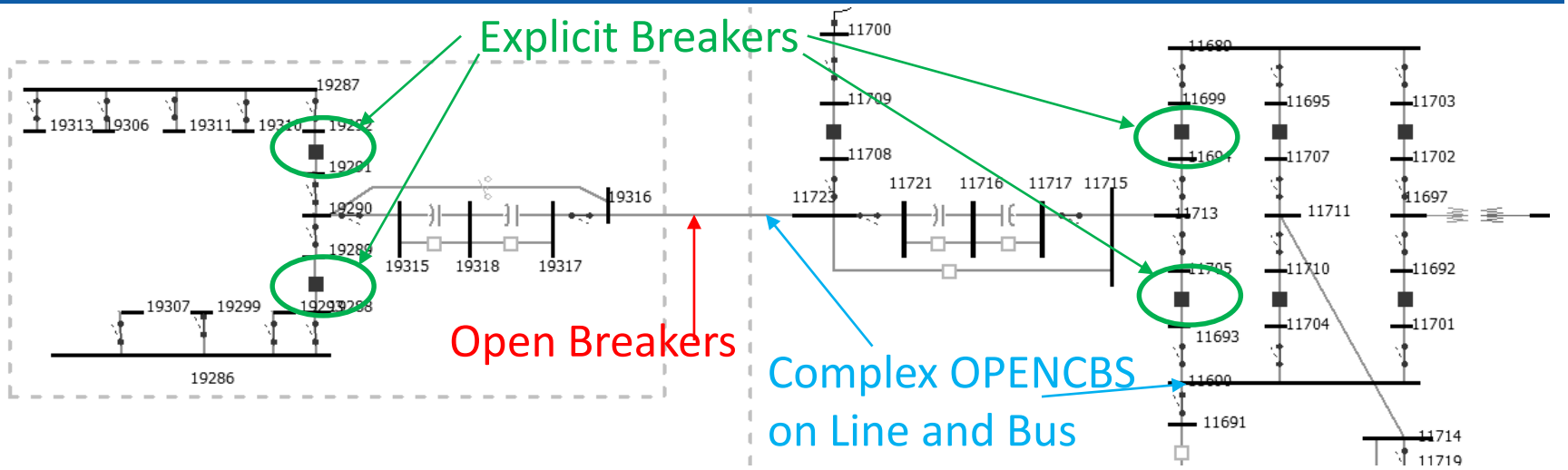
- Bad News
  - In a real-time model these can get very complicated and confusing
    - A “Single Line Outage” turns into 4 different breakers opening together
    - The breakers necessary to isolate a line change as system topology changes
  - We need a better way to define a contingency (which we have)
- Good News
  - We can model a breaker failure easily now

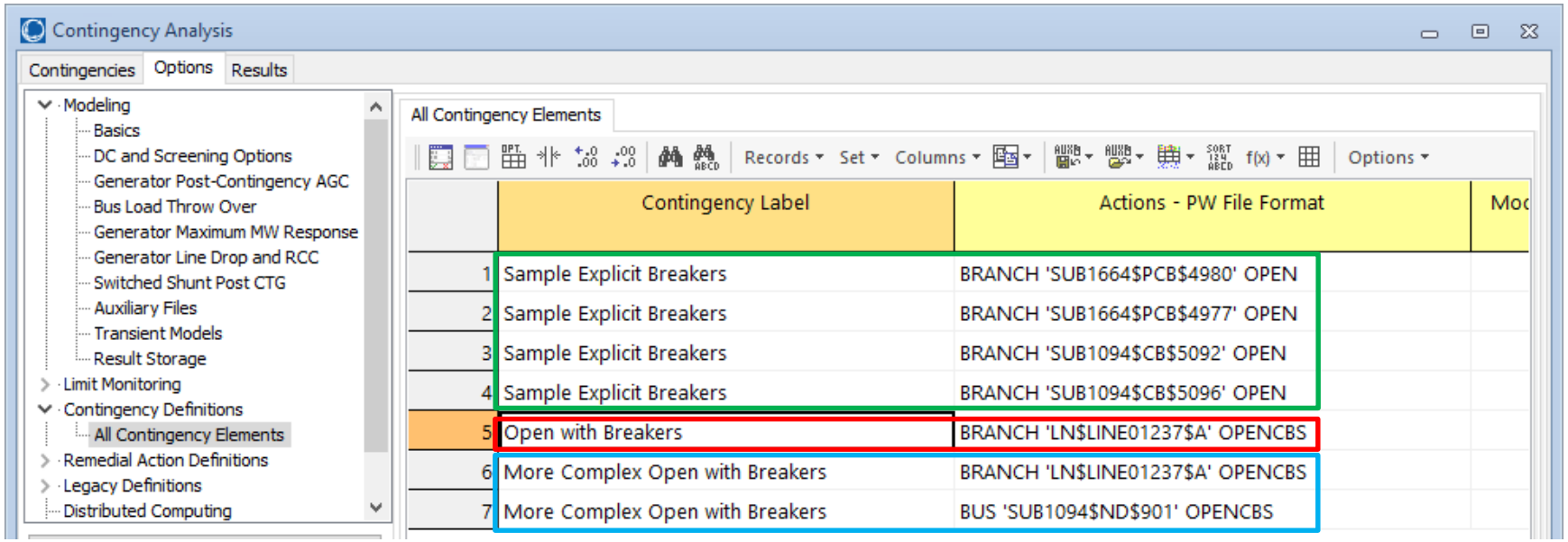
“Open with Breakers” and “Close with Breakers” Contingency Actions

- Open a device using breakers instead of changing the status of the device directly
- Ensures that accurate modeling of real-time system is achieved
- Automatically determine *Breakers* that need to open to isolate an element
- Breaker failure scenarios can be modeled by applying this action to a breaker
- Same idea for a “Close with Breakers” action



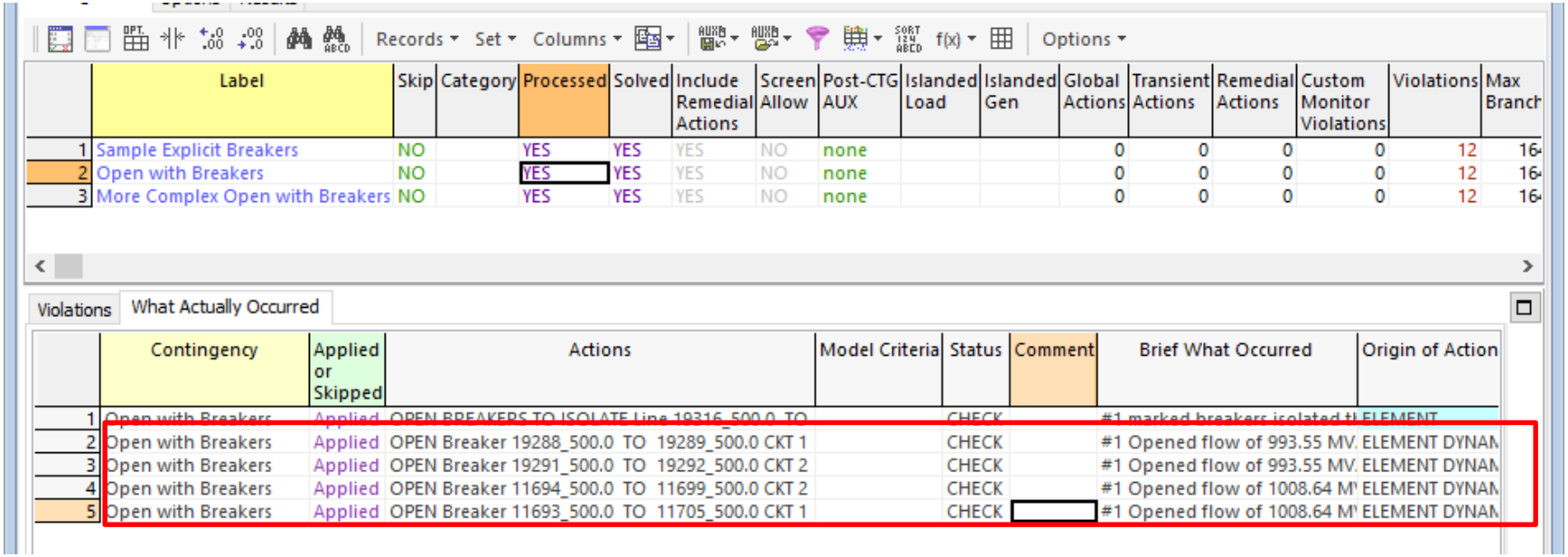
Example Contingency Analysis





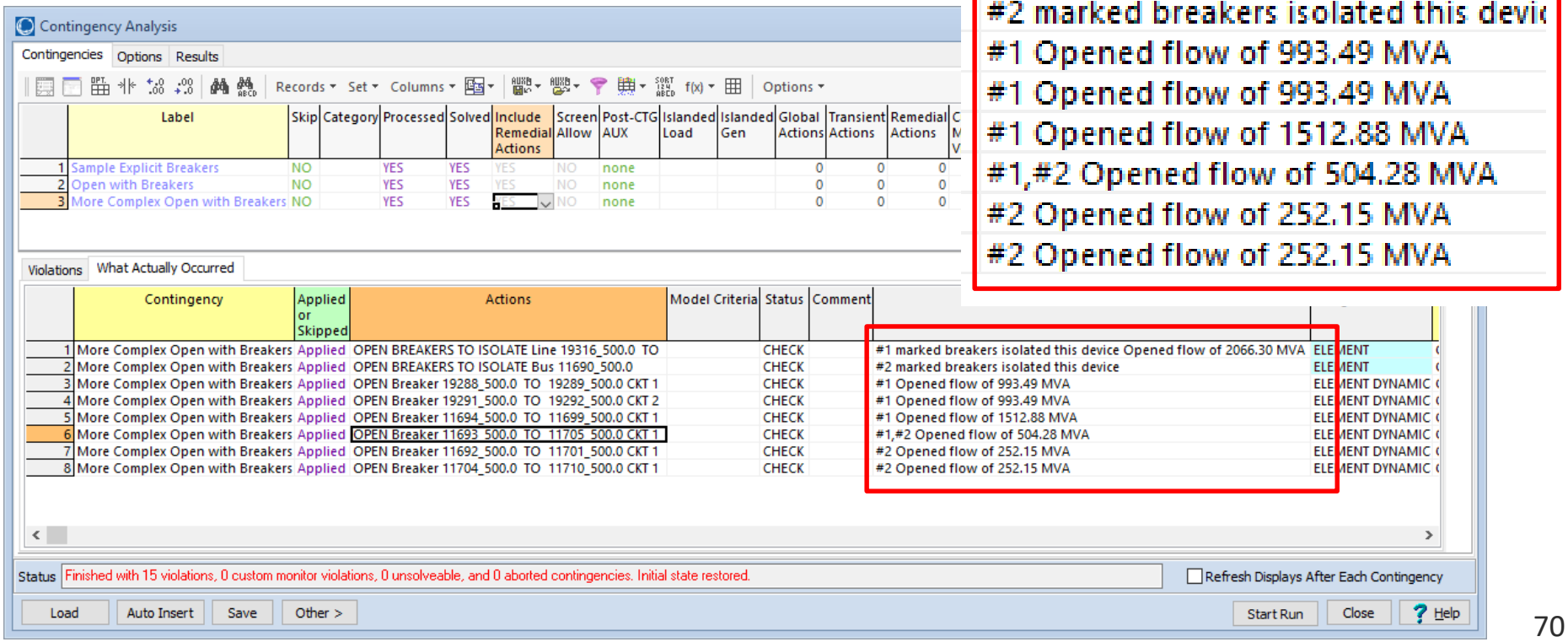
What Actually Occurred Reporting

- OPENCBS action will report which breakers where actually open
  - "Origin of Action" = ELEMENT DYNAMIC
  - This means Simulator dynamically figured out what to open
  - What opens will not always be the same
    - If a disconnect is open that is normally closed then the contingency actions that occur are different



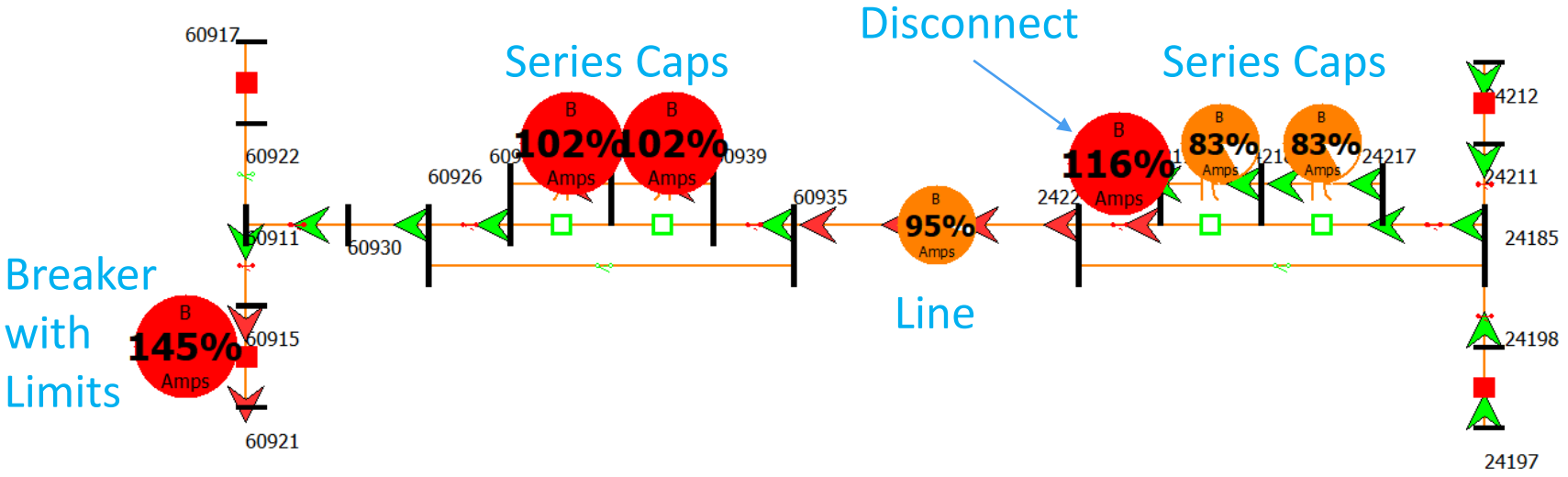
More Complex
What Actually Occurred Reporting

- Special #1, #2, #3 etc. marking in the “What Occurred” indicates which devices required which breakers to open

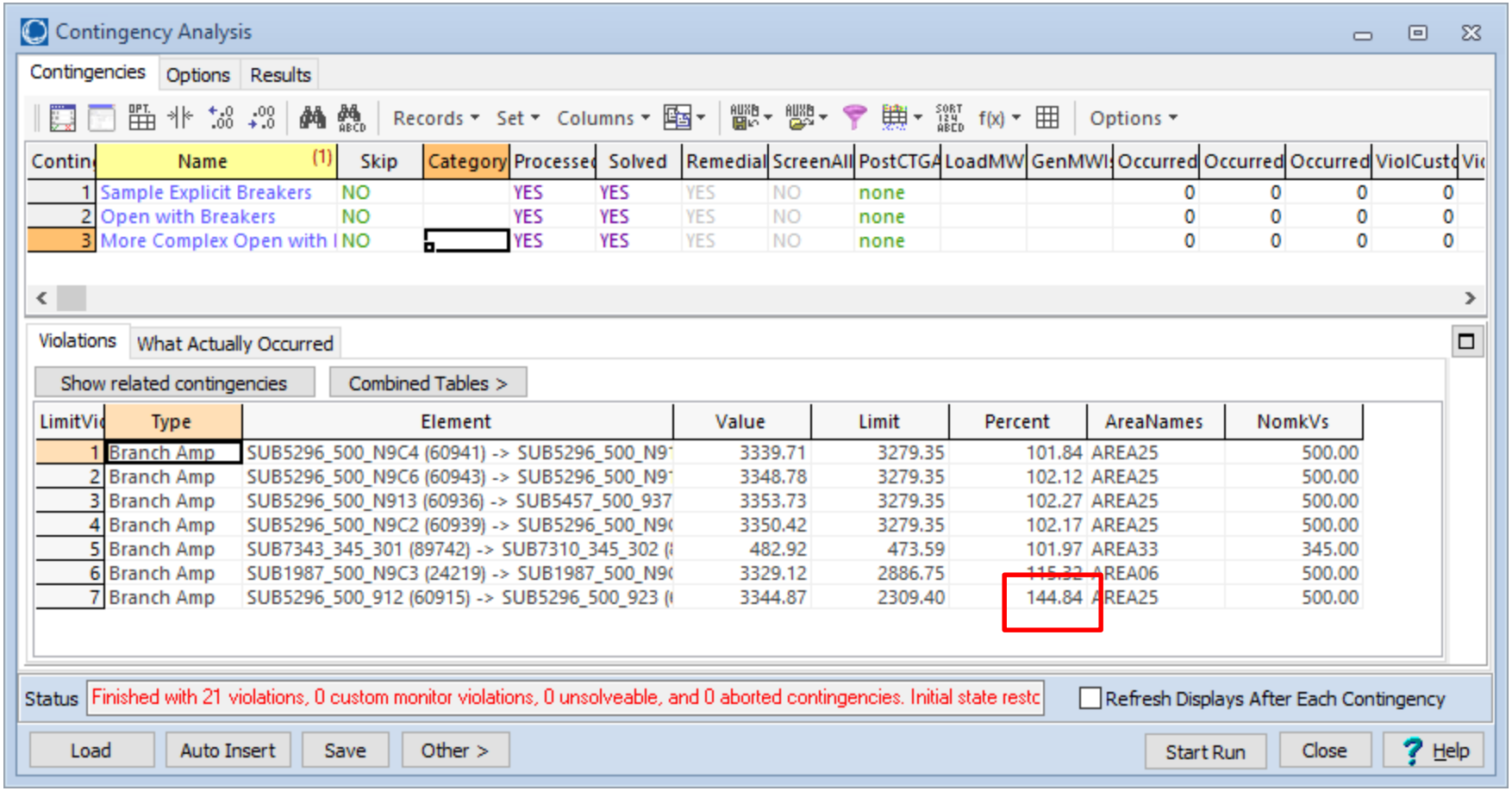


Monitoring of Switching Devices in Contingency Analysis and Power Flow

- Nothing different than before
- A breaker, disconnect, line, transformer, and series cap are all the same
  - Any device *that has a limit* specified is monitored regardless of what is going on inside the solution
  - Software calculates flows on everything



Violations shown as normal

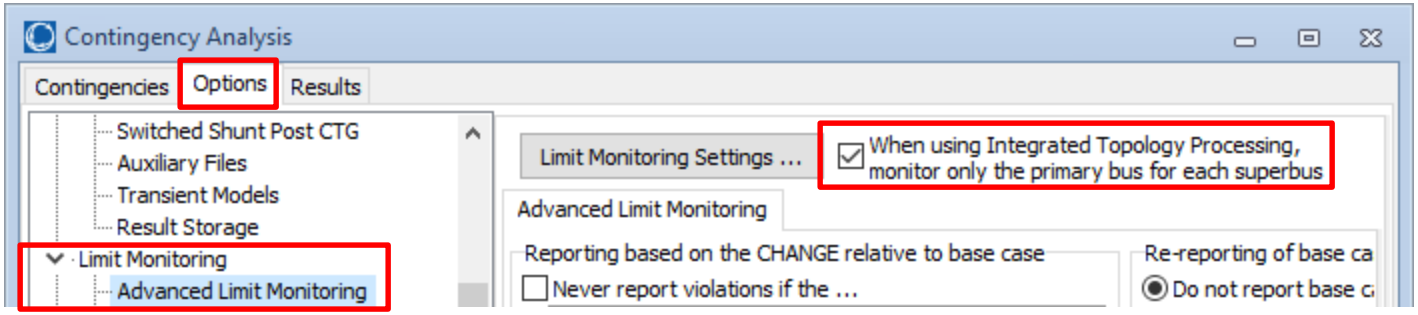


Contin	Name (1)	Skip	Category	Processed	Solved	Remedial	ScreenAll	PostCTGA	LoadMW	GenMWI	Occurred	Occurred	Occurred	ViolCusto	Vi
1	Sample Explicit Breakers	NO		YES	YES	YES	NO	none			0	0	0	0	
2	Open with Breakers	NO		YES	YES	YES	NO	none			0	0	0	0	
3	More Complex Open with I	NO		YES	YES	YES	NO	none			0	0	0	0	

LimitVi	Type	Element	Value	Limit	Percent	AreaNames	NomkVs
1	Branch Amp	SUB5296_500_N9C4 (60941) -> SUB5296_500_N9	3339.71	3279.35	101.84	AREA25	500.00
2	Branch Amp	SUB5296_500_N9C6 (60943) -> SUB5296_500_N9	3348.78	3279.35	102.12	AREA25	500.00
3	Branch Amp	SUB5296_500_N913 (60936) -> SUB5457_500_937	3353.73	3279.35	102.27	AREA25	500.00
4	Branch Amp	SUB5296_500_N9C2 (60939) -> SUB5296_500_N9	3350.42	3279.35	102.17	AREA25	500.00
5	Branch Amp	SUB7343_345_301 (89742) -> SUB7310_345_302 (	482.92	473.59	101.97	AREA33	345.00
6	Branch Amp	SUB1987_500_N9C3 (24219) -> SUB1987_500_N9	3329.12	2886.75	115.32	AREA06	500.00
7	Branch Amp	SUB5296_500_912 (60915) -> SUB5296_500_923 (	3344.87	2309.40	144.84	AREA25	500.00

Bus Voltage Limit Monitoring

- Option (checked by default) will monitor only the primary bus for each super bus
  - Caveat, buses inside a Superbus could have different limits (strange but happens)
    - Also monitors the “highest minimum” and “lowest maximum” voltage inside a Superbus



Is my Line Open? Branch Status Confusion

- Planning software and bus-branch models
  - Two Fields: *Status* and *Online*
  - *Status*: an explicit field to determine if a device is closed/open (because breakers are not modeled)
  - *Online*: whether or not a device is energized is affected by the status of branches
- Real-time models
  - Breaker or disconnect statuses determine the status of other devices
  - No explicit status field for other devices (Generators, Loads, Lines, Transformers, etc.)

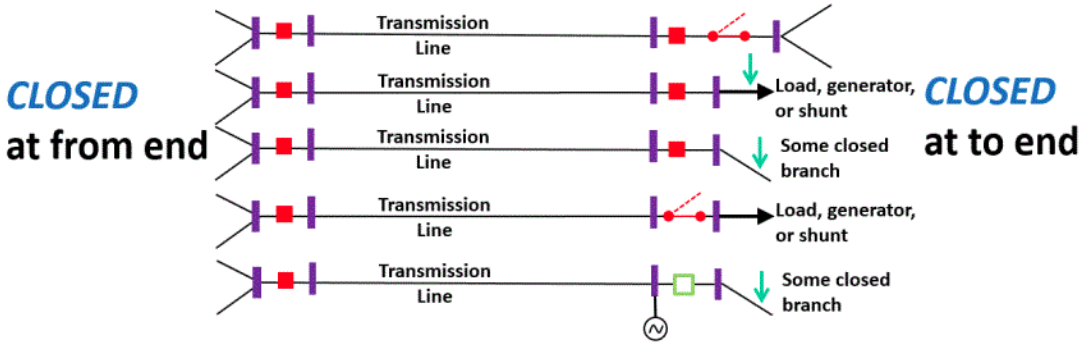
Derived Status: Device Status Confusion

- Typically, when using a full-topology model, *Status* = *Closed* for all non-switching devices (Generators, Loads, Lines, etc.)
- Hybrid model with only parts of the system modeled with breaker detail can still use *Status* field of a non-switching device
- Actual status of a device is confusing
  - Status of a line is really derived from other information (breaker statuses)
  - Software automatically traverses the topology at the terminals of a device to determine its "*Derived Status*"
    - Looks at status of *Breakers* near terminals
  - Software also has a field "*Derived Online*"

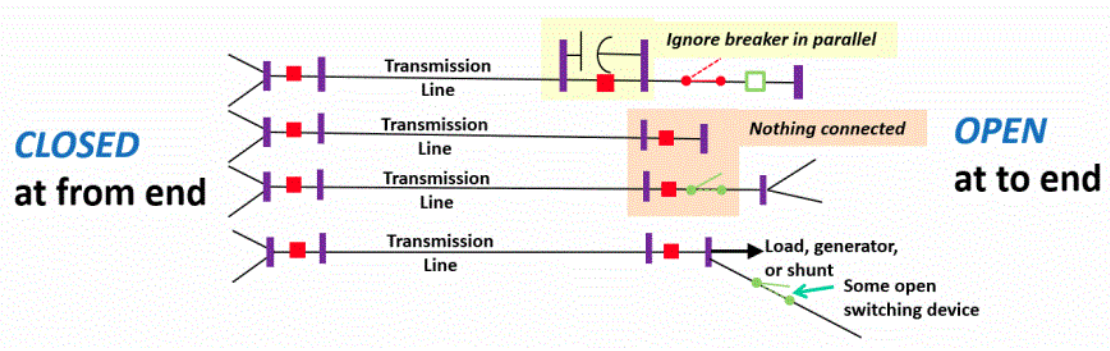
For more details see Simulator Help

- https://www.powerworld.com/WebHelp/#MainDocumentation_HTML/Device_Derived_Status.htm

The following are examples of **Derived Status** = *Closed* lines:



The following are examples of **Derived Status** = *Open To* lines:



Script Command: ExpandBusTopology()

- This can be used to take a bus and split it up automatically
  - You then have to rearrange all the connections that come into this bus though
  - Was added for professors building fake power systems for research purposes
  - You aren't building fake stuff, so just go get your EMS data

ExpandBusTopology(BusIdentifier, TopologyType);

This action is used to expand the topology around the specified bus according to the specified topology type. New breakers and nodes (buses) will be inserted as necessary.

BusIdentifier	:	A bus can be identified in one of these formats: BUS busnum, BUS name_nomkv, BUS label.
TopologyType	:	These types of breaker configurations are allowed: DOUBLEBUSDOUBLEBREAKER, MAINTRANSFER, RINGBUS, BREAKERANDAHALF, SINGLEBUS, and SECTIONALIZEBUS.

More *already maintained data* from the EMS system

- Over the past 2 years, PowerWorld has worked with Peak Reliability to directly import additional information
  - Contingency Definitions from Areva system
  - Remedial Action Scheme definitions from Areva system
  - Scheduled Outage information from the CROW outage schedules
- This is all possible because these systems use the same label convention as used in the EMS
- This is a presentation for another day

Summary

- PowerWorld has a lot of experience working with EMS data
- Hard-learned lessons learned
  - Investment of a huge amount of additional staff time into building parallel data sets won't work
    - It might work for a pilot project but will fail in practice
  - You need to use the already maintained data sets as much as possible
  - Industry's response to asking that additional data sets be maintained is
    "Don't change my data, change your software"

What should the industry do

- Do NOT build a parallel process maintaining a second full-topology model
  - This is not sustainable
  - Would require an enormous new permanent expense of additional engineering staff
- Instead: change the starting model
  - Start with a recent EMS system model
    - Comes with already maintained: model, diagrams, contingency definitions, RAS, etc.
  - Discuss with the EMS system folks and ask them to add some more detail
    - EMS software already supports - just add more model info

Existing EMS model updates

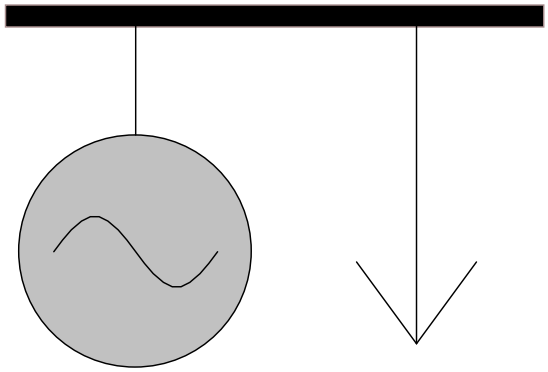
- EMS engineers already struggle to keep models up to date communicating amongst themselves
- I can not envision a reliable process that adds to this workload by adding coordination with planning models as well

What do Planners need to ask of EMS Engineers

- Add more detail to EMS models.
- Existing EMS software supports: just add more model info
  - Generator station auxiliary loads
  - Generator step-up transformers
  - Keep the “normal” status of switching devices up-to-date (breakers, disconnects)
    - This are vital to putting lines, gens, etc back into service
  - Remove artificial device aggregation
    - 2 generators grouped into a single generator in the model
- Historically this detail was not vital to EMS tools such as SCADA / State Estimation / Contingency Analysis
  - This detail is important for transient stability and voltage stability analysis though

Generator Station Load

- In real-time systems, sometimes the generator station load is not modeled explicitly.
  - May not have separate measurements for generator output and station load
  - This will be a problem if trying to do some types of analysis (Transient Stability)
  - Example of where additional detail in “planning” model may need to be pushed into the real-time model



Planning Software tools need to be updated

- Must support full topology
- Remove artificial device aggregation
  - EMS models do not group together 10 capacitor banks into a single “switched shunt”
- Longer-term discussion of more complex equipment
  - DC transmission devices in particular are not consistently modeled across EMS and Planning software tools
- Use as much *already-maintained* data from EMS system as possible
  - Model, oneline, contingencies, RAS, etc.

Envisioned Process

- Planning engineers already have to integrate future projects into a model
  - They've done this for decades
  - They will always do this
- Just switch the starting model to be a recent EMS model export instead
  - Maybe grab this snapshot at an interval
  - The "normal" status of switching devices matter here (must put that in the EMS model)