



# Event-based RAS Implementation in Powerworld

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# Overview

- Cover current practices
- Theory in implementation of RAS
- Functionality of RAS
  - Outage Conditions
  - Arming levels



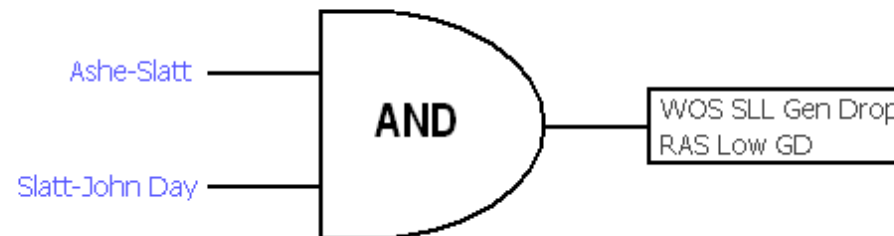
# Problems with present practice

- RAS is currently being modeled inside each individual contingency
  - Means that contingency list has to be updated for every topology change that could affect which contingency triggers a RAS operation.
  - Condition-based RAS is only included with contingencies thought to cause it's initiation
- RAS arming levels may also change with outage conditions.
  - These have to be updated manually when these impacting outages occur.



# Current Methodology

- Given a contingent loss of both lines “Ashe-Slatt” and “Slatt-John Day” will result in some RAS Action(s)





# Current Methodology (cont.)

- These RAS Actions are modeled inside of the contingency definition

The screenshot shows the 'Contingency Analysis' software interface. The main window displays a table of contingencies with columns for Label, Skip, Process, Solved, Violator, Max Branch %, Min Volt, # of unlinked actions, Memo, # of actions, and # of iterations. Contingency 95 is highlighted in orange.

Label	Skip	Process	Solved	Violator	Max Branch %	Min Volt	# of unlinked actions	Memo	# of actions	# of iterations
80 BFR 4870 Big Eddy-John Day/Big Eddy TX B	NO	YES	YES	0			0	N-2 BIG EDDY JOHN DAY BIGEDDY 1	2	1
94 BFR 5003 (or 5006) Boardman PH	NO	YES	YES	0			0	N-2 SLATT BOARD F	2	1
95 BFR 5018 Ashe-Slatt/Slatt-John Day	NO	YES	YES	0			0	N-2 ASHE SLATT JOHN DAY RAS= WOS SLL Gen Drop RAS Low GD	4	2
96 BFR 5028 Buckley-Grizzly/Grizzly-Summer L	NO	YES	YES	0			0	N-2 GRIZZLY GRIZZ R3 PONDROSA SUMMER L BUCKLEY RAS= RAS L	3	4

The 'Contingency Definition' window for contingency 95 shows the following actions:

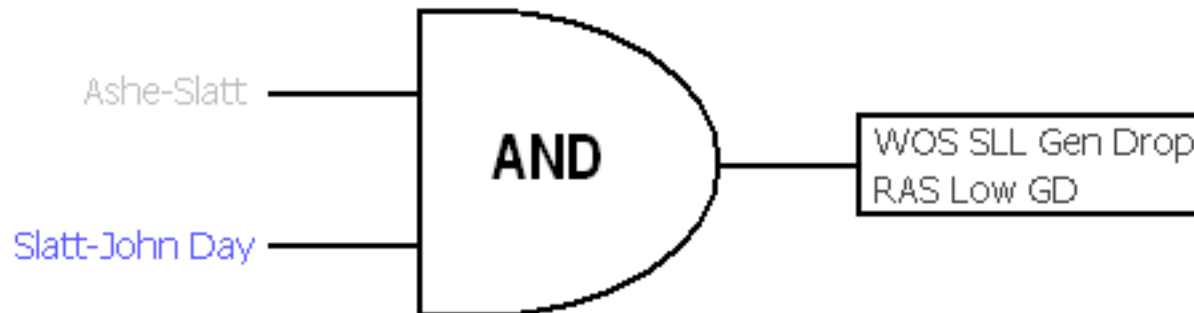
Number	Name From	Model Criteria	Status	Comm
1	OPEN Line ASHE_500.0 (40061) TO SLATT_500.0 (40989) CKT 1		CHECK	
2	OPEN Line JOHN DAY_500.0 (40585) TO SLATT_500.0 (40989) CKT 1		CHECK	
3	Perform the actions in block "WOS SLL Gen Drop"		CHECK	
4	Perform the actions in block "RAS Low GD"		CHECK	

The status bar at the bottom indicates 'Status: Initialized' and includes buttons for 'Load', 'Auto Insert', 'Save', 'Other >', 'Start Run', 'Close', and 'Help'.



## Current Methodology (cont.)

- Outage conditions will alter which contingencies could cause a RAS Action





# Current Methodology (cont.)

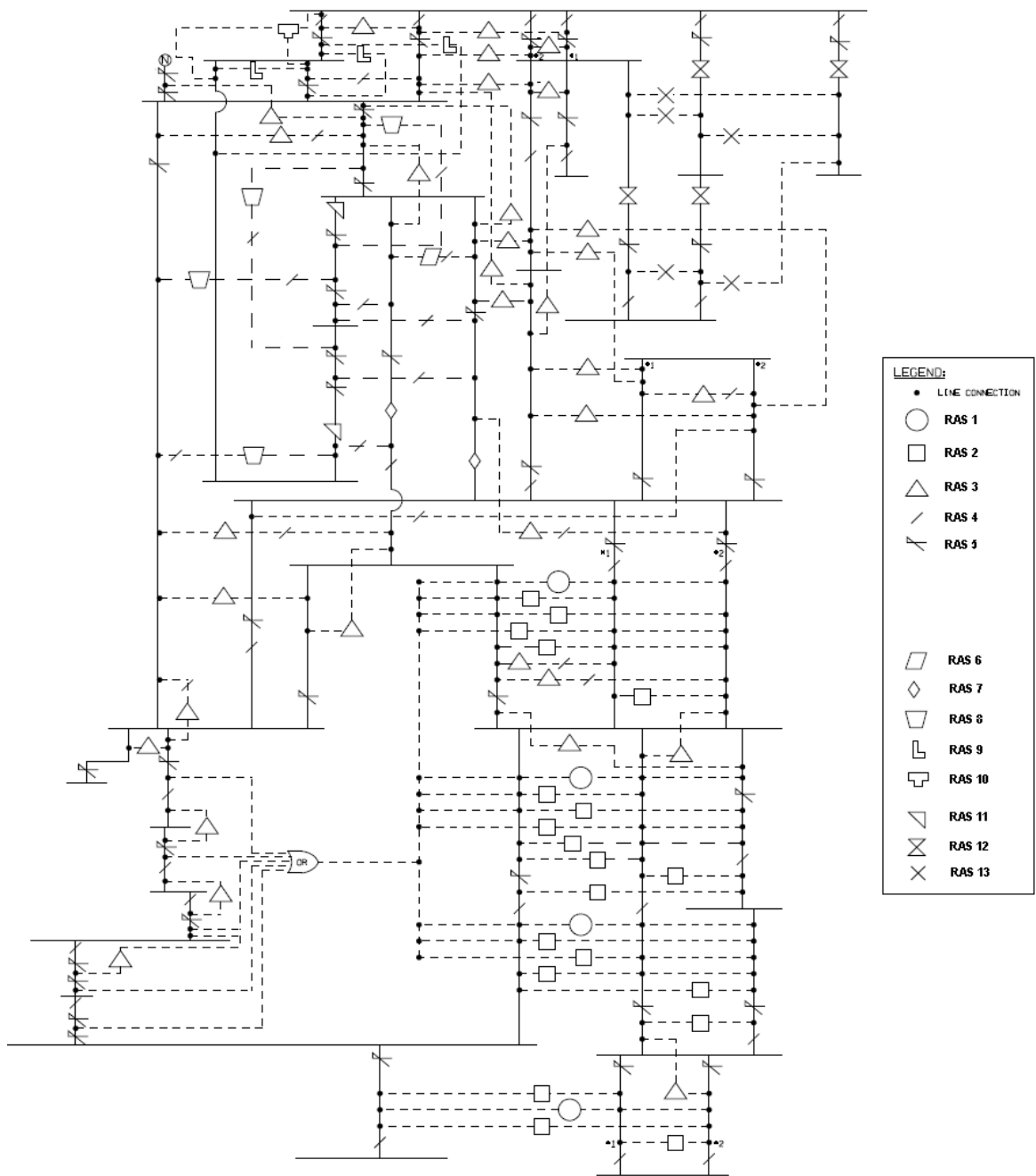
- This then requires the manual manipulation of contingency definitions

The screenshot shows the 'Contingency Analysis' software interface. The main window displays a table of contingencies with columns for Label, Skip, Process, Solved, Violator, Max Branch %, Min Volt, # of unlinked actions, Memo, # of actions, and # of iterations. The table lists six contingencies, with the sixth one, 'L/D Slatt-Buckley/Slatt-John Day NOT CREDIBLE', highlighted in orange.

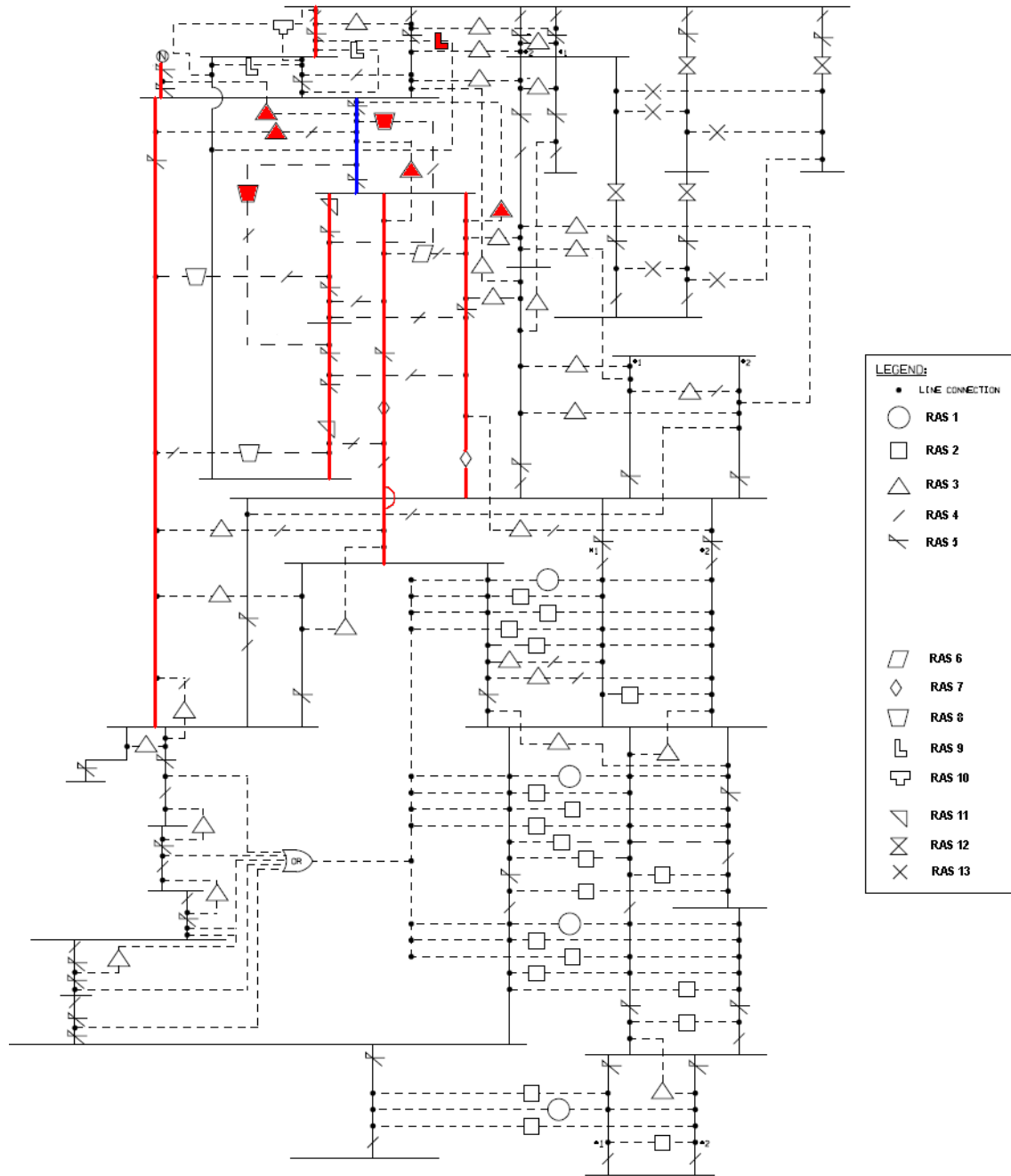
Below the main table, there are two sub-panels: 'Violations' and 'Contingency Definition'. The 'Contingency Definition' panel is active, showing a table of actions for the selected contingency. The actions are:

Number	From	Name From	Model Criteria	Status	Comm
1		OPEN MultiSectionLine BUCKLEY_500.0 (40155) TO SLATT_500.0 (40989) CKT 1		CHECK	
2		OPEN Line JOHN DAY_500.0 (40585) TO SLATT_500.0 (40989) CKT 1		CHECK	
3		OPEN Line ASHE_500.0 (40061) TO SLATT_500.0 (40989) CKT 1		CHECK	
4		Perform the actions in block "RAS Low GD"		CHECK	

The interface also includes a 'Status' field set to 'Initialized', a 'Refresh Displays After Each Contingency' checkbox, and buttons for 'Load', 'Auto Insert', 'Save', 'Other >', 'Start Run', 'Close', and 'Help'.









# Theory behind RAS Improvements

- Automatic alterations of RAS actions in different system topologies
  - This required the need to separate the system topology from the base (outage) case from changes in topology caused by a contingency action



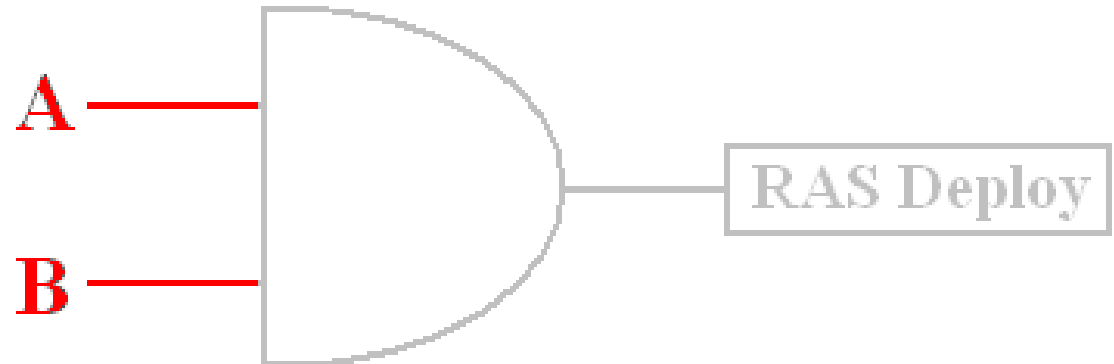
## Defining Element “status”

- Powerworld has the ability to monitor any variable on any given element through any equality, inequality or equation.
  - This is called “**Model Condition**”
  - If it meets the given criteria it will output a logical “True”



# Application

**Model Condition(s)**





# Assignment of Model Conditions

**Define Model Conditions**

Model Condition Name: Ashe-Slatt 1 500kV Line (Open)

Buttons: Save, Save As, Rename, Delete

Evaluate in Contingency Reference State

**Disable if True in Contingency Reference State**

Element Type: Area, Branch (selected), Bus, DC Transmission Line, Generator, Injection Group, Interface, Limit Set, Load, Model Expression, Multi-Terminal DC Record, Nomogram, Owner, Substation, Super Area, Switched Shunt, Transformer, Zone

Sort by: Name (selected), Number

Filter: Advanced, Branch

Use Area/Zone Filters

Buttons: Define/Find..., Remove, Search Next, Search All

You can use wildcard characters \* or ?

```

ASCARATE ( 11020 ) TO TROWBRIG ( 11041 ) CKT 1 [ 115 kV]- [115 kV]
ASCARATE ( 11020 ) FROM DURAZNO ( 11174 ) CKT 1 [ 115 kV]- [115 kV]
ASCARATE ( 11020 ) FROM SUNSET_N ( 11157 ) CKT 1 [ 115 kV]- [115 kV]
ASCARATE ( 11021 ) TO ASCARATE ( 11019 ) CKT 1 [ 13.8 kV]- [69 kV]
ASCARATE ( 11022 ) TO ASCARATE ( 11019 ) CKT 1 [ 4.16 kV]- [69 kV]
ASH TP ( 22012 ) FROM ASH ( 22008 ) CKT 1 [ 69 kV]- [69 kV]
ASH TP ( 22012 ) FROM FELICITA ( 22288 ) CKT 1 [ 69 kV]- [69 kV]
ASH TP ( 22012 ) FROM VALCNTR ( 22870 ) CKT 1 [ 69 kV]- [69 kV]
ASH ( 22008 ) TO ASH TP ( 22012 ) CKT 1 [ 69 kV]- [69 kV]
ASH ( 22008 ) FROM ESCNDIDO ( 22256 ) CKT 1 [ 69 kV]- [69 kV]
ASH 132 ( 50327 ) TO ASH 13G1 ( 50298 ) CKT 1 [ 132 kV]- [13.8 kV]
ASH 132 ( 50327 ) FROM GCL 132 ( 50325 ) CKT 1 [ 132 kV]- [132 kV]
ASH 13G1 ( 50298 ) FROM ASH 132 ( 50327 ) CKT 1 [ 13.8 kV]- [132 kV]
ASHE ( 40059 ) TO ASHE F ( 40060 ) CKT 1 [ 230 kV]- [230 kV]
ASHE ( 40059 ) TO ASHE TAP ( 40065 ) CKT 1 [ 230 kV]- [230 kV]
ASHE ( 40059 ) TO TR5 ( 40064 ) CKT 1 [ 230 kV]- [230 kV]
ASHE ( 40059 ) TO WHITE BL ( 41149 ) CKT 1 [ 230 kV]- [230 kV]
ASHE ( 40059 ) TO WNP1 ( 40058 ) CKT 1 [ 230 kV]- [230 kV]
ASHE ( 40061 ) TO ASHE R1 ( 40062 ) CKT 2 [ 500 kV]- [500 kV]
ASHE ( 40061 ) TO CG5 ( 40063 ) CKT 1 [ 500 kV]- [25 kV]
ASHE ( 40061 ) TO HANFORD ( 40499 ) CKT 1 [ 500 kV]- [500 kV]
ASHE ( 40061 ) TO LOW MON ( 40683 ) CKT 1 [ 500 kV]- [500 kV]
ASHE ( 40061 ) TO SLATT ( 40989 ) CKT 1 [ 500 kV]- [500 kV]
    
```

Meets the filter below: Set Filter Same As

Select Filter Type: Branch

Pre-filter using Area/Zone/Owner Filters

Enabled (normally checked)

Logical Comparison: AND (selected), OR, Not AND, Not OR

Condition 1: Find... Status, string starts with, O

Use Another Filter

Buttons: Add >>, Delete ...

Enable Field to Field Comparisons

Buttons: OK, Help, Cancel



# Defining a logic gate

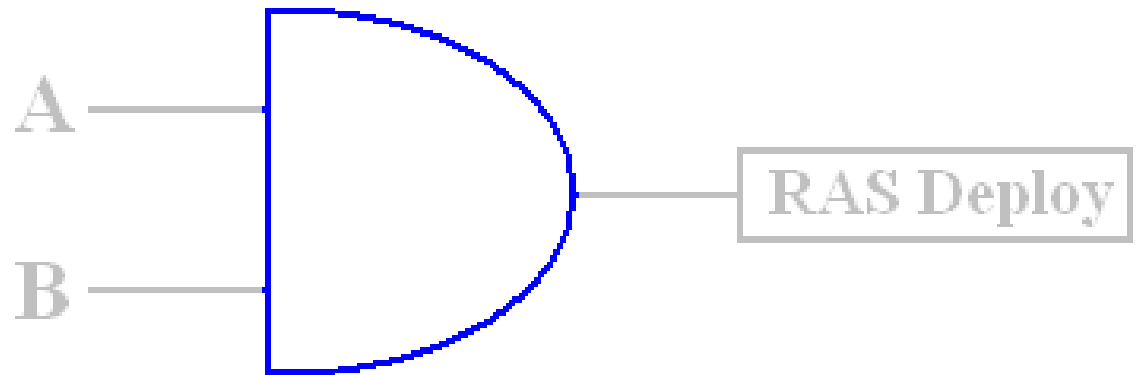
- A model condition can only be used to provide a logical output for a given element.
  - To pair multiple line conditions together, a “model filter” is used



# Application

## Model Filter

Model Condition(s)





# Assignment of Model Filters

**Filter Conditions** [X]

Filter Name: Low Gen Drop: ASHE-SLAT & SLAT-JDAY

Save Save As Rename Delete View Filter Logic

Logical Comparison

AND  OR  Not AND  Not OR

Model Condition 1

Find... Slatt-John Day 1 500kV Line (Open)  Condition  Filter  Not

Model Condition 2

Find... Ashe-Slatt 1 500kV Line (Open)  Condition  Filter  Not

Add >> Delete ... Modify Model Conditions

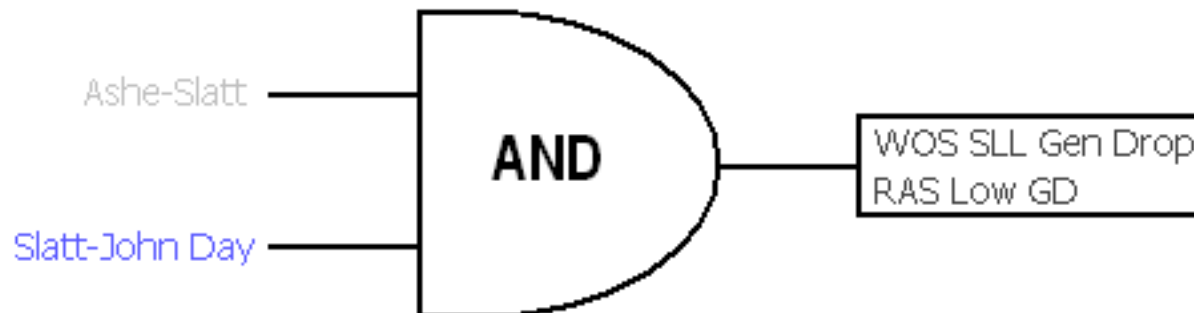
OK Help Cancel





# Example

- If “Ashe-Slatt” is out of service in the base case, the logic status of the “Ashe-Slatt” will be ignored, therefore the only logic input that will be considered is for the “Slatt-John Day”. This means if the “Slatt-John Day” status changes for ANY contingency, the RAS Action will occur





## Defining a RAS action

- “Contingency Global Actions” are used for specifying the action that the RAS would cause when deployed.
- The requirement needed to be met for it’s action can either be a model condition or filter.

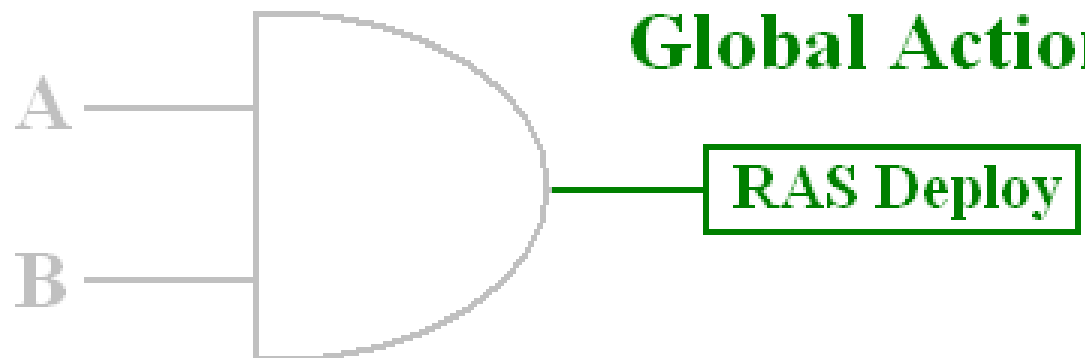


# Application

Model Filter

**Global Action**

Model Condition(s)





### Contingency Element Dialog

**Element Type**

- Branch
- Generator
- Load
- Switched Shunt
- Bus
- Interface
- Injection Group
- Series Capacitor
- DC Line
- DC Converter
- Phase Shifter
- 3-Winding Transformer
- Area
- Solve Power Flow
- Contingency Block

**Choose the Element**

Sort by  Name  Number

- Paul area load
- Pelton
- PG&E blocked
- Port Westward
- Priest Rapids
- Puget total load
- Puget variable load
- RAS BCH-NW Gen Drop Units
- RAS High Gen Drop Units
- RAS Jones Canyon Wind Gen
- RAS Low Gen Drop Units**
- RAS NOH Gen Drop Units
- RAS P-A/M-A Gen Drop Units
- RAS PDCI Gen Drop Units
- RAS Raver-Paul Gen Drop Units
- RAS South of Allston Gen Drop units
- RAS WOJD Gen Drop
- RAS WOM DLL Gen Drop Units
- RAS WOM SLL Gen Drop Units
- RAS WOM Gen Drop Units

**Action Type**

- Open
- Close
- Move
- Set To
- Change By

**Amount**

Low Gen Drop Armed

Model Expression

Evaluate in Reference State

**in**

Percent

MW

Use Merit Order for Generators

Open Generators in Merit Order

Status:  TOPOLOGYCHECK

Model Criteria:  Low Gen Drop (Deploy)

Inclusion Filter:

Comment:



# Defining a Model Expression

- If the severity of the RAS action is dependent and varies based upon an independent variable (i.e. path flow), then a “Custom Model Expression” is used.
- The use of Model Expressions allow an equation, limit or inequality to be used for calculating values
  - Has the same capability as the “Model Condition” for defining any value as a variable
  - Can also use logical outputs from model Conditions or Filters as a conditional output

**If(statement = "True",Output(true),Output(false))**



**Define Model Custom Expressions**

Custom Expression: Arming: HGD = COI minus 1000MW (COI>1200MW)

Buttons: Save, Save As, Rename, Delete

Choose the Type of Expression: Expression, Lookup Table

x1= Define... Interface COI (66) : MW Flow

**Model Field**

Element Type: Area, Branch, Bus, DC Transmission Line, Generator, Injection Group, **Interface**, Limit Set, Load, Model Condition, Model Expression, Model Filter

93 entries, Sort by: Name, Number

Filter: Advanced, Interface

Buttons: Define/Find..., Remove, Search Next, Search All

You can use wildcard characters \* or ?

- 55 (BROWNLEE EAST)
- 58 (ELDORADO - MEAD 230 KV LINES)
- 59 (WALC BLYTHE - SCE BLYTHE 161 KV)
- 6 (WEST OF HATWAI)
- 60 (INYO - CONTROL 115 KV TIE)
- 61 (LUGO - VICTORVILLE 500 KV LINE)
- 62 (ELDORADO - MCCULLOUGH 500 KV)
- 63 (PERKINS - MEAD - MARKETPLACE 500)
- 65 (PDCI)
- 66 (COI)**
- 67 (Columbia Traction)

Choose a Field: Find... MW\MW Flow

Buttons: OK, Remove, Help, Cancel



### Define Model Custom Expressions

Custom Expression: **Arming: HGD = COI minus 1000MW (COI>1200MW)**

Save Save As Rename Delete

Choose the Type of Expression

Expression | Lookup Table

x1= Define...	Interface COI (66) : MW Flow
x2= Define...	ModelFilter Arming: HGD = COI minus 1000MW (COI>1200MW)
x3= Define...	Choose a Model Field
x4= Define...	Choose a Model Field
x5= Define...	Choose a Model Field
x6= Define...	Choose a Model Field
x7= Define...	Choose a Model Field
x8= Define...	Choose a Model Field

function ( x1, x2, x3, x4, x5, x6, x7, x8) =

```
iif(x2=="YES",-iif(x1>1200,min(x1-1000,2700),0),0)
```

OK Help Cancel



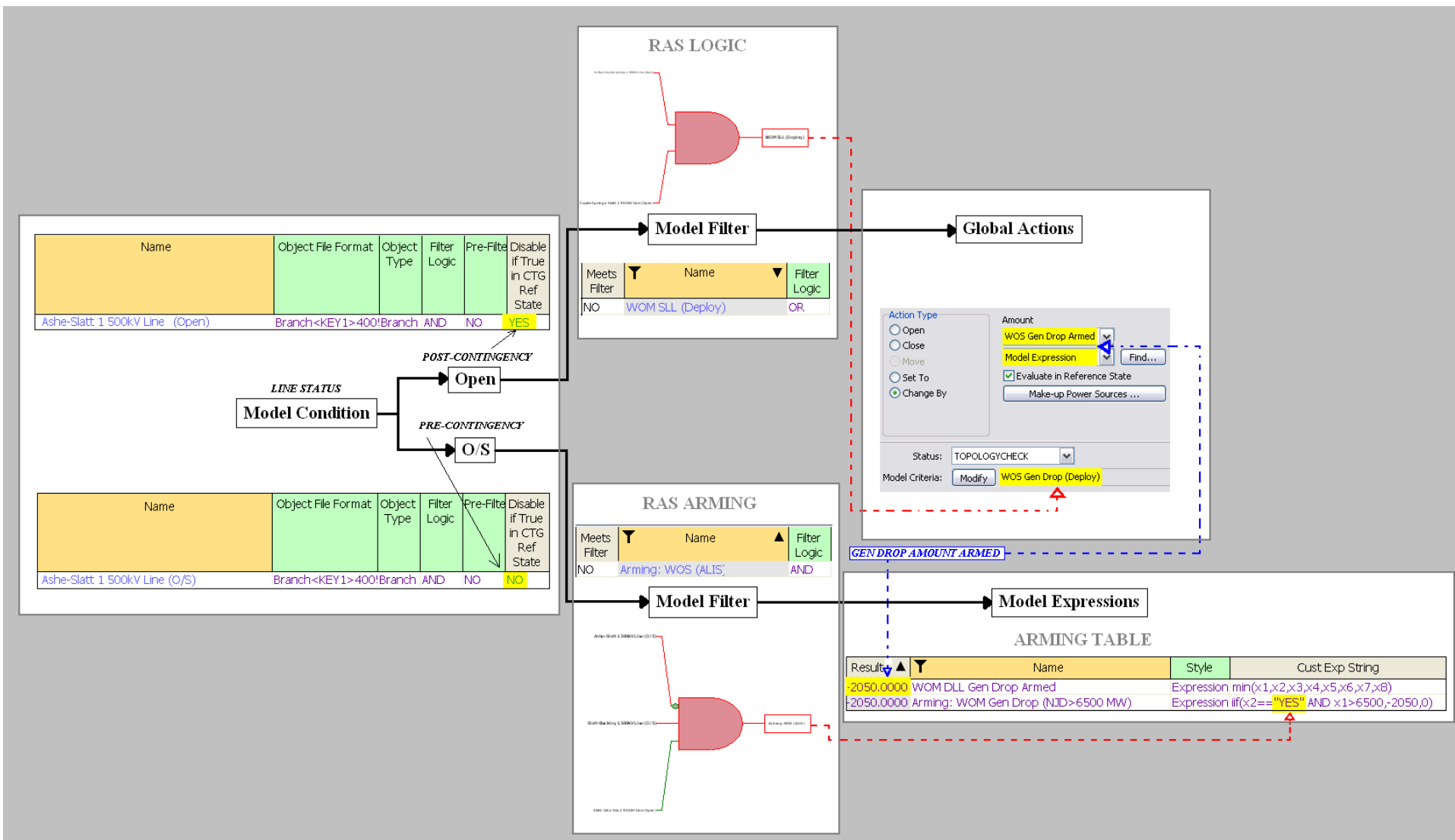
# Application

- This method allows the RAS action to then become responsive in it's severity to case conditions

The screenshot displays the configuration interface for the 'RAS High Gen Drop Units' action. The interface is divided into several sections:

- Dropdown List:** A list of actions is shown, with 'RAS High Gen Drop Units' selected and highlighted in blue. Other options include 'Puget total load', 'Puget variable load', 'RAS Low Gen Drop Units', and 'RAS NOH Gen Drop Units'.
- Action Type:** A group of radio buttons allows selecting the action type: 'Open', 'Close', 'Move', 'Set To', and 'Change By' (which is selected).
- Amount:** A dropdown menu is set to 'High Gen Drop Armed'. Below it, a dropdown menu is set to 'Model Expression', which is highlighted with a red box. A 'Find...' button is located to the right of this dropdown. Below the 'Model Expression' dropdown, the checkbox 'Evaluate in Reference State' is checked and highlighted in yellow. A 'Make-up Power Sources ...' button is located at the bottom of this section.
- in:** A group of radio buttons allows selecting the unit: 'Percent' and 'MW' (which is selected).
- Checkboxes:** Two checkboxes are checked: 'Use Merit Order for Generators' and 'Open Generators in Merit Order'.





B O N N E V I L L E P O W E R A D M I N I S T R A T I O N



B O N N E V I L L E P O W E R A D M I N I S T R A T I O N



B O N N E V I L L E P O W E R A D M I N I S T R A T I O N

