

PowerWorld Corporation

Customer-Driven Development



Jamie Weber

weber@powerworld.com

217-384-6330 ext. 13



PowerWorld
Corporation

**2001 South First Street
Champaign, Illinois 61820
+1 (217) 384.6330**

**support@powerworld.com
<http://www.powerworld.com>**

Recap



- I presented the following slides at our Client Conference in January 2013

PowerWorld RAS Modeling



- This has a very long history in PowerWorld Simulator dating to 2000
- The contingency analysis tool has been designed from its beginning in about 2000 to include RAS modeling
 - Work done with BPA in 2000-2004 timeframe
 - Follow-on work at BPA to ensure concepts were inherited in ATC and PVQV tools (2004-2006)
 - Also work with ISO – NE and TVA throughout 2006 – 2012
 - Continued work with BPA recently as well
- This presentation is a recap of features going back to 2000 and an introduction of some new ones added recently

Features Related to Modeling Contingency Analysis RAS (1/3)



- Advanced filtering (created in 2000)
- Conditional contingency actions (2001)
 - Model Criteria (Model Conditions and Model Filters)
 - CHECK and POSTCHECK actions
- Lookup tables or expressions in Contingencies (2002)
 - Model Expressions
- Contingency actions grouped together (2003)
 - Contingency Blocks
 - Contingency Global Actions
- Storing which actions were triggered
 - What Actually Occurred (2003)
 - Specifying origin of action – Blocks, Global Actions (2011)
- Generation Drop Modeling
 - Injection Group Contingency Actions (2002)
 - Injection Group Generator Scale in Merit Order(2004)

Features Related to Modeling Contingency Analysis RAS (2/3)



- Limit Monitoring by Exception (2007)
- Generation Drop Modeling Revisit
 - Injection Group Generator Open in Merit Order (2009)
 - Accounting for overlapping gen drop (2012)
 - Contingency Action - Evaluate Model Expression in Reference State (2012)
- Full Topology Models (on next page)
- Contingency Analysis Custom Monitoring
 - Ability to monitor anything during a contingency (2011)
- Conditional Actions based on Status Only (2012)
 - TOPOLOGYCHECK actions
- Global RAS Modeling (2012)
 - Use Global Contingency action with new Model Condition Feature: *Evaluate in Reference State*

Features Related to Modeling Contingency Analysis RAS (3/3)



- Using Full Topology Models (node-breaker models) (2007)
 - Integrated Topology Processing (Incremental Topology Processing) (2007)
 - Limit Monitoring restriction to Superbus (2008)
 - Open with Breakers contingency actions (2009)
 - Close with Breakers contingency actions (2011)
 - Derived Status and Derived Online (2011)
 - Refinements (2012)

History of Software Development



- History of the Contingency Analysis Tool
 - Initial development in early PowerWorld Simulator versions before 1999
 - Work with BPA to make conditional actions and many advanced features (2000 – 2004)
 - Work with ISO – New England to implement features for full-topology models (2006 – 2008)
 - Work with ISO-NE and TVA on Full-Topology Model (2008 – 2012)
 - Work with BPA to permit more generic modeling of RAS (2011 – 2012)
 - Global RAS so don't need to embed RAS in particular contingencies
 - Allows use in full-topology models
 - Consistent modeling for all users inside BPA
- History of other tools in Simulator are very similar
 - A handful of customers drive the *incremental* development in lots of small projects
 - Almost all of Simulator's tools have been made in this manner
 - ATC, PVQV, OPF, SCOPF, OPF Reserves, Scheduled Actions, SimAuto, Integrated Topology Processing, Transient Stability, Sensitivity tools, Connection tools, etc...
 - Only exception we can think of is GIC (nobody even did this previously)

Software Development Process



- More than 100 small incremental tasks done over more than 13 years with several clients
 - As small as a 0.5 person-days, no bigger than 2 person-months
- Project Timing
 - Most tasks are spelled out with 3 – 5 days of software development time and a deliverable within 2 weeks
 - Expectation is that user will test the new features *immediately* and within a few days we're certain it functions as desired
 - Feedback with the PowerWorld developer and actual end-user is frequent (weekly, if not daily at times)
 - Even large project get broken up into small tasks so progress can be measured and user is constantly engaged in providing feedback
- Why do it this way?
 - Software developer doesn't understand what the user needs
 - Often the user isn't certain either
 - Small tasks ensure everyone learns quickly what works and what doesn't
 - constant short engagements builds trust
 - Nice thing about software is manufacturing process is free (compile, move file to web server, email notice)

How much does this cost?



- Because of some recent discussions I have been hearing within WECC, it's become clear to me folks don't realize how good a deal this can be
- Complete Transparency
 - Following slides show the amount of user-funded development that has been done at PowerWorld Corporation since our company founding in 1996
 - \$2.3 million = TOTAL! For 18 years
 - \$143,000 per year (Average for 2004-2013)

Who funds the rest?



- Clearly we've spent more than \$2.3 million on this development
 - Obviously it costs more than \$143,000 per year to support this software
- PowerWorld has invested tens of millions on the development of Simulator over the years
- So who funds this investment?
 - *All our customers do*
 - That is what software license fees fund
 - That is what software renewal fees fund

Funding By Year



Row Label	Sum of Funding
1996	\$5,800
1997	\$9,215
1998	\$16,000
1999	\$73,935
2000	\$44,000
2001	\$78,200
2002	\$405,910
2003	\$192,000
2004	\$48,000
2005	\$125,500
2006	\$121,514
2007	\$93,560
2008	\$91,320
2009	\$244,640
2010	\$68,020
2011	\$144,100
2012	\$144,590
2013	\$349,436
2014	\$33,280
Grand Total	\$2,289,020

- Average 2004-2013
 - \$143,000 per year

Funding By Feature



- \$152,036: Contingency Analysis

- Covers *everything* related to RAS modeling
- Actually, at least 25% is related to reporting results, so simply modeling RAS is probably closer to \$120,000

Row Labels	Sum of Funding
ATC	\$133,280
Case Info	\$74,014
Contingency Analysis	\$152,036
Dialog	\$50,680
Full Topology	\$139,940
GIC	\$100,000
Online	\$147,660
OPF	\$324,860
OPF Reserves	\$72,800
Power Flow	\$227,450
PVQV	\$73,780
Retriever	\$221,280
Scheduled Actions	\$46,800
SimAuto	\$75,800
State Estimation	\$145,000
Time Step	\$18,240
Trainer	\$50,400
Transient	\$235,000
Grand Total	\$2,289,020

Funding By Company



- 15 companies have done this
- One company has funding about 50%
 - But that is over 15 years

Row Label	Sum of Funding
Company A	\$1,139,140
Company B	\$262,410
Company C	\$205,960
Company D	\$104,950
Company E	\$100,000
Company F	\$92,000
Company G	\$76,110
Company H	\$75,800
Company I	\$72,800
Company J	\$50,400
Company K	\$37,500
Company L	\$29,414
Company M	\$15,000
Company N	\$14,576
Company O	\$12,960
Grand Total	\$2,289,020

Sum of Funding	Column Labels
Row Labels	Company A
2000	\$44,000
2001	\$2,400
2002	\$186,400
2003	\$92,000
2004	\$48,000
2005	\$73,500
2006	\$33,500
2007	
2008	\$2,400
2009	\$244,640
2010	\$19,780
2011	\$64,900
2012	\$33,680
2013	\$260,660
2014	\$33,280
Grand Total	\$1,139,140

Funding By Feature, By Year



Sum of Funding	Column Labels	-																				
Row Labels	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Grand Total		
ATC							\$31,000		\$5,000	\$12,000	\$13,500		\$2,400	\$24,000	\$19,780	\$4,800			\$20,800	\$133,280		
Case Info						\$2,400	\$6,000	\$10,000	\$3,000	\$15,000	\$29,414				\$7,200			\$1,000		\$74,014		
Contingency Analysis					\$32,000		\$47,000	\$13,000	\$5,500					\$2,400		\$9,600	\$19,680	\$15,576	\$7,280	\$152,036		
Dialog							\$6,400	\$2,000	\$10,000	\$2,000	\$4,000				\$1,920	\$19,200	\$1,000	\$4,160		\$50,680		
Full Topology													\$86,520			\$33,220		\$15,000	\$5,200	\$139,940		
GIC																		\$100,000		\$100,000		
Online							\$13,000	\$26,000	\$4,500	\$53,000		\$20,760						\$30,400		\$147,660		
OPF	\$5,800	\$9,215	\$16,000	\$73,935			\$203,110											\$16,800		\$324,860		
OPF Reserves												\$72,800								\$72,800		
Power Flow					\$12,000		\$59,000	\$2,000	\$12,000	\$43,500	\$16,000					\$3,840	\$39,110	\$40,000		\$227,450		
PVQV							\$12,000	\$39,000	\$8,000				\$2,400		\$2,880				\$9,500	\$73,780		
Retriever							\$28,400	\$100,000			\$33,600				\$36,240	\$23,040				\$221,280		
Scheduled Actions																	\$27,600	\$19,200		\$46,800		
SimAuto						\$75,800														\$75,800		
State Estimation																		\$145,000		\$145,000		
Time Step														\$18,240						\$18,240		
Trainer																\$50,400				\$50,400		
Transient											\$25,000			\$200,000			\$10,000			\$235,000		
Grand Total	\$5,800	\$9,215	\$16,000	\$73,935	\$44,000	\$78,200	\$405,910	\$192,000	\$48,000	\$125,500	\$121,514	\$93,560	\$91,320	\$244,640	\$68,020	\$144,100	\$144,590	\$349,436	\$33,280	\$2,289,020		

WECC Budget Links



- WECC 2015 Budget

- [http://www.nwppa.org/wcmedia/documents/_newsletters/WECC 2015 Budget one page explanation.pdf](http://www.nwppa.org/wcmedia/documents/_newsletters/WECC%202015%20Budget%20one%20page%20explanation.pdf)
- [http://www.nwppa.org/wcmedia/documents/_newsletters/2015 WECC Budget-update 032014-3.pdf](http://www.nwppa.org/wcmedia/documents/_newsletters/2015%20WECC%20Budget-update%20032014-3.pdf)