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Closing the Crevice

Achieving A Process For Asset Performance & Maintenance Analyses

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Outline

- Part I – Background
- Part II – Data Processing & Preparation Tool
- Part III – CBM Modeling in EXAKT
- Part IV – Conclusions

Part I

Background

Outline of Part I – Background

- Hydro One Distribution System
  - Facts and Figures
- *EXAKT* Modeling/Decision Agent
  - Process and Value
- *EXAKT* Data Preparation Tool for Hydro One
  - OMDEC and BI-Cycle

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Setup

Hauler Truck

Conveyor Syncrude

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The Distribution Setting

- Electricity Flow:
  - produced in generating stations (GS) around the province
  - delivered to end-use customers on wires through the high voltage “grid” transmission system and lower voltage "radial" **distribution system**.
  - Distribution system includes 1000 distribution and regulating stations
- Voltage “stepped-down” at Transformer Stations (TS) and Distribution Stations (DS)
  - Distribution: step-down transformers on poles, underground, or on the ground before entering customer premises

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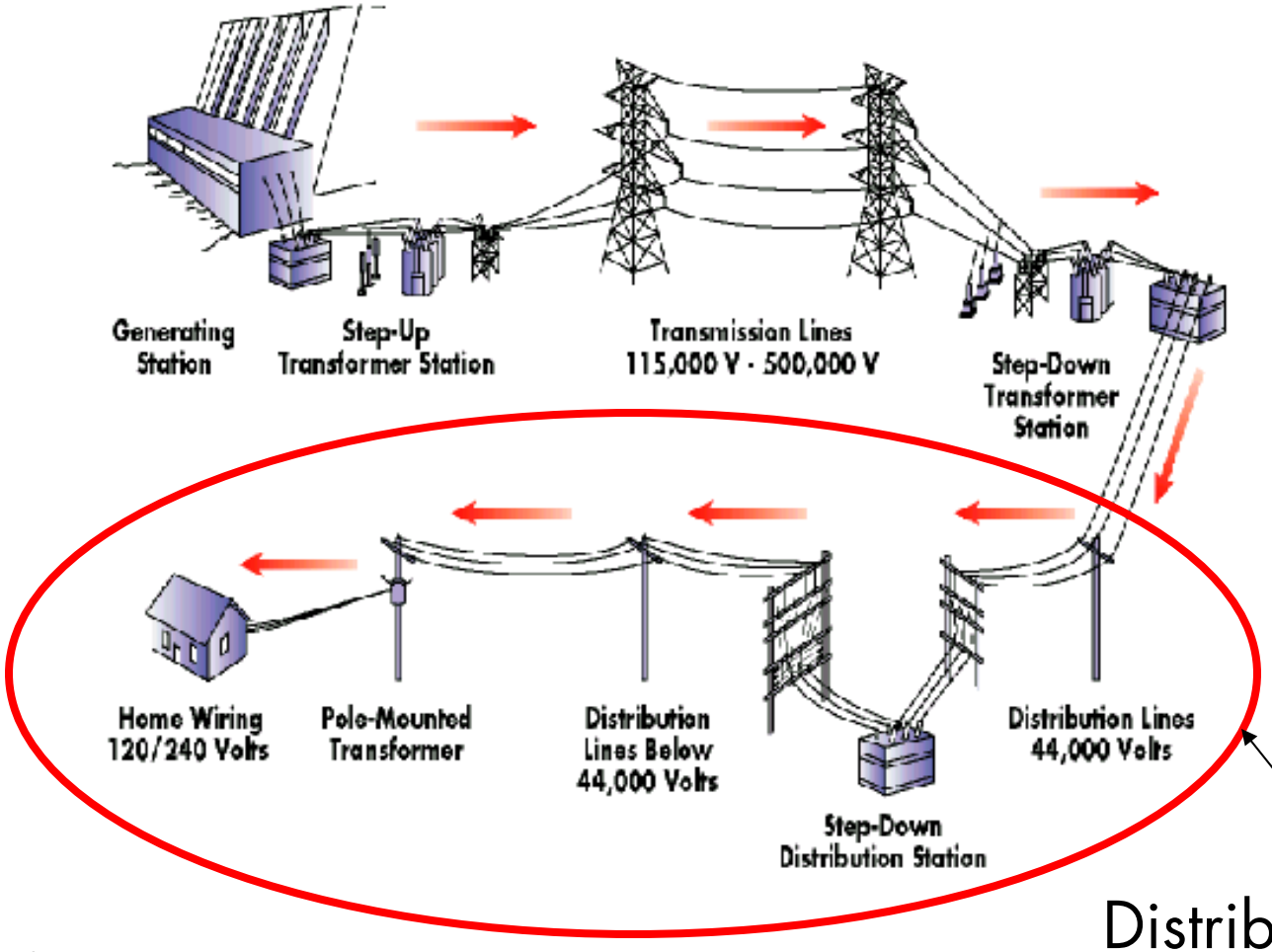
The Distribution Setting



Distribution System

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The Distribution Setting

Distribution Stations (Dx)

Transformer Station (Tx)

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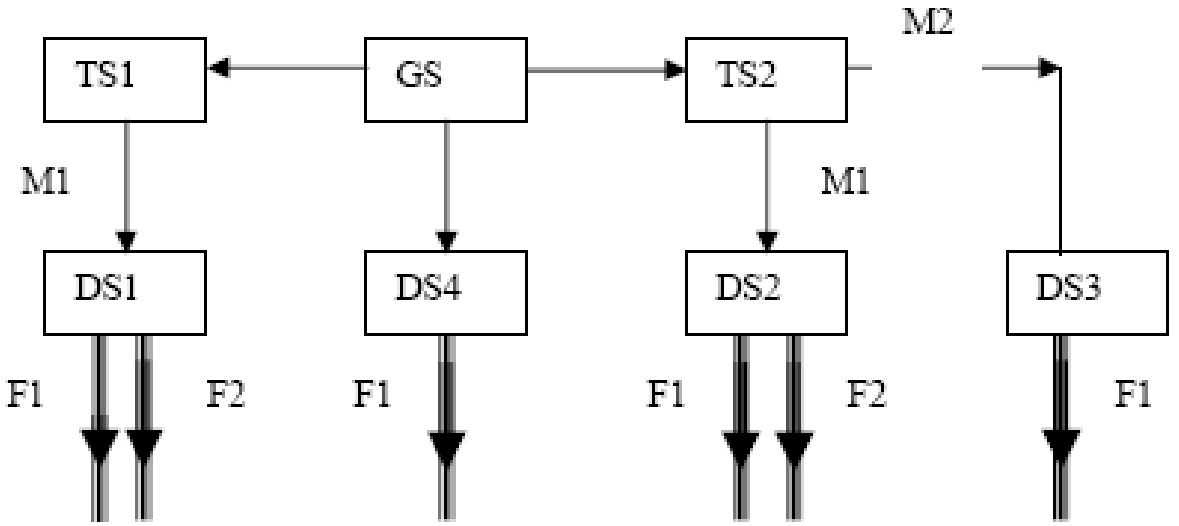
The Distribution Setting

- Feeder - electrical circuit used to distribute electricity from the DS.
  - Typically 2-3 feeders (F1, F2, etc.) from each DS. Identified by station and feeder name (i.e. FEEDER DS F1)



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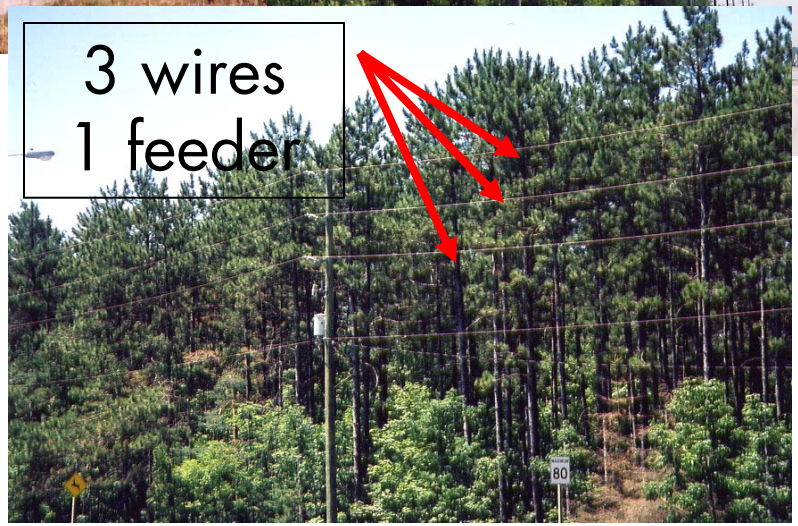
The Distribution Setting

Distribution Circuits



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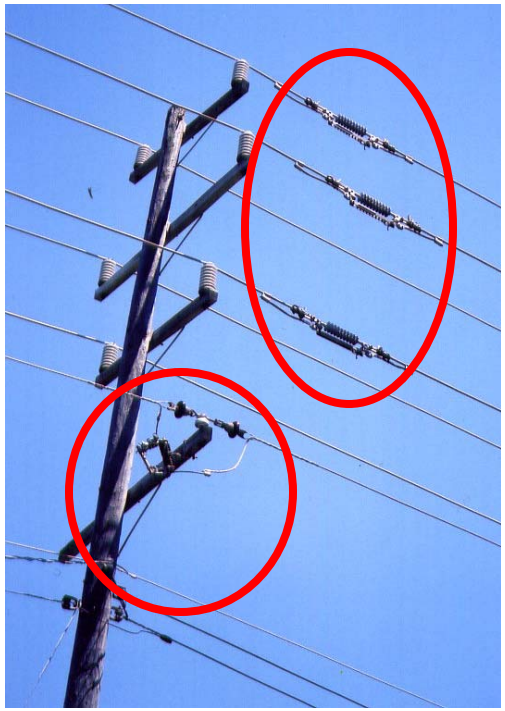
The Distribution Setting

Distribution Switches

– Numerous switches on each feeder. Switch will open when there is a problem on the electrical feeder (circuit)



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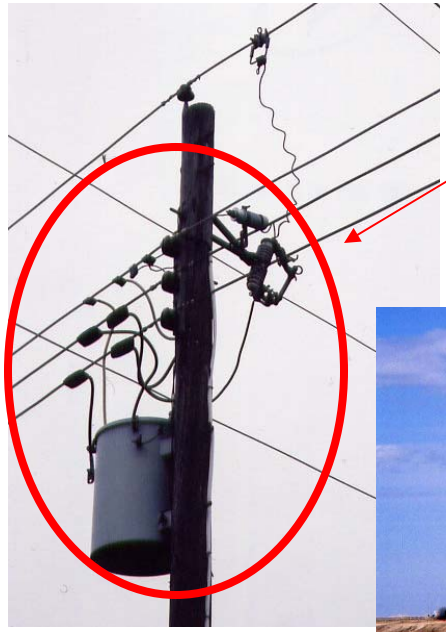
The Distribution Setting

Distribution Customer Transformers



Open
Wire Bus

Triplex

Private Primary

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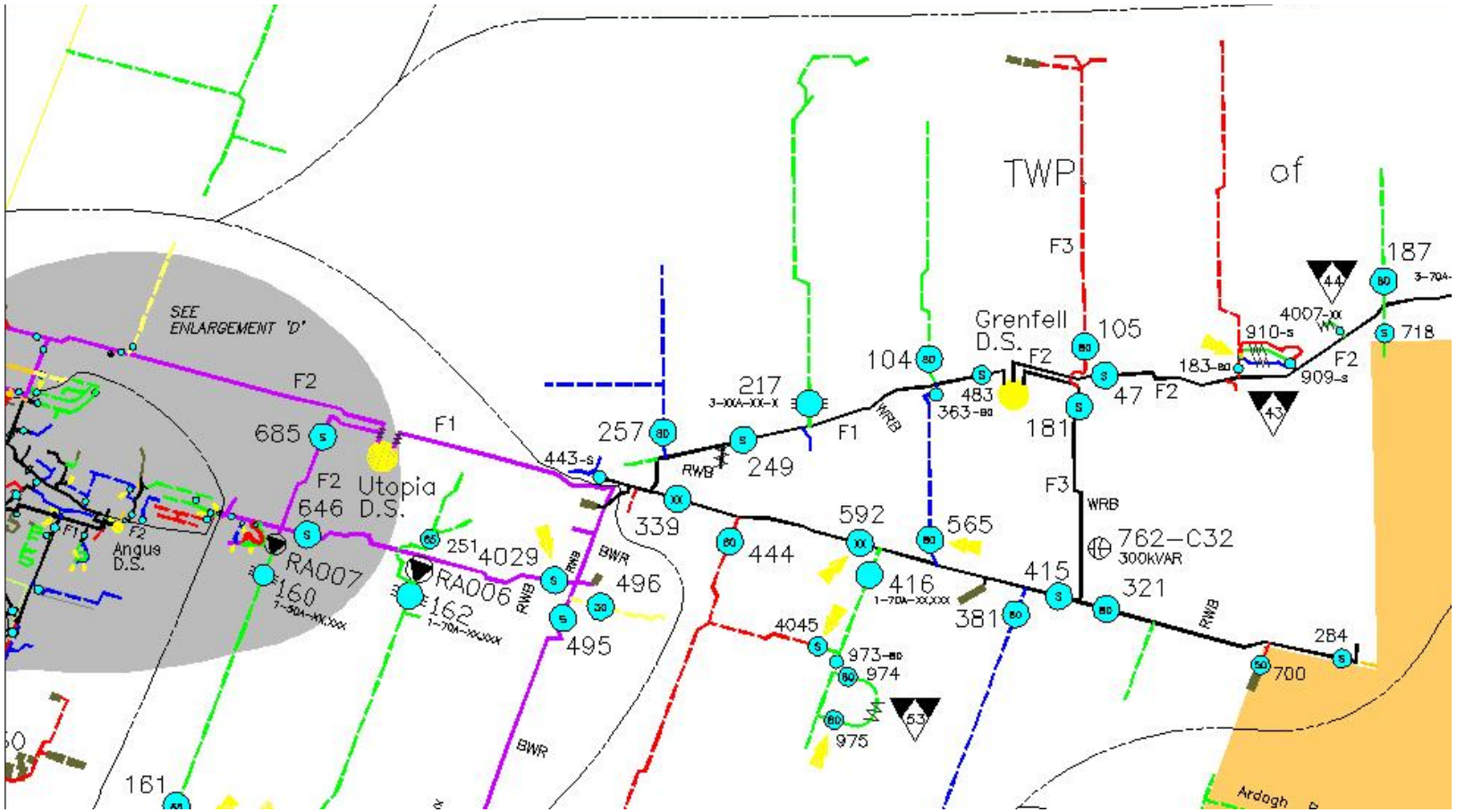
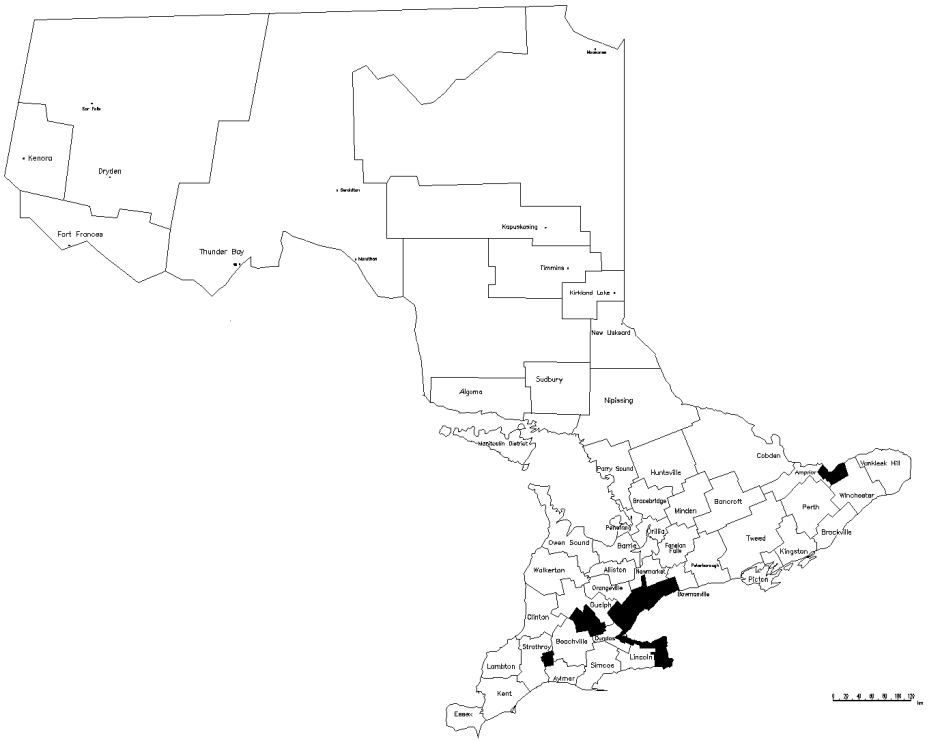
The Distribution Setting



The Distribution Setting

Approx. 3000 Feeders



serving 1.2 million customers across Ontario

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The Distribution Setting

Multiple Geographies

– Trees, rocks, water and swamp, open fields

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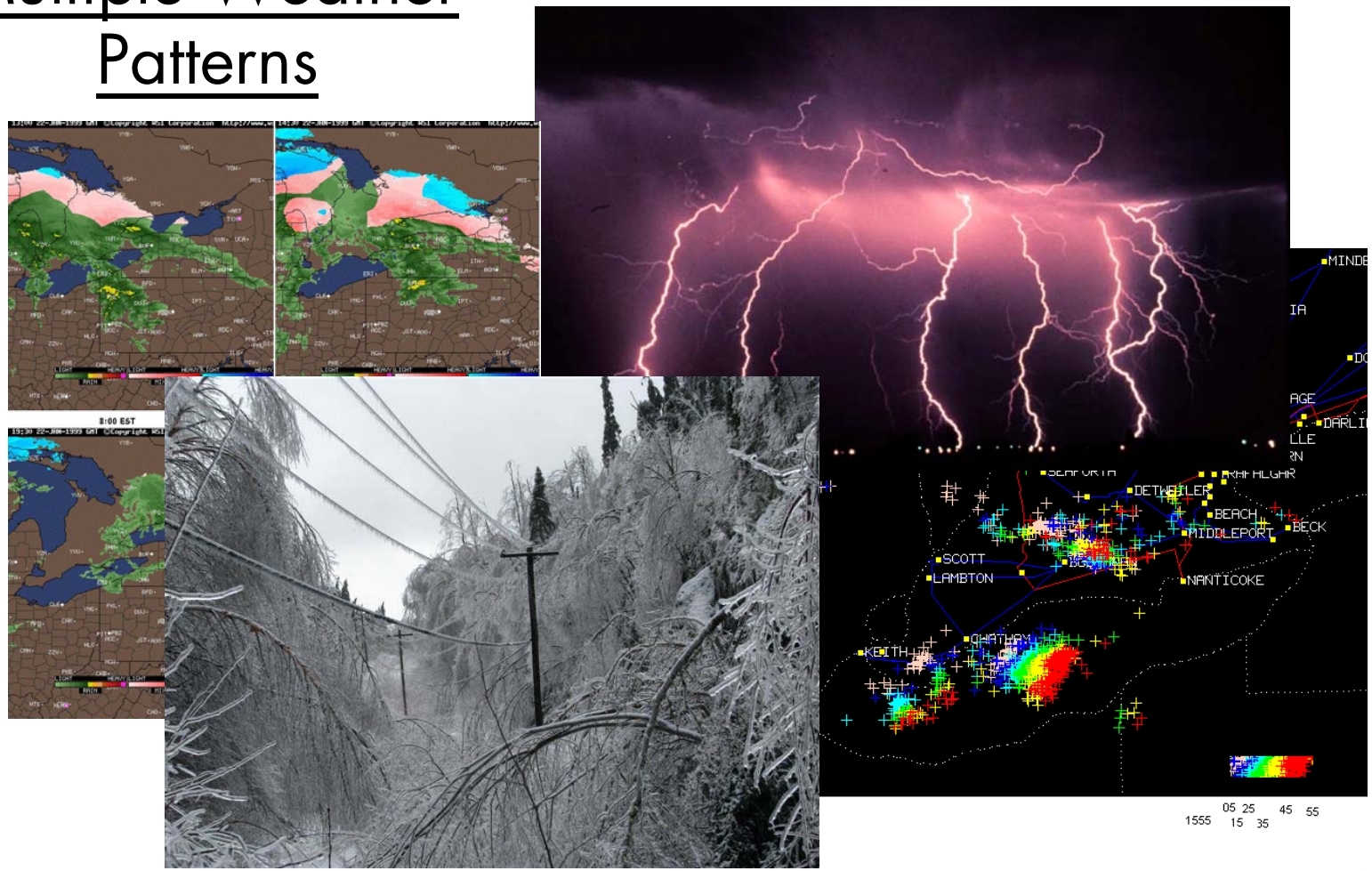
The Distribution Setting

Multiple Weather Patterns



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Distribution Data Collection

- 53 Operating Centres in Hydro One's distribution system throughout the province of Ontario
- Multiple Stations within each operating centre, and each station has typically 2-3 feeders
- Data are collected or purchased for each Operating Centre or provincial area. Generally, there are 3 groups of data:
  - Outage, Environmental, and Asset data
- Data is analyzed to determine locations of concern

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OEB Outage Cause Codes

Table 15.2 Cause of Service Interruption	
Code	**Cause**
0	**Unknown/Other** Customer interruptions with no apparent cause that contributed to the outage
1	**Scheduled Outage** Customer interruptions due to the disconnection at a selected time for the purpose of construction or preventive maintenance
2	**Loss of Supply** Customer interruptions due to problems in the bulk electricity supply system
3	**Tree Contacts** Customer interruptions caused by faults resulting from tree contact with energized circuits
4	**Lightning** Customer interruptions due to lightning striking the distribution system, resulting in an insulation breakdown and/or flash-overs
5	**Defective Equipment** Customer interruptions resulting from equipment failures due to deterioration from age, incorrect maintenance, or imminent failures detected by maintenance
6	**Adverse Weather** Customer interruptions resulting from rain, ice storms, snow, winds, extreme temperatures, freezing rain, frost, or other extreme weather conditions (exclusive of Code 3 and Code 4 events)
7	**Adverse Environment** Customer interruptions due to equipment being subject to abnormal environments, such as salt spray, industrial contamination, humidity, corrosion, vibration, fire, or flowing (previously Code 9)
8	**Human Element** Customer interruptions due to the interface of distributor staff with the system (previously Code 7)
9	**Foreign Interference** Customer interruptions beyond the control of the distributor, such as animals, vehicles, dig-ins, vandalism, sabotage, and foreign objects (previously Code 8)

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EXAKT Modeling/Decision Agent

- Condition Based Management (CBM) software
- Measurement and analysis of the performance of Distribution Assets
  - Uses data to make timely maintenance decisions
  - Many companies use data from testing to find the significant "internal" variables
  - For Hydro One, the significant "external" variables are also contributors to the interruptions
- Two primary source database tables used by EXAKT
  - Events Table
  - Inspections Table

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Events & Inspections Table

- Events Table – provides information on an item's "lifetime"
  - records date (time), cause, and device of interruption; each interruption categorized as either *failure* or *suspension*
- Inspections Table – contains weather data
  - (Wind Speed, Wind Direction, Air Pressure, Temperature, Lightning Strikes etc.)

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EXAKT Modeling/Decision Agent Data Types

- *EXAKT* uses interruption and environmental data directly in the statistical modeling process
- Interruption Data
  - Provides "lifetime" data on equipment operating in the distribution system
  - Information that is used to model equipment's risk of failing in the future
- Environmental Data
  - Including wind, air pressure, temperature, lightning strikes

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EXAKT Modeling/Decision Agent

- Includes:
  - Weibull Module, Proportional Hazards Model (PHM), Sensitive of Optimal Policy

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EXAKT Modeling/Decision Agent

- *EXAKT* provides a method for:
  - Measuring risk with these models to help optimize decisions on mitigating and avoiding interruptions in the future
  - continually refining the process to improve the accuracy of the model and the decisions that are made

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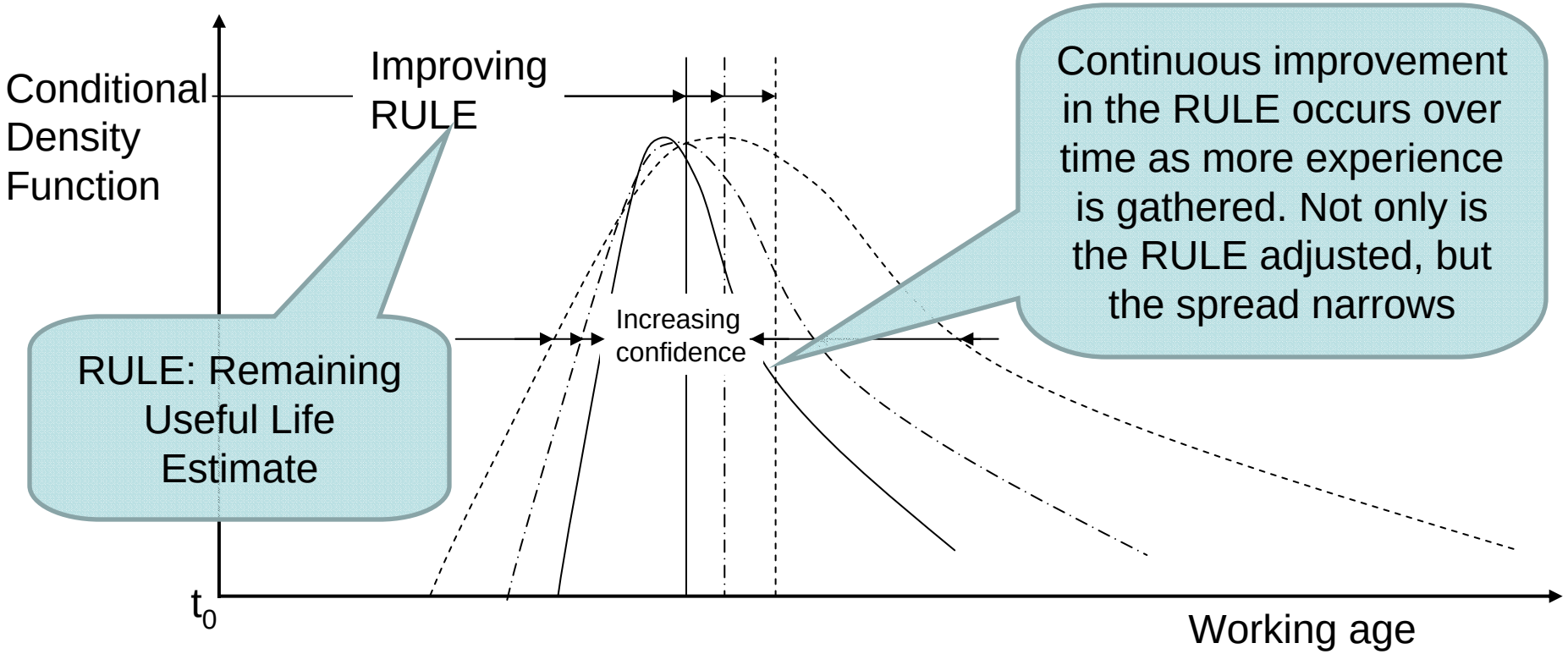
EXAKT Refining the process



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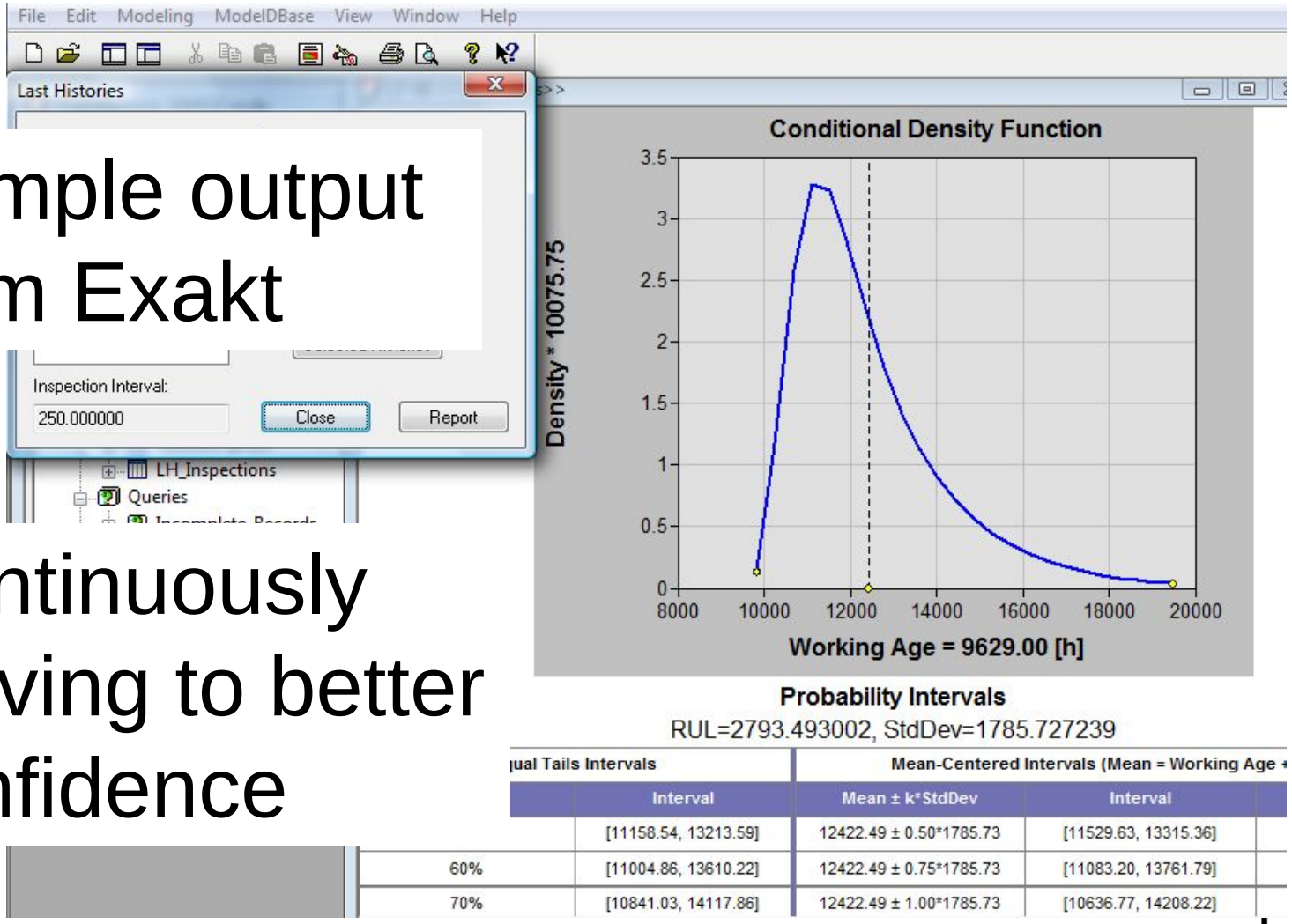
Conditional Density in *EXAKT*

Sample output from Exakt

Continuously moving to better confidence



Probability Intervals

RUL=2793.493002, StdDev=1785.727239

	ual Tails Intervals	Mean-Centered Intervals (Mean = Working Age +
	Interval	Mean ± k*StdDev	Interval
	[11158.54, 13213.59]	12422.49 ± 0.50*1785.73	[11529.63, 13315.36]
60%	[11004.86, 13610.22]	12422.49 ± 0.75*1785.73	[11083.20, 13761.79]
70%	[10841.03, 14117.86]	12422.49 ± 1.00*1785.73	[10636.77, 14208.22]

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EXAKT Preparation Tool

- Currently, data received by Hydro One is not formatted or structured to easily perform statistical analysis for asset management using EXAKT
- *EXAKT* Preparation Tool for Hydro One
  - Supported by OMDEC and BI-Cycle
  - Facilitates data formation for compatibility with EXAKT software

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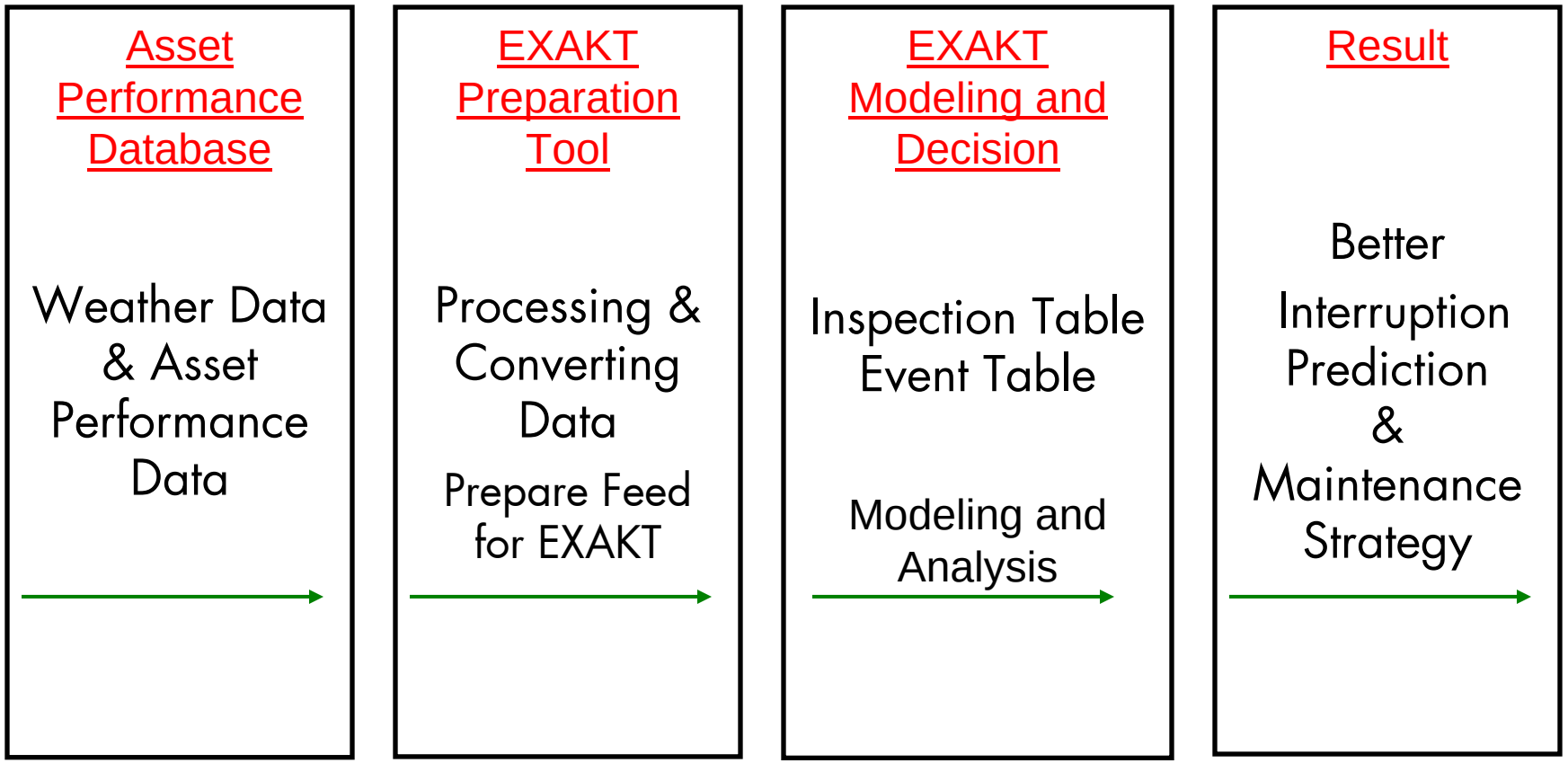

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Part II

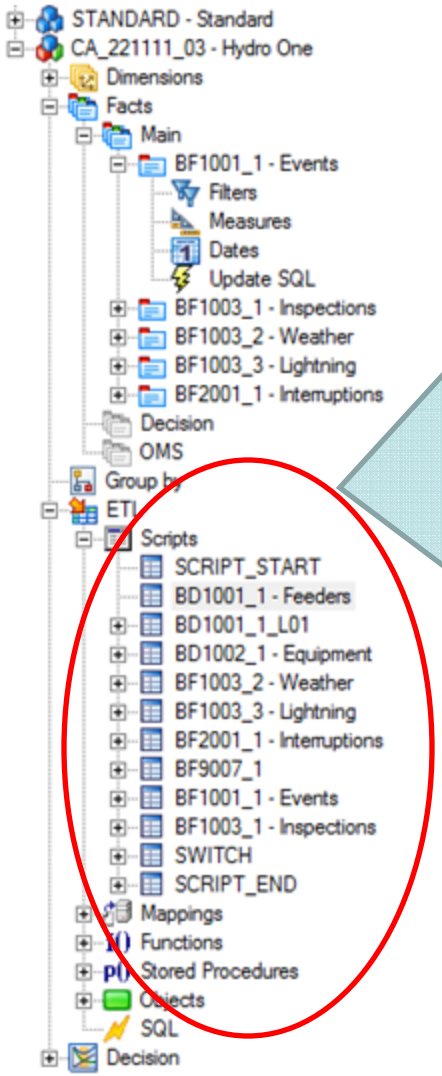
Data Processing & Preparation Tool

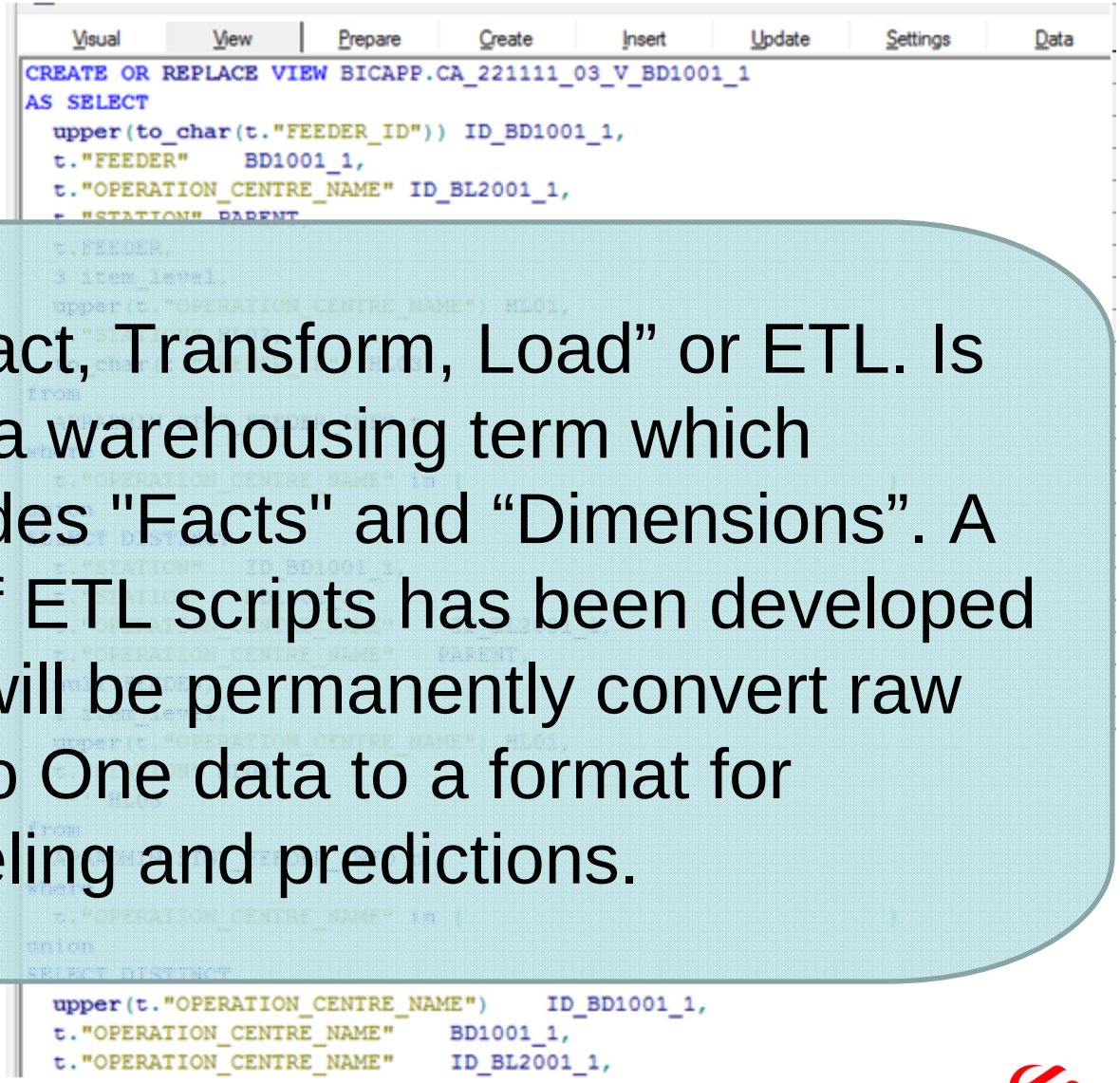
Outline of Part II – Data Processing

The preparation of the data is needed to:

- Extract, Transform & Load the data
- tailor data – through various filters
- investigate data – looking for anomalies
- Generate the Events table
- Generation the Inspections tab'

ETL SQLs





"Extract, Transform, Load" or ETL. Is a data warehousing term which includes "Facts" and "Dimensions". A set of ETL scripts has been developed that will be permanently convert raw Hydro One data to a format for modeling and predictions.

Raw Interruption Data

OPS_CENTE	STATION_NAME	FEEDER_NAME	SWITCH	TRANSFORMER	CEA_CAUSE	CEA_DESCRIPTION	INTERUPTION_DATETIME	STRCTUR_NO
					34	Major Storm	1/2/2000 12:40:00 PM	
					62	Equip. failure	1/2/2000 4:30:00 PM	
					60	Loss of BES	1/2/2000 9:00:00 PM	
					62	Equip. failure	1/3/2000 11:30:00 AM	
					62	Equip. failure	1/3/2000 2:24:00 PM	
					62	Equip. failure	1/4/2000 6:24:00 AM	
					62	Equip. failure	1/4/2000 5:25:00 PM	
					62	Equip. failure	1/10/2000 5:30:00 PM	
					62	Equip. failure	1/11/2000 3:30:00 PM	
					62	Equip. failure	1/12/2000 12:15:00 PM	
					52	Tree falling(weather)	1/16/2000 8:30:00 PM	
					63	Other-forced	1/18/2000 12:30:00 PM	
					63	Other-forced	1/19/2000 9:10:00 AM	
					63	Other-forced	1/19/2000 2:00:00 PM	
					51	Tree falling	1/21/2000 7:45:00 PM	
					56	Other-foreign inter.	1/21/2000 9:55:00 PM	
					52	Tree falling(weather)	1/22/2000 7:30:00 PM	
					62	Equip. failure	1/24/2000 2:24:00 PM	
					55	Cust. equipment	1/24/2000 4:18:00 PM	
					62	Equip. failure	1/25/2000 9:00:00 AM	
					62	Equip. failure	1/26/2000 9:00:00 AM	

Interruption data records when, where and what happened during an interruption, for the events table

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Raw Weather Data

OPS_CENTER	YEAR	MONTH	DAY	ELEMENT	ELEMENT_DESCRIPTION	T00	T01	T02	T03	T04	T05	T06	T07
	1999	1	1	78	Dry Bulb Temperature (deg C)	-19.8	-20.4	-19.1	-19	-19.1	-19.1	-19.1	-19.9
	1999	1	1	156	Wind Direction	NE	NE	NNE	NNW	NW	NNW	NW	NNW
	1999	1	1	73	Sea Level Pressure (kilopascals	1013.3	1013	1013.3	1014.4	1014.7	1015.5	1016.8	1018.5
	1999	1	1	76	Wind Speed (km/h)	7	2	6	11	9	15	15	26

Weather data records the hourly readings of 9 weather elements (for the inspections table):

- Sea level pressure
- Temperature
- Wind speed
- Wind direction
- Rain
- Freezing rain
- Freezing drizzle
- Thunderstorm
- Snow

Raw Lightning Data

S_DATE1	OPS_AREA
5/22/1999 8:00:00 PM	
6/2/1999 6:00:00 PM	
6/2/1999 6:00:00 PM	
6/2/1999 6:00:00 PM	
6/2/1999 6:00:00 PM	
6/2/1999 9:00:00 PM	
6/2/1999 6:00:00 PM	
6/2/1999 6:00:00 PM	
6/2/1999 6:00:00 PM	
6/2/1999 6:00:00 PM	
6/6/1999 3:00:00 PM	
6/7/1999 4:00:00 PM	
6/7/1999 4:00:00 PM	
6/7/1999 4:00:00 PM	
6/7/1999 4:00:00 PM	
6/7/1999 4:00:00 PM	
6/7/1999 3:00:00 PM	
6/7/1999 4:00:00 PM	
6/7/1999 3:00:00 PM	
6/20/1999 2:00:00 PM	
6/20/1999 2:00:00 PM	
6/20/1999 3:00:00 PM	
6/20/1999 3:00:00 PM	

Lightning data records the time and location of each strike for the inspection table

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Raw Data

All from different programs and sources.

- Hydro Ones Outage Management and Asset Systems
- Environment Canada
- Ministry of Natural Resources

Now What????

We have the data

We have the tool

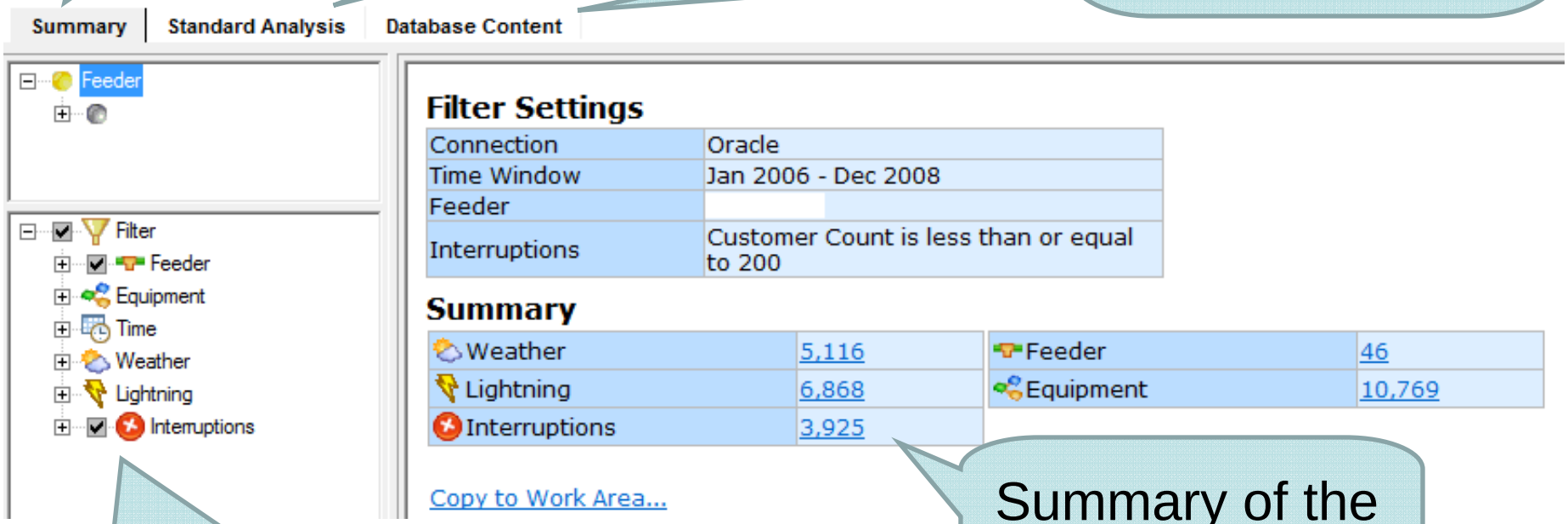
What does in do for us?

Features for Data Processing & Analysis

Summary of Data of interest

Graphs for investigating and analyzing data

Display of events and inspections tables generated



Filters to tailor data as desired

Summary of the data set tailored

Summary for One Geographic Area

Filter Settings

Connection	Oracle
Time Window	Jan 1999 - Dec 2008
Feeders	

Summary

Weather	14,991	Feeders	82
Lightning	7,990	Equipment	9,747
Interruptions	5,066		

The 14,991 weather records represent 9 distinct weather elements. And each weather element is recorded hourly, 24 hours per day.

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Drill Down into data Details

Filter Settings

Connection	Oracle
Time Window	Jan 1999 - Dec 2008
Feeders	

Summary

Weather	14,991	Feeders	82
Lightning	7,990	Equipment	9,747
Interruptions	5,066		

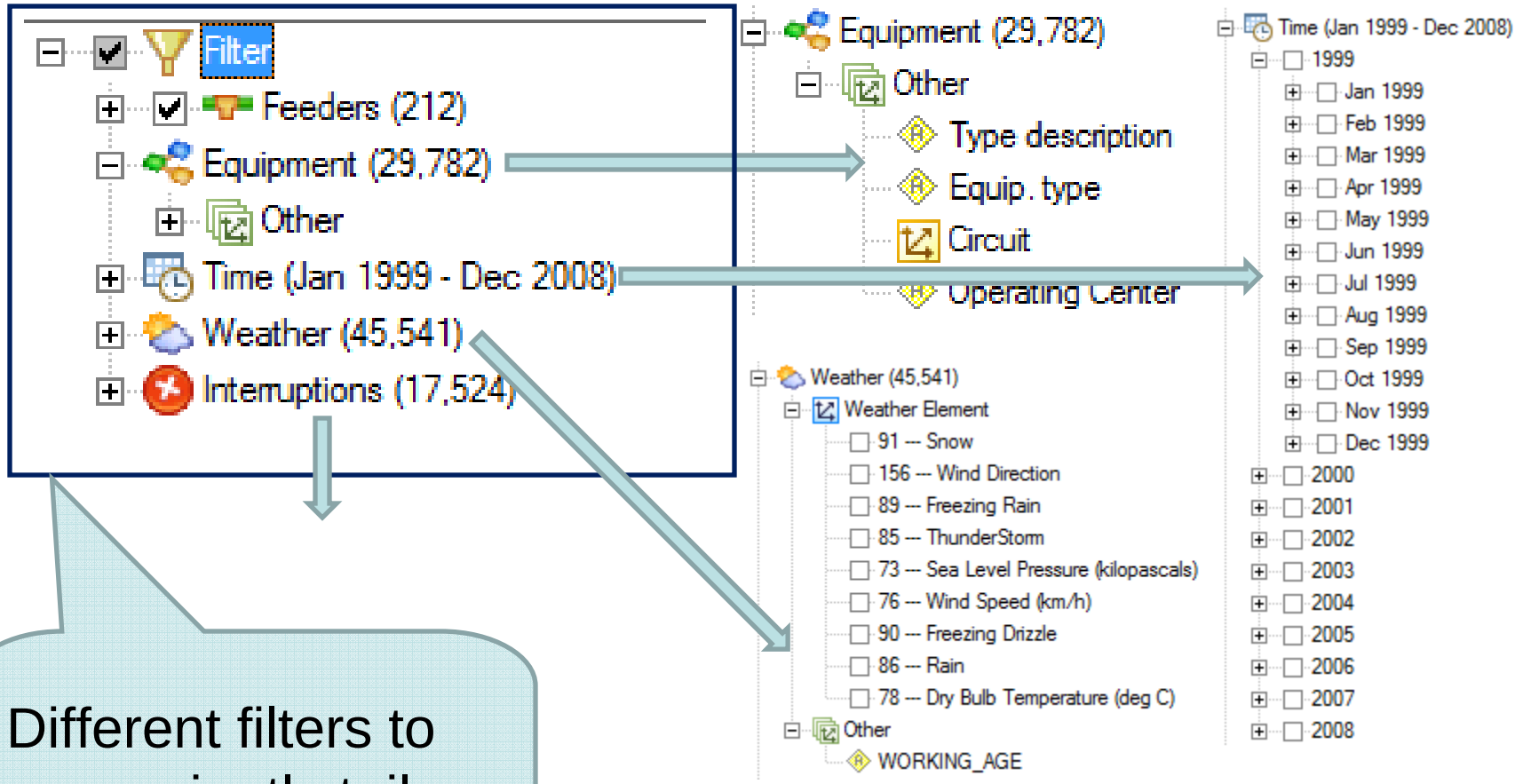
			Equipment				
Row	Ex.	Operating Center	Equip. Id	Equip. type	Trans. low Voltage	Type description	Circuit
1						OVERHEADTRANSFORMEF	46184
2						OVERHEADTRANSFORMEF	46184
3						OVERHEADTRANSFORMEF	46184
4						OVERHEADTRANSFORMEF	46184
5					120/240 Volts	OVERHEADTRANSFORMEF	46184
6						OVERHEADTRANSFORMEF	46184
7						OVERHEADTRANSFORMEF	46184
8						OVERHEADTRANSFORMEF	46184
9						OVERHEADTRANSFORMEF	46184
10						UNDERGROUNDTRANSFOI	46184
11						OVERHEADTRANSFORMEF	46184
12						OVERHEADTRANSFORMEF	46184
13						OVERHEADTRANSFORMEF	46184
14						OVERHEADTRANSFORMEF	46184
15						OVERHEADTRANSFORMEF	46184
16						OVERHEADTRANSFORMEF	46184

Other data details can also be drilled down from the links in the data summary

Data Navigation

An Equipment tree enables easy and fast navigation of equipment based on Hydro One terminology

Data Segregation



Different filters to conveniently tailor data as desired

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Preparation Tool – Relationships

- Possible weather conditions that will affect electricity distribution interruption
  - Pressure
  - Temperature
  - Wind speed
  - Wind direction
  - Rain
  - Freezing rain
  - Freezing drizzle
  - Thunderstorm
  - Snow
- Relations are showed in BI-Cycle Charts

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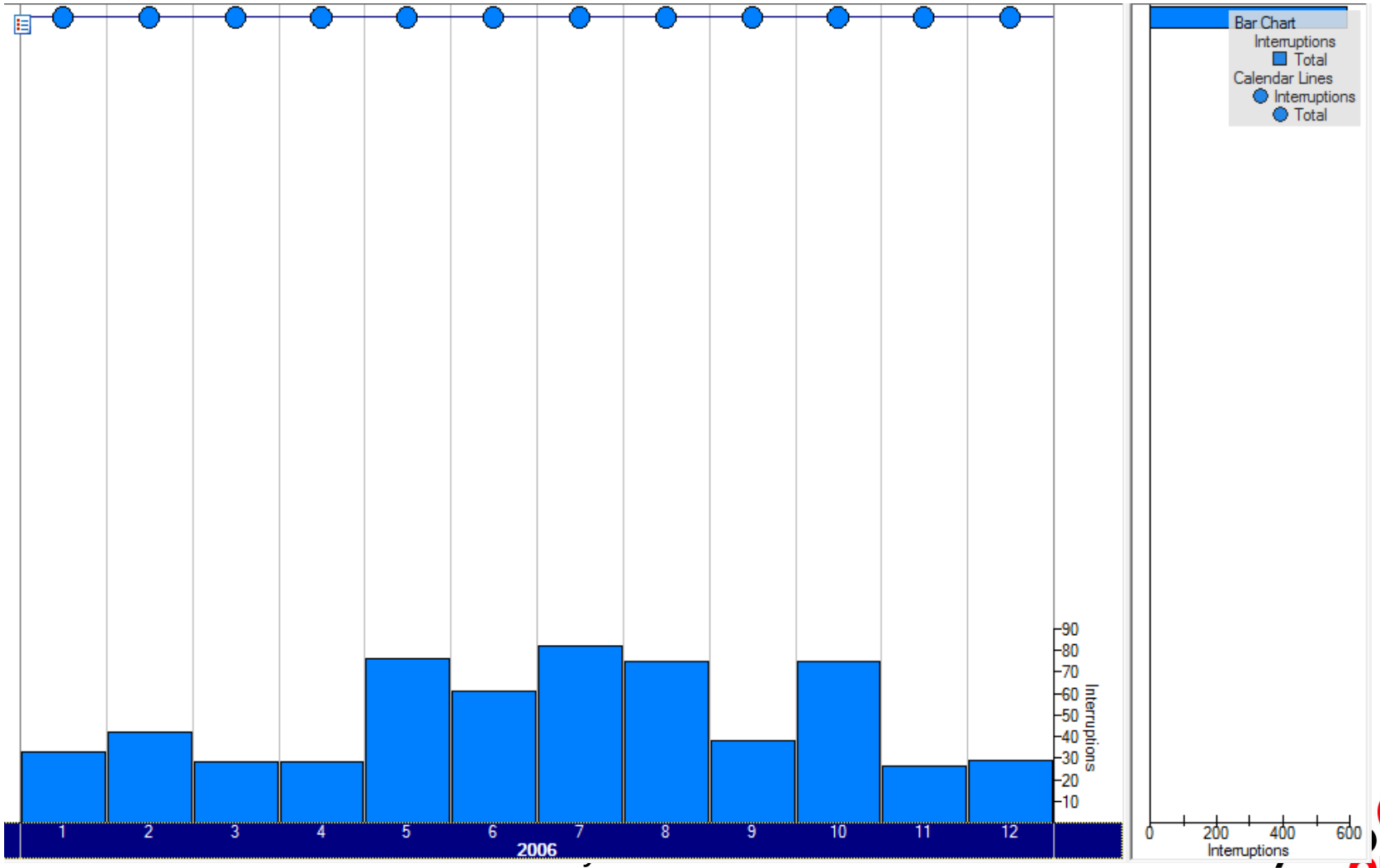
The Results

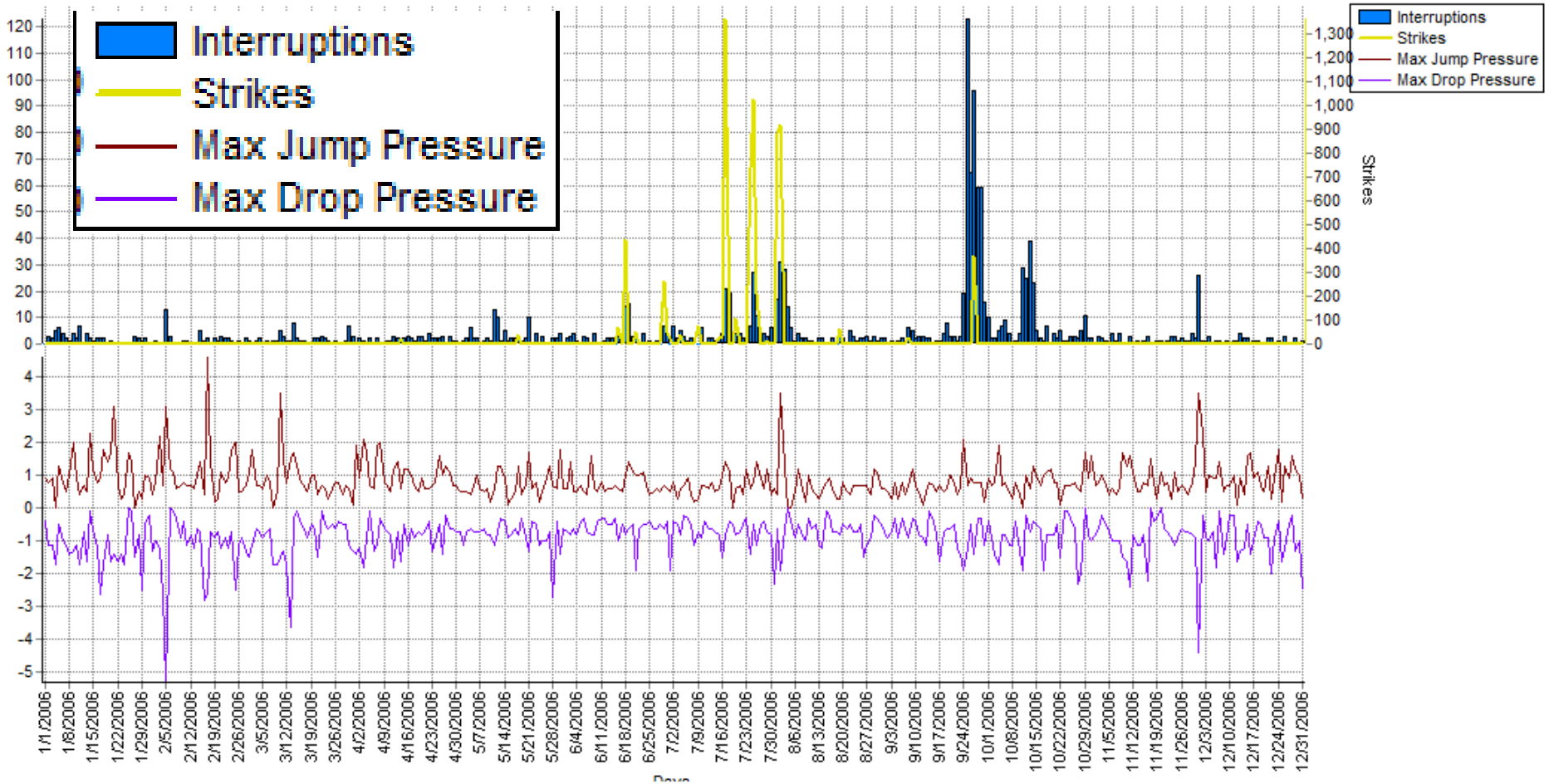
We have the data
We have the tool
What does in do for us?

Provides quick results

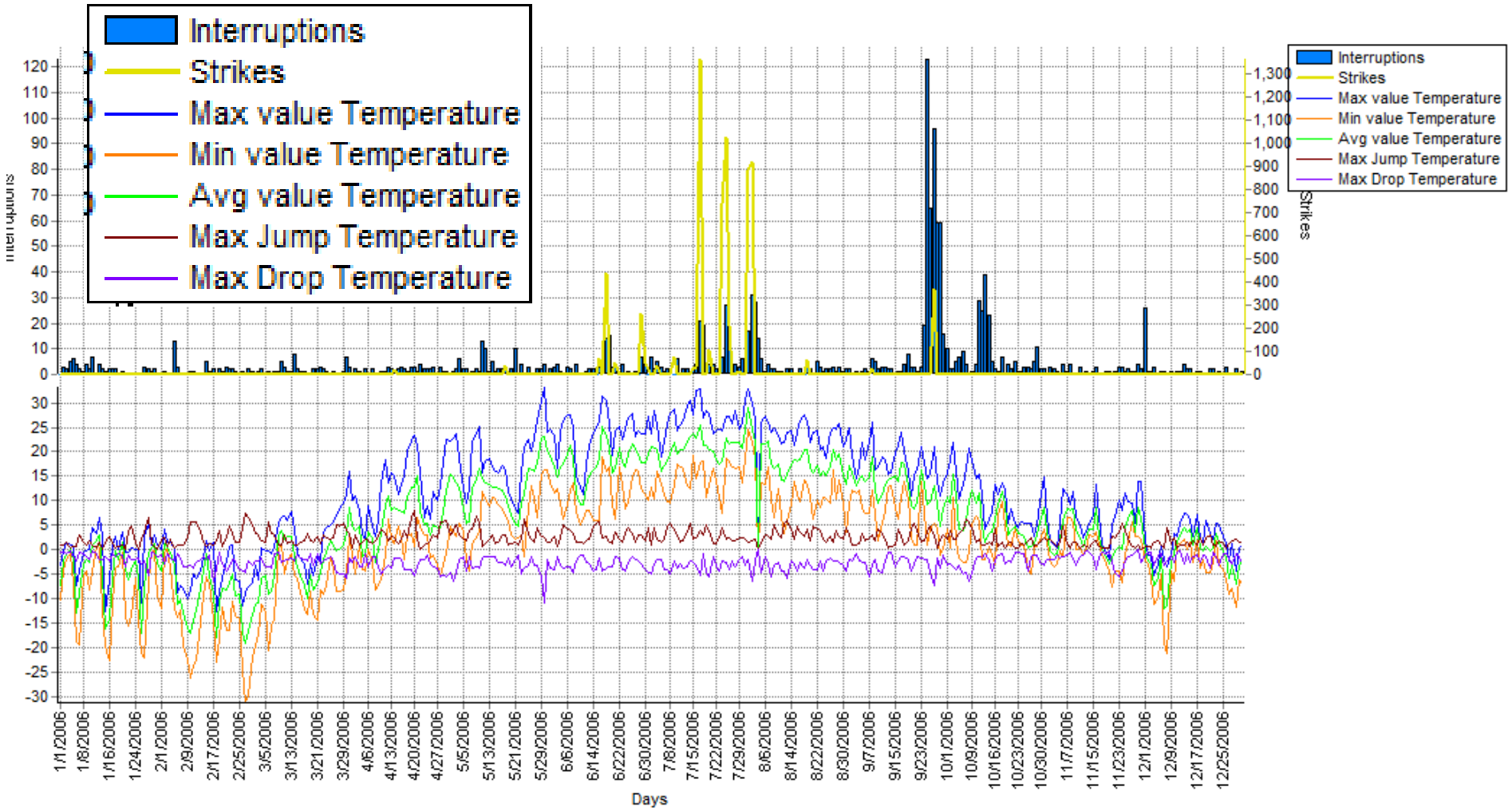
Interruptions Distribution



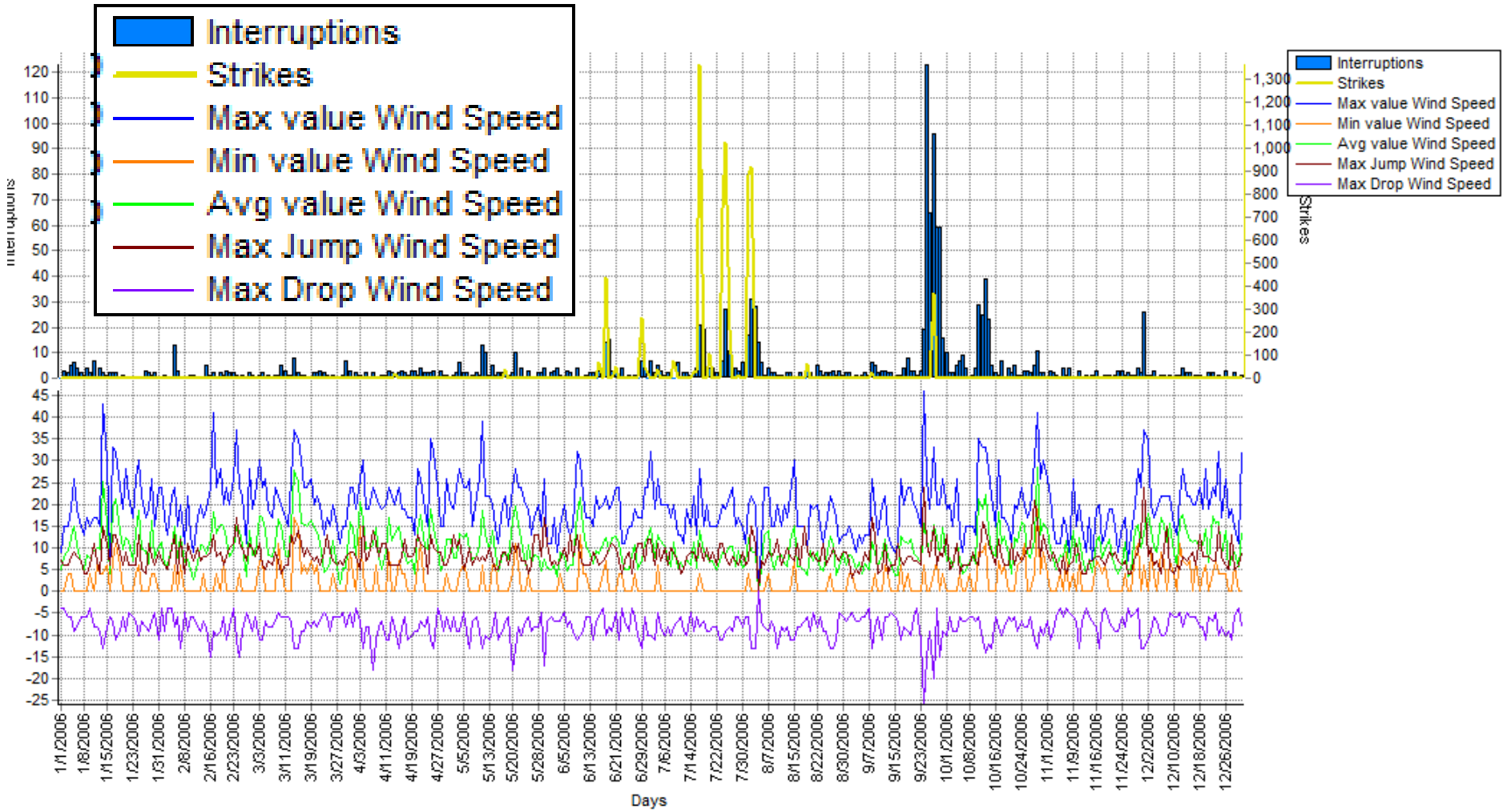
Interruptions VS Daily Air Pressure & Lightning



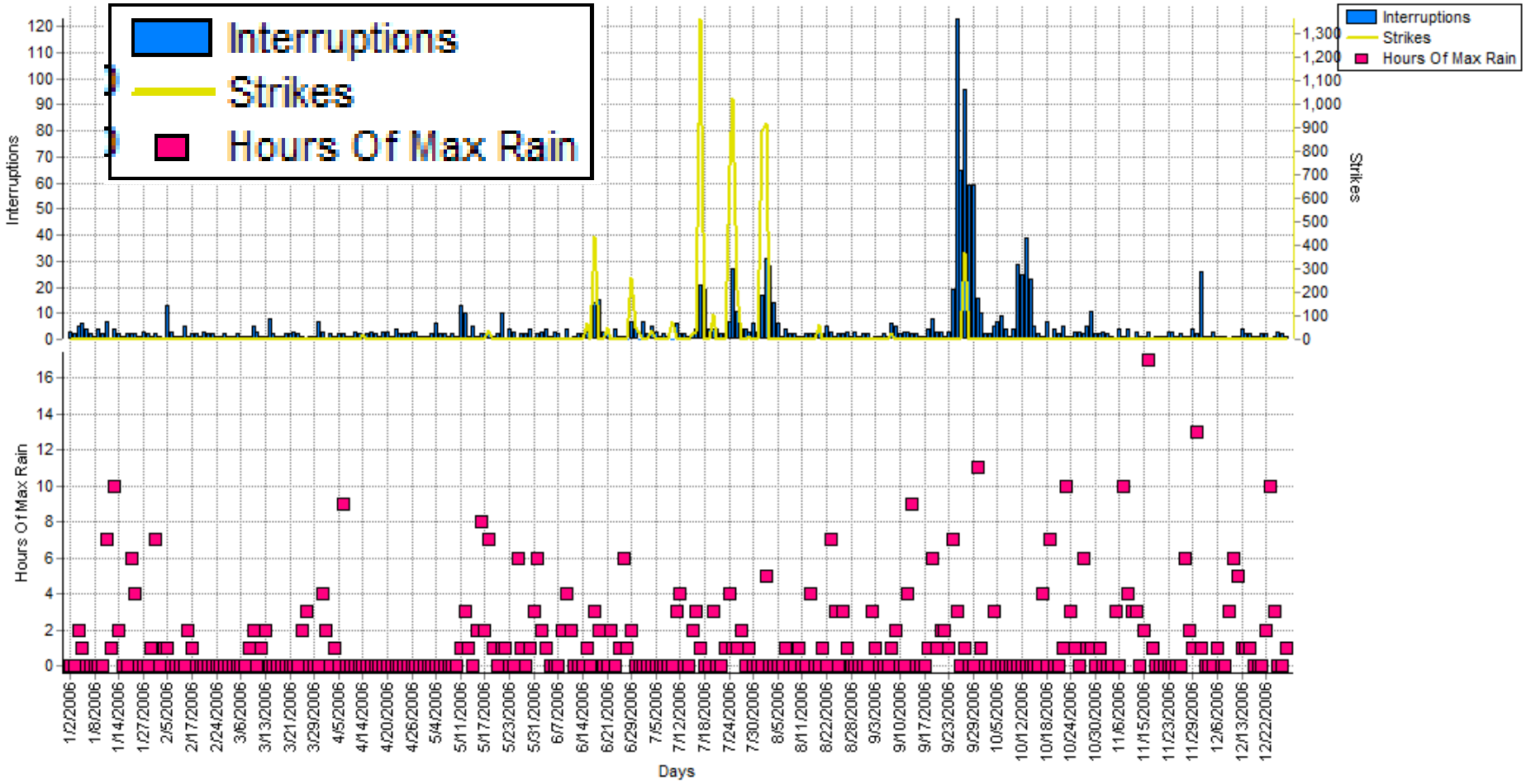
Interruptions VS Daily Temperature & Lightning



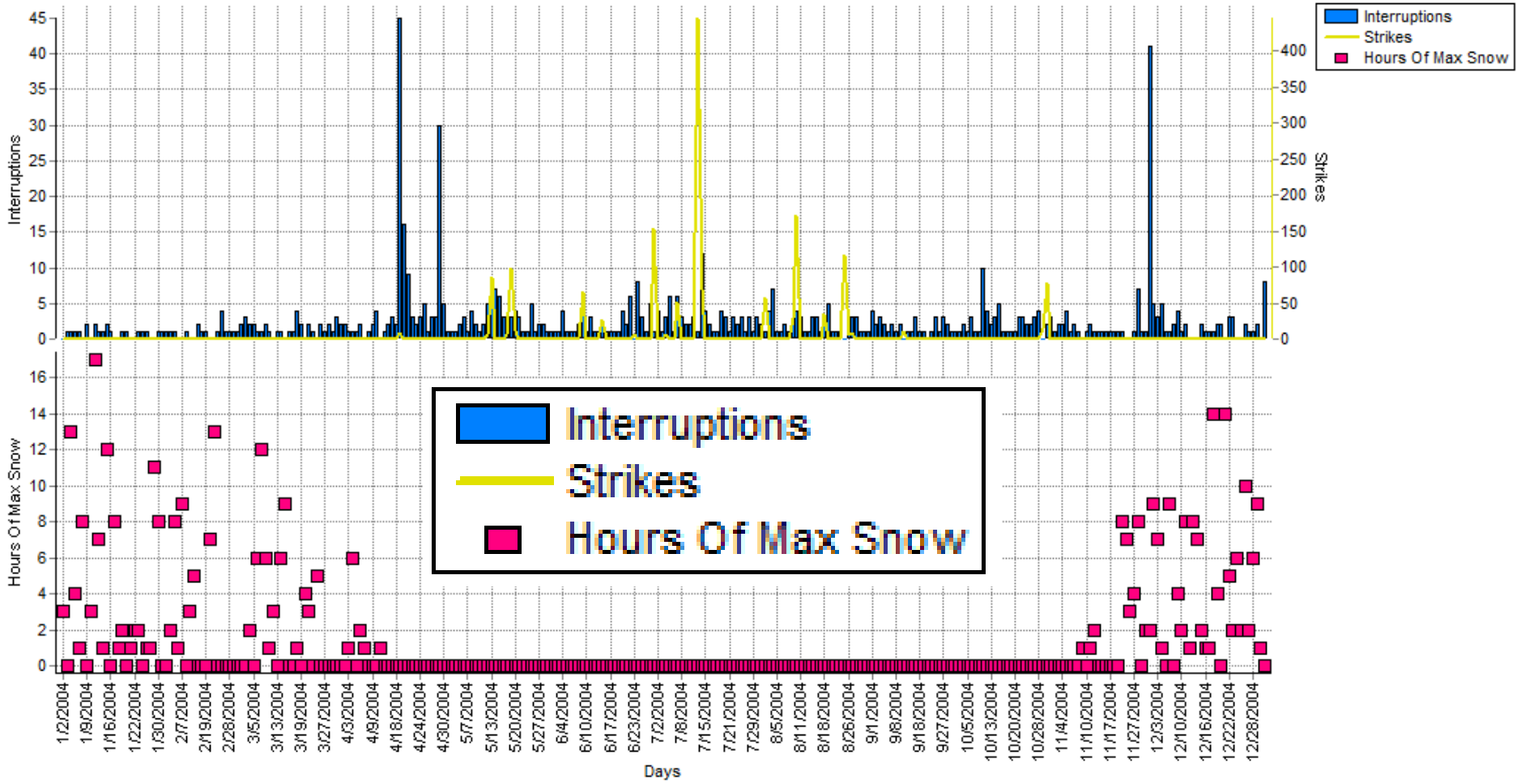
Interruptions VS Daily Wind Speed & Lightning



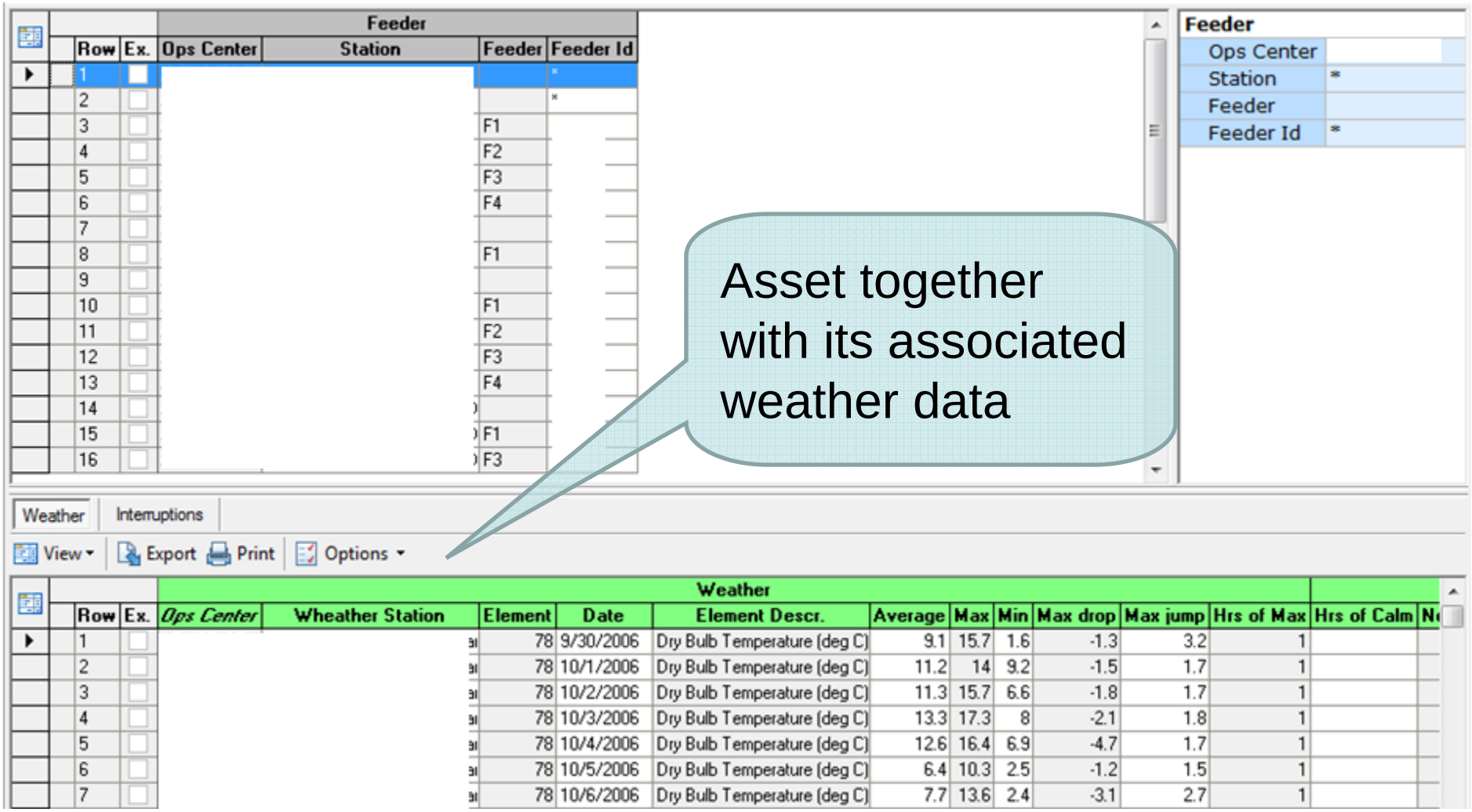
Interruptions VS Daily Rain & Lightning



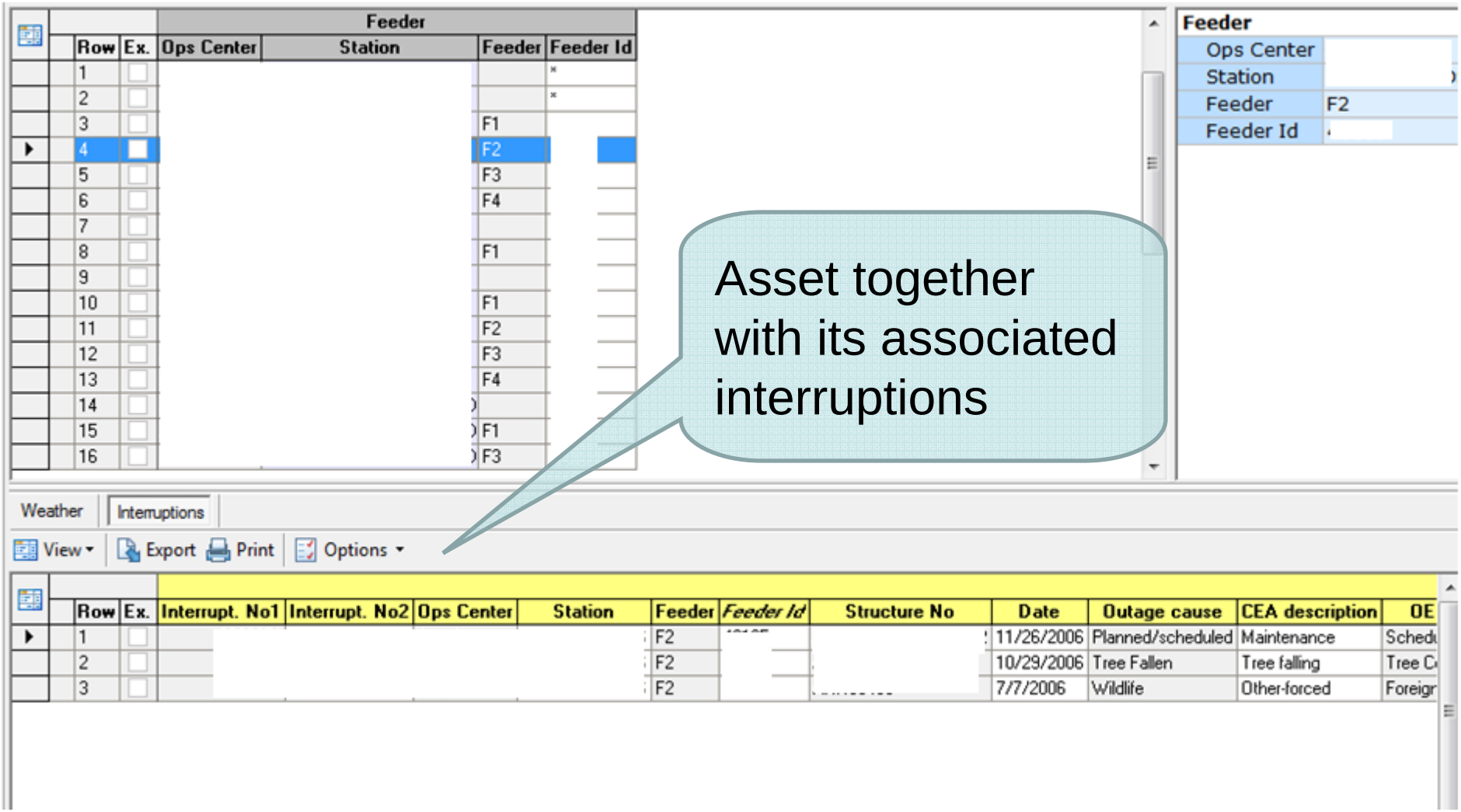
Interruptions VS Daily Snow & Lightning



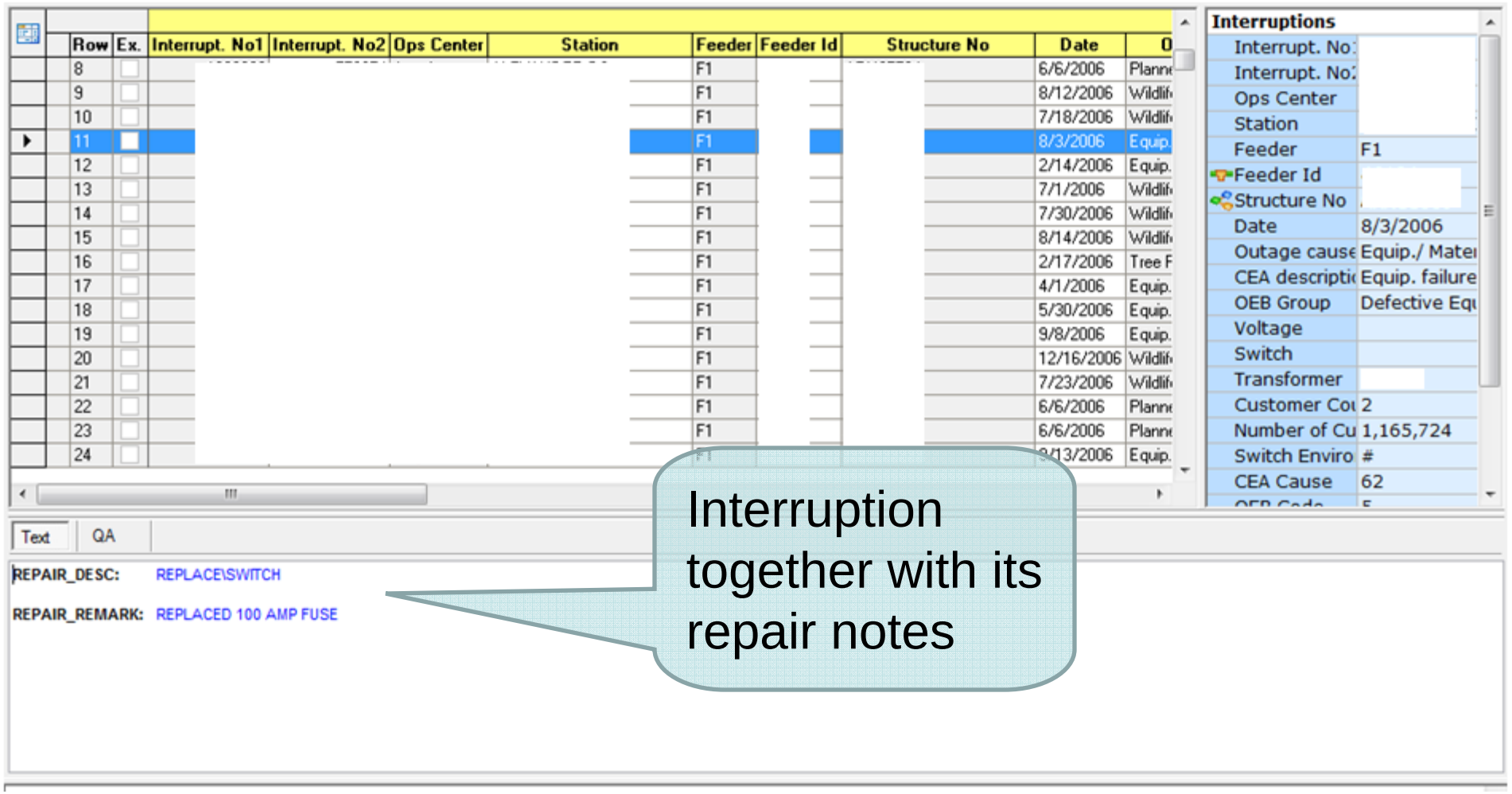
Assets linked to Weather data



Asset with Its Interruptions



Interruption with Repair Notes



The Crevice is Closed!

Click for next

Event Data Is Ready

	Row	Ex.	Events					
			Feeder	Date	Age	Ident	Event Cause	Event OEB
▶	1		46209	1/2/2000	366	ARN03370	E62	E5
	2		46209	1/2/2000	366	ARN03370	B62	B5
	3		46198	1/2/2000	366	ARN00075	B34	B6
	4		46198	1/2/2000	366	ARN00075	E34	E6
	5		46212	1/3/2000	367	ARN09984	B62	B5
	6		46225	1/3/2000	367	ARN04574	B62	B5
	7		46212	1/3/2000	367	ARN09984	E62	E5
	8		46225	1/3/2000	367	ARN04574	E62	E5
	9		46225	1/4/2000	368	ARN05431	B62	B5
	10		46329	1/4/2000	368	ARN09268	E62	E5
	11		46225	1/4/2000	368	ARN05431	E62	E5
	12		46329	1/4/2000	368	ARN09268	B62	B5
	13		46204	1/10/2000	374	ARN05732	E62	E5
	14		46204	1/10/2000	374	ARN05732	B62	B5
	15		46200	1/11/2000	375	ARN03386	B62	B5
	16		46200	1/11/2000	375	ARN03386	E62	E5
	17		46204	1/12/2000	376	ARN04101	E62	E5
	18		46204	1/12/2000	376	ARN04101	B62	B5
	19		46198	1/16/2000	380	ARN01222	E52	E3
	20		46198	1/16/2000	380	ARN01222	B52	B3
	21		46209	1/18/2000	382	ARN02415	E63	E5
	22		46209	1/18/2000	382	ARN02415	B63	B5
	23		46192	1/19/2000	383	ARN06180	E63	E5
	24		46192	1/19/2000	383	ARN06180	B63	B5
	25		46200	1/19/2000	383	ARN04741	B63	B5
	26		46200	1/19/2000	383	ARN04741	E63	E5
	27		46197	1/21/2000	385	ARN78	E56	E8
	28		46197	1/21/2000	385	ARN78	B56	B8
	29		46197	1/22/2000	386	ARN78	E52	E3

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Inspection Data is Ready

	Row	Ex.	Measurements				Sea Level Pressure (kilopascals)					Wind Sp		
			Operating Center	Ident	Date	Age	Average	Max	Min	Max Jump	Max Drop	Average	Max	Min
▶	1		OPS 12	ARN04873	1/4/2006	2560	1,013.1	1,020.1	1,004.2	0.0	-2.1	11.6	17.0	4.0
	2		OPS 12	ARN04873	1/17/2006	2573	1,018.4	1,023.1	1,009.4	1.0	-1.8	18.7	33.0	4.0
	3		OPS 12	ARN04873	4/7/2006	2653	1,004.6	1,008.0	1,000.9	2.0	-1.2	11.9	30.0	0.0
	4		OPS 12	ARN04873	1/14/2006	2570	999.4	1,009.3	992.7	2.5	-1.3	28.2	44.0	7.0
	5		OPS 12	ARN04873	4/24/2006	2670	1,008.1	1,010.3	1,006.6	0.6	-0.9	13.4	22.0	7.0
	6		OPS 12	ARN04873	8/24/2006	2792	1,017.1	1,018.2	1,016.2	0.9	-0.5	6.4	19.0	0.0
	7		OPS 12	ARN04873	12/23/2006	2913	1,006.8	1,014.8	1,003.3	0.3	-1.6	13.6	32.0	0.0
	8		OPS 12	ARN04873	9/24/2006	2823	998.7	1,006.6	992.4	2.0	-1.7	24.2	50.0	6.0
	9		OPS 12	ARN04873	3/13/2006	2628	1,006.7	1,015.5	994.0	0.4	-3.1	15.1	32.0	0.0
	10		OPS 12	ARN04873	11/7/2006	2867	1,018.8	1,022.7	1,015.3	0.3	-1.1	9.3	17.0	4.0
	11		OPS 12	ARN04873	12/30/2006	2920	1,032.1	1,038.2	1,028.8	0.7	-1.4	9.5	15.0	4.0
	12		OPS 12	ARN04873	11/26/2006	2886	1,023.1	1,025.1	1,021.1	1.1	-0.5	7.5	13.0	4.0
	13		OPS 12	ARN04873	10/20/2006	2849	1,005.0	1,007.8	1,002.4	0.8	-1.3	15.4	24.0	0.0
	14		OPS 12	ARN04873	11/15/2006	2875	1,014.6	1,016.6	1,011.4	0.6	-0.4	6.5	13.0	0.0
	15		OPS 12	ARN04873	11/2/2006	2862	1,015.0	1,016.4	1,013.6	0.8	-0.5	11.0	20.0	4.0
	16		OPS 12	ARN04873	12/16/2006	2906	1,015.8	1,020.5	1,005.7	2.0	-0.9	13.3	22.0	0.0
	17		OPS 12	ARN04873	12/14/2006	2904	1,009.3	1,011.7	1,004.7	0.3	-1.5	10.7	17.0	4.0
	18		OPS 12	ARN04873	9/10/2006	2809	1,026.7	1,029.7	1,022.9	1.0	-0.3	11.9	17.0	6.0
	19		OPS 12	ARN04873	9/5/2006	2804	1,016.7	1,019.0	1,013.9	0.5	-1.0	6.3	9.0	4.0
	20		OPS 12	ARN04873	9/3/2006	2802	1,018.0	1,023.0	1,014.9	0.3	-0.9	16.5	26.0	4.0
	21		OPS 12	ARN04873	5/10/2006	2686	1,013.0	1,014.7	1,011.0	0.3	-0.8	17.1	26.0	6.0
	22		OPS 12	ARN04873	7/11/2006	2748	1,016.6	1,018.0	1,014.6	0.6	-0.2	7.3	15.0	4.0
	23		OPS 12	ARN04873	8/6/2006	2774	1,020.1	1,023.2	1,013.6	0.7	-1.2	10.5	20.0	4.0
	24		OPS 12	ARN04873	2/23/2006	2610	1,008.7	1,010.7	1,004.6	0.3	-0.8	6.8	22.0	0.0
	25		OPS 12	ARN04873	2/4/2006	2591	1,008.9	1,014.5	995.5	1.1	-3.5	18.3	43.0	0.0
	26		OPS 12	ARN04873	1/3/2006	2559	1,020.5	1,021.6	1,019.6	0.7	-1.0	15.2	26.0	7.0
	27		OPS 12	ARN04873	1/25/2006	2581	1,002.8	1,014.0	996.5	1.5	-0.2	17.9	32.0	4.0
	28		OPS 12	ARN04873	1/24/2006	2580	1,004.4	1,012.4	996.8	0.2	-2.1	12.8	22.0	6.0

Measurements	
Operatin	ARNPRIOR
Ident	ARN04873
Date	1/4/2006
Age	2560
Sea Level Pressure (kilopascals)	
Average	1,013.1
Max	1,020.1
Min	1,004.2
Max Jump	0.0
Max Drop	-2.1
Wind Speed (km/h)	
Average	11.6
Max	17.0
Min	4.0
Max Jump	7.0
Max Drop	-6.0
Dry Bulb Temperature (deg C)	
Average	-6.9
Max	9.6
Min	-9.4
Max Jump	18.9
Max Drop	-19.0
Thunderstorm	
Max	
Min	
Max Jump	
Hours of	
Rain	
Average	

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Part III

CBM Modeling in EXAKT

Weather and Lightning Variables

ELEMENT	ELEMENT_DESCRIPTION	Max	Min	Avg	Max Jump	Max Drop	Hours Of Max
73	Sea Level Pressure (kilopascals)	√	√	√	√	√	
76	Wind Speed (km/h)	√	√		√	√	
78	Dry Bulb Temperature (deg C)	√	√	√	√	√	
85	ThunderStorm	√	√		√		√
86	Rain	√	√	√	√		√
89	Freezing Rain	√	√	√	√		√
90	Freezing Drizzle	√	√	√	√		√
91	Snow	√	√	√	√		√
156	Wind Direction						

Wind Direction	Hours
Calm	√
N	√
E	√
S	√
W	√
NE	√
NW	√
SE	√
SW	√

Lightning	Number of Strikes
Lightning Strike	√

Raw hourly weather and lightning data are summarized into daily (or weekly, or monthly) data consisting of 48 variables listed in these 3 tables, to reduce the huge amount of weather and lightning data for processing and modeling.

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Summary of Data for EXAKT Modeling

Basic Data Analysis

Number of Idents:	**1059**
Number of Histories:	**1424**
Number of beginnings (B):	**1424**
Number of failures (EF):	**265**
Number of suspensions (ES):	**91**
Number of temporary suspensions (*ES):	**1068**
Number of inspections (IN):	**23439**
Number of histories without inspections (IN)	**37**

Basic Statistical Analysis

	Average	Std. Dev.
Inspection Interval	**6.81**	**0.92**
Inspections per History	**16.46**	**11.00**
History (Overall)	**112.86**	**76.53**
History (Failed)	**75.69**	**69.67**
History (Suspended)	**69.65**	**59.08**
History (Temp. Suspended)	**125.76**	**75.09**
History (Failed+Suspended)	**74.15**	**67.18**

(-) Not applied

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EXAKT Model

Number of lifecycles

Preventive renewals

Units presently operating

Summary of Events and Censored Values

Sample Size	Failed	Censored (Def)	Censored (Temp)	% Censored
1415	265	91	1068	81.3

Age influence parameter

Variable is Significant – yes /no

Measure of scatter

Other statistical tests for assessing model applicability

Summary of Estimated Parameters (based on ML method)

Parameter	Estimate	Sign. (*)	Standard Error	Wald	DF	p - Value	Exp of Estimate	95 % CI	
								Lower	Upper
Scale	2709	-	1032	-	-	-	-	687.7	4731
Shape	0.781	Y	0.04546	23.21	1	0	-	0.6919	0.8701
MaxWinSpeDrop	0.06944	Y	0.02	12.05	1	0.0005179	1.072	0.03023	0.1086

(-) Not applied

(*) Based on 5% significance level. Shape = 1 tested, Gamma (Cov) = 0 tested

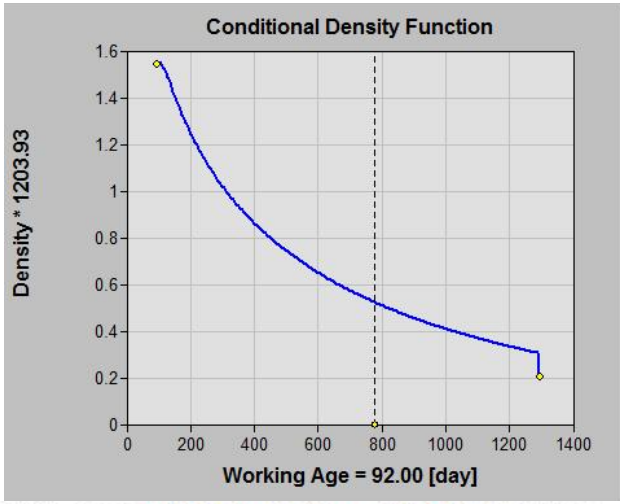
Test for “statistical significance” the found relationship between interruption probability and MaxWind Speed Drop.

Summary of Goodness of Fit Test

Test	Observed Value	p - Value	PHM Fits Data
Kolmogorov - Smirnov	0.0402135	0.0201051	Rejected (*)

(*) based on 5% significance level

Remaining Useful Life Estimate

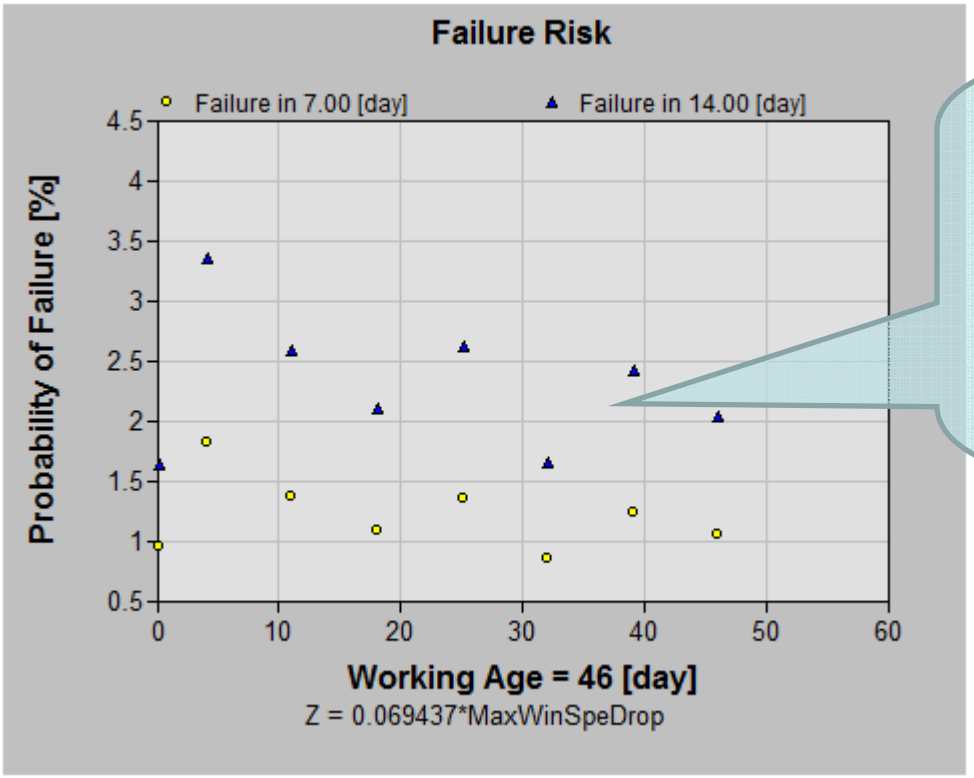


RUL=180.065828, StdDev=77202.972879

Equal Tails Intervals		Mean-Centered Intervals (Mean = Working Age + RUL)		
Probability	Interval	Mean ± k*StdDev	Interval	Probability
50%	[335.21, >1293.09]	272.07 ± 0.50*77202.97	[92.00, 38873.55]	<1.00
60%	[275.71, >1293.09]	272.07 ± 0.75*77202.97	[92.00, 58174.30]	<1.00
70%	[222.26, >1293.09]	272.07 ± 1.00*77202.97	[92.00, 77475.04]	<1.00
80%	[174.33, >1293.09]	272.07 ± 1.50*77202.97	[92.00, 116076.53]	<1.00
90%	[131.37, >1293.09]	272.07 ± 1.75*77202.97	[92.00, 135377.27]	<1.00
95%	[111.46, >1293.09]	272.07 ± 2.00*77202.97	[92.00, 154678.01]	<1.00
99%	[95.89, >1293.09]	272.07 ± 2.50*77202.97	[92.00, 193279.50]	<1.00

Prediction of Interruption

Recommendation:	**Don't intervene.**
Expect to Replace in [day]:	**1116.53**
Probability of Failure in (7) [day]:	**0.0103549**
Probability of Failure in (14) [day]:	**0.020311**
Report Date:	**09/06/09**
Current Status:	**In operation**



Probability of interruption in:

- 7 days (yellow points)
- 14 days (blue triangles)

Area Summary under 3 modes

criteria			Ops 4	Ops 5	Ops 6	Ops 7	Ops 8	Ops 9	Ops 10	Ops 11	Ops 12
2000	All failure modes combined	Sample Size	335	658	488	583	423	682	547	390	712
		Failed (EF)	87	251	143	152	115	289	109	93	229
		Censored (ES)	61	99	36	112	50	76	121	59	116
		Temp Censored (ES)	187	308	309	319	258	317	317	238	367
		Shape β (Estimate)	0.7717	0.8343	0.9547	1.012	0.8217	0.9291	0.9196	1.111	0.8672
		Scale μ (Estimate)	4356.17	2041.84	3314.2	3026.46	4158.17	1668.34	4782.06	3316.8	2662.71
		Mean Life (Estimate)	5069.78	2247.95	3383.8	3012.05	4624.57	1726.22	4974.05	3190.43	2861.77
		Goodness of Fit Test p-value	0.0021	0.0003	0.5306	0.8729	0.0099	0.1255	0.3059	0.2805	0.008
		Scale and Mean Life (Shape fixed to 1)	3137.74	1791.16	3154.5	3063.67	3275.17	1601.08	4245.57	3735.56	2339.51
5500	Failure mode "Tree fallen"	Sample Size	222	489	370	383	280	496	410	280	531
		Failed (EF)	14	110	49	19	11	143	21	16	102
		Censored (ES)	21	71	12	45	11	36	72	26	62
		Temp Censored (ES)	187	308	309	319	258	317	317	238	367
		Shape β (Estimate)	1.143	0.9927	1.295	1.569	1.013	1.117	1.511	2.214	1.061
		Scale μ (Estimate)	13963.9	4125.7	5937.2	8618.31	32835.3	2908.14	8525.51	4800.37	4830.84
		Mean Life (Estimate)	13315.1	4138.63	5487.8	7741.57	32655.2	2791.97	7689.5	4251.43	4720.24
		Goodness of Fit Test p-value	0.6257	0.9316	0.0937	0.0984	0.9645	0.1592	0.0986	0.0215	0.5265
		Scale and Mean Life (Shape fixed to 1)	19500.6	4086.63	9205.8	24511.3	34242.4	3236	22037.4	21716.4	5252.7
5500	Failure mode "Equipment / Material failure"	Sample Size	236	436	381	440	334	412	442	304	497
		Failed (EF)	28	57	60	76	65	59	53	40	68
		Censored (ES)	21	71	12	45	11	36	72	26	62
		Temp Censored (ES)	187	308	309	319	258	317	317	238	367
		Shape β (Estimate)	0.7172	0.9646	0.8994	1.067	0.8242	1.375	0.9931	1.267	1.08
		Scale μ (Estimate)	21791.5	8445.84	9157.9	5542.05	8000.63	4800.78	8848.3	5824.44	6873.05
		Mean Life (Estimate)	26967.2	8581.43	9639.1	5404.41	8879.55	4388.53	8874.51	5408.7	6672.58
		Goodness of Fit Test p-value	0.0294	0.7657	0.3646	0.5575	0.0679	0.0242	0.9565	0.1551	0.5104
		Scale and Mean Life (Shape fixed to 1)	9747.14	7887.43	7518.2	6127.71	5794.79	7842.87	8731.94	8686.59	7879.23

Part IV

Conclusions

Conclusions

- There are many opportunities to move our businesses forward when we look for them!
  - Analysis can be done with internal or external variables
- Analysis may be carried out on small machines in a plant or on equipment covering an area the size of the province of Ontario
- Data can be in many structures and formats

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Conclusions

- More data over time improves the opportunity for analysis and decision making
- Closing the "crevice" is much more than creating a few tables
  - It has lead to additional opportunities for exploration and mining of the data
- The process is easy to use and manages hundreds of thousands of records and data

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Conclusions

- BI-Cycle together with OMDEC know-how and Hydro One business expertise provide the necessary data processing methods to feed EXAKT

- EXAKT provides the mathematical algorithms to

Conclusions

move from a foggy to a clear view

and CLOSE the CREVICE!

Click for next

Closing the Crevice

- With this process implemented, we are moving forward in our analysis and decision making
- There's no worry even when

deer get tangled in the wires

Click for next

Thank You

Norm.Hann@**HydroOne**.com

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