



Aplicações Especiais em Sistemas de Suporte à Decisão Tendências Futuras

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- ▶ **LIGHT - COS e COR1** - **Open VMS**
- ▶ **AES ELETROPAULO** - **LINUX**
- ▶ **AES TIETE** - **SCADA LINUX**
- ▶ **ONS** - **UNIX**
 - ◆ *COS Brasília – Florianópolis – Recife*
- ▶ **SIEPAC – América Central** - **LINUX**
 - ◆ *(Honduras, Guatemala, Nicarágua, Costa Rica, Panamá e El Salvador)*
- ▶ **CDEC SING – Chile** - **WINDOWS**
- ▶ **PEMEX – Mexico** - **WINDOWS**

Líder de mercado



COS - 200 subestações AES ELETROPAULO





Energy Management System (EMS) Background



- ▶ **Após black-out em 2003, Utilities devem demonstrar “Situation Awareness” nos centros de operação de sistema.**

- ▶ **Operadores e analistas devem:**
 - ◆ **Entender o estado atual do sistema.**
 - ◆ **Ser capazes de reagir a eventos rapidamente.**
 - ◆ **Coordenar ações para evitar black-outs.**
 - ◆ **Manter operação confiável do sistema de transmissão.**
 - ◆ **Gestão do conhecimento da rede elétrica.**



Principais Causas do Black-Out de 14/Ago/2003

- 1. Critérios de operação impróprios: entendimento incompleto das inadequações do sistema**
 - 2. Falha em reconhecer condições de degradação do sistema**
 - 3. Crescimento de participantes no sistema de transmissão**
 - 4. Ferramentas de confiabilidade não provêm suporte a diagnóstico em tempo-real**
- ▶ **Causas 1, 2 e 4 diretamente associadas a centros de controle:**
- ◆ **Ferramentas de Software**
 - ◆ **Práticas de comunicação**
 - ◆ **Treinamento**



Control Centers: “Keep the lights on”

- ▶ **Control Centers manage the flow of energy in the power system grid:**
 - ◆ **EMS manages the “physical flow”**
 - ◆ **Market Systems (MMS) manage the “financial flow”**



- ▶ **Electricity as a Commodity Cannot be Stored!**
- ▶ **Electricity Demand changes from instant to instant**
- ▶ **Supply needs to change instantaneously to meet Demand...**
- ▶ **If supply does not equal demand, Frequency goes off-normal (not 60Hz)... which results in:**
 - ◆ **Protective relay trips of generating units, loads, etc.**
 - ◆ **Potential for a cascading blackout..**
 - ◆ **And your electric alarm clocks would not keep correct time! 😊**

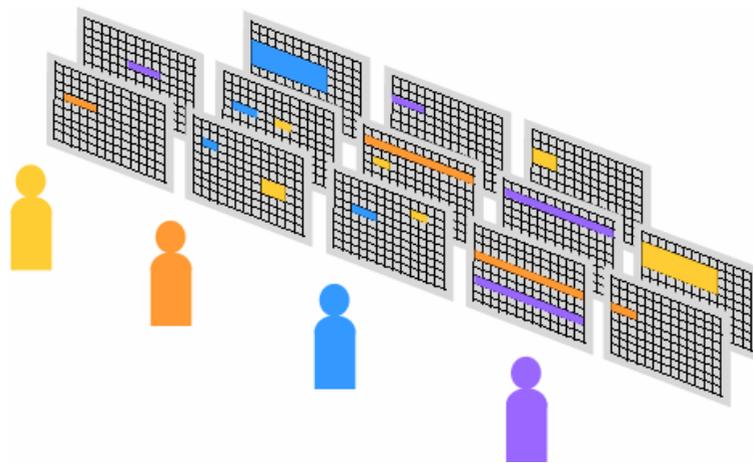


Energy Management System (EMS)

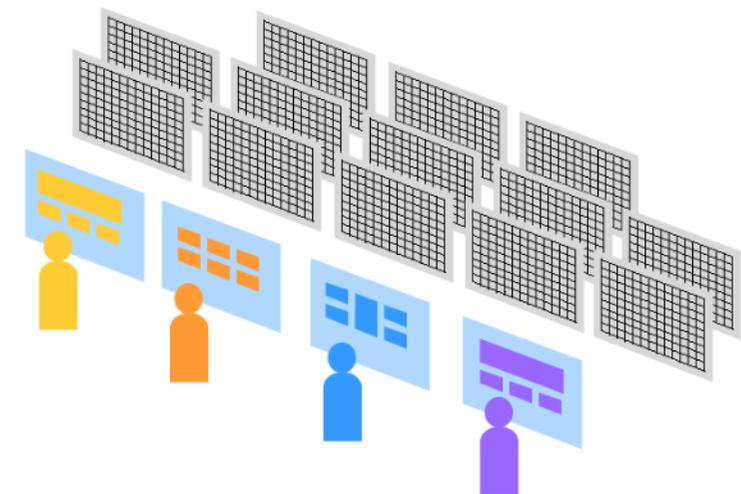
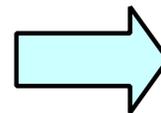
- ▶ **Energy Management Systems (EMS) capabilities have evolved over the past 40 years (since the 1965 blackout)**
- ▶ **EMS manage the “physical flow” of electricity in the grid.**
 - ◆ **Operate the electric grid within safe limits**
 - ◆ **Operate the system reliably – “Prevent Blackouts”**
 - ◆ **Automatically adjust generation in response to Instantaneous customer load changes**
(Remember, Electricity Cannot be Stored....)
 - ◆ **Identify potential risks and take preventive action**
 - ◆ **Expedite restoration of customers after an emergency**



Evolução das Necessidades de Operadores Mais Informações, Menos Dados



Operadores verificam dados



Operadores necessitam informações



- ▶ **“Black-outs ocorrerão novamente no futuro...”**
 - ◆ **Rede elétrica complexa e “antiquada” para ser tornada segura!**
- ▶ **Na última década, a nível mundial:**
 - ◆ **Investimento em geração excedeu o de transmissão...**
 - ◆ **Tornou-se uma “barreira” para a transmissão de energia**
 - ◆ **Significa mais congestionamento...**
- ▶ **Nosso desafio:**
 - ◆ **Prevenir e controlar um black-out que estiver iniciando.**
 - ◆ **E mais importante:**
 - **Restaurar energia aos consumidores, o mais rápido possível!**





EMS ***Software Applications***

▶ Supervisory Control and Data Acquisition (SCADA)

- ◆ *Monitor physical system conditions in real time (2-4 sec)*
- ◆ *Perform supervisory controls*
- ◆ *Exchange data with external functions*
- ◆ *Mapboard and strip-charts*

▶ Generation Applications

- ◆ *System load forecast (SLF)*
- ◆ *Generation/Interchange scheduling*
- ◆ *Real-time economic dispatch (ED) & reserve monitoring*
- ◆ *Real-time automatic generation control (AGC) (4-10 sec)*



▶ Transmission Applications

- ◆ *State Estimation (SE)*
- ◆ *Network Security Analysis: real time contingency analysis (CA) for N-1 system security*
- ◆ *System Optimization: remedial actions, volt/var control*

▶ Dispatcher Training Simulator

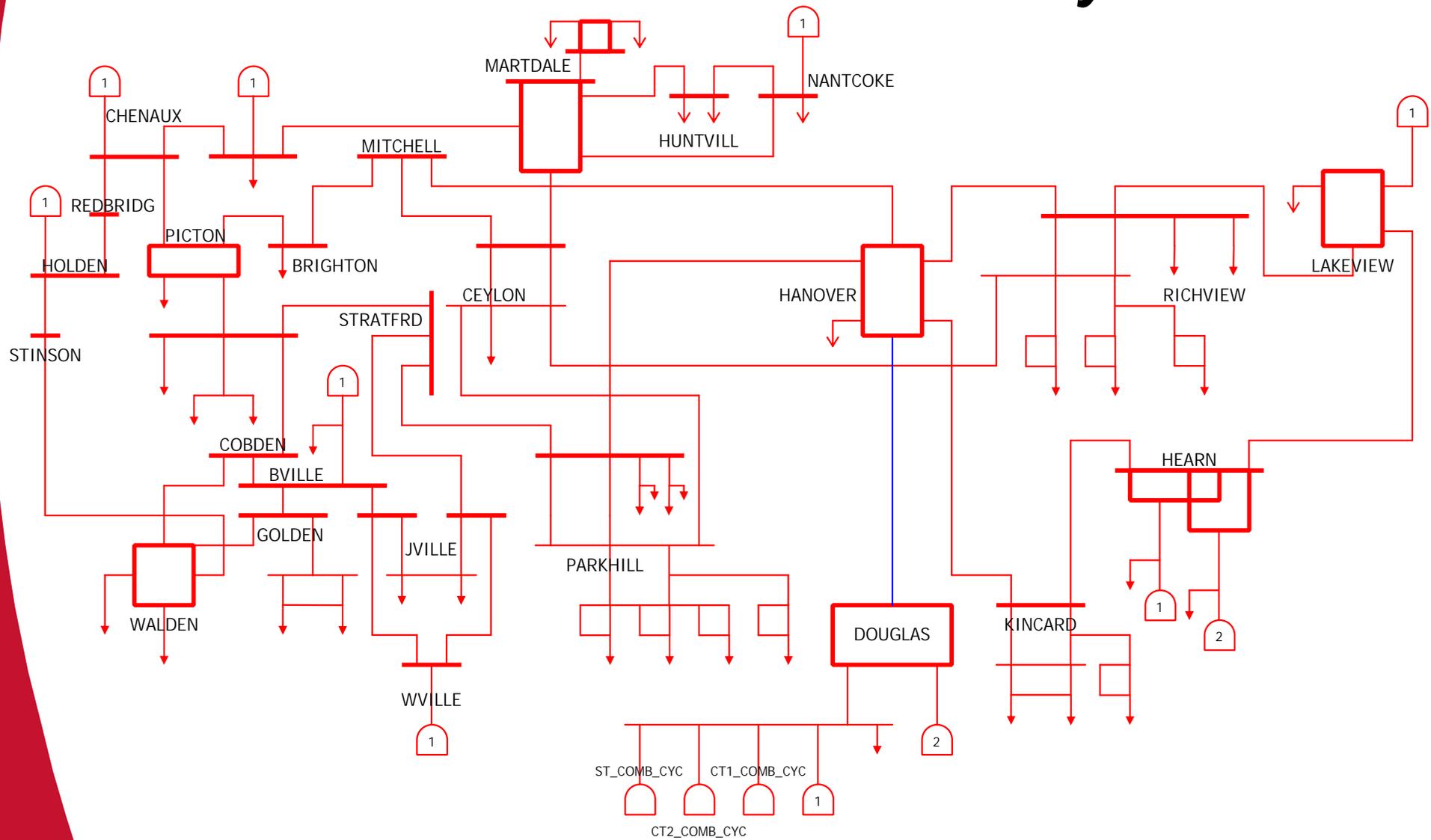
- ◆ *Dispatcher Training Simulator (DTS) of historical and hypothetical scenarios*

▶ Others Business Functions:

- ◆ *Modeling and Database management*
- ◆ *Display Management*
- ◆ *Energy accounting, Archival, etc*



Mapboard Layout





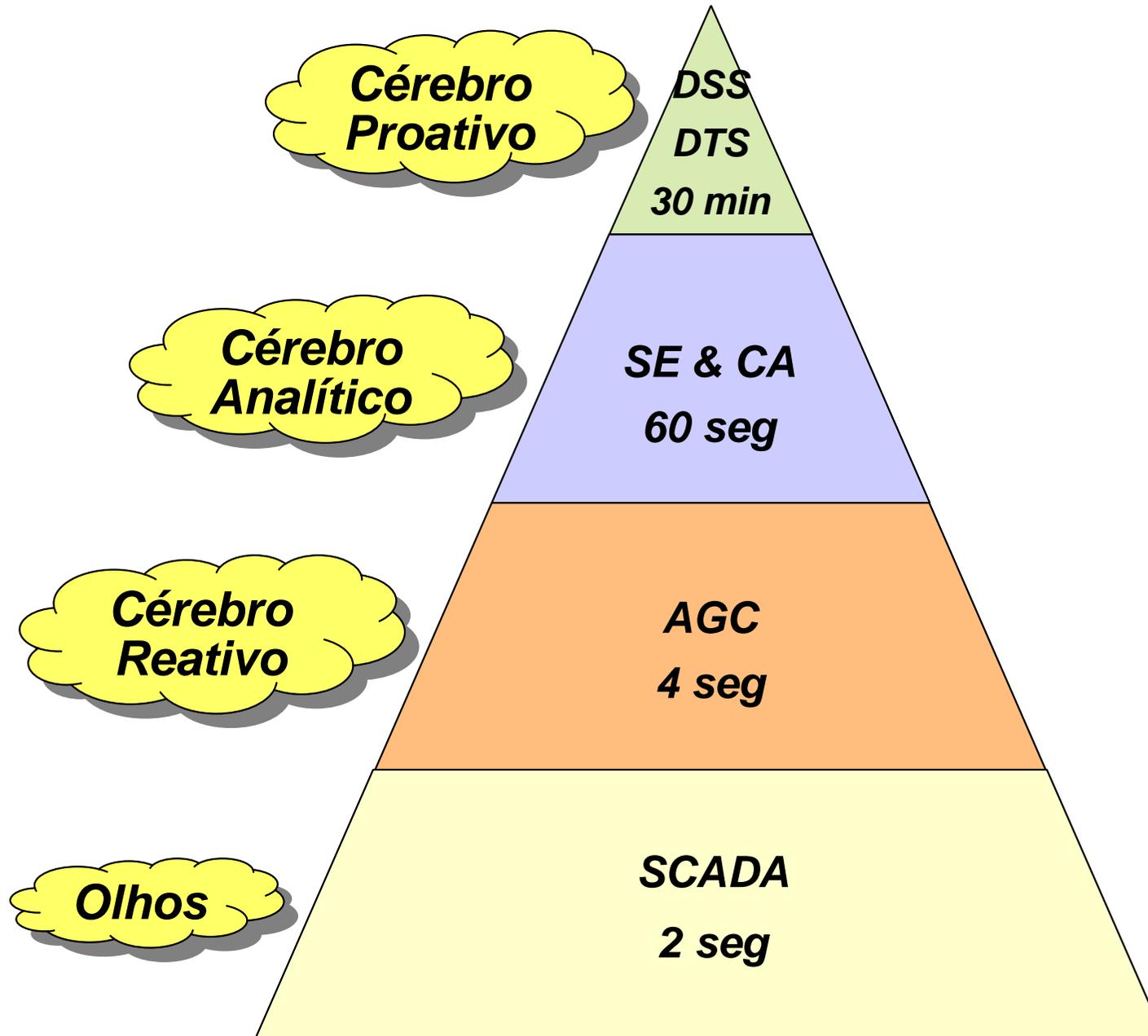
Recap of EMS Objectives

- ▶ *Ensure successful operation of what is considered to be the greatest engineering achievement of the 20th century.*
- ▶ *Make operational decisions using the information available to you.*
- ▶ *Plan for emergencies... Steer away from pitfalls.*
- ▶ **KEEP THE LIGHTS ON!!!!**



Aplicações / Ferramentas EMS Críticas a Situation Awareness



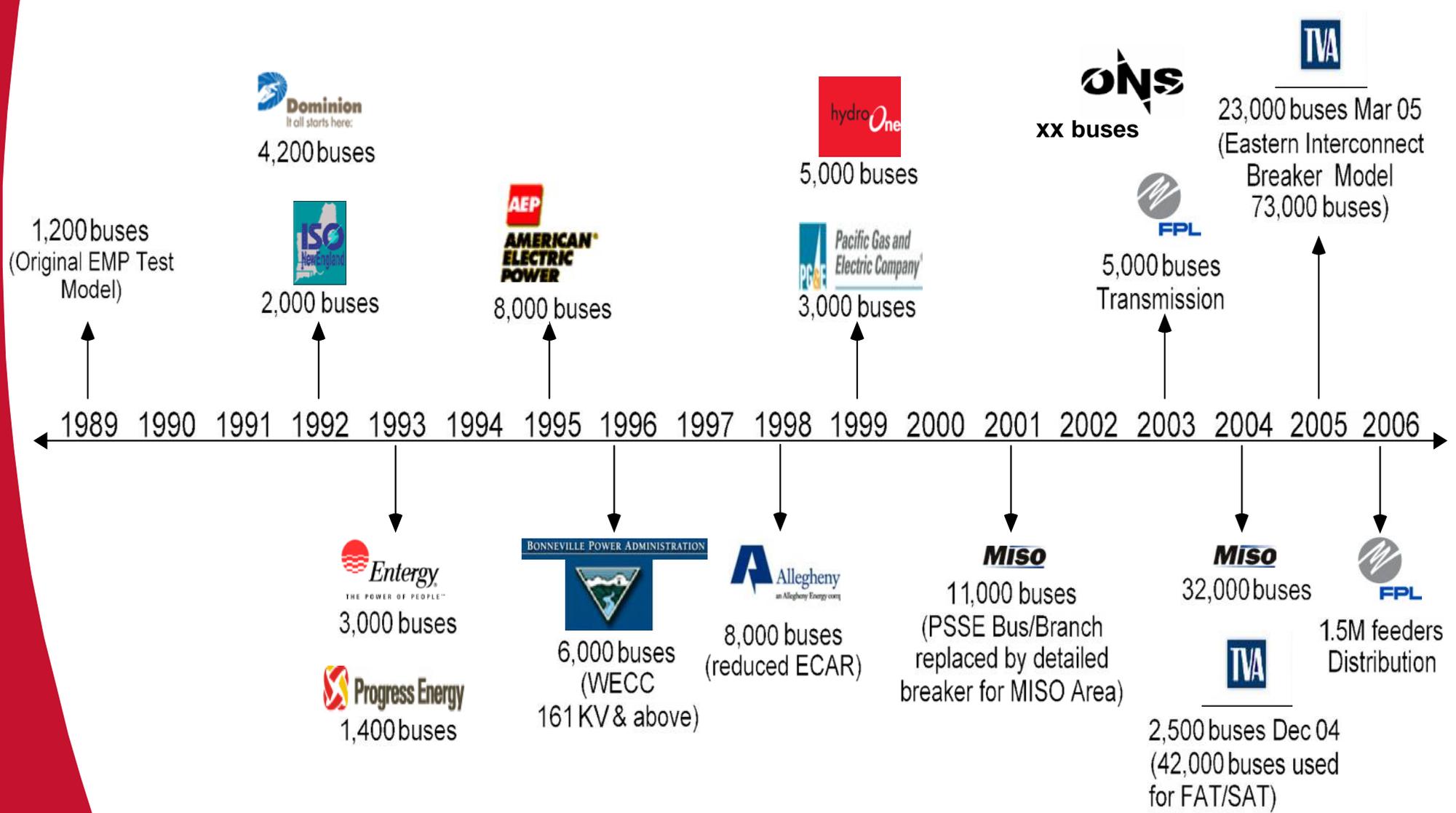


Situational Awareness

Desafios Atuais para Sistemas EMS



Evolução dos Modelos de Rede





1980

1990

2000

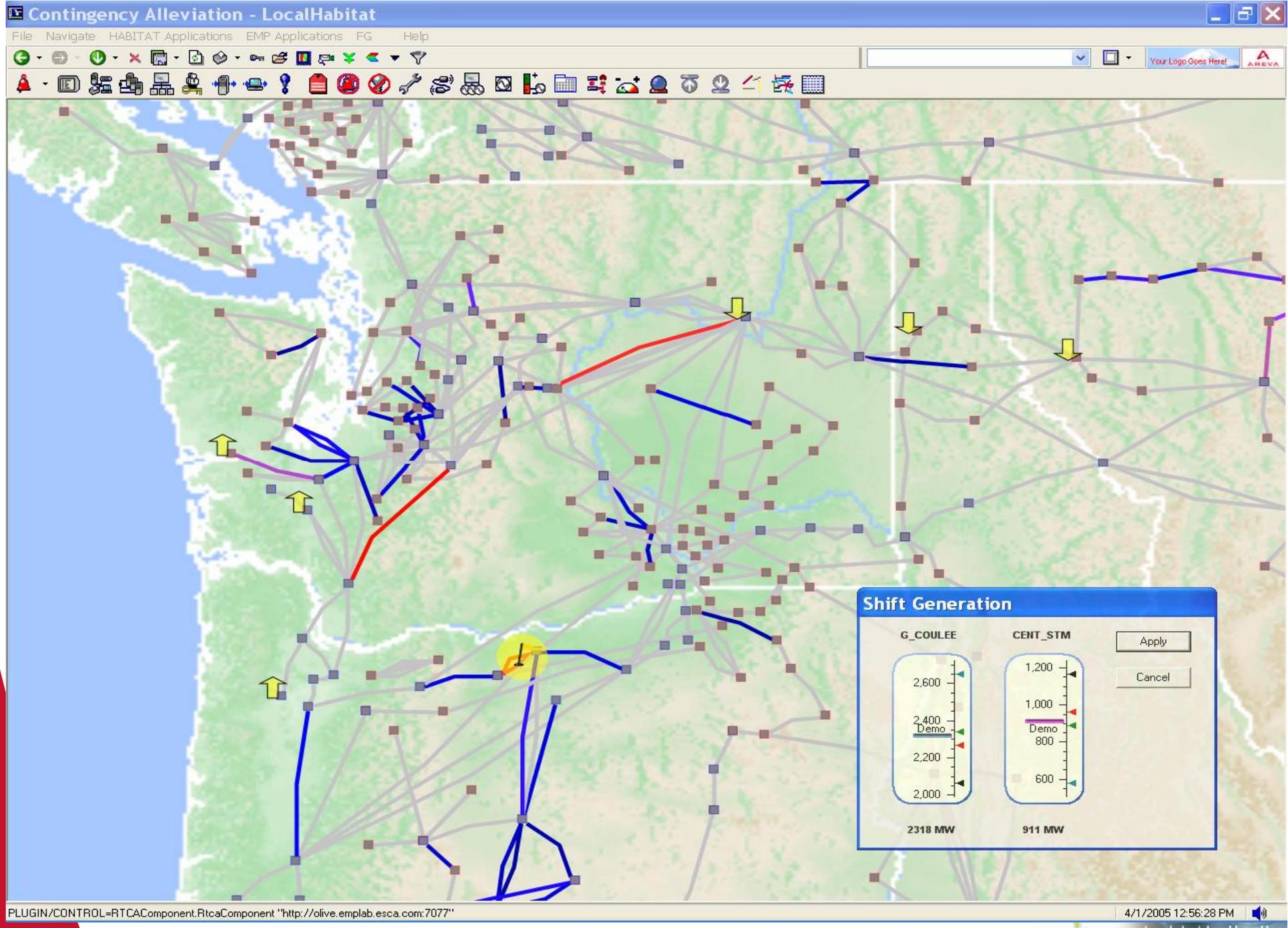
Dados

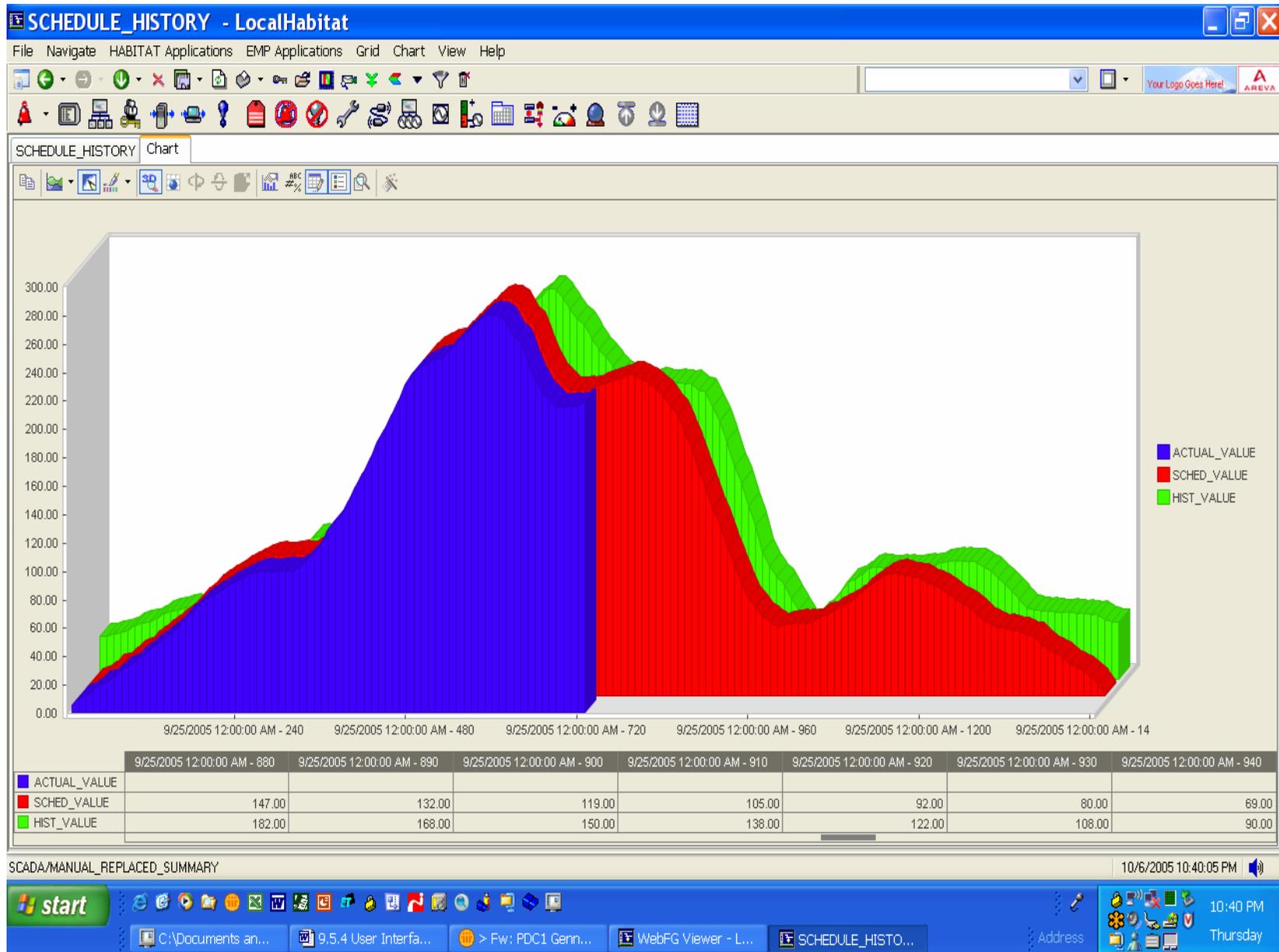
Grande Volume de Dados

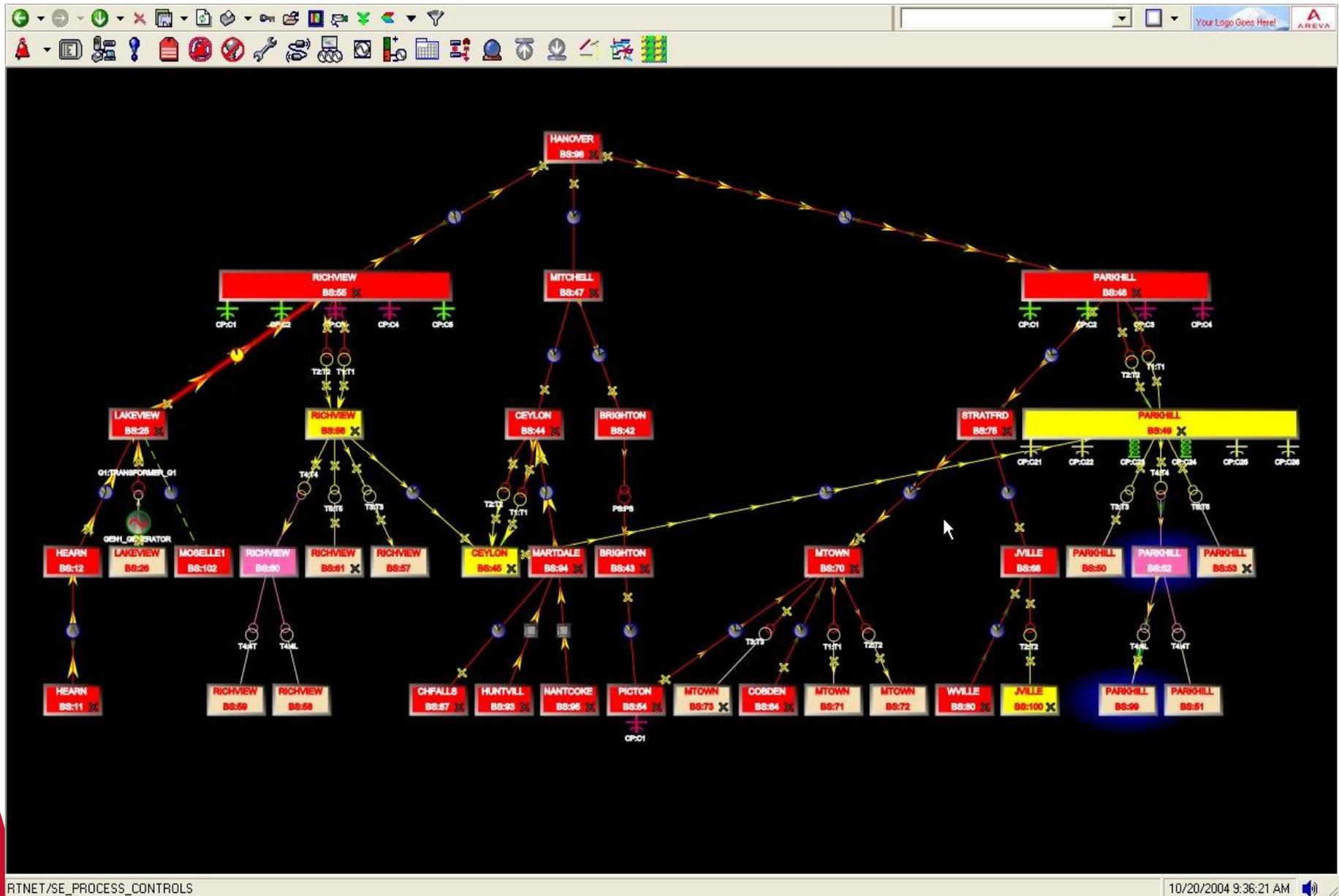


- ▶ **Dynamic updates with SCADA and SE data**
 - ◆ *Topology & major lines, units*
- ▶ **More of a geographical layout.....**
- ▶ **Ability to select geographical area of interest**
- ▶ **Ability to zoom into an area of interest for more details**
- ▶ **Ability to navigate and implement actions**





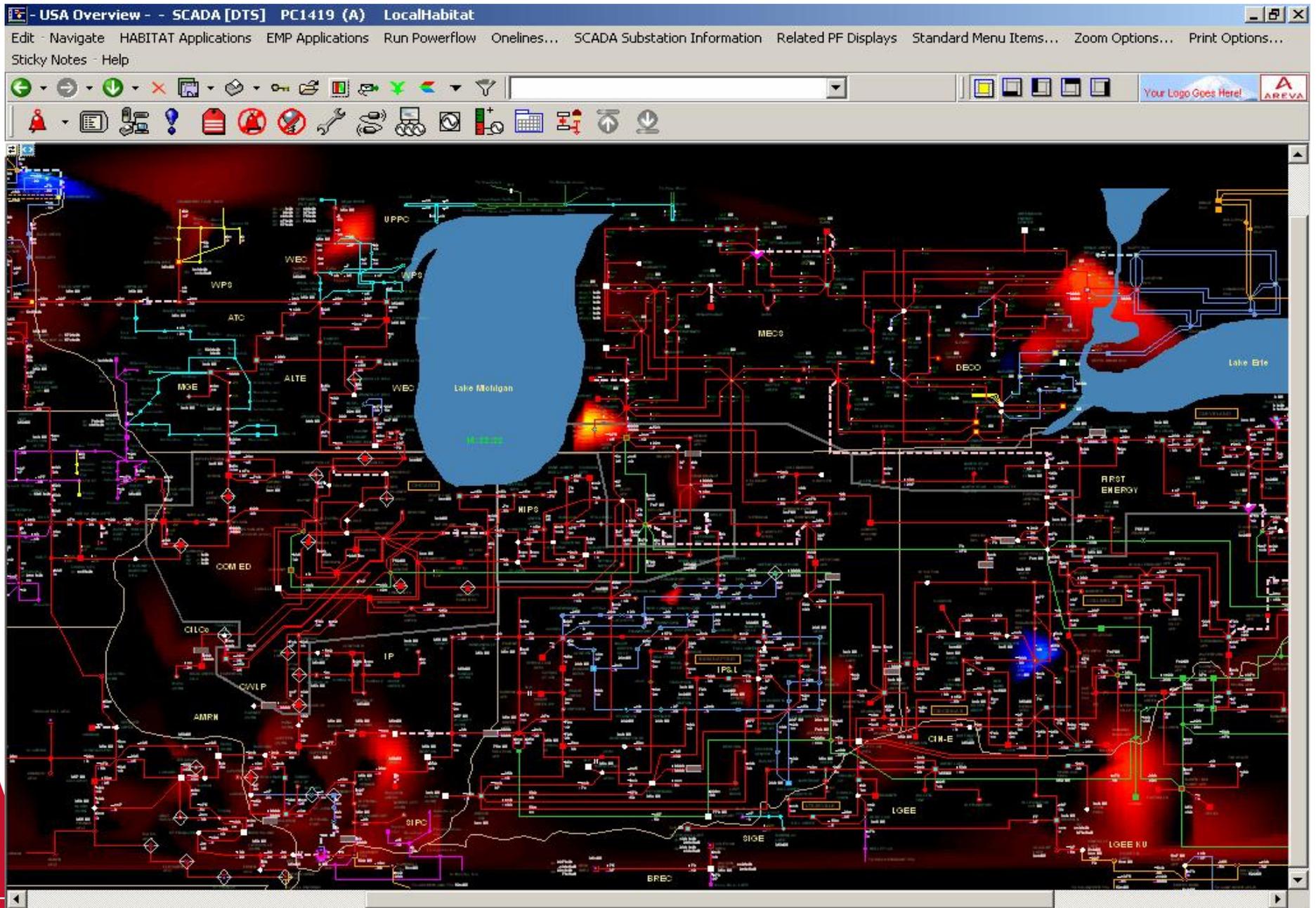




Neighborhood Display: Sample

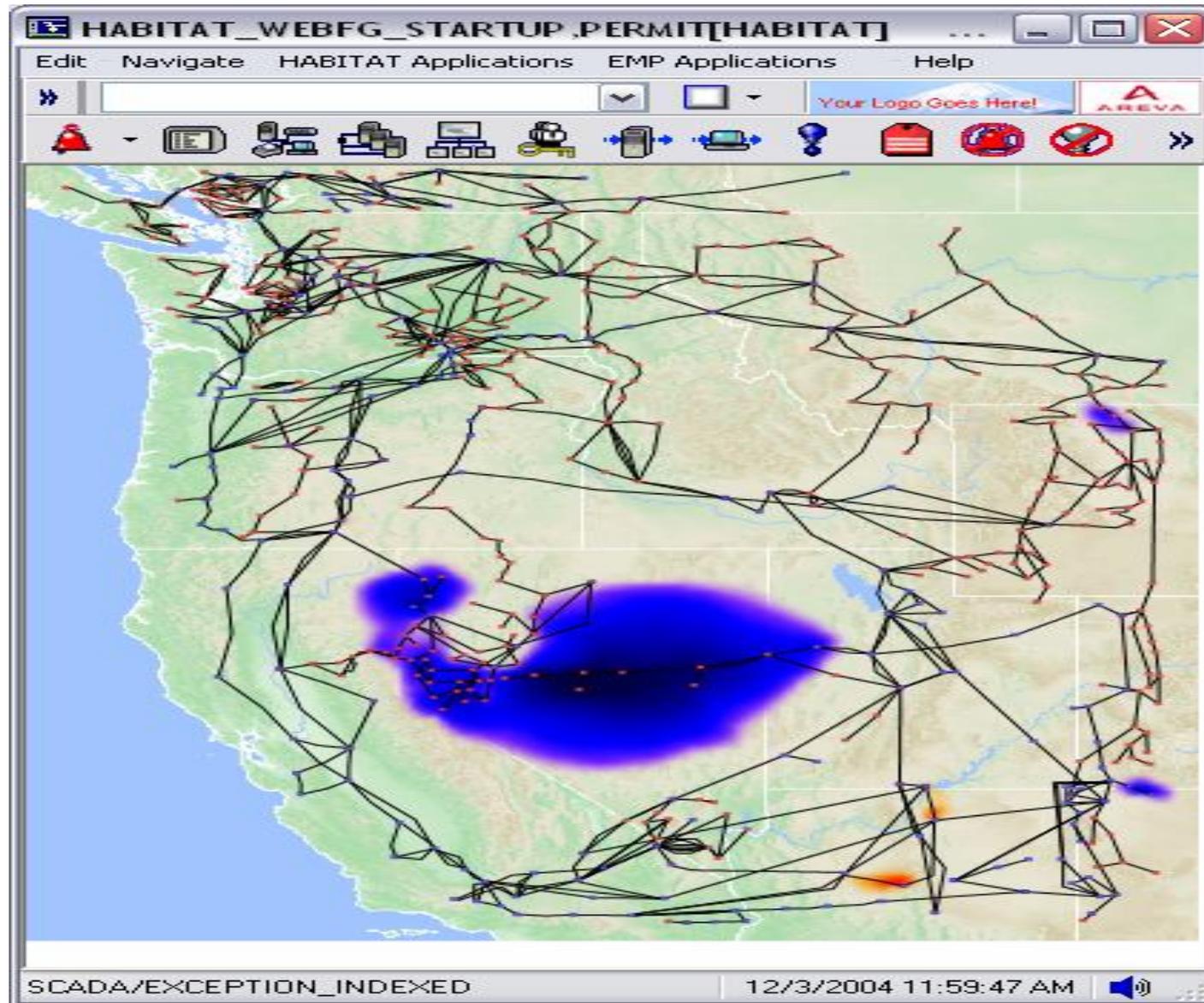


Visualization of dynamic clusters and frequency



Enhanced Wide-Area Visualization

- ▶ Monitor System Voltage Contours, LMPs, Flowgate MWs:

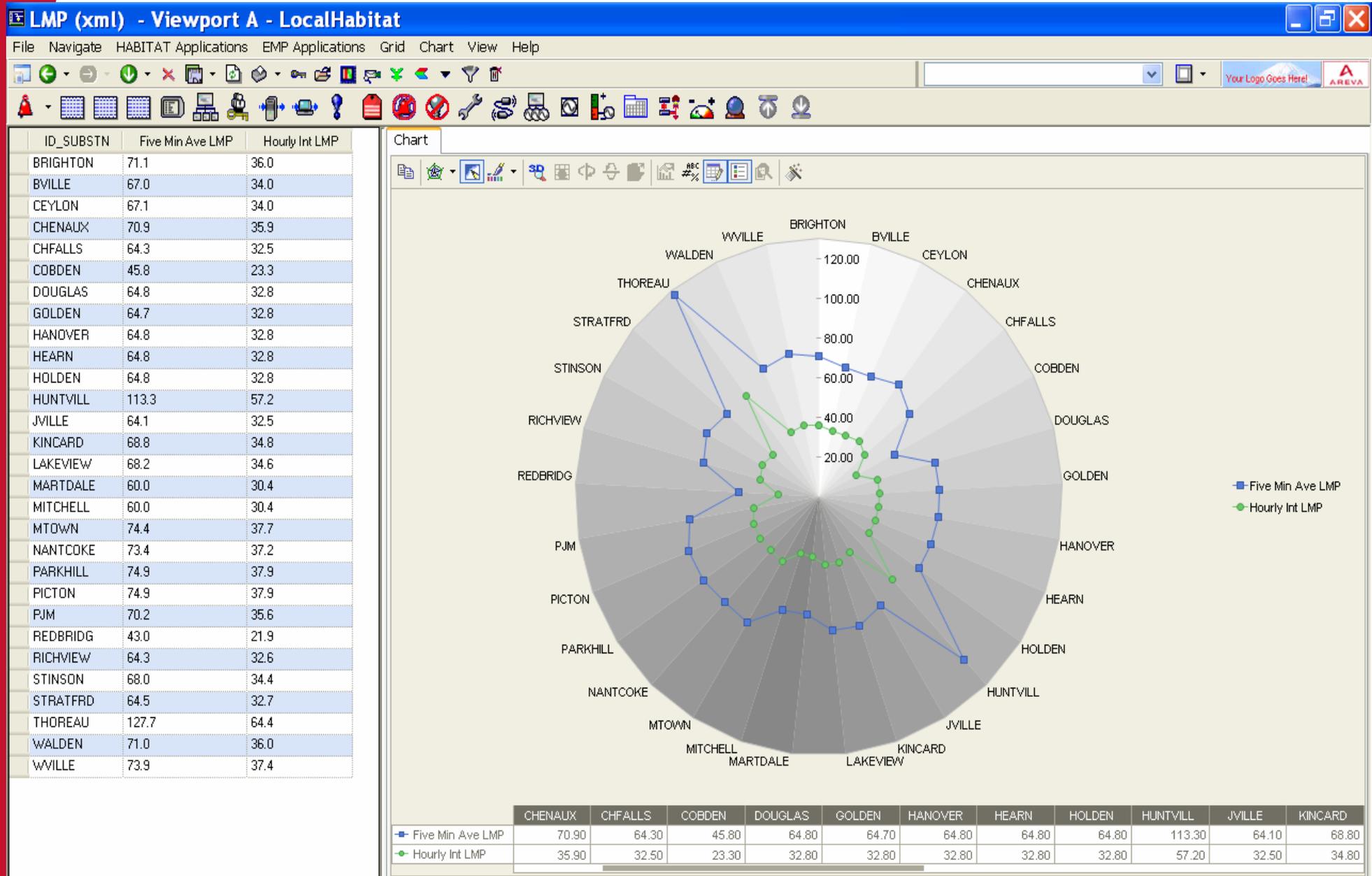


Multiple windows with complementary info

The screenshot displays a SCADA system interface with four main windows:

- Web Browser:** Shows the U.S. Department of Energy National Security page.
- Alarm Summary:** A table listing system events.
- Power System Diagram:** A schematic showing busbars (100101, 99101, 103104, 102104, 104105, 107108) and their associated power ratings (MW, MVAR, MVA).
- Trend Graph:** A line graph showing data over time from 12:00:00 PM to 12:30:00 PM.

Time	State	Message
06 / 11:33:43	▲	HANOVER LN T538 MVA EMERGENCY -675.0 -675.0
06 / 11:27:15	▲	DOUGLAS LN T538 MVA EMERGENCY 676.0 675.0
06 / 11:19:35	▲	DOUGLAS XFMR G2 MW RAMP HIGH 6.8 5.0
06 / 11:18:23	▶▶	WEST -EASTJOU G2W UNIT ONLINE STATUS TLM AVAILABLE
06 / 11:18:23	▶▶	WEST -EASTJOU G2W UNIT MW GEN TELEMETRY AVAILABLE
06 / 11:18:23	▶▶	WEST -EAST JTIEW2 TIE MW TELEMETRY AVAILABLE
06 / 11:18:23	▶▶	EAST -DOUGLAS DB-B PLC RETURN FROM PAUSED
06 / 11:18:23	▶▶	EAST -DOUGLAS DB-A PLC RETURN FROM PAUSED
06 / 11:18:23	▶▶	EAST -HEARN HRN1 PLC RETURN FROM PAUSED
06 / 11:18:23	▶▶	EAST AGC CLEARED FROM PAUSE - AGC RUNNING
06 / 11:18:15	▶▶	EAST -ECAR JTIEE2 TIE MW TELEMETRY AVAILABLE
06 / 11:18:15	▶▶	EAST -ECAR JTIEE1 TIE MW TELEMETRY AVAILABLE
06 / 11:18:15	▶▶	EAST -WEST JTIEW1 TIE MW TELEMETRY AVAILABLE



SCADA/MANUAL_REPLACED_SUMMARY

9/1/2005 5:15:34 PM

Phasor data

- ◆ Refresh rate 30 samples/sec
- ◆ Time tagged data
- ◆ Compatible with modern communication technology
- ◆ Responds to system dynamic behavior
- ◆ Angle-pair change means: MW change; ‘electrical distance change’

EMS SCADA data

- ◆ Refresh rate 2-5 seconds
- ◆ Latency and skew
- ◆ Relies on legacy ‘older’ communication technology
- ◆ Responds to system static behavior
- ◆ Freq change means: Generation/Load imbalance

1 “Phasor” is in quotes to suggest that we are not talking strictly about phasors, but about high speed, accurately time-tagged ‘synchronous’ data in general.



Comparison of SE output with PMU Measurements within a few degrees!

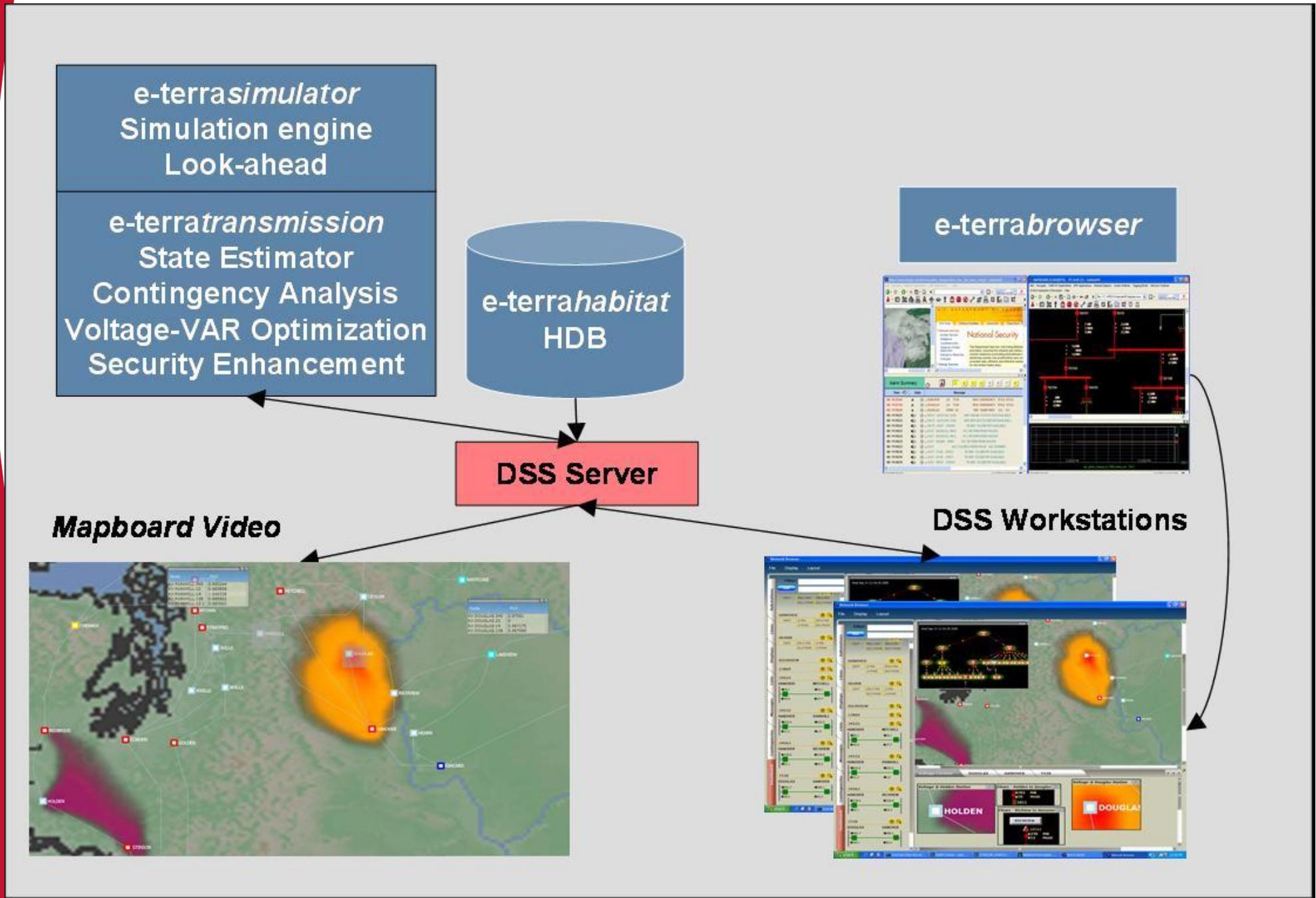
courtesy BPA

Developer PCPrint HAB Apps EMP Apps AGC Analyst Navigate Related Displays Help									
Estimated / Measured Phase Angles									
REAL-TIME NETWORK									
RTNET (Last RTNET Run) 20-Jun-2006 08:46:55				SCADA (Live Data) 20-Jun-2006 08:47:18				Difference (degrees)	
NP01 GRAND COULEE - JOHN DAY	23.79	Deg.		COUL-JDAY_PANG	24.21	Deg.		0.42	
NP02 GRAND COULEE - MALIN	36.16	Deg.		COUL-MALN_PANG	36.92	Deg.		0.76	
NP03 JOHN DAY - MALIN	12.36	Deg.		JDAY-MALN_PANG	12.71	Deg.		0.35	
NP06 GRAND COULEE - COLSTRIP	20.95	Deg.		COLS-COUL_PANG	21.21	Deg.		0.26	
NP10 COLSTRIP - JOHN DAY	44.74	Deg.		COLS-JDAY_PANG	45.52	Deg.		0.78	
NP11 GRAND COULEE - MAPLE VALLEY	21.43	Deg.		COUL-MPLV_PANG	22.01	Deg.		0.58	
NP12 MAPLE VALLEY - KEELER	9.61	Deg.		MPLV-KEEL_PANG	9.50	Deg.		-0.11	
NP13 GRAND COULEE - BIG EDDY	25.62	Deg.		COUL-BIGE_PANG	26.81	Deg.		1.19	
NP14 KEELER - BIG EDDY	5.43	Deg.		KEEL-BGED_PANG	5.40	Deg.		-0.03	
NP15 BIG EDDY - MALIN	10.54	Deg.		BIGE-MALN_PANG	10.11	Deg.		-0.43	
NP17 MALIN - VINCENT	17.95	Deg.		MALN-VINC_PANG	17.81	Deg.		-0.14	
NP16 BIG EDDY - SYLMAR	31.90	Deg.		BGED-SYLM_PANG	32.42	Deg.		0.52	
NP18 JIM BRIDGER - IPC MIDPOINT	26.31	Deg.							
NP19 JIM BRIDGER - MALIN	29.86	Deg.							

Situational Awareness

Future Trends

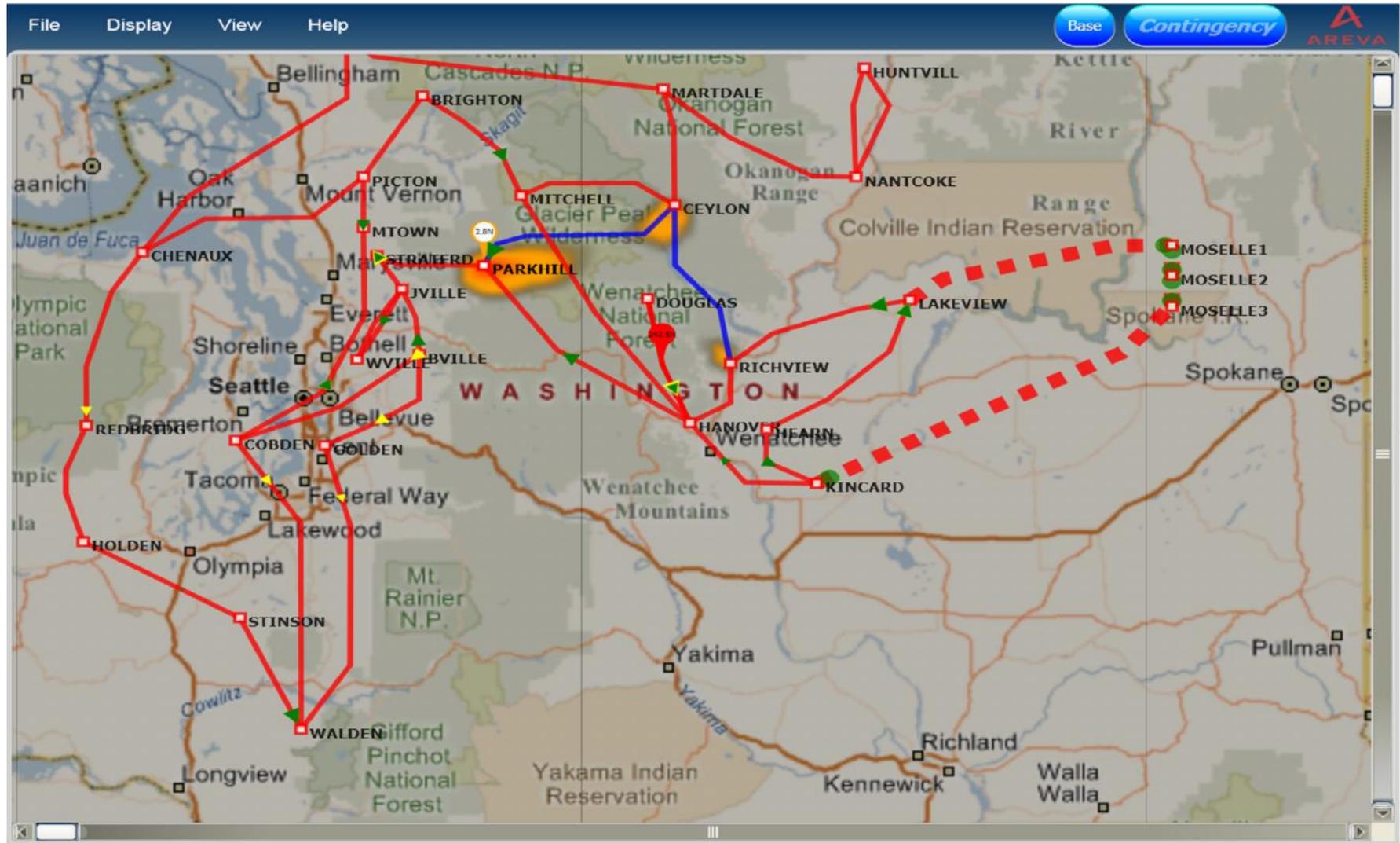




Futura Geração de Displays de Visão Geral



Futura Geração de Telas de Visão Geral



- ▶ **Visão geográfica**
- ▶ **Visão esquemática regional**
- ▶ **Atualizado por BD em tempo-real EMS**



Exemplo de Drill-Down: Tensão / VAR

Network Browser [1] - esca60_overview

File Display View Help

Base Contingency

Context Panel - Violations

Violation Summary

Warning Violation Alarm

Base 4 Ctgy 10

Unsolved Contingencies: 1

MVARs

	Inject	Absorb
Units	1,661.96	2,586.38
Caps	195.00	275.00
Reactors	0.00	35.00
SVS	0.95	74.05
Total	1,857.91	2,970.43

Location	Value
NANTCOKE	739.94 / 402.20
LAKEVIEW	480.20 / 748.41
DOUGLAS	253.03 / 809.00
HEARN	189.75 / 426.04
PAI	170.00

Status

SE

02:09:08 02:09:38

1/3/00 1/3/00

CA

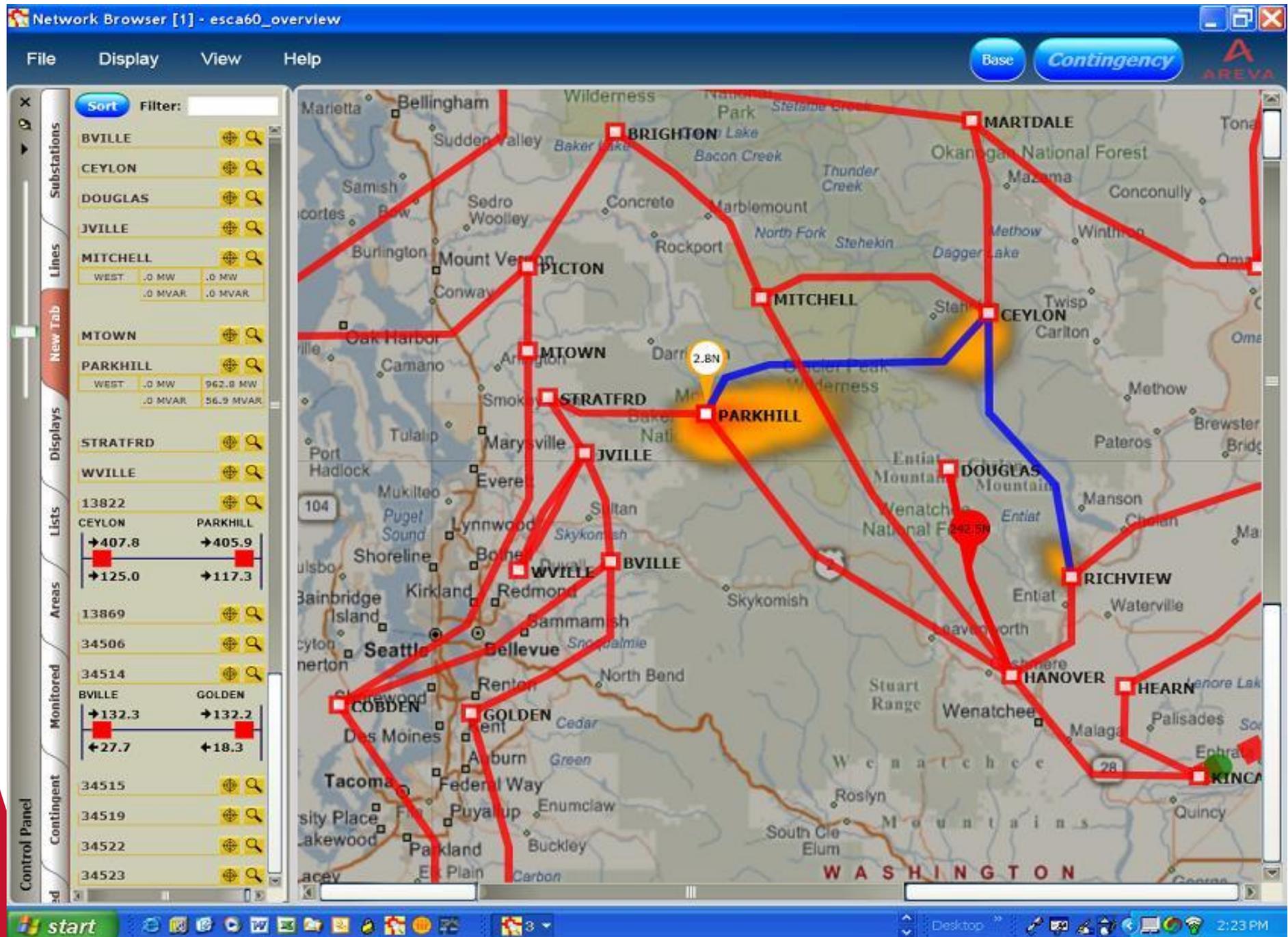
02:09:08 02:09:38

1/3/00 1/3/00

Map showing power lines and substations in Washington state. Key locations include Seattle, Tacoma, Olympia, and Spokane. Numerical values are overlaid on the map, corresponding to the MVAR data in the table above.

Dashboard

start Desktop 3:38 PM







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