

PSerc Seminar

INTEGRATION OF OPERATIONAL AND NON-OPERATIONAL DATA FOR IMPROVED EMS MONITORING

Mladen Kezunovic
Texas A&M University

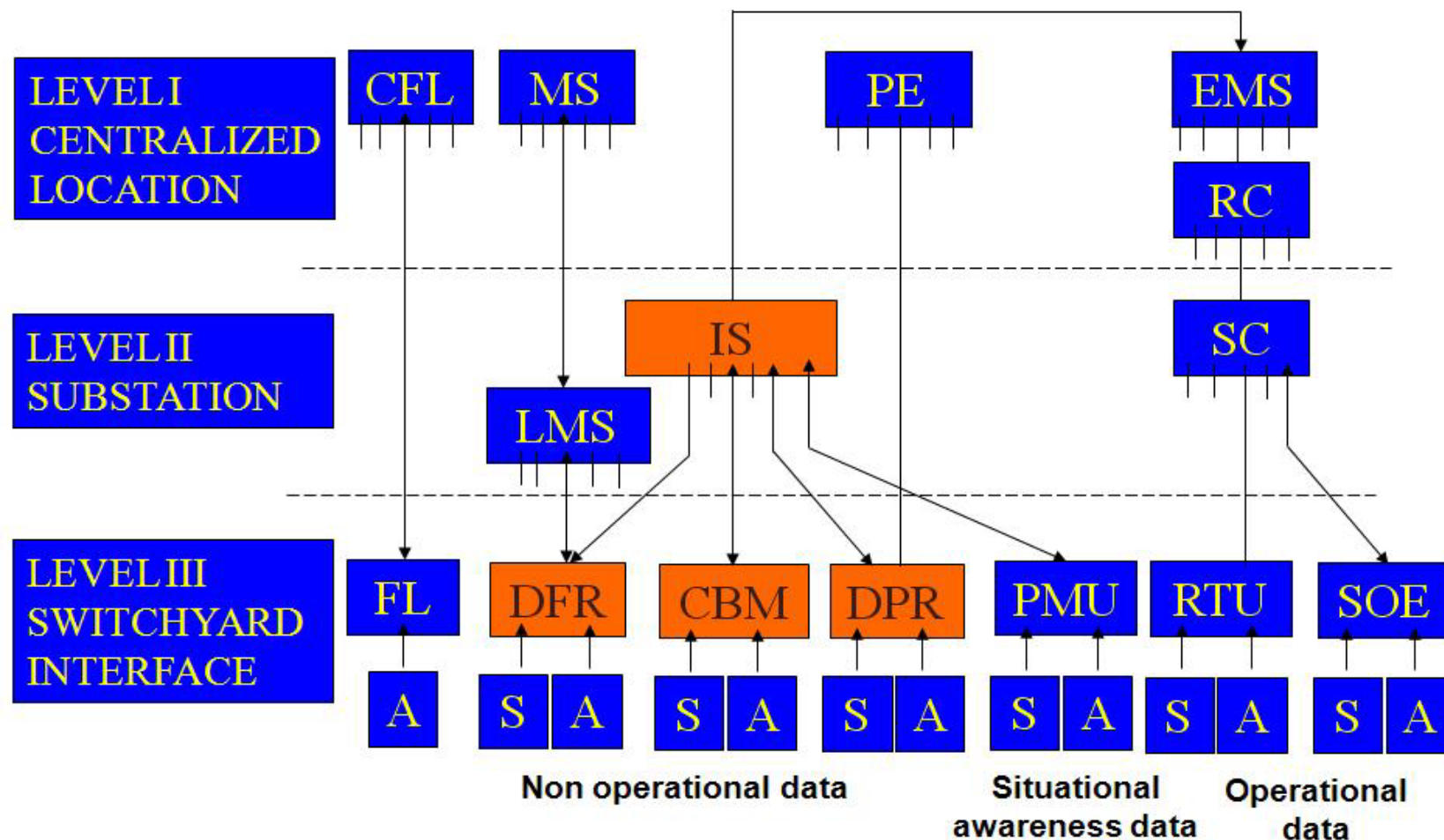
November 18, 2008

OUTLINE

- Introduction
- System View
- Substation Processing
- EMS Uses: FL Example
- Q/A

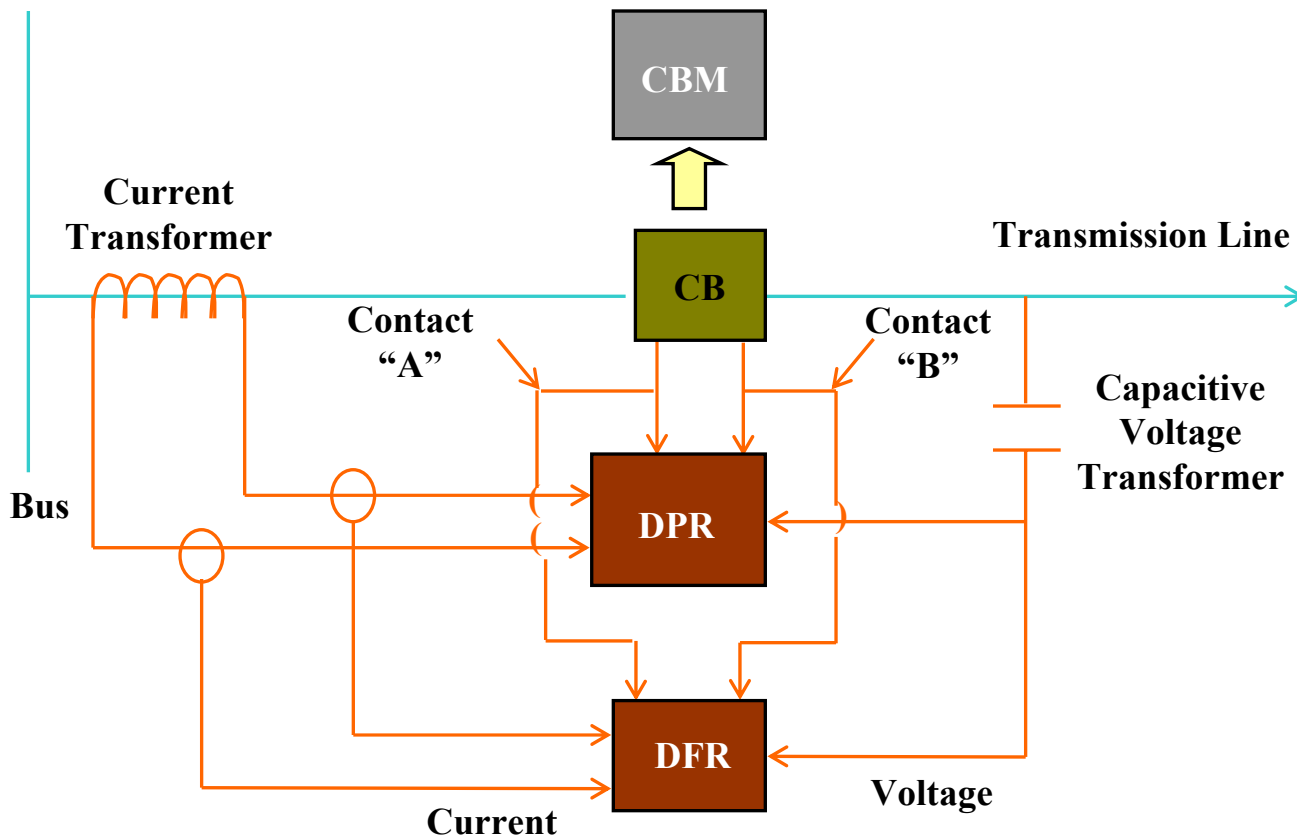
- What is operational and non-operational data?
- Why integration?
- When it makes sense?
- How it is done?

WHAT IS OPERATIONAL AND NON-OPERATIONAL DATA?



WHY INTEGRATION?

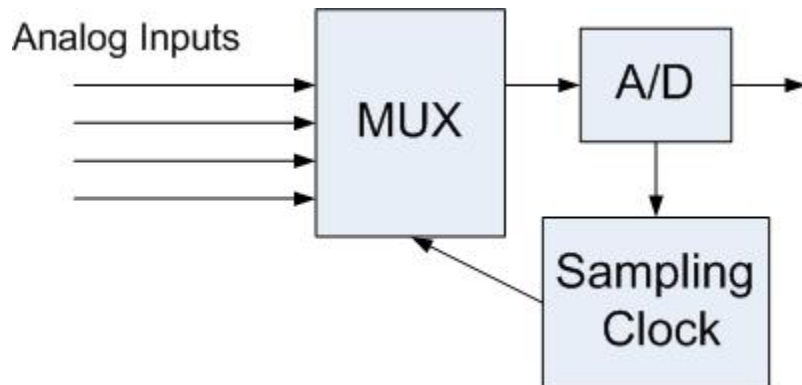
Redundant measurements



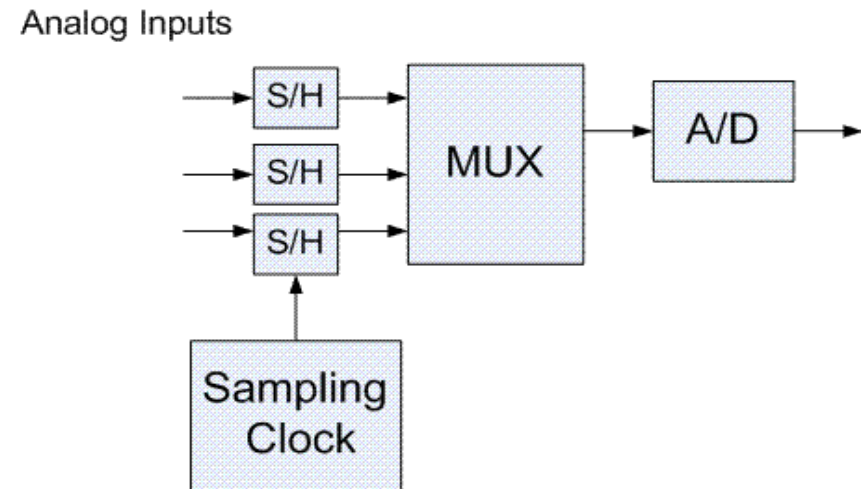
WHY INTEGRATION?

Improved capturing of events

Operational data



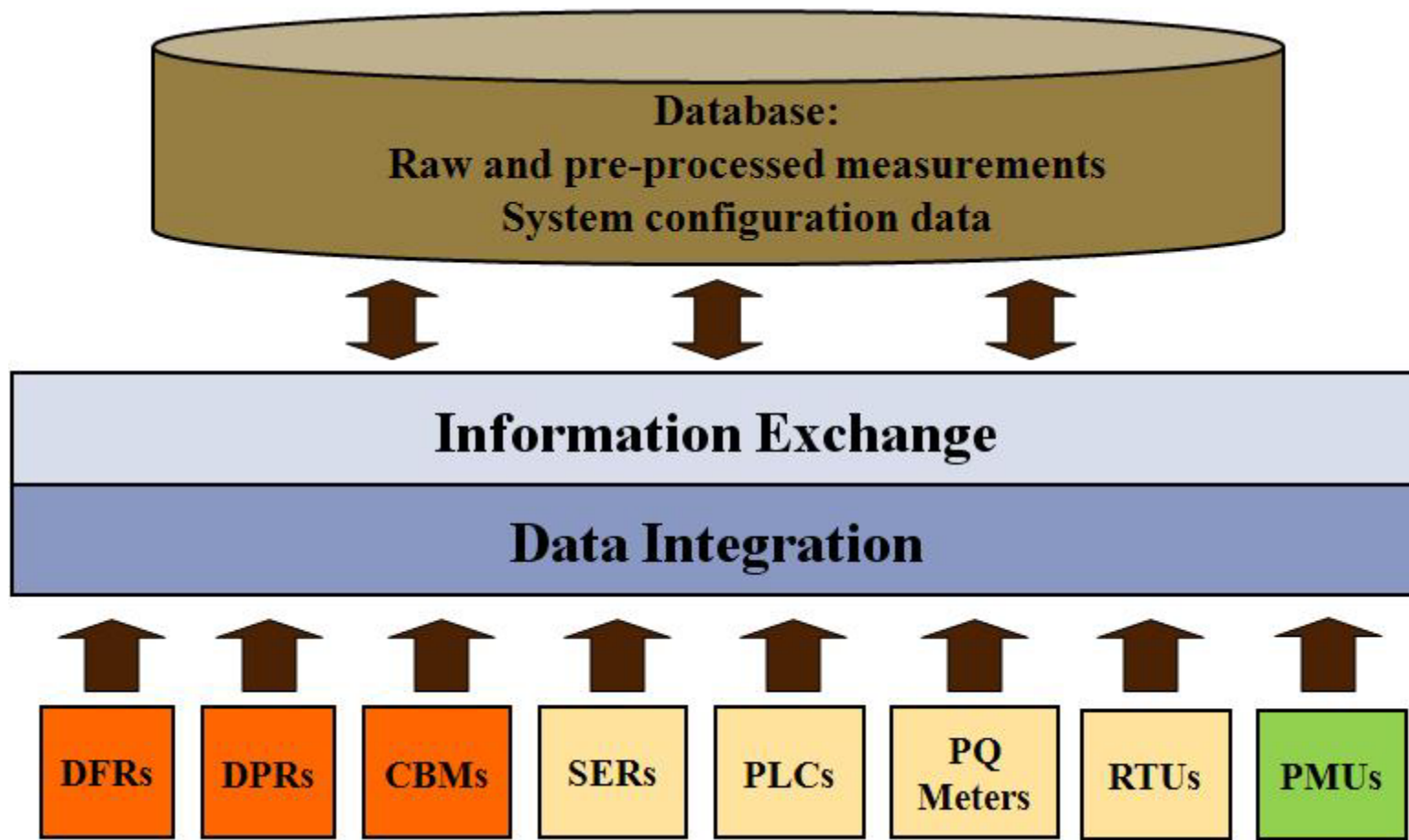
Non-operational data



WHEN IT MAKES SENSE?

- When redundancy matters:
 - bad measurements
 - inconsistent measurement
 - communication failures
- When capturing dynamic signals matters:
 - faults (transients)
 - evolving dynamics (phasors)
 - fast equipment switching

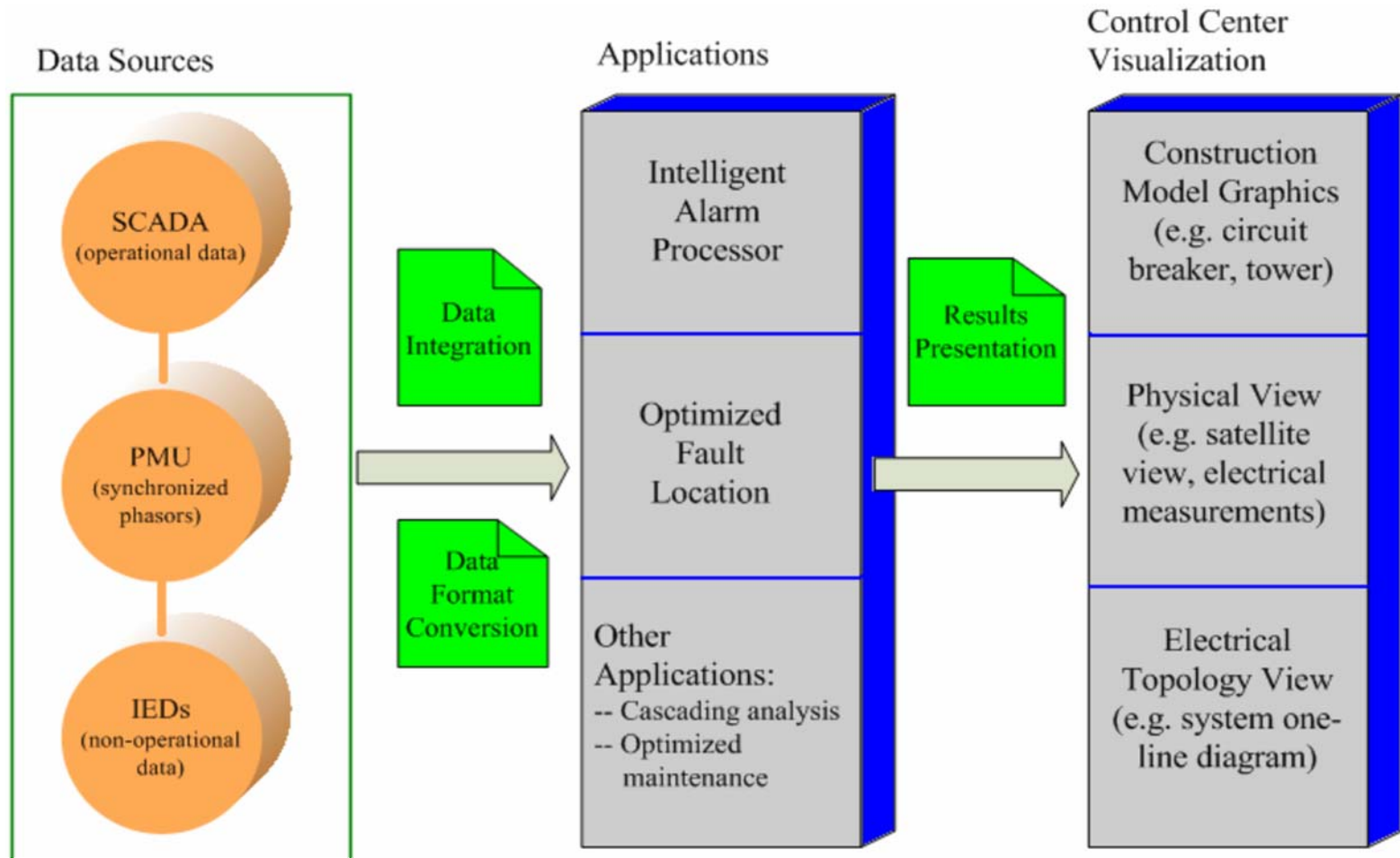
HOW IT IS DONE?



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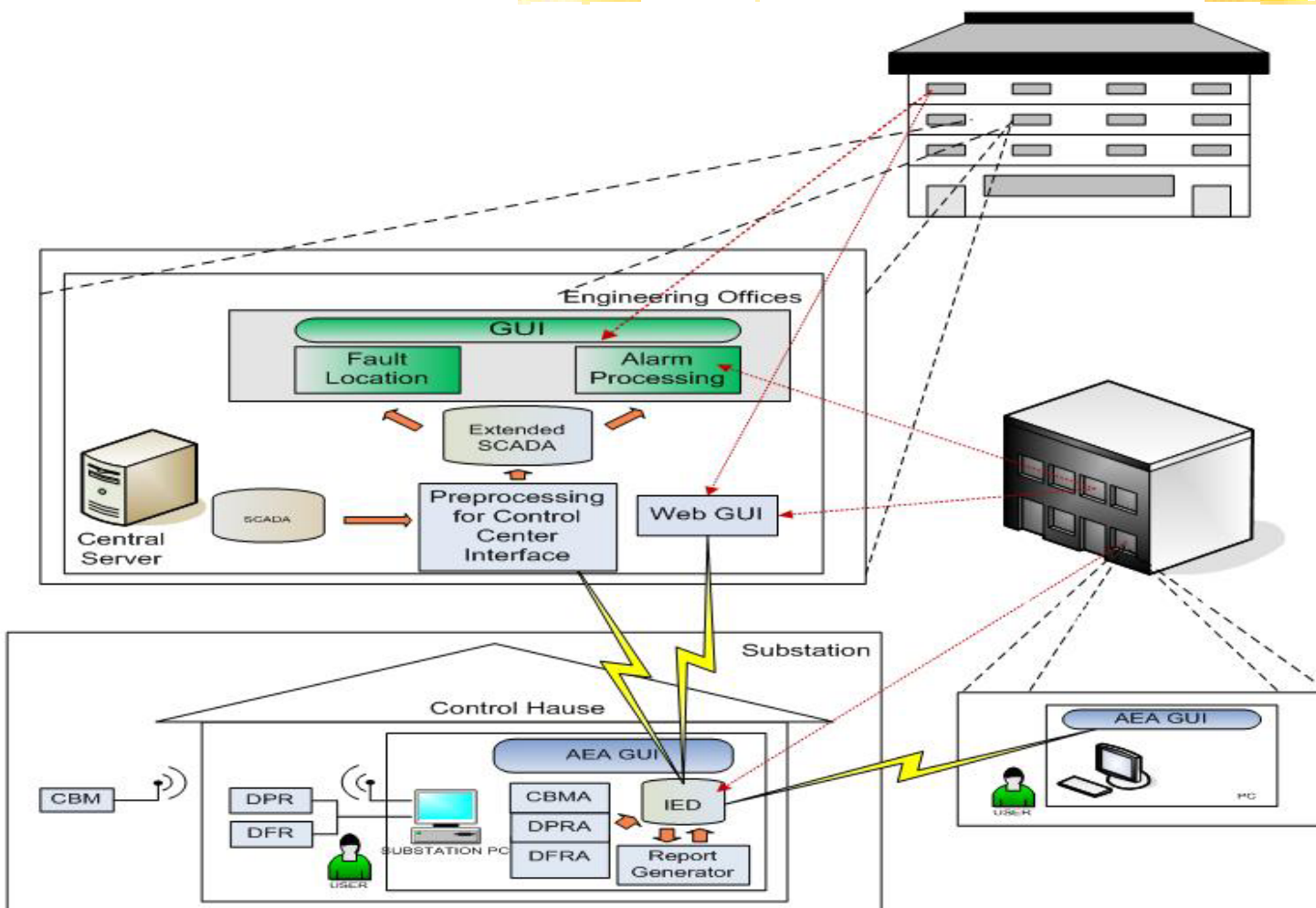
SYSTEM VIEW: Flow of data and computations



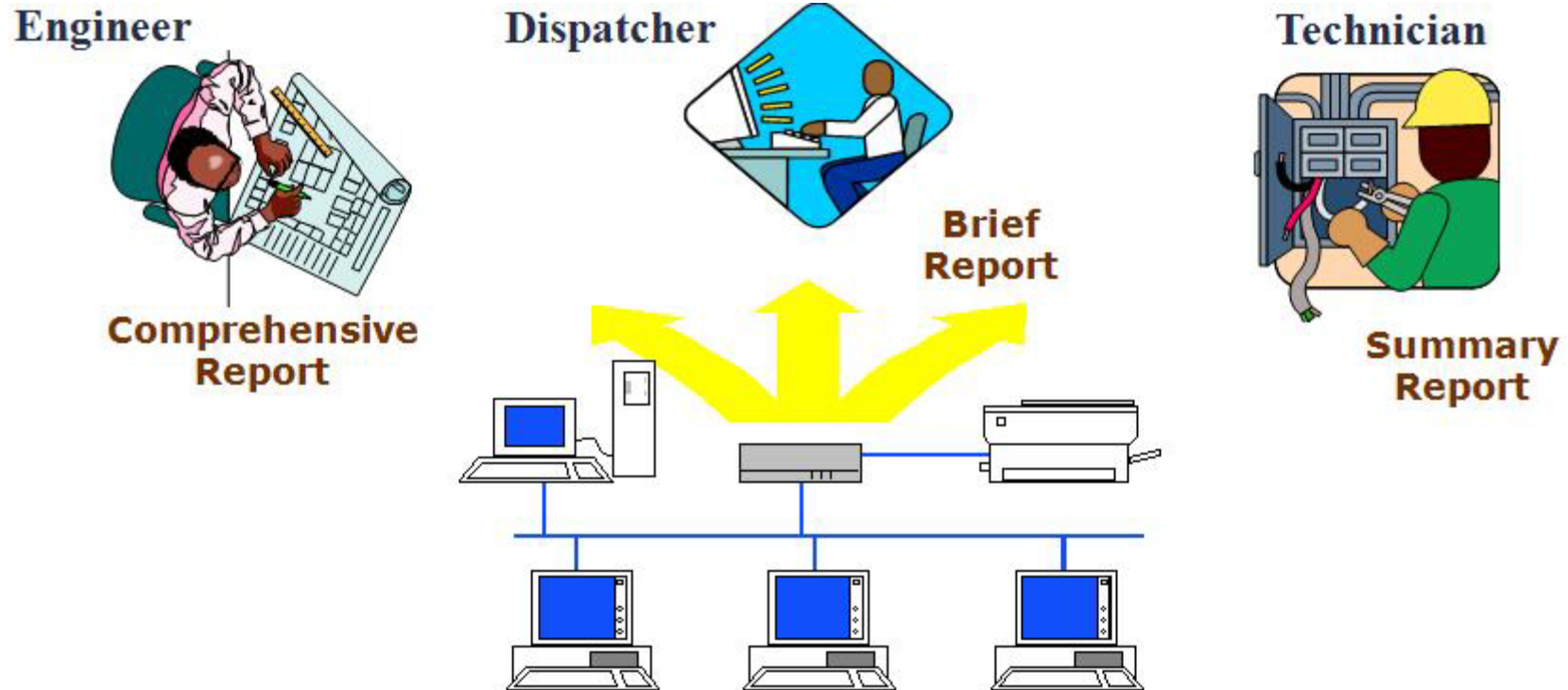
SYSTEM VIEW: Inputs

Applications	Input Information	Outputs
<i>Intelligent Alarm Processor (IAP)</i>	Circuit Breaker control circuit signals	1. Timestamp; 2. Analysis result; 3. Suggested actions; 4. Additional information
	SCADA measurements	
	Phasors (or synchrophasors)	
	Alarm signals	
<i>Optimized Fault Location (OFL)</i>	IED samples of voltage and current	1. Estimated fault section 2. Fault location within the estimated section; 3. Fault type
	Synchrophasors	
	SCADA data	
<i>Other applications (e.g. cascading analysis, optimized maintenance)</i>	Phasors or synchrophasors	1. Cascade detection 2. Cascade classification 3. Equipment failure rate 4. Optimized maintenance shedule
	IED samples of voltage and current	
	SCADA data	

SYSTEM VIEW: Processing



SYSTEM VIEW: Users



Reports can be **customized** according to the need of a particular category of users and disseminated via fax, e-mail, website, pager, etc.

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SUBSTATION PROCESSING

- Switchyard Interface
- IED Processing
- Data Integration

SUBSTATION PROCESSING

SWITCHYARD INTERFACE

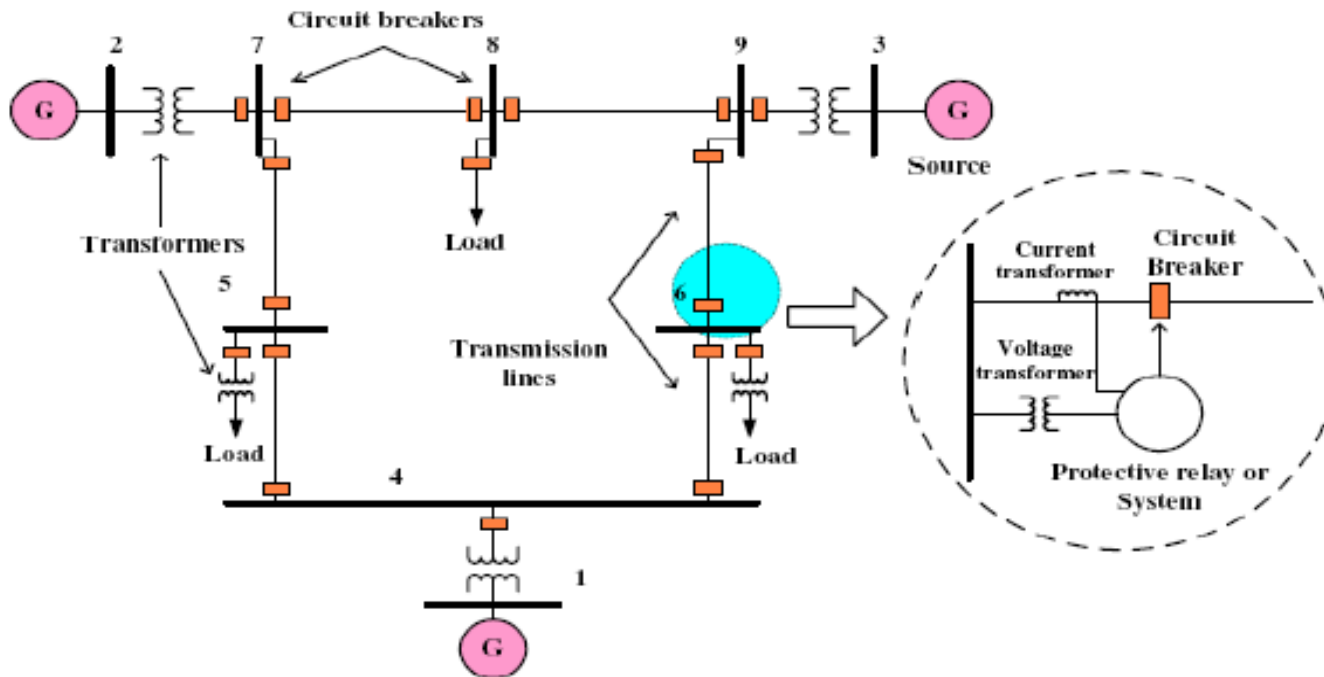
DATA SENSING &
ACCURACY

DATA SENSING: Sources of Data

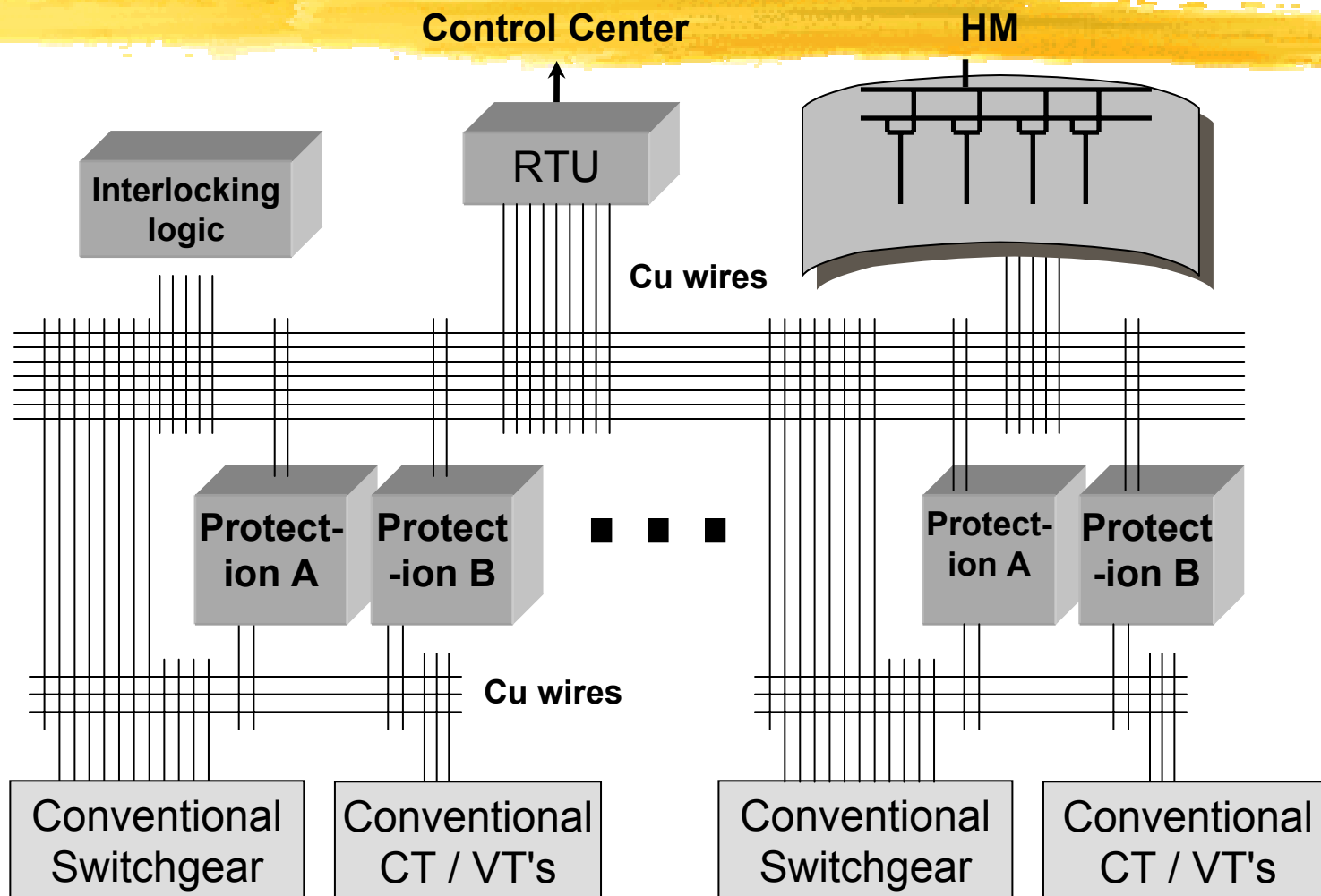
Measurement devices (sensors):

- Transducer
- Relaying transformer
- Metering transformer
- Electronic (optical) transformer
- Control circuit transformers

DATA SENSING: Location of System Measurements



DATA SENSING: Location of Substation Measurements



ACCURACY OF SENSORS

Accuracy classes and standard burdens for metering and relaying transformers from

- IEEE Standard C57.13 on Requirements for Instrument Transformers
- IEC Standard 60044 on Instrument Transformers
 - 60044-1 : Part 1: Current Transformers
 - 60044-2 : Part 2: Inductive Voltage Transformers
 - 60044-5 : Part 5: Capacitor Voltage Transformers

SUBSTATION PROCESSING

IED PROCESSING

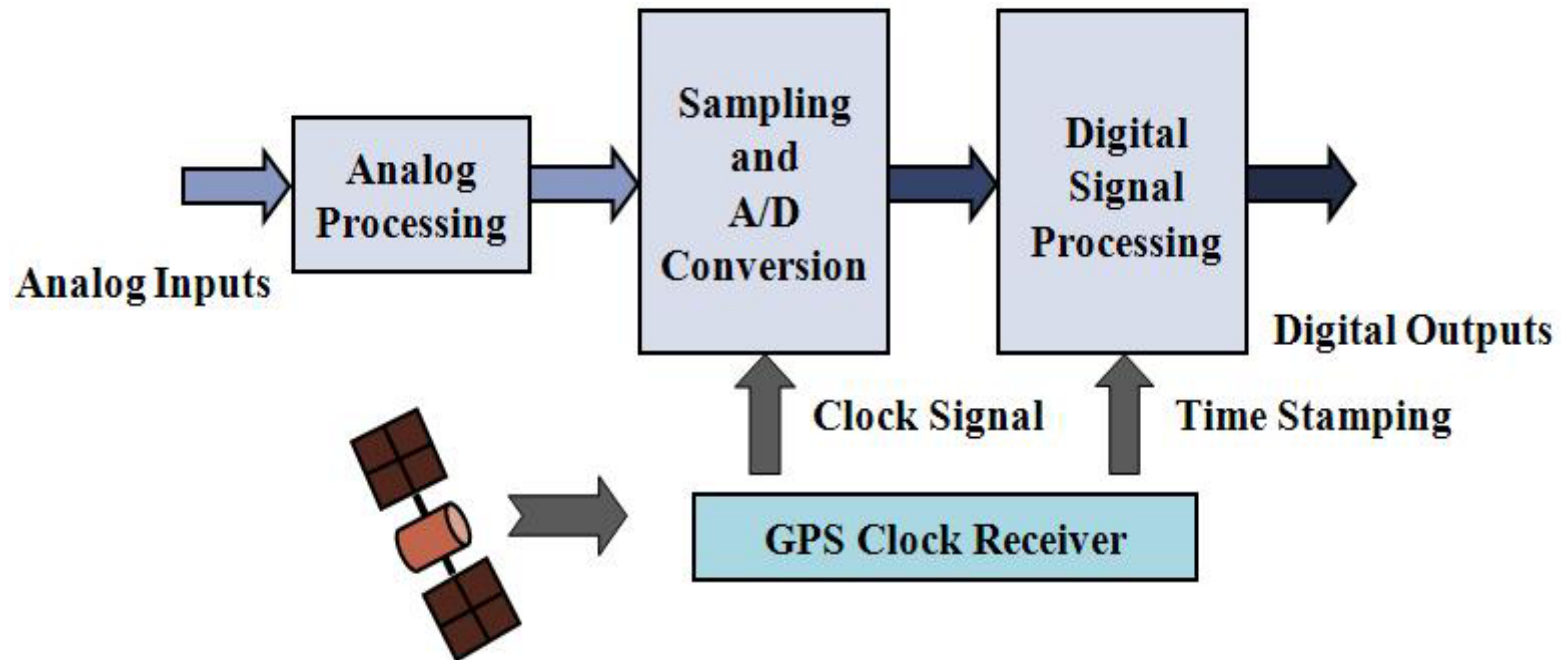
DATA ACQUISITION &
TIMING

DATA ACQUISITION: Sources of Data

Intelligent Electronic Devices

- Substation remote terminal unit (RTU)
- Phasor measurement unit (PMU)
- Other IEDs
 - Digital protective relay (DPR)
 - Digital fault recorder (DFR)
 - Power quality meter (PQM)
 - Sequence of event recorder (SER)
 - Fault locator (FL)
 - Circuit breaker monitor (CBM)

DATA ACQUISITION: Internal Processing of IEDs

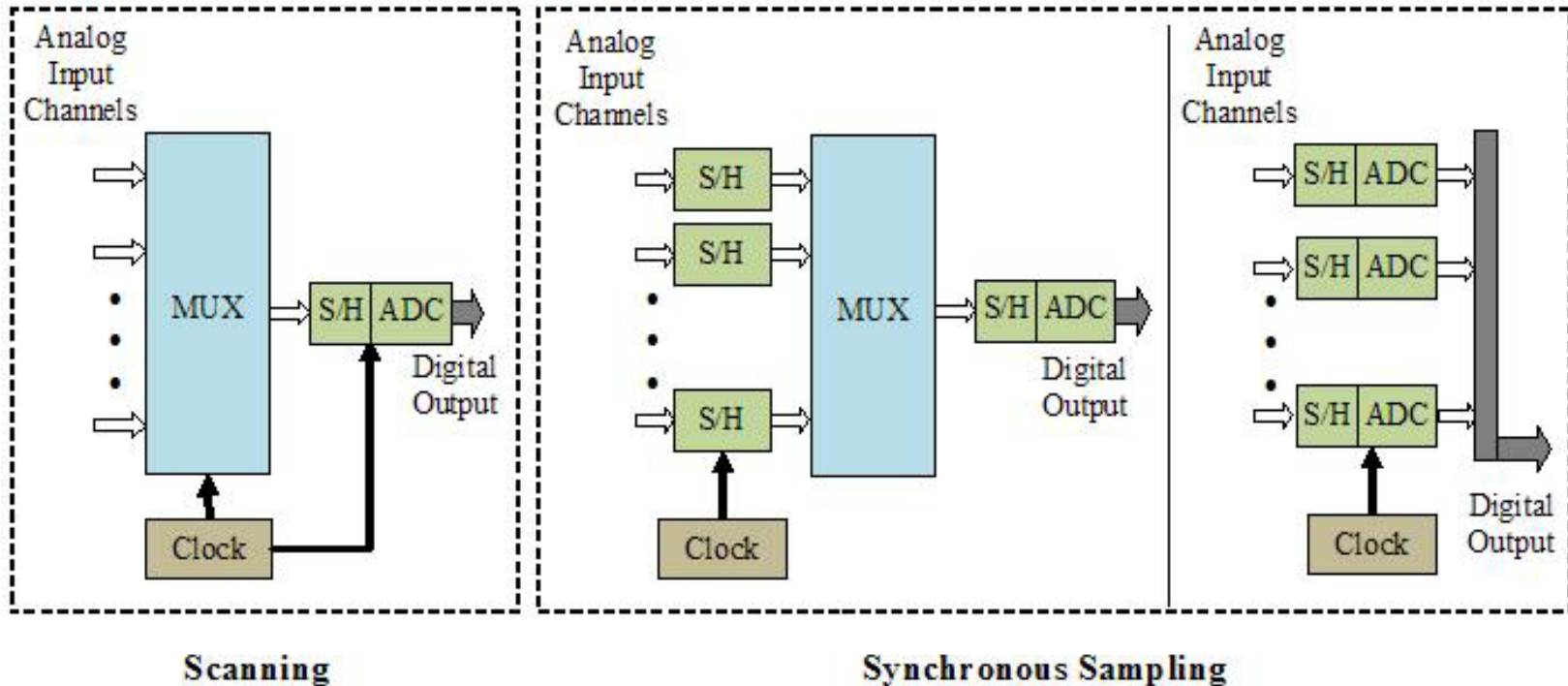


DATA ACQUISITION:Accuracy

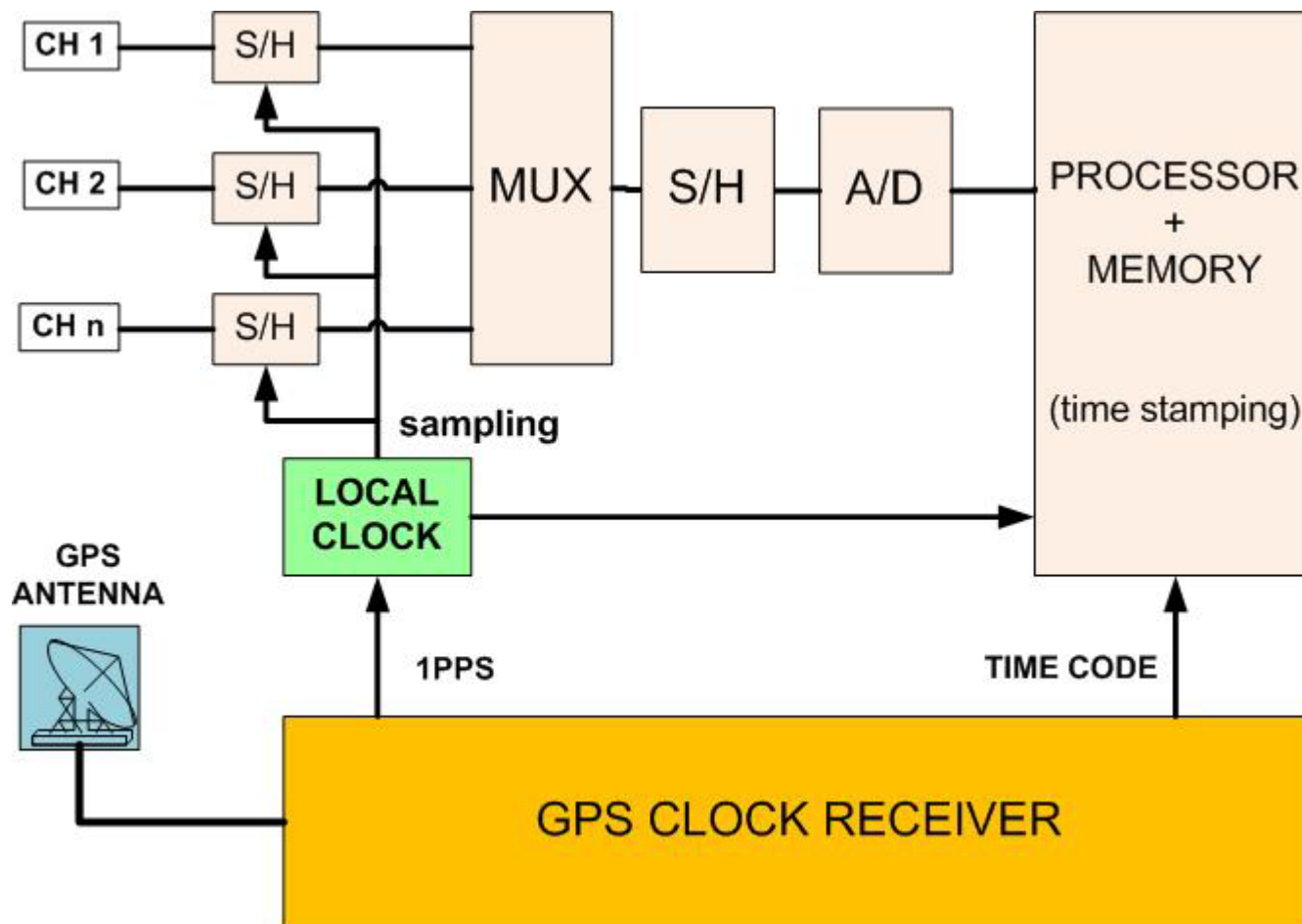
Impact on accuracy

- Auxiliary transformers
- Mode of sampling
- Anti-aliasing filter
- Sampling rate
- Resolution of A/D conversion

DATA ACQUISITION: Timing of Data Sampling



DATA ACQUISITION: Time Stamping



SUBSTATION PROCESSING

SUBSTATION

DATA INTEGRATION &
INFORMATION EXTRACTION

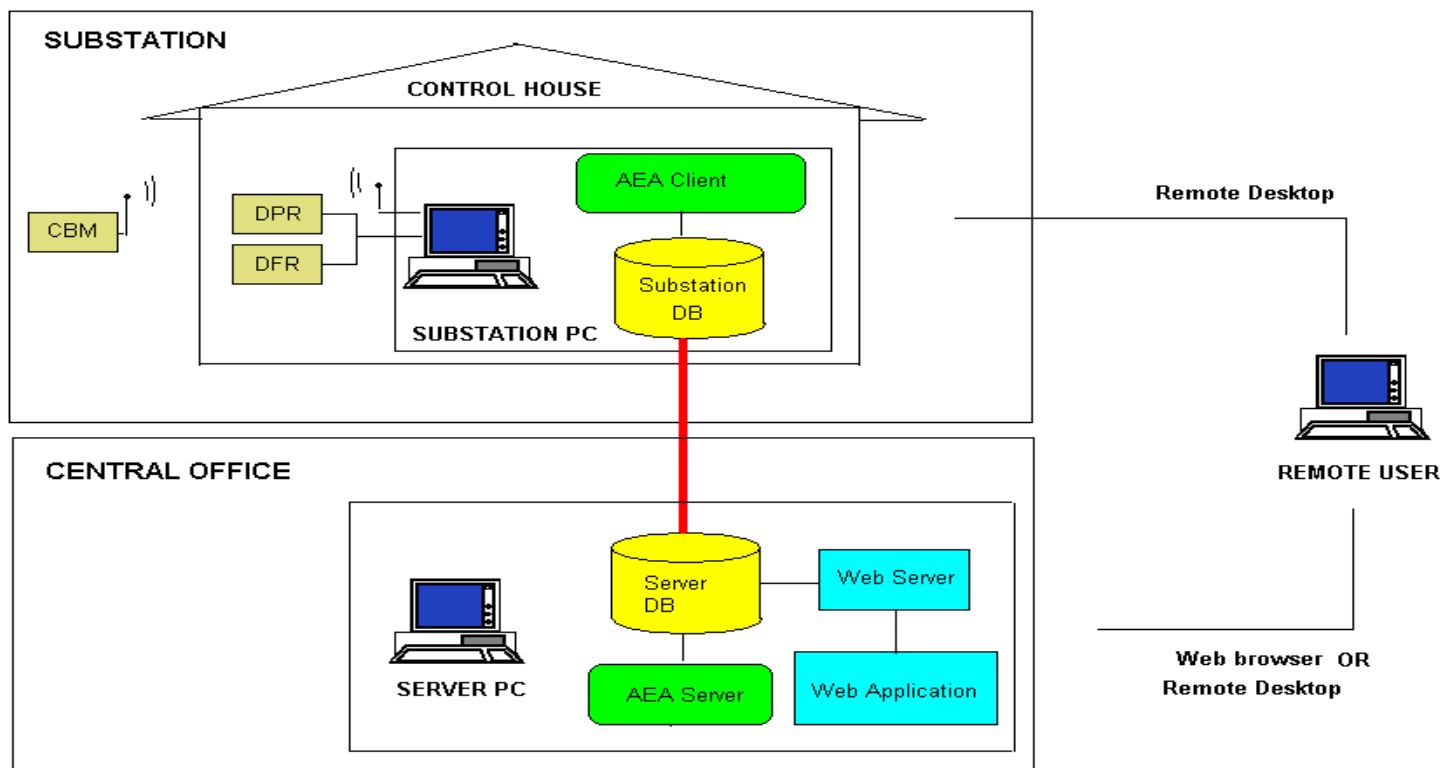
DATA INTEGRATION: Substation Database

- Static system data containing description of the system components and their connections
- Data from IEDs and RTUs (operational and non-operational data)
- Substation interpretation data to correlate recording device channels and static system model

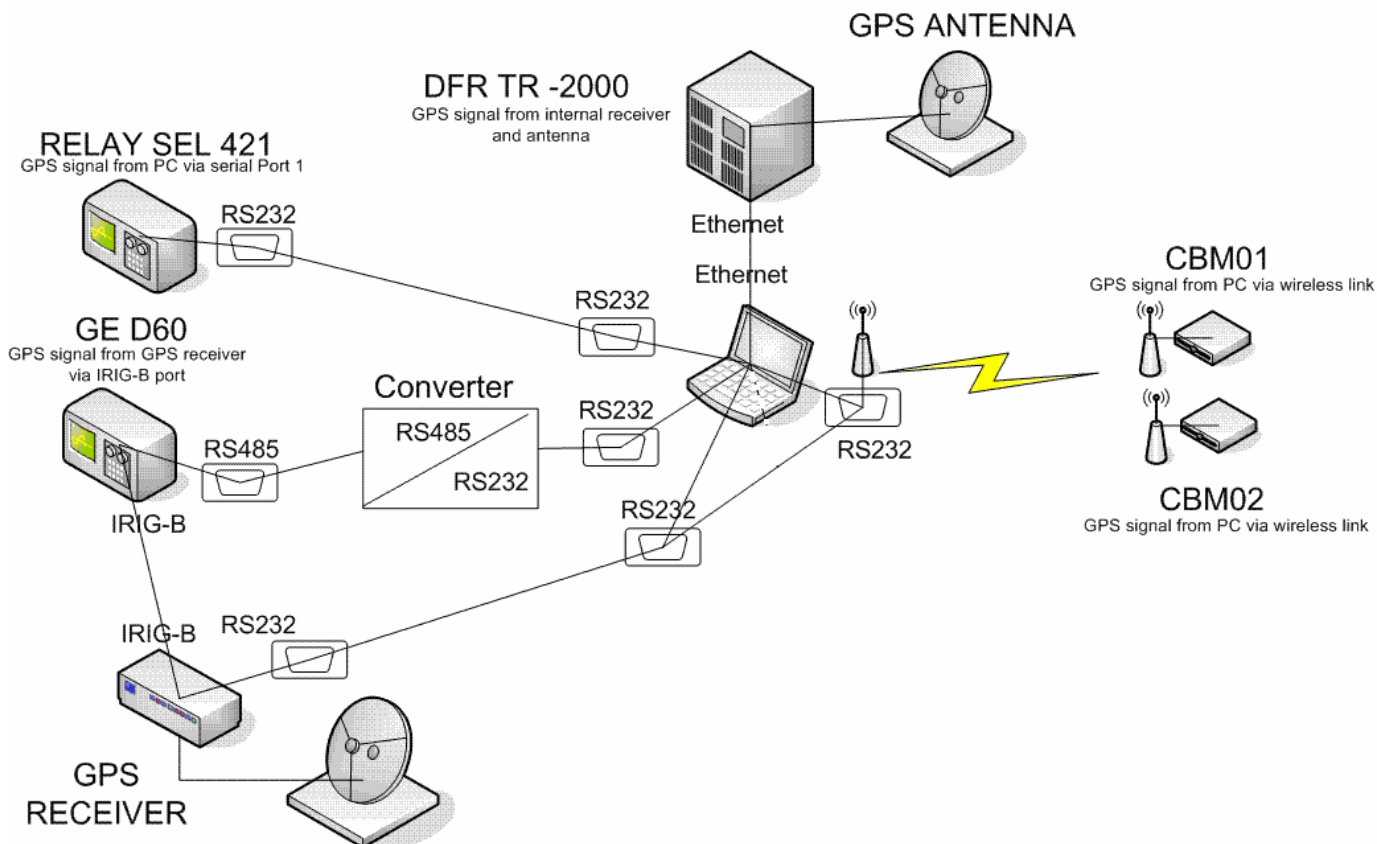
Types of standards

- Data Acquisition (IEC 61850-9.2)
- Data Format (COMTRADE, Synchrophasor, PQDIF, Naming Convention)
- Data Communications (IEC61850, DNP)
- Data Modeling (IEC61970, IEC 61968)

INFORMATION EXTRACTION: System Architecture



DATA EXTRACTION: IED GPS Synchronization



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EMS USES: FAULT LOCATION EXAMPLE

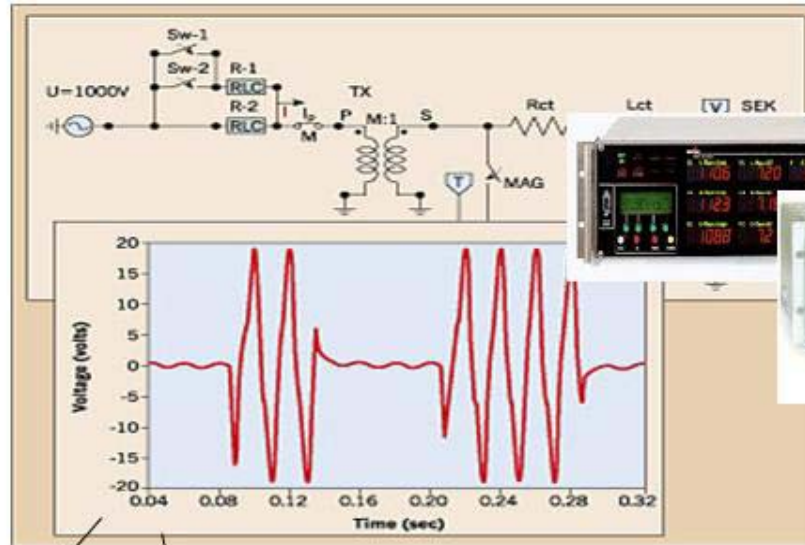
- Requirements
- Traditional Data Handling
- Automated Data Handling
- Visualization

REQUIREMENTS:

Detect Occurrence and Confirm Clearing



REQUIREMENTS: Verify Equipment Operation



Relays



Trip signal

Fault is temporary

Fault is permanent



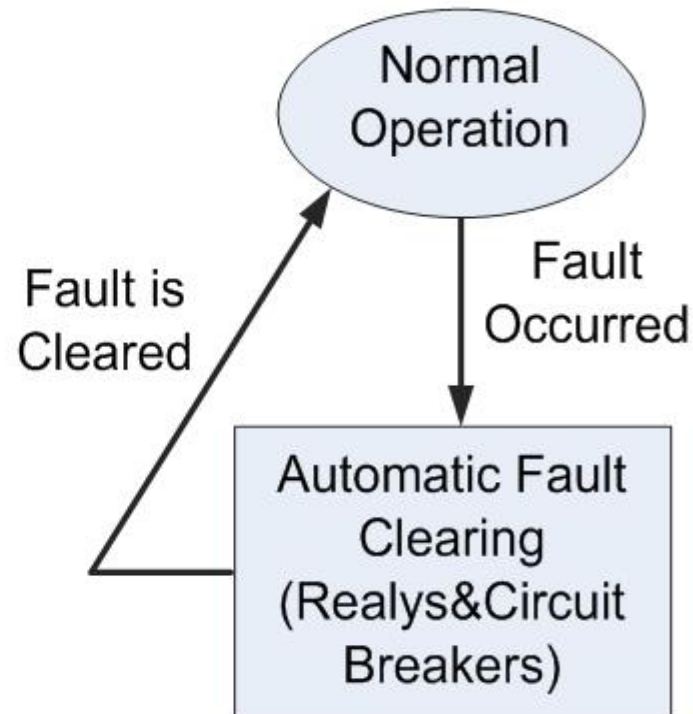
Circuit breakers

Determine type of fault (temporary)



Equipment reacts automatically.
Fault is cleared.

No need for operator action, but
event is recorded and archived.



REQUIREMENTS:

Determine Type of Fault (Permanent)



Automatic fault clearing makes decision to disconnect faulted part of the power system without any more attempts to automatically recover disconnected part → LOCKOUT
→ Disconnected part must be returned to working state MANUALLY

TRADITIONAL DATA HANDLING: The Role of Personnel

Operator tracks system 24/7; coordinates other groups as needed.

Output: **Event report**

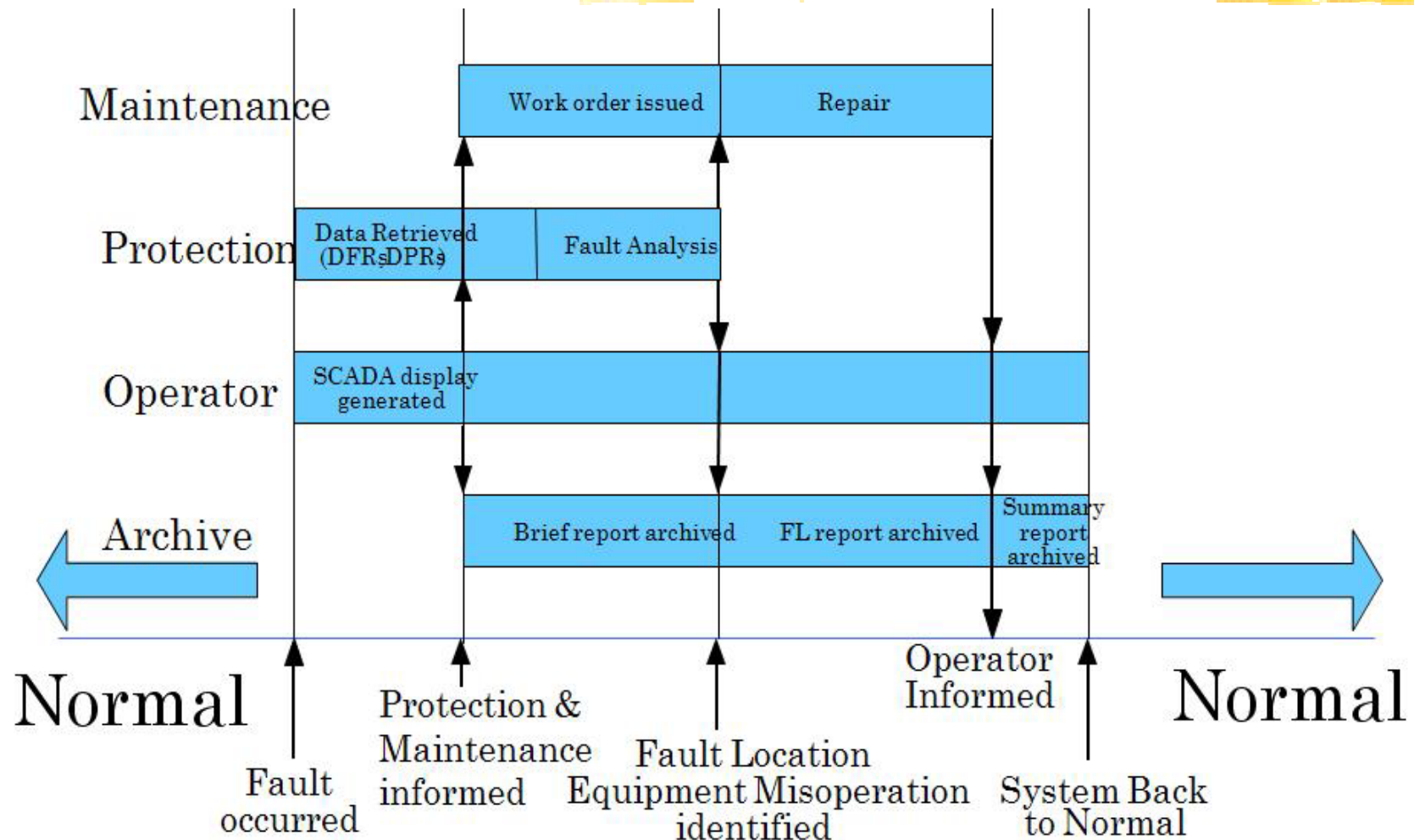
Protection Group analyses events 8am-5pm; identifies fault location and equipment misoperation.

Output: **Comprehensive analysis report**

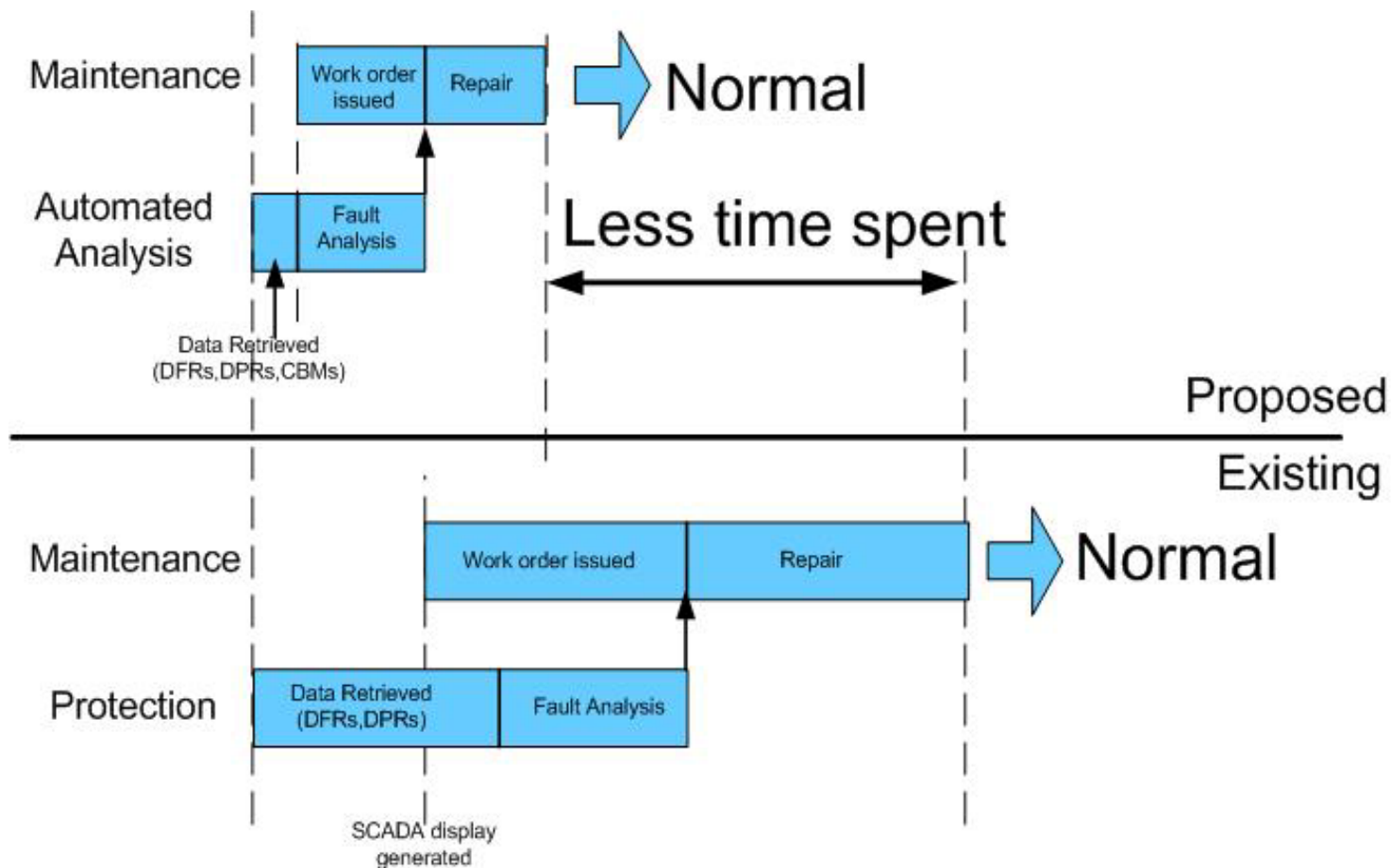
Maintenance responds to calls 24/7; inspects and repairs equipment as needed.

Output: **Repair report from field visits**

TRADITIONAL DATA HANDLING: Action For Permanent Fault



AUTOMATED DATA HANDLING: Improved Timeline



AUTOMATED DATA HANDLING:

Data Requirements

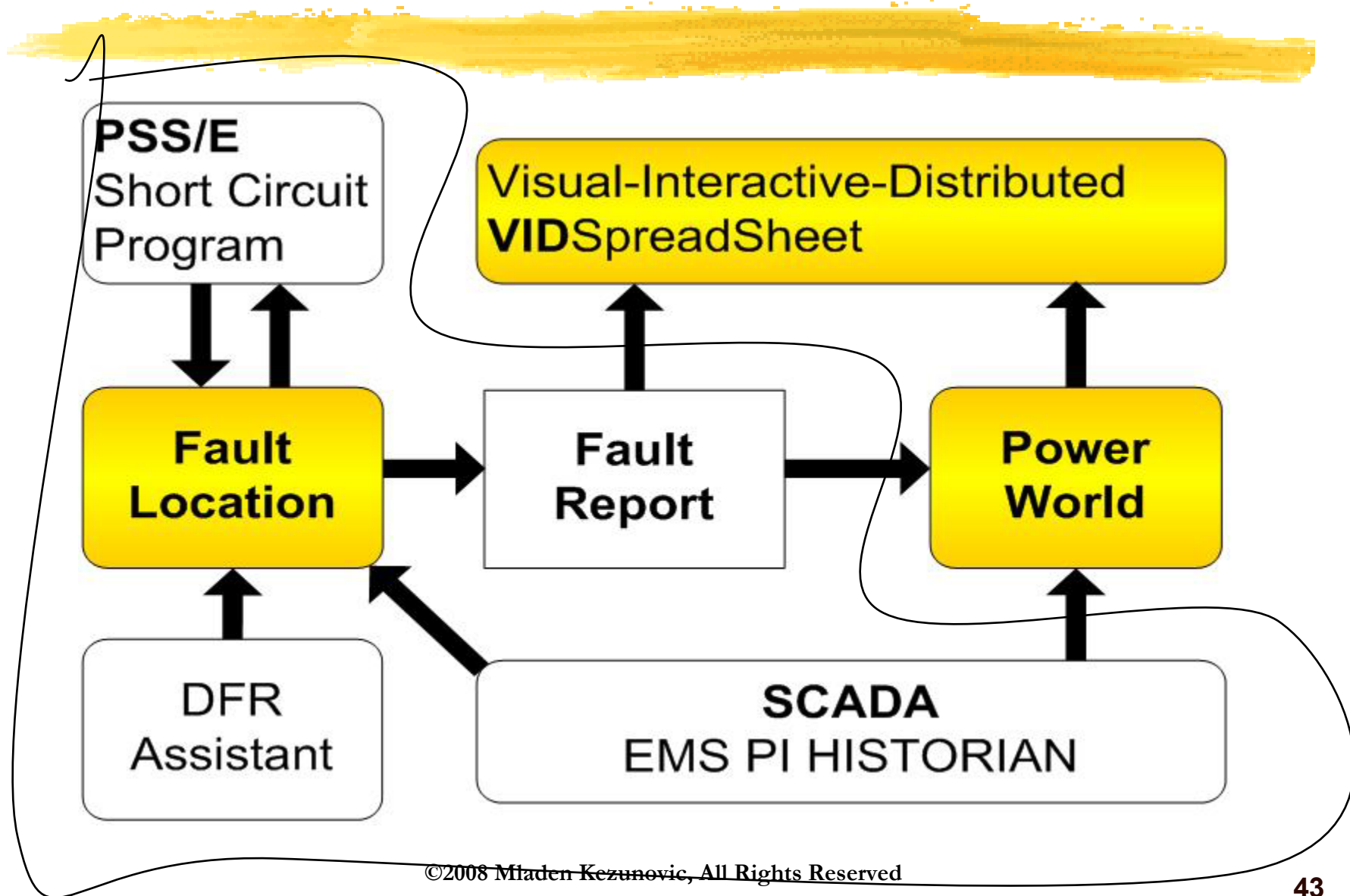
- Field data :
 - Event data recorded by different IEDs after occurrence of any abnormality

- System level data :
 - Historical SCADA Data
 - Power system model data
 - Satellite Data

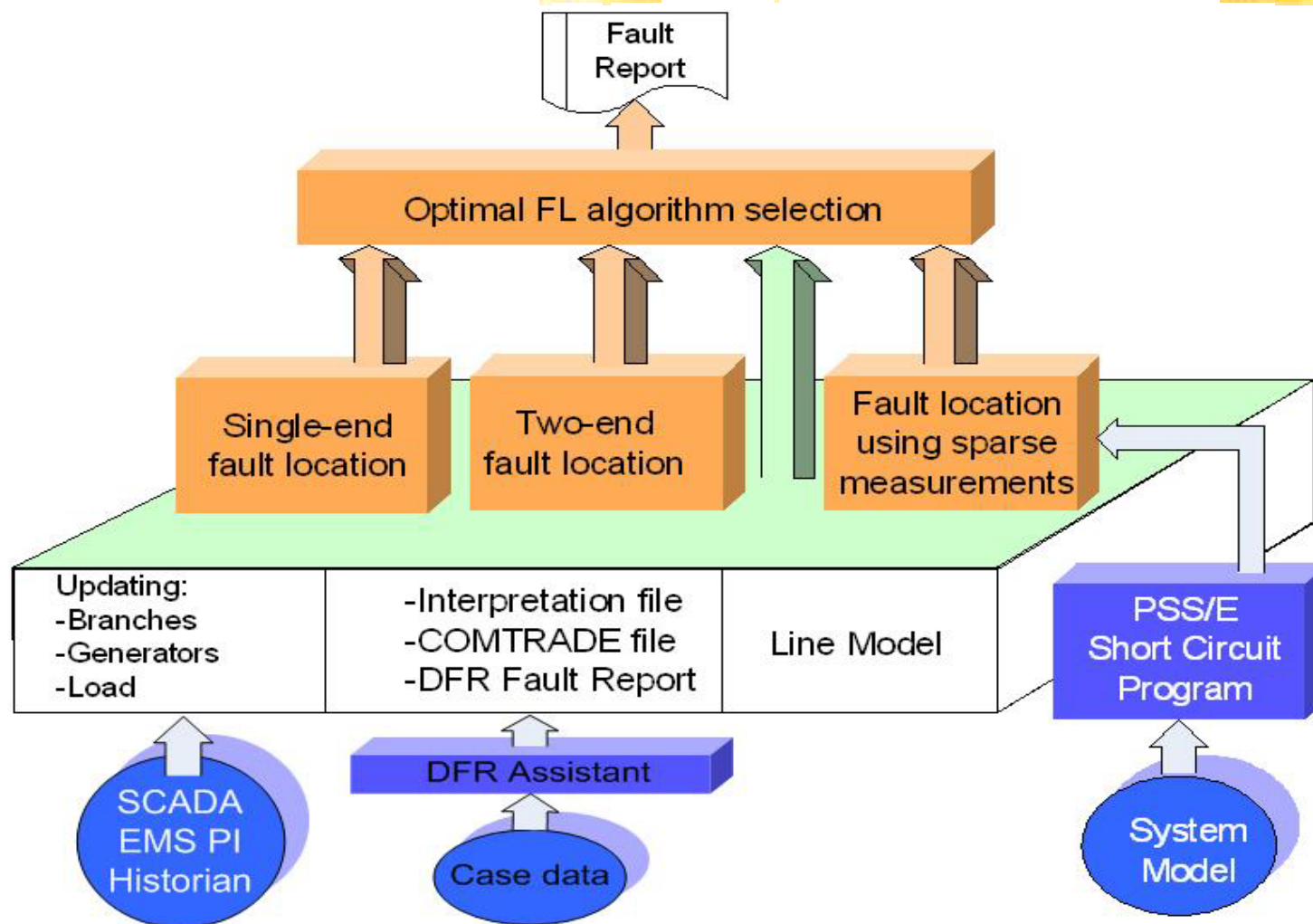
AUTOMATED DATA HANDLING: Preparation of measurements

- Extraction of phasors
- Synchronization of phasors
- Retrieval of the Power Grid Switching Status

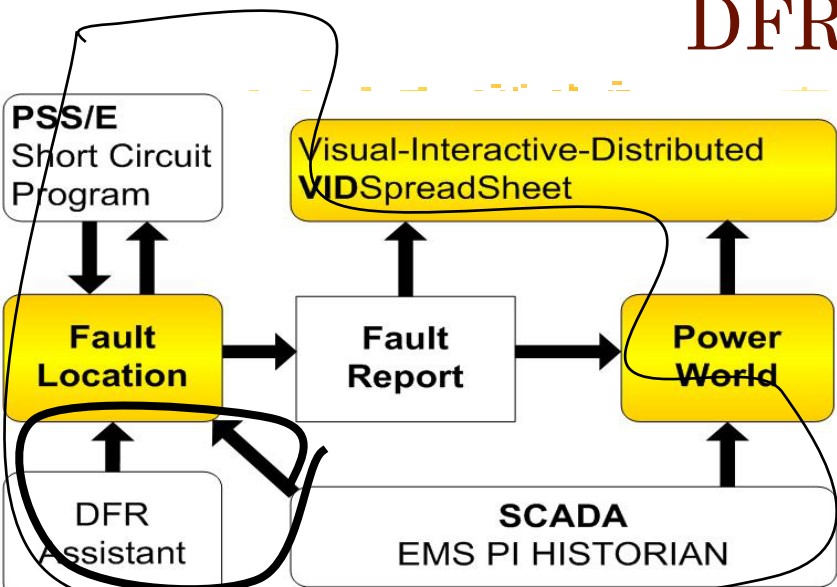
AUTOMATED DATA HANDLING: System Architecture



AUTOMATED DATA HANDLING: Fault Location Module



AUTOMATE DATA HANDLING: DFR Assistant™



The bus breaker opened in 11 cycle
 The middle breaker opened in 11 cycle!
 The middle breaker opened in 2 cycle after the trip!
 The bus breaker opened in 2 cycle after the trip!
 The bus breaker OK!
 The middle breaker OK!
 Backup relay did not trip since the fault was not detected!

*** Event Origin ***
 DFR Assistant Client : Limestone
 Substation : Limestone
 DFR Native File Name : Event867.pre
 Affected Circuit: TP&L - Jewett Ckt 74

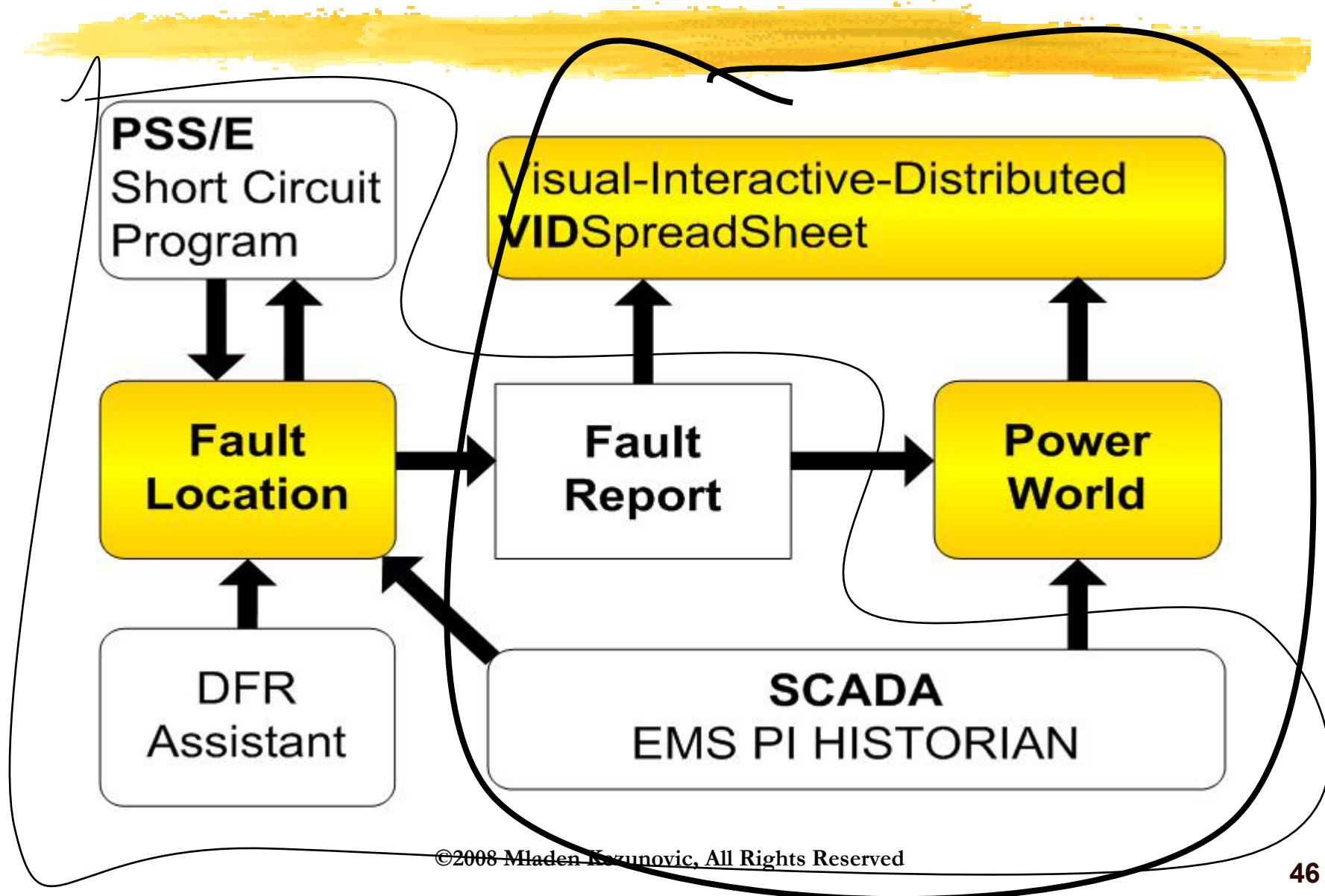
*** Event Summary ***
 Trigger Date and Time: 10-15-2000 04:58:47
 Event Description : GND_FAULT
 Fault Location : 7.282919 [miles]
 Event Outcome : NO_CLEARANCE
 Breaker Operation : 1st, CB_OK
 Breaker Operation : 2nd, CB_OK
 Relay Operation : BACK, RL_NOTRIP2_OK

*** Analog Signal Values ***		
Prefault Values:	Fault Values:	Postfault Values:
I0 = 0.6191 [kA]	I0 = 18.3239 [kA]	I0 = 0.0006 [kA]
Ia = 1.8076 [kA]	Ia = 18.4111 [kA]	Ia = 0.0018 [kA]
Ib = 1.1896 [kA]	Ib = 0.5773 [kA]	Ib = 0.0022 [kA]
Ic = 1.2574 [kA]	Ic = 0.4960 [kA]	Ic = 0.0005 [kA]
U0 = 3.1848 [kV]	U0 = 49.7262 [kV]	U0 = 7.6336 [kV]
Ua = 277.0459 [kV]	Ua = 136.1295 [kV]	Ua = 2.6933 [kV]
Ub = 275.6616 [kV]	Ub = 259.8350 [kV]	Ub = 9.8864 [kV]
Uc = 278.6484 [kV]	Uc = 258.2197 [kV]	Uc = 7.9171 [kV]
Vab = 474.7668 [kV]	Vab = 347.4030 [kV]	Vab = 12.5697 [kV]
Vbc = 480.6124 [kV]	Vbc = 470.4073 [kV]	Vbc = 9.2833 [kV]
Vca = 484.5131 [kV]	Vca = 330.9022 [kV]	Vca = 9.2970 [kV]

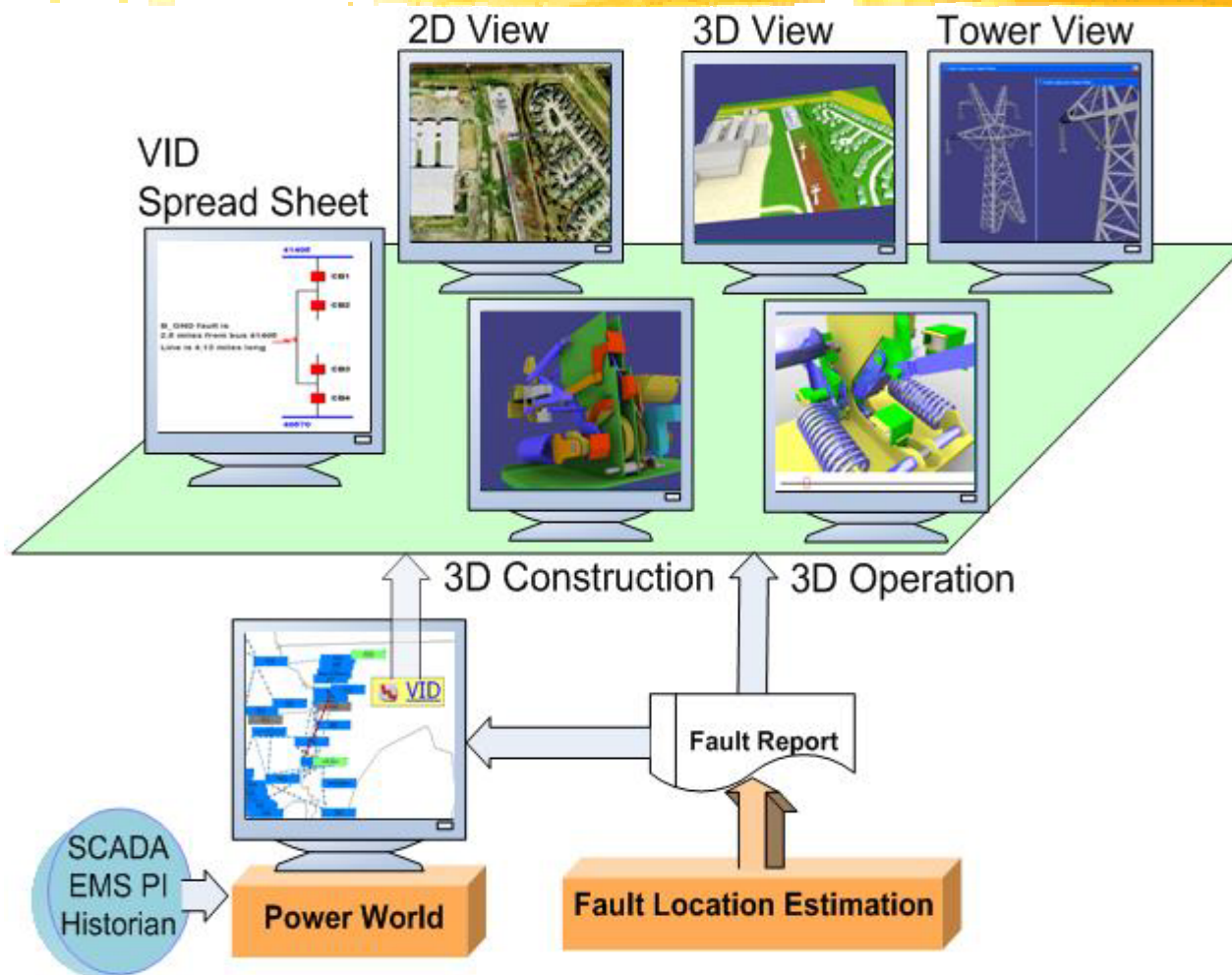
Fault report

DFR

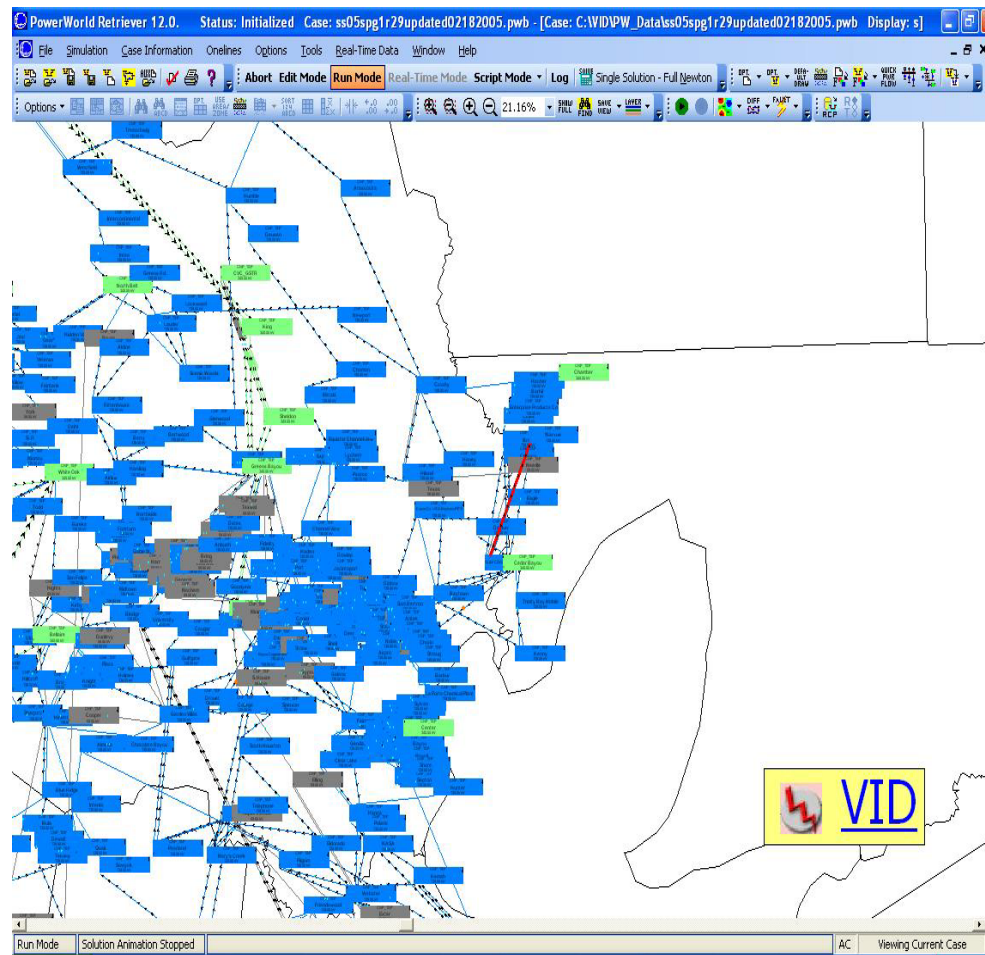
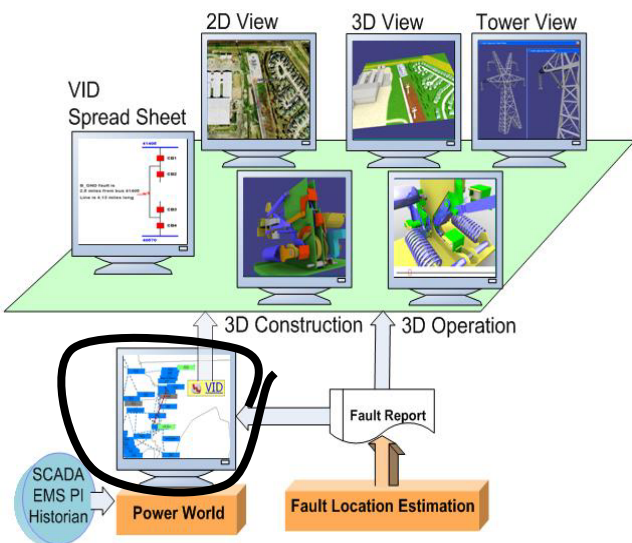
VISUALIZATION



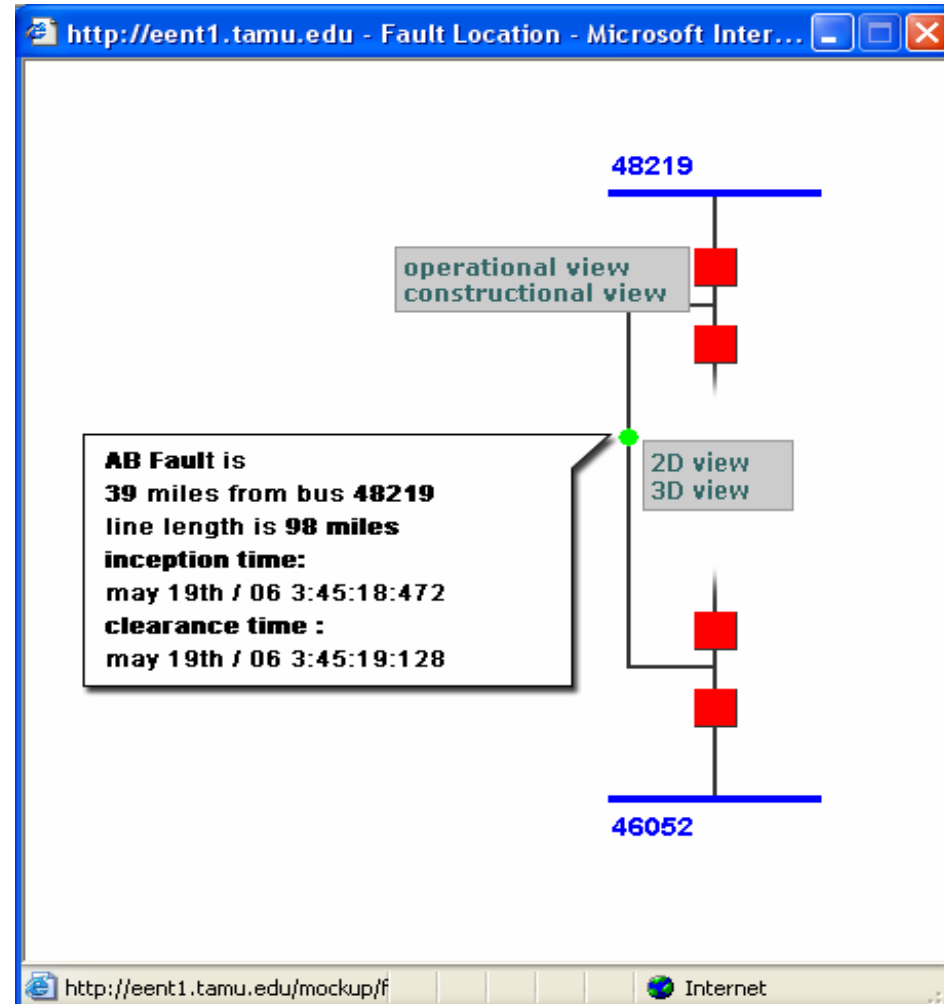
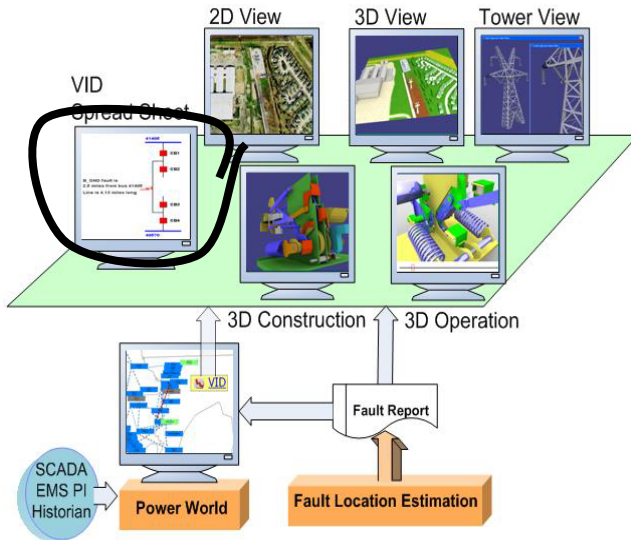
VISUALIZATION: Modules



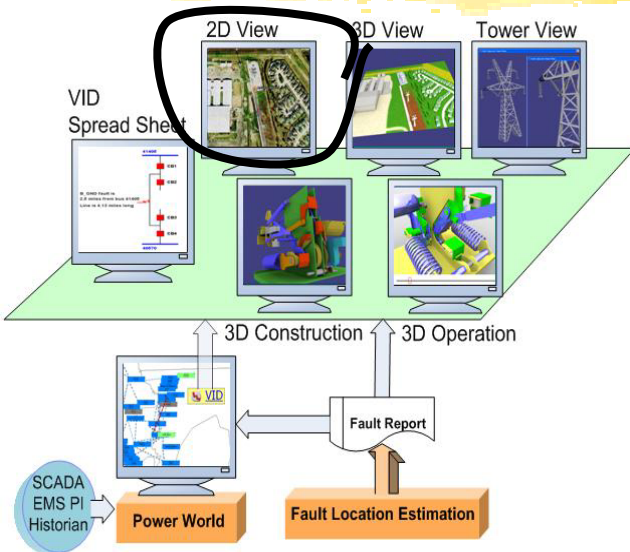
VISUALIZATION: Traditional View



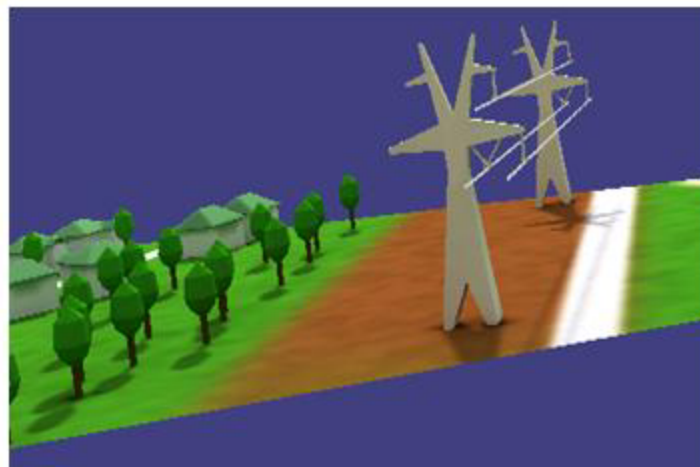
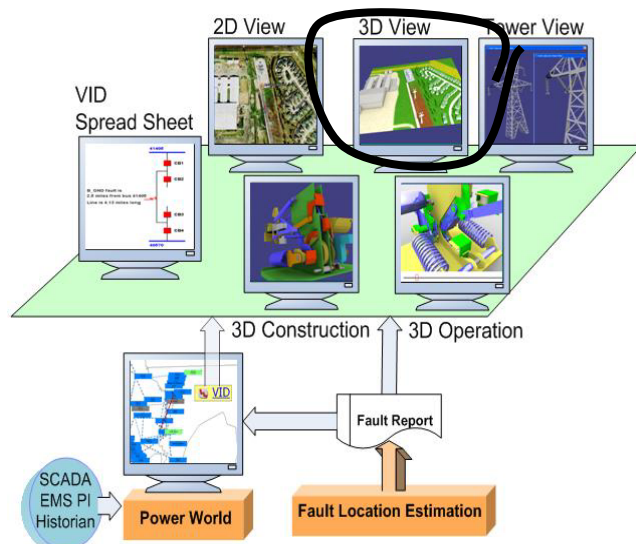
VISUALIZATION: VID Spreadshit



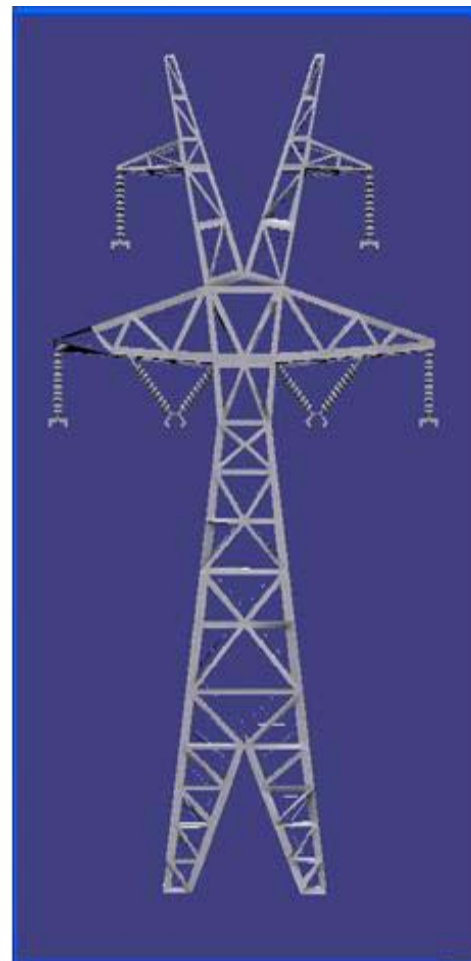
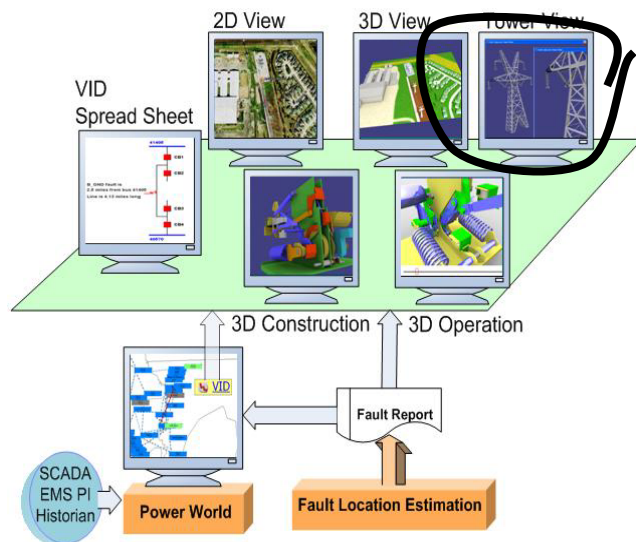
VISUALIZATION: 2D SATELLITE IMAGE



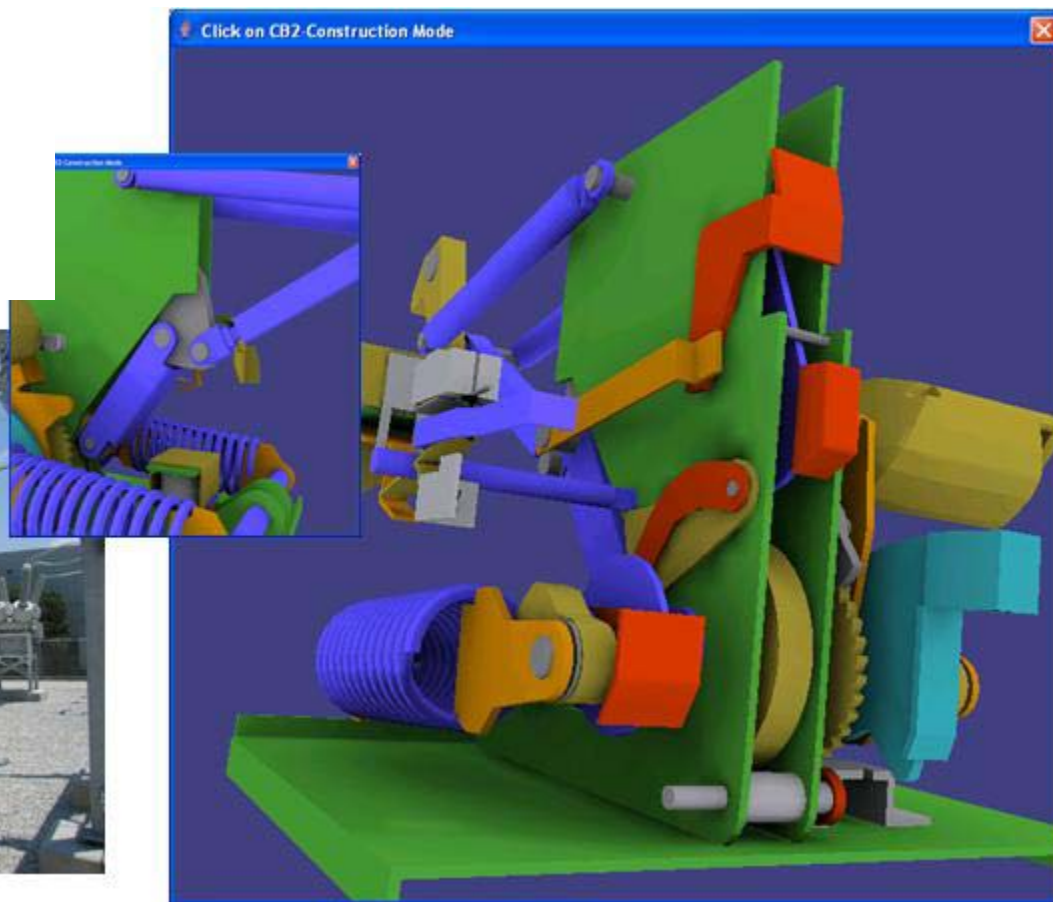
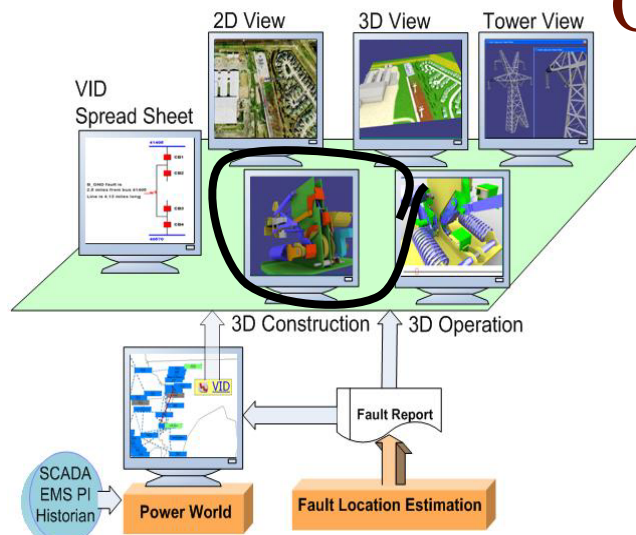
VISUALIZATION: 3D View



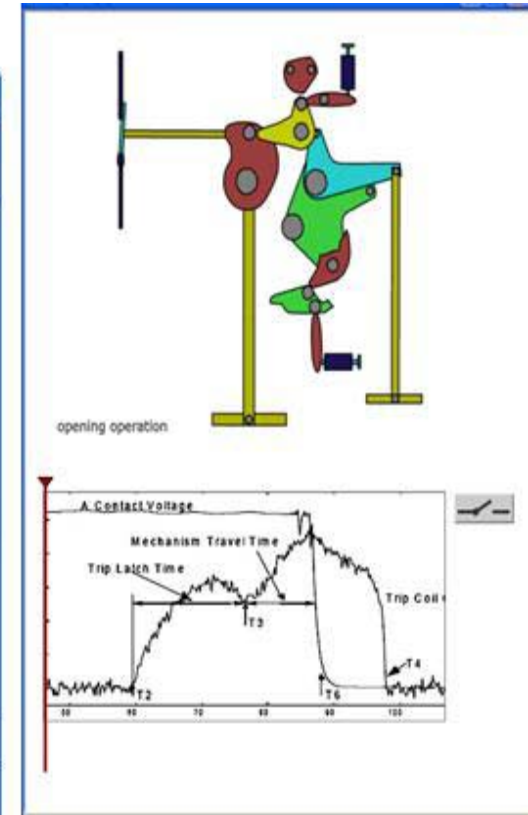
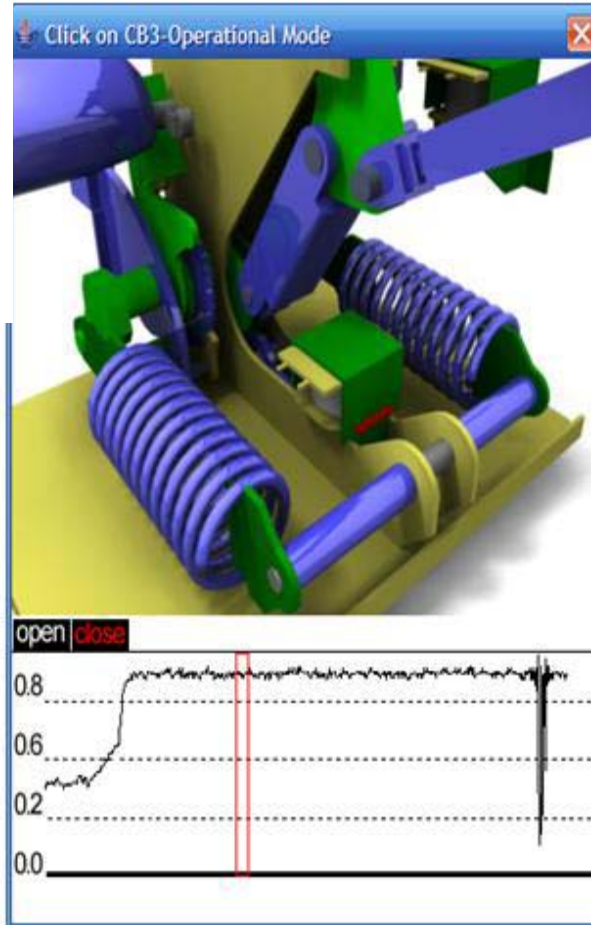
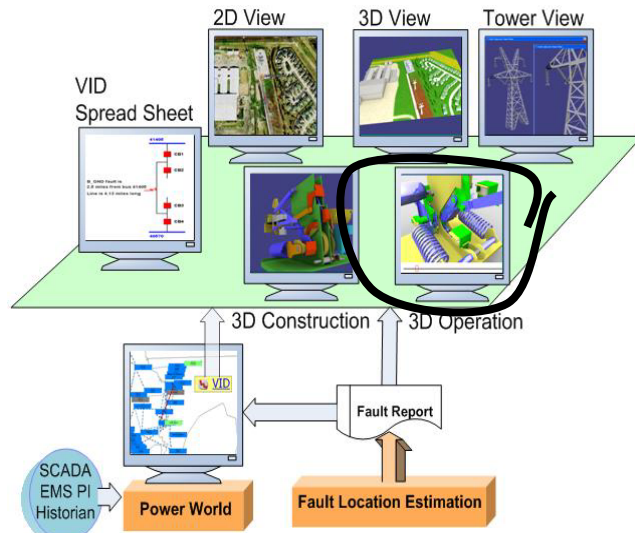
VISUALIZATION: TOWER VIEW



VISUALIZATION: CB CONSTRUCTIONAL VIEW



VISUALIZATION: CB OPERATIONAL VIEW



CONCLUSION

- Data Handling is Automated:
 - Data Collection
 - Data Processing
 - Data Integration
 - Data Extraction
- Performance is Improved:
 - Understanding of Events is Enhanced
 - Reaction Time is Reduced
 - Decision Making is Facilitated



PSERC

Questions?