

## Development of information-analytical system for automatic fault analysis and relay protection performance evaluation

D.A. ZHUKOV

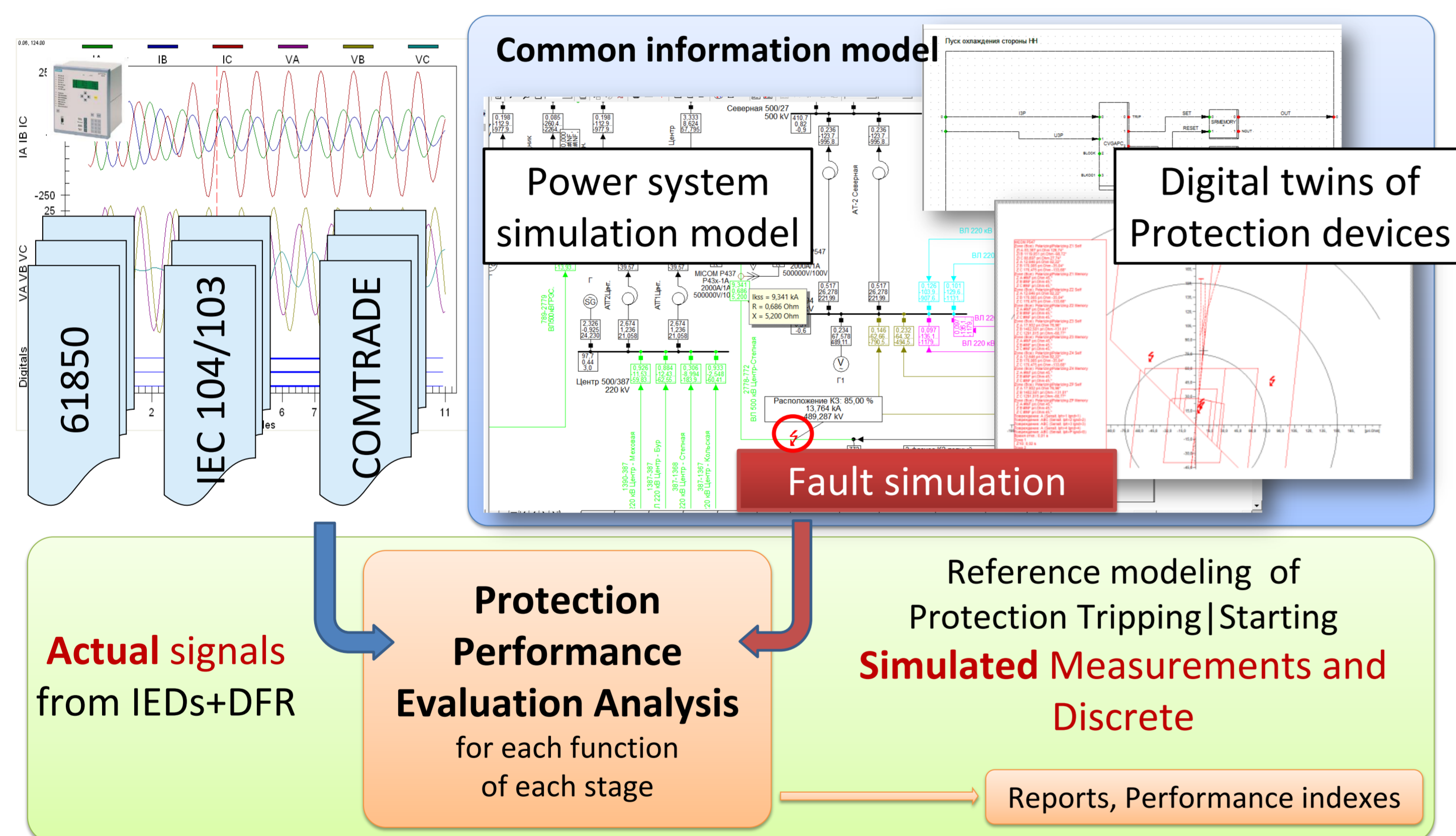
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### Motivation

Implementation of automatic fault analysis and relay protection performance evaluation:

- To reduce number of power outages and system blackouts due to misoperation of relay.
- To design IT Infrastructure and analytical functions for organizing Condition-based Relay maintenance, reducing OPEX.
- To diagnose hidden failures in protection devices via detailed modelling.

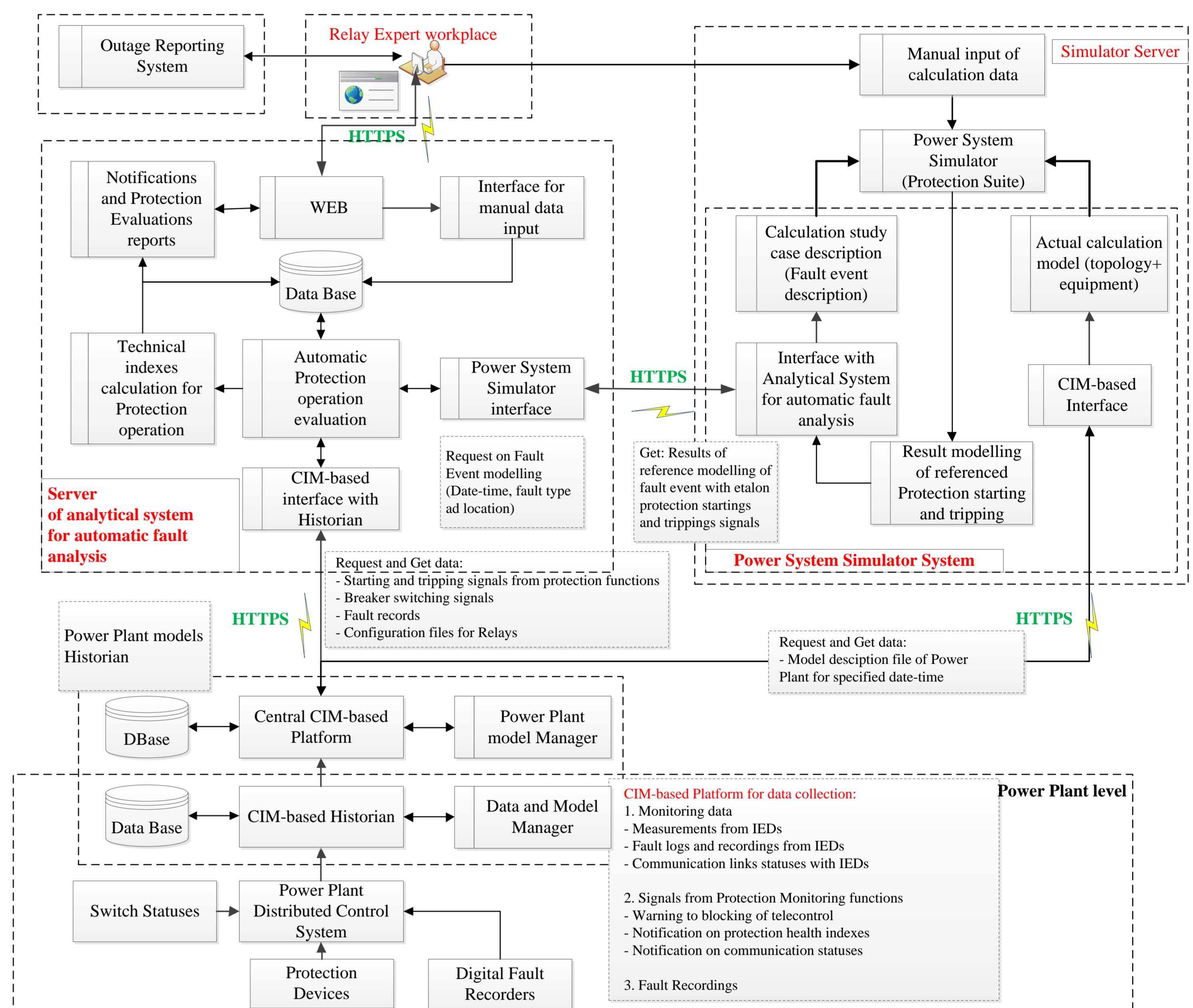
### Method/Approach



### Objects of Investigation

- Common information model of power plant that contains topology, primary + secondary equipment, CT+VT and protection devices with associated settings and semantics of their signals and recordings.
- Organization of fault data collection and preprocessing available for further automatic analysis.
- Automatic execution of fault event identification and fault location.
- Automatic express fault analysis based on available preprocessed data at power plant level.
- Relay modelling for comparative analysis of real and modelled protection behavior at fault event.
- Automatic analysis and evaluation of starting and tripping of relay devices during fault events.

### Experimental setup & test results



### Discussion

#### Future work:

- Implementation of new methods for determining fault locations for complex faults.
- Model creation of new types of protection devices, participation of manufactures in results verification.
- Step forward to condition-based maintenance via automatic analysis of protection performance evaluation.

### Conclusion

- Presented solution is verified in prototype.
- Protection performance evaluation is based on automatic comparison of information from DPR, DFR, RTU with the reference operation obtained through digital modelling.

#### Technological challenges solved:

- Information model according to IEC 61970/61968 was extended with new semantics for protection and fault event data.
- Detailed calculation models of power system and relay protection devices were verified to perform evaluation algorithm.
- Integration of software from different vendors is made.

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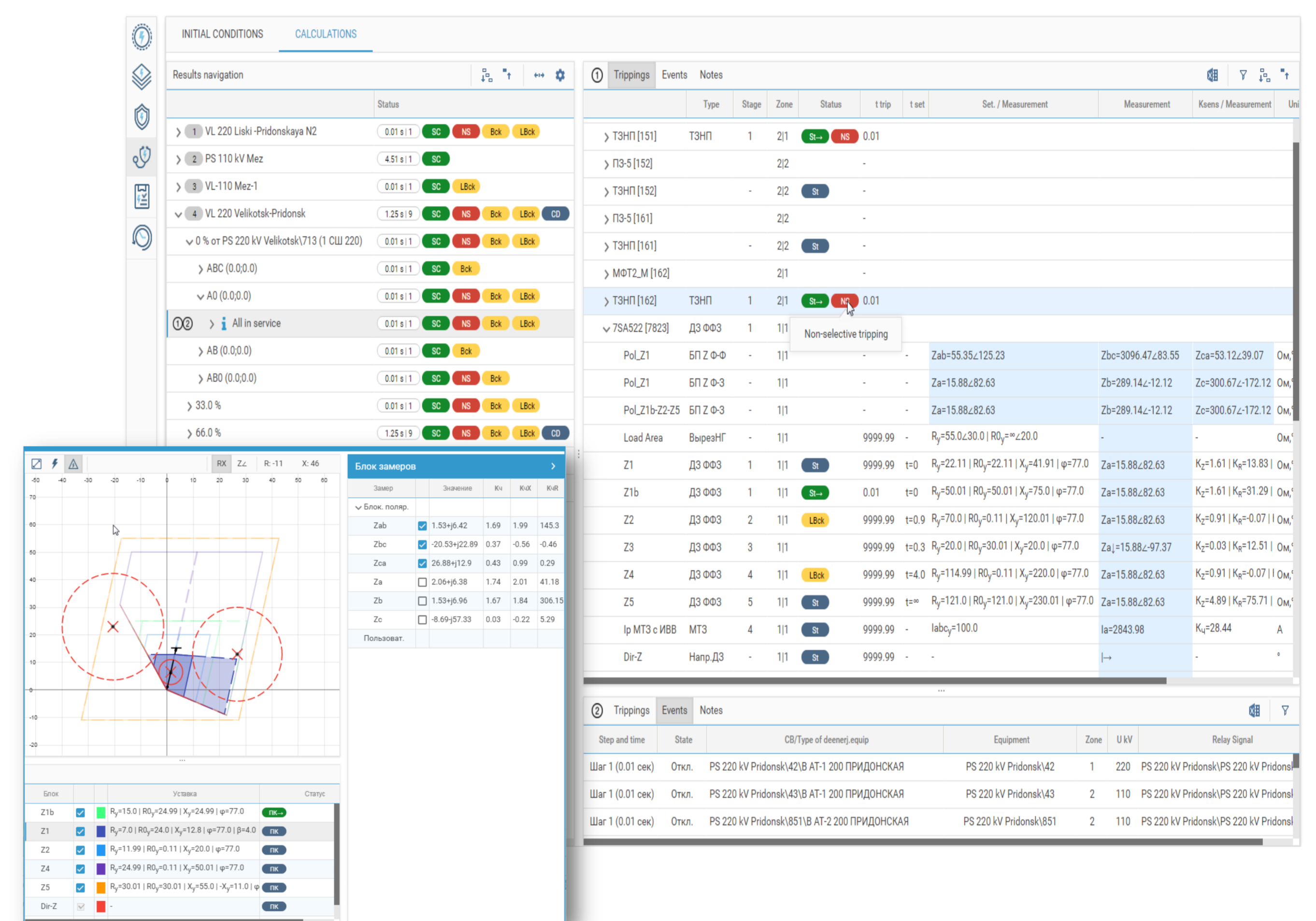
## System Concept

- Determination of fault time.
- Collection the initial field fault data (operational and non-operational) at time stamps close to identified time of fault event.
- Determination of fault location and type.
- Determination of the list of protection functions, which actually tripped/started.
- Determination of the existence of conditions for each protection function tripping/starting.
- Fault event modelling using power system calculation model.
- Calculation of output analog and discrete signals from relay models for each protection function based on the modelling of internal functional logic of relay protection.
- Comparative analysis of real and modelled protection behavior at fault event.

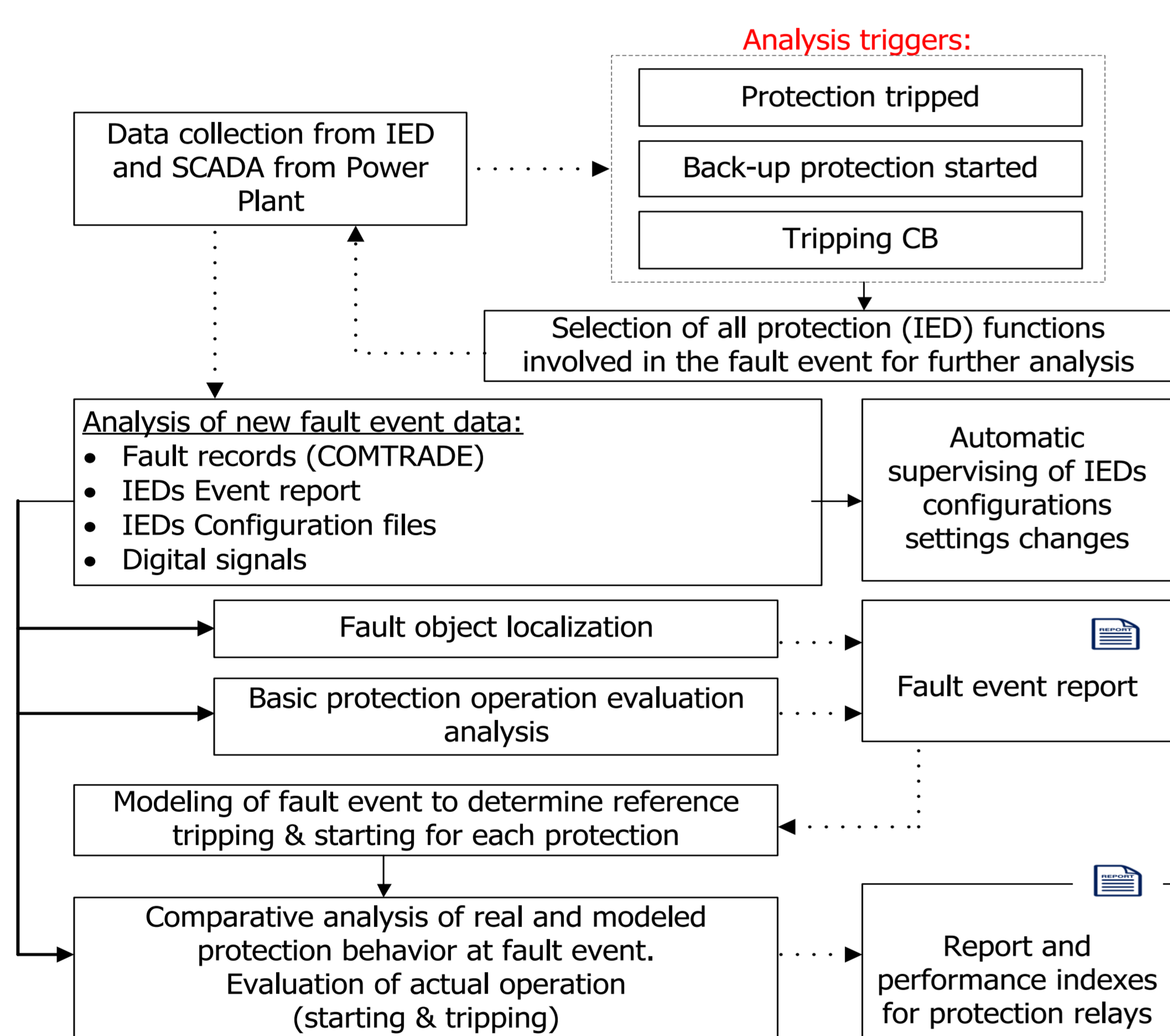
## Data Integration

- Collection of operational and non-operational data into a single database of the power plant.
- Data integration accomplished through the use of common information model (IEC 61970/61968).
- Implementation of uniform requirements for the formation of COMTRADE files on the basis of the internal data format of IED.

## Using power system models and protection modelling for analysis

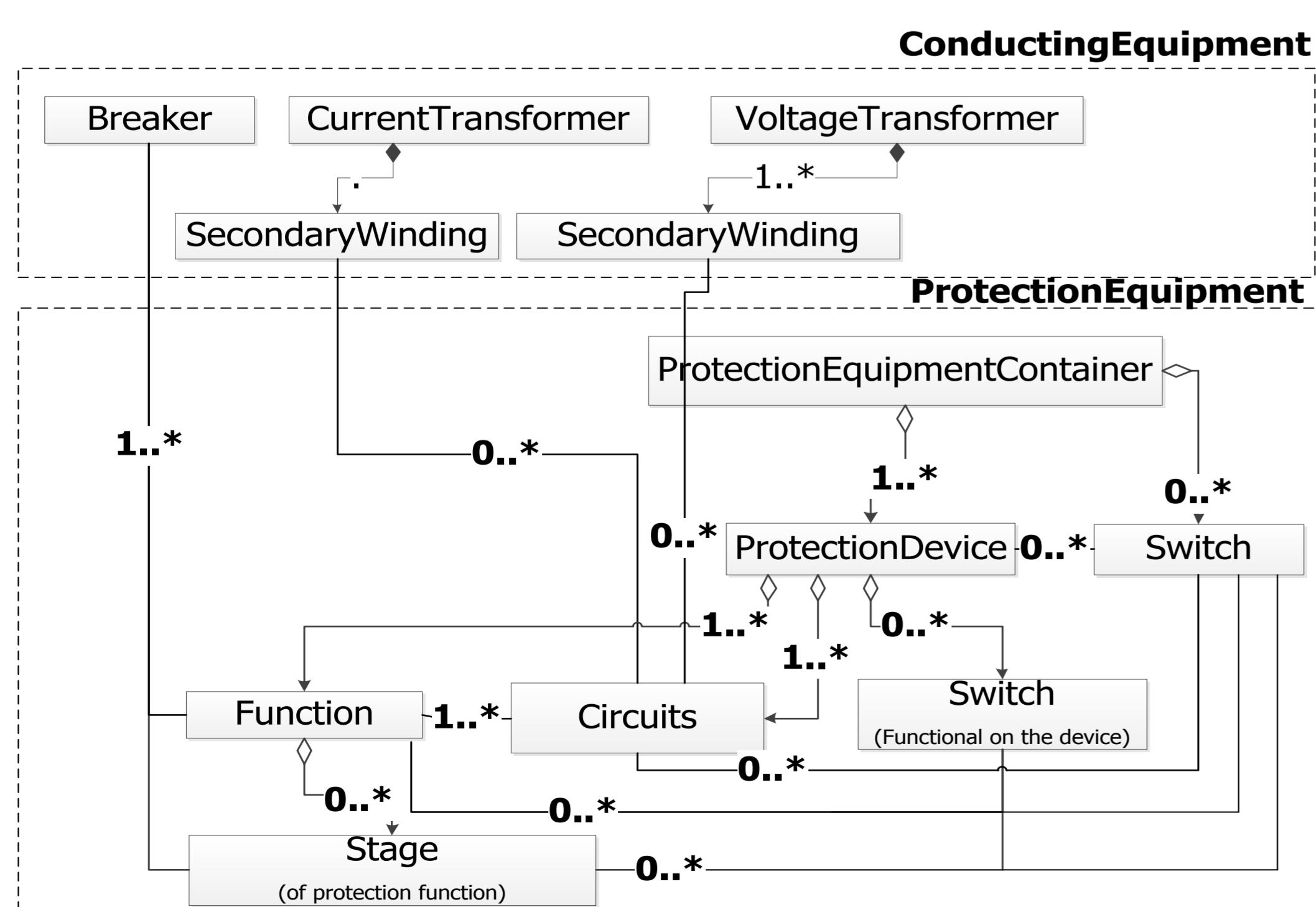


## Protection evaluation algorithm

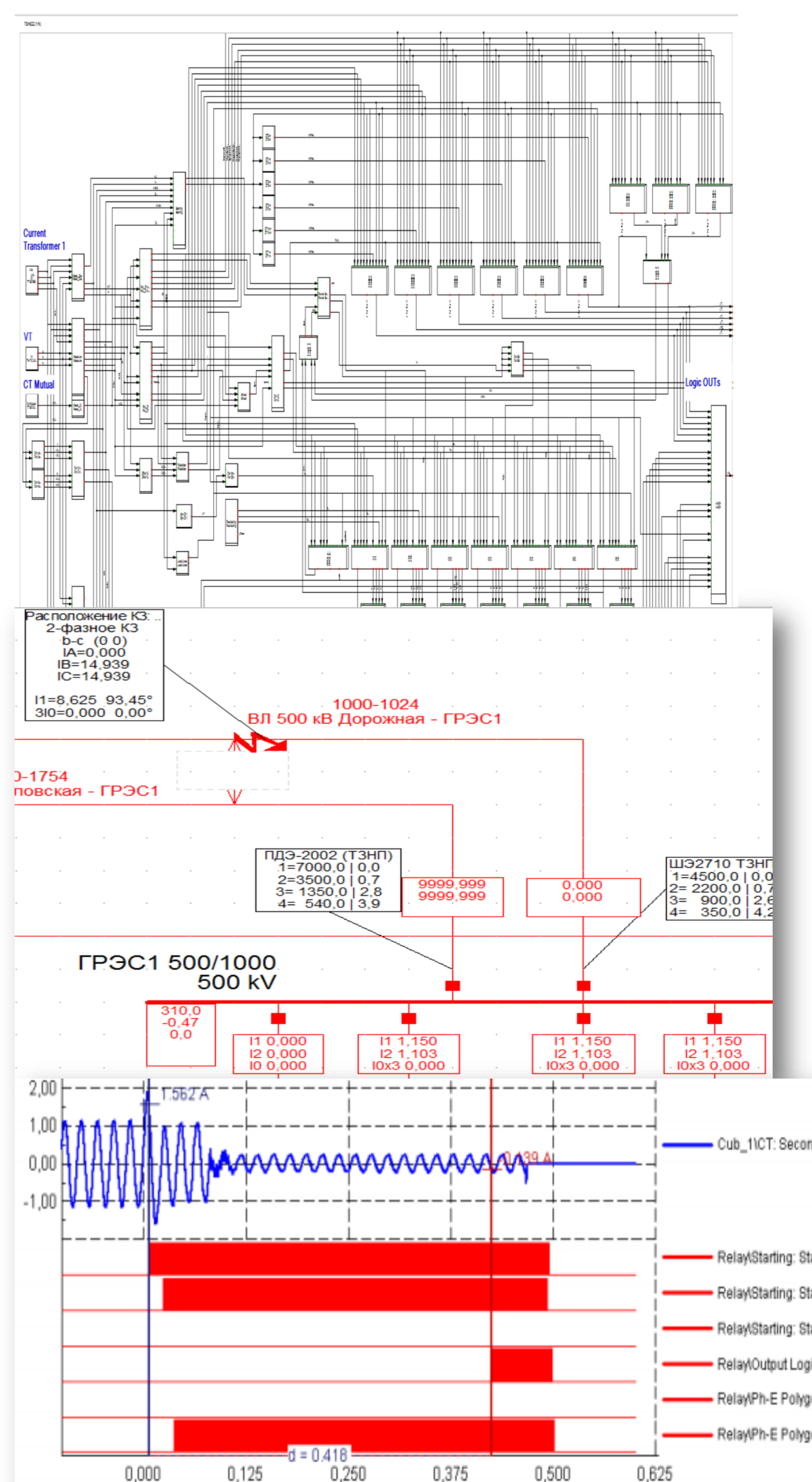


## Information platform

- Based on CIM IEC 61970/61968 platform with extension classes



## Relay modelling for protection evaluation



- Develop Relay Model:
  - simplified relay schema from Manual
  - no EMT phenomena, no know-how filters
- Accuracy: all settings change Relay functional logic as actual expected in Manual
- Verify on Short circuit complete method (no time-domain simulation) Use actual test scenarios from real Relay site commissioning phase
- Accuracy: 0% error for tripping/starting signals compared to site tests
- Fine-tune with COMTRADEs input/outputs (time-domain simulation)
- Accuracy: <12% error for discrete tripping\ starting signals compared to recorded data