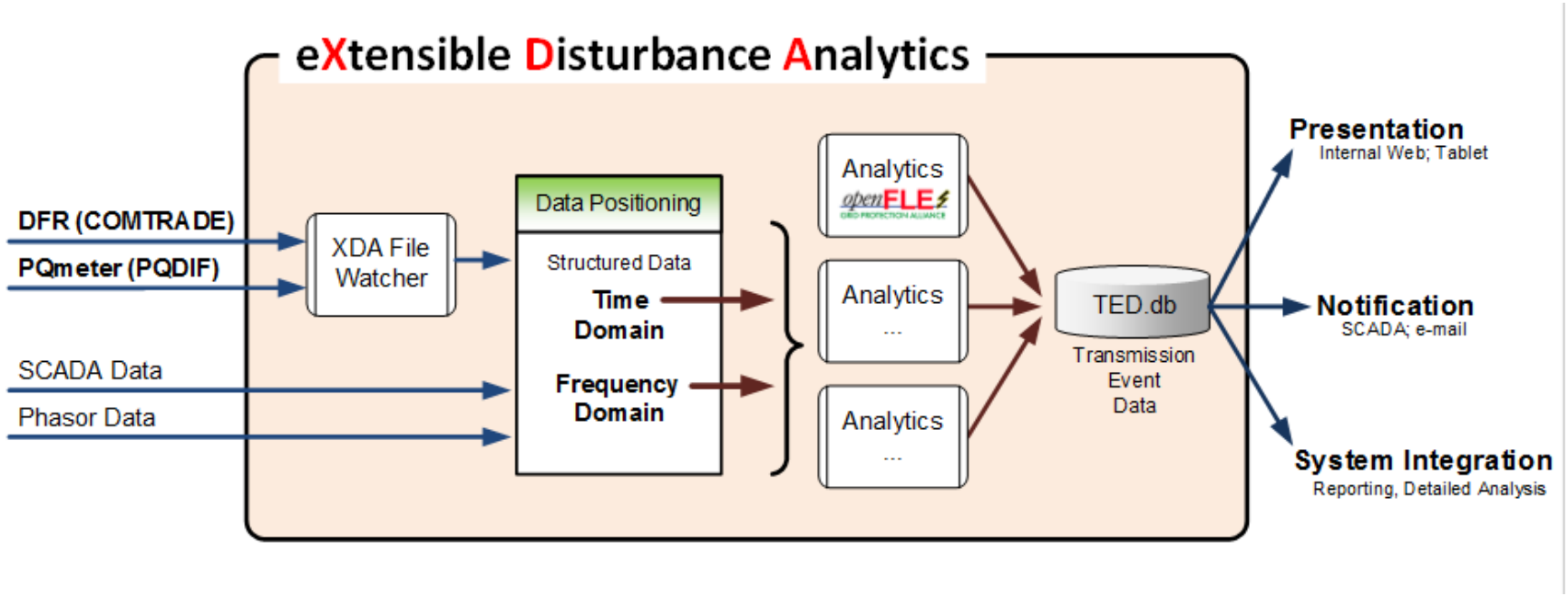
openXDA Overview

August 2014

GRID PROTECTION ALLIANCE

openXDA is a Platform

Vision in 2012



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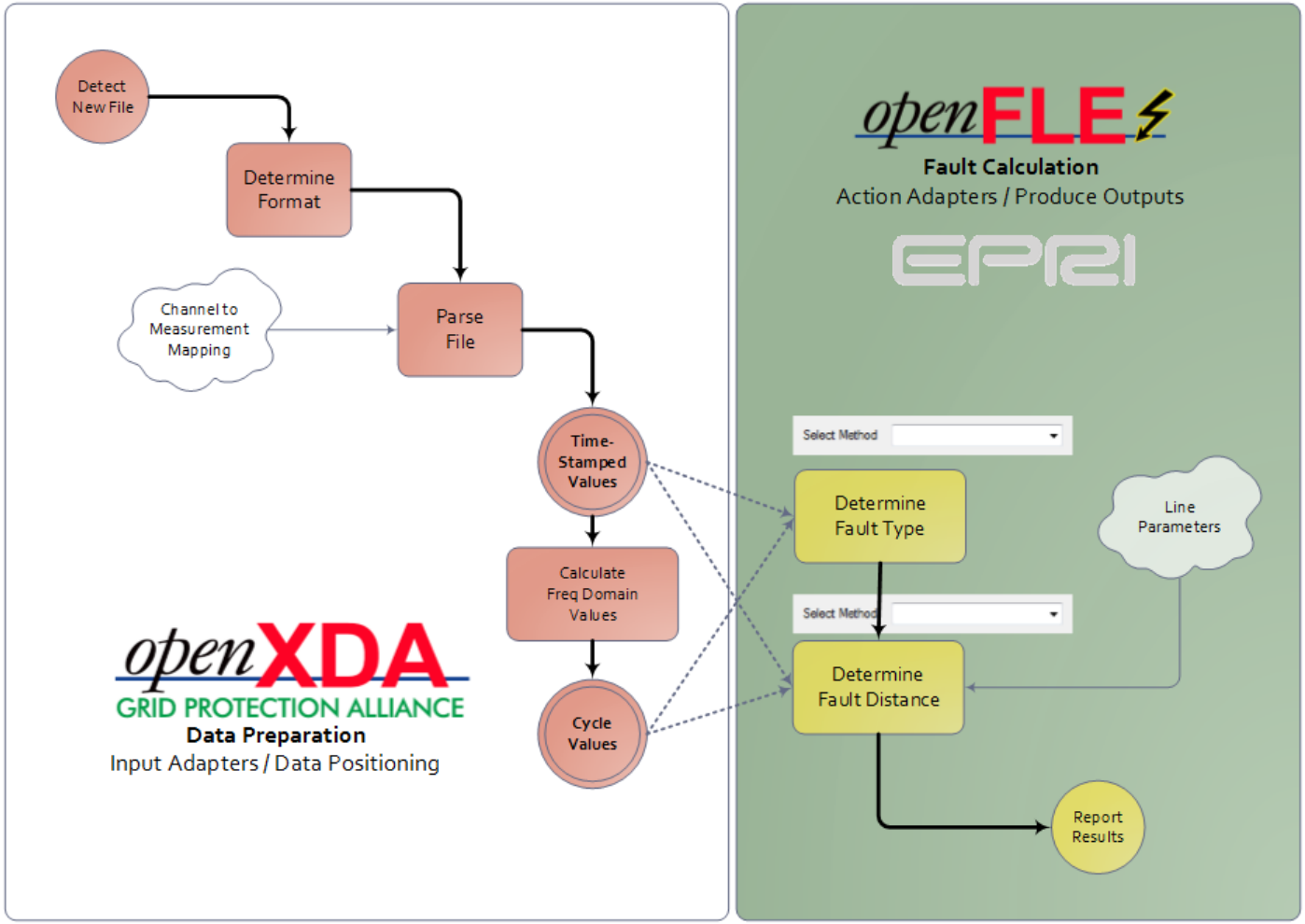
openXDA Computational Approach



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Fault Location Data Set

Fault Data Set Properties

- Currents
- Cycles
- FaultCalculationCycle
- FaultCycleCount
- FaultDistance
- FaultDistances
- FaultedCycles
- FaultType
- Frequency
- LineDistance
- LoopImpedance
- PositiveImpedance
- RatedCurrent
- this[string]
- Voltages
- Z0
- Z1
- ZeroImpedance
- Zs

CYCLES

Frequency domain data for every “cycle” of data in the waveform

A
B
C

Voltage
Current

RMS Value
Peak Value
Phase Angle
Frequency

e.g., a.voltage.RMSvalue

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Novosel Method

- **The Math --**

$$\frac{V_{\text{Pre}}}{I_{\text{Pre}}} = mZ_{L1} + Z_{Load,1}$$

$$\therefore Z_{Load,1} = \frac{V_{\text{Pre}}}{I_{\text{Pre}}} - mZ_{L1}$$

$$Z_G = -\frac{\Delta V_G}{\Delta I_G}$$

$$\left(\frac{V_G}{Z_{L1} I_G} + \frac{Z_{Load,1}}{Z_{L1}} + 1\right) = a + jb$$

$$\frac{V_G}{Z_{L1} I_G}\left(1 + \frac{Z_{Load,1}}{Z_{L1}}\right) = c + jd$$

$$\frac{\Delta I_G}{Z_{L1} I_G}\left(1 + \frac{Z_{Load,1} + Z_G}{Z_{L1}}\right) = e + jf$$

$$\therefore m = \frac{\left(a - \frac{eb}{f}\right) \pm \sqrt{\left(a - \frac{eb}{f}\right)^2 - 4\left(c - \frac{ed}{f}\right)}}{2}$$

m = pu distance to fault

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Fault Location Code for Novosel

```
return voltages.Zip(currents, (v, i) =>
{
    ComplexNumber sourceImpedance = (v - vPre) / (i - iPre);
    ComplexNumber ab = (v / (z * i)) + (loadImpedance / z) + 1;
    ComplexNumber cd = (v / (z * i)) * (1 + (loadImpedance / z));
    ComplexNumber ef = ((i - iPre) / (z * i)) * (1 + ((loadImpedance + sourceImpedance) / z));

    double a = ab.Real, b = ab.Imaginary;
    double c = cd.Real, d = cd.Imaginary;
    double e = ef.Real, f = ef.Imaginary;

    double left = (a - ((e * b) / f));
    double right = Math.Sqrt(left * left - 4.0D * (c - ((e * d) / f)));
    double m1 = (left + right) / 2.0D;
    double m2 = (left - right) / 2.0D;

    if (m1 >= 0.0D && m1 <= 1.0D)
        return m1;

    return m2;
})
```

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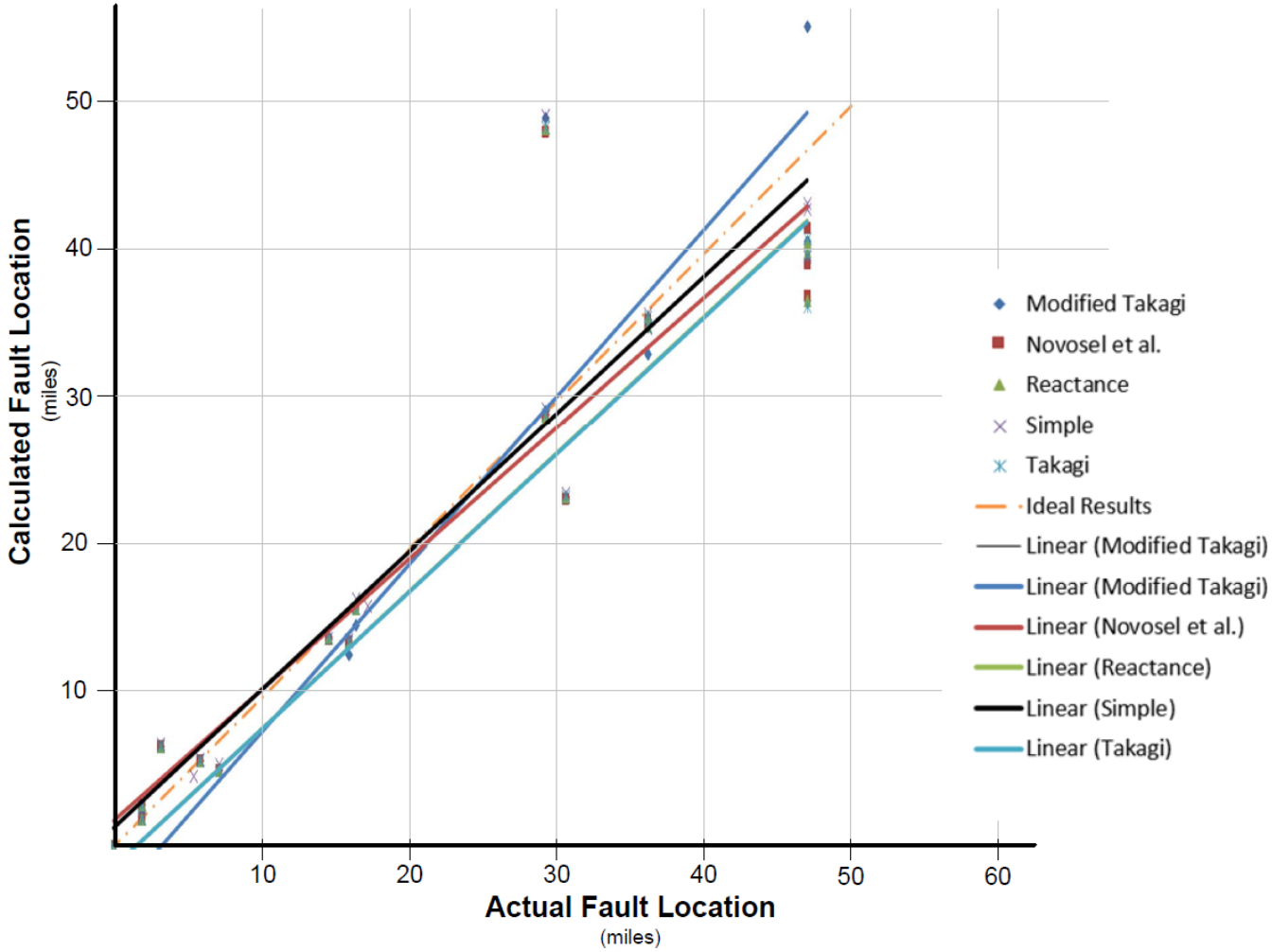
December 2013 openXDA Sprint

Added five more location determination methods



Records Received Last 60 Minutes in Black-Bold, Rest Gray

Distance is From This Substation

DFR Clock Not Always Correct

Automated Fault Location

Last Refreshed: 22:27:02

Record	Meter Clock Day	Meter Clock Time (CT)	Line #	Line Name	Meter Location	Distance (miles)	Closest Structure	Fault Type	Time Received
6	**Mar-13**	**22:14:28**	**L5109**	**Dougless-to-Knoxville**	**S1234**	**3.70**	**59**	**CN**	22:25:54
5	Apr-13	9:24:22	L5621		S1234	27.54	237	BC	9:25:54
4	Apr-13	9:24:22	L5762		S1234	0.00	--	ABC	9:25:54
3	Apr-13	9:01:00	L5762		S1234	0.59	7A	CA	9:02:32
1	Mar-13	7:40:02	L5762		S1234	0.59	7A	CA	7:41:34

Records listed In order received

Click on Any Record for the Details

Closest Structure From Maximo

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TVA

Example output screen from TVA.

Recent Improvements

- **Configuration Structure Changes**
  - Store waveform in database
  - Moved XML configuration to data base
  - Table created to break a fault record up into individual fault events or segments

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Active Dominion Work

- **Reporting / Visualization**
  - Automatically output the fault algorithm result charts in COMTRADE form
- **Add additional fault algorithms to the full set described in IEEE C37.114**
- **Read/Parse EMAX DFR fault records in native format**
- **Determine Fault Inception Time**
- **Correctly analyze fault records with multiple faults in a single record**
- **Correctly determine the evolution of a fault through multiple types**

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