Distribution Fault Locating with PI

Presented by **Cameron D. Sherding,** *Sr. Software Engineer*

DTE Energy is an Integrated Energy Company

Strong, Stable and Growing Utilities	Complementary Non-Utility Businesses

DTE Electric
- Electric generation and distribution
- 2.1 million customers
- Fully regulated by Michigan Public Service Commission

DTE Gas
- Natural gas distribution
- 1.2 million customers
- Fully regulated by Michigan Public Service Commission

Gas Storage & Pipelines (GSP)
Transport and store natural gas

Power & Industrial Projects (P&I)
Own and operate energy related assets

Energy Trading
Generate economic value and provide strategic benefits

Utility / non-utility earnings mix of 80% / 20% evolves to 70% / 30% by 2018

Profile of DTE Electric

- Twelfth largest US electric utility with 2.1 million customers
- ~$5 billion in revenue, $17 billion in assets
- Regulated by the Michigan Public Service Commission (MPSC)
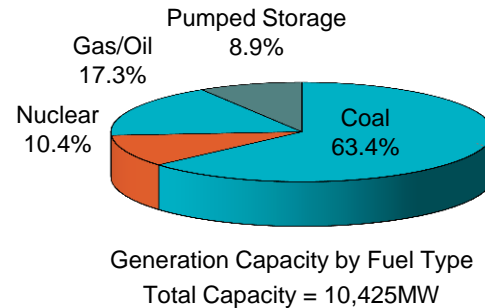- Contributed nearly 64% of DTE's 2014 earnings

Customer	Count	Load
Residential	1,920k	34%
Commercial	197k	44%
Industrial	1k	22%

Service Territory / Generating Facilities

- Fossil Generation
- Nuclear Generation
- Wind Generation
- Hydro Pumped Storage
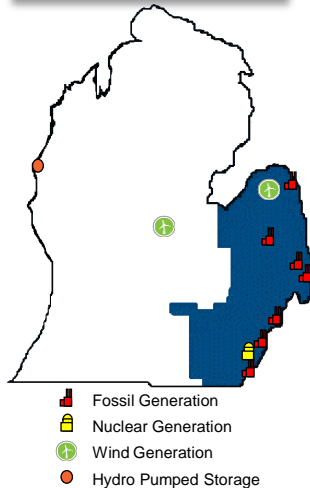
Generation Assets

- 7 Fossil fuel generating plants
- 1 Nuclear power plant
- 1 Hydroelectric pumped storage facility

Pumped Storage 8.9%
Gas/Oil 17.3%
Nuclear 10.4%
Coal 63.4%

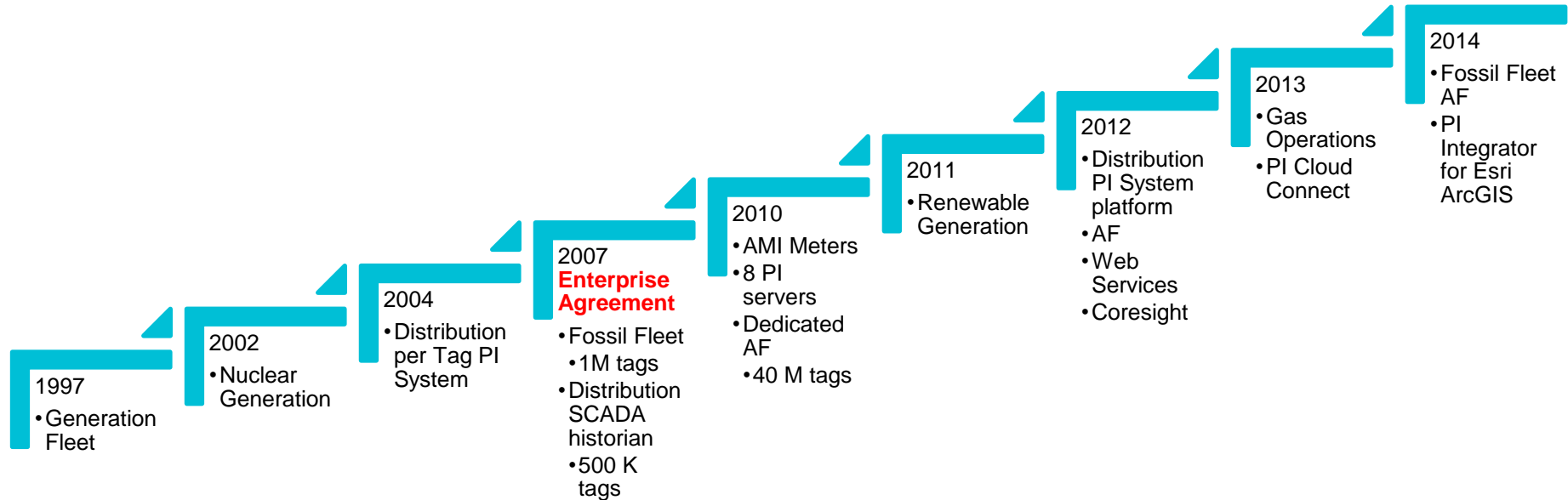Generation Capacity by Fuel Type
Total Capacity = 10,425MW

Distribution Assets

- 7,600 square-mile service area
- 671 distribution substations
- 12 Service Centers
- 46,000 miles of power lines

- *By 2015, DTE Energy will generate 10 percent of the electricity we provide for our Southeastern Michigan customers from renewable energy sources.*
- *Initiatives like the Echo-Wind Park will help to produce energy from renewable sources like wind.*

History of PI at DTE

1997
- Generation Fleet

2002
- Nuclear Generation

2004
- Distribution per Tag PI System

2007
Enterprise Agreement
- Fossil Fleet
  - 1M tags
- Distribution SCADA historian
  - 500 K tags

2010
- AMI Meters
- 8 PI servers
- Dedicated AF
  - 40 M tags

2011
- Renewable Generation

2012
- Distribution PI System platform
- AF
- Web Services
- Coresight

2013
- Gas Operations
- PI Cloud Connect

2014
- Fossil Fleet AF
- PI Integrator for Esri ArcGIS

Business Challenge

DTE is actively working to reduce customer outage minutes (CAIDI) on the distribution system.

1. Fault Locating

– Many outages are result of faults on the line caused by vegetation, animals, cable or equipment failures

– Quickly locating the source of these faults is critical to minimizing restoration time

2. Low Cost Monitoring

– Aging substations aren't cost-effective to install full SCADA. Basic load data can provide valuable visibility into the system at these locations.

Fault Locating

Wire Contact
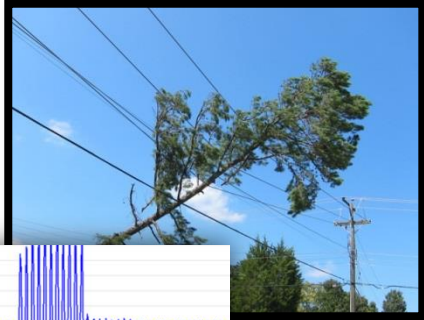
Failing Pole Top Transformer
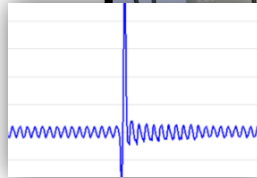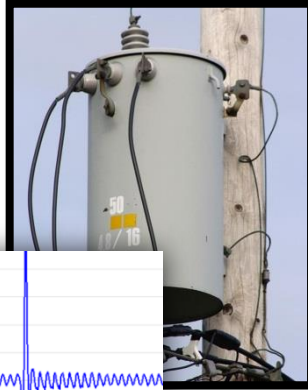
Failing Underground Cable
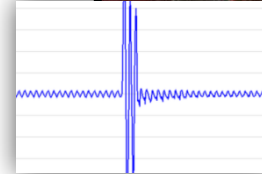
Minimizing patrol distances can improve restore time

Ground Fault
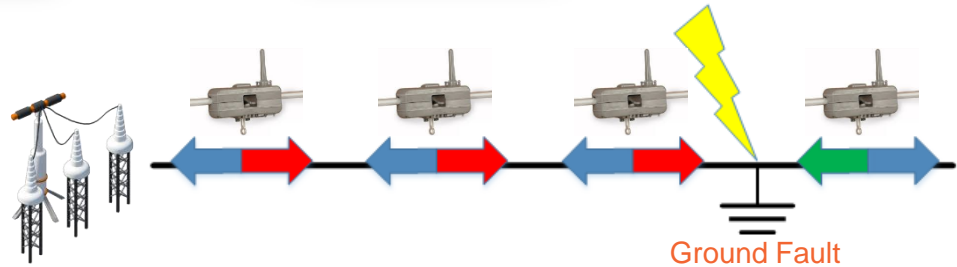
DTE Electric's Distribution Operations

- 450,000+ tags in SCADA historian
- 29,000,000 tags and growing in AMI PI

- PI to PI APS SCADA and DR historian to DO-PI

- PI Server 2014 (HA configuration)
- AF 2014
- Coresight 2014

Distribution PI System

Fault Locating

Display Device Status, Faulted Line, etc.

Mobile Map

Device Health

PI Tools

SCADA / EMS

PI

Firewall

DO-PI

PI Integrator for Esri ArcGIS

GIS

AMI PI

Fault Sensors

PI to PI (APS)

PI Notifications (XML)

Distributed Resources

PI

Firewall

Enterprise Service Bus

PI Notifications (email/SMS)

Asset Management

DMS

AMI
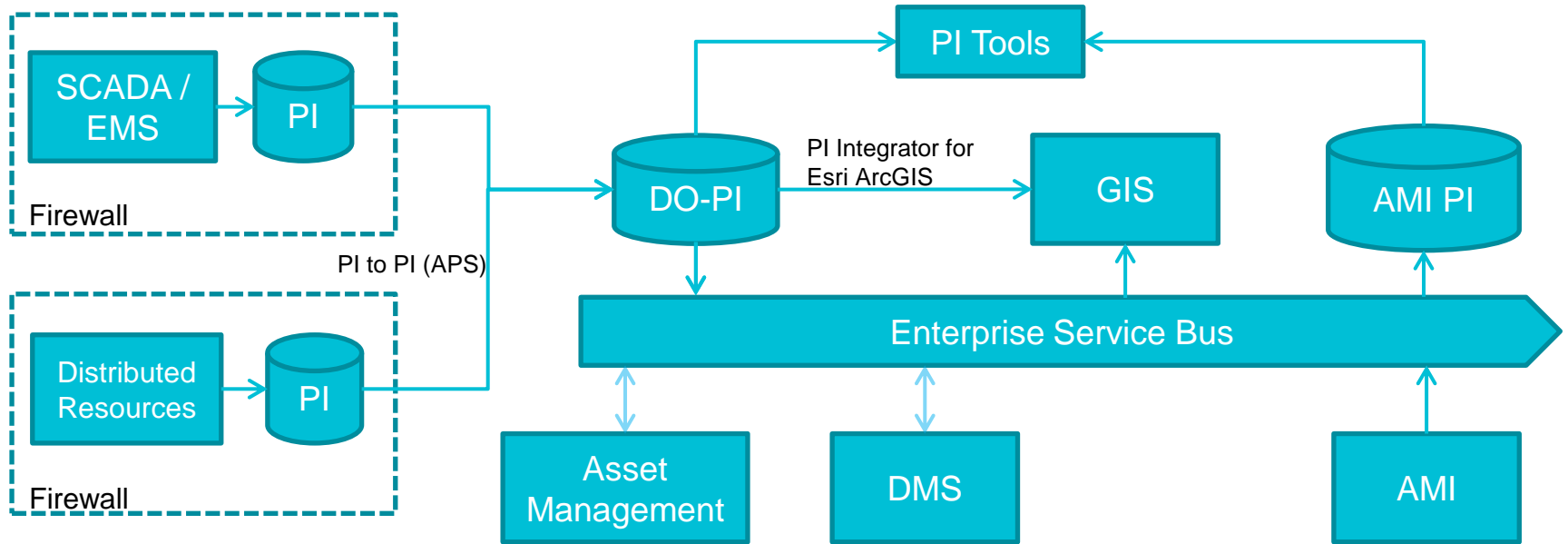
Compute Fault Location
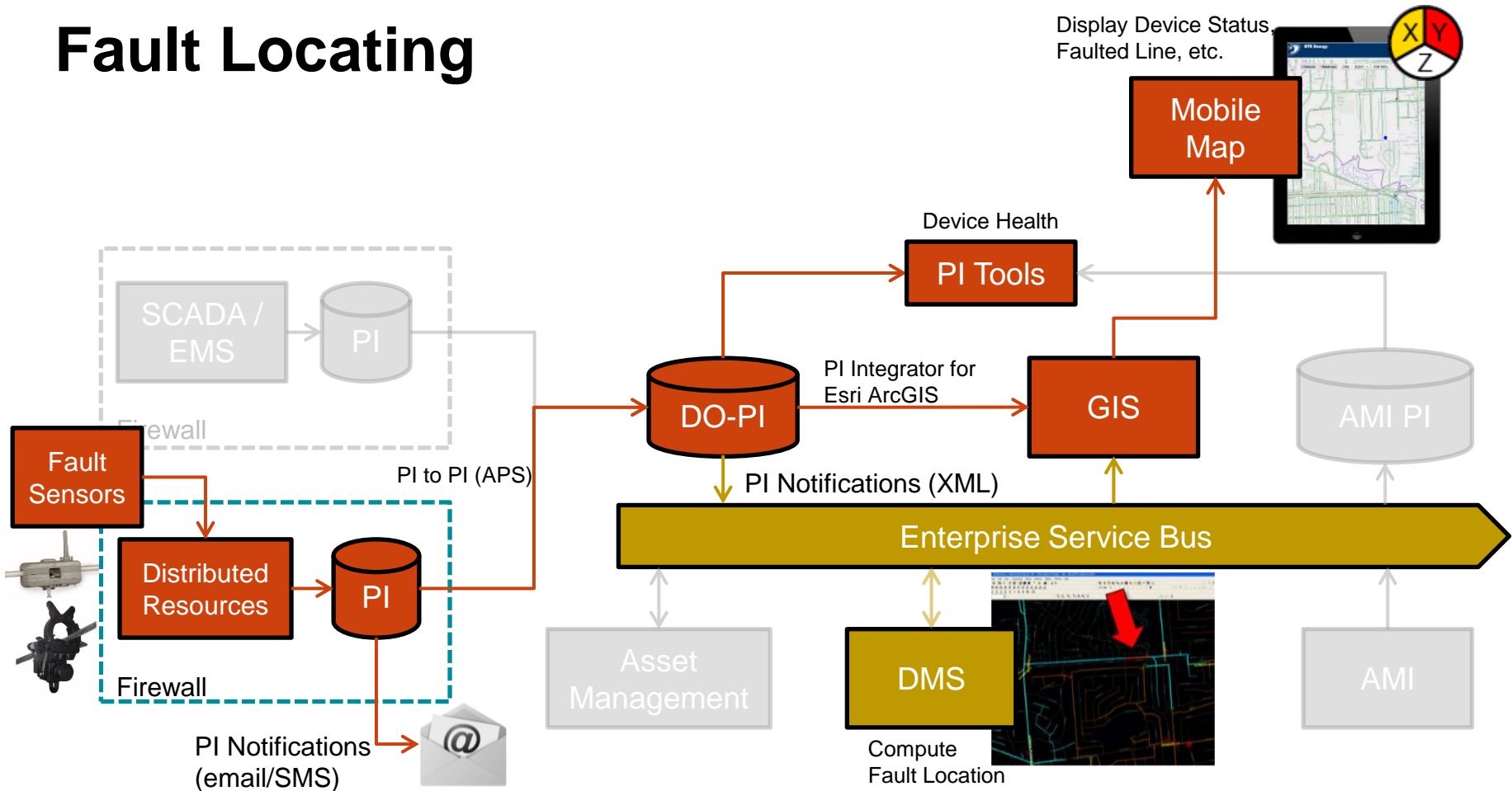
PI Solution Architecture

Asset Framework

Site-level Template
- Aggregate of all 3 phases at a location
- Notification Target

FAULT_INDICATOR_SITE

X, Y, Z Phases

Sensor Base Template
FAULT_INDICATOR

Sensor Child Templates
FAULT_INDICATOR_LIGHTHOUSE_MV_SENSOR
FAULT_INDICATOR_OUTAGE_ADVISOR_V1
FAULT_INDICATOR_OUTAGE_ADVISOR_V2
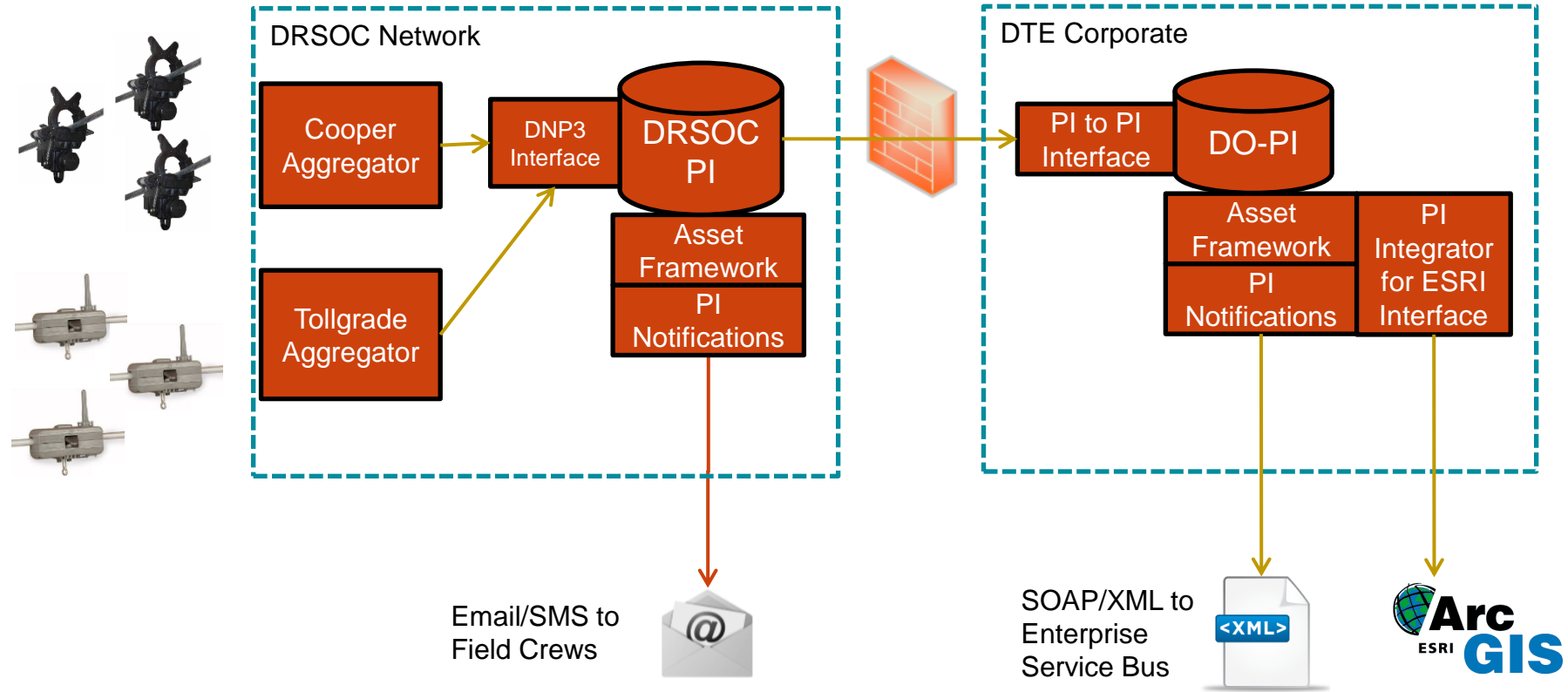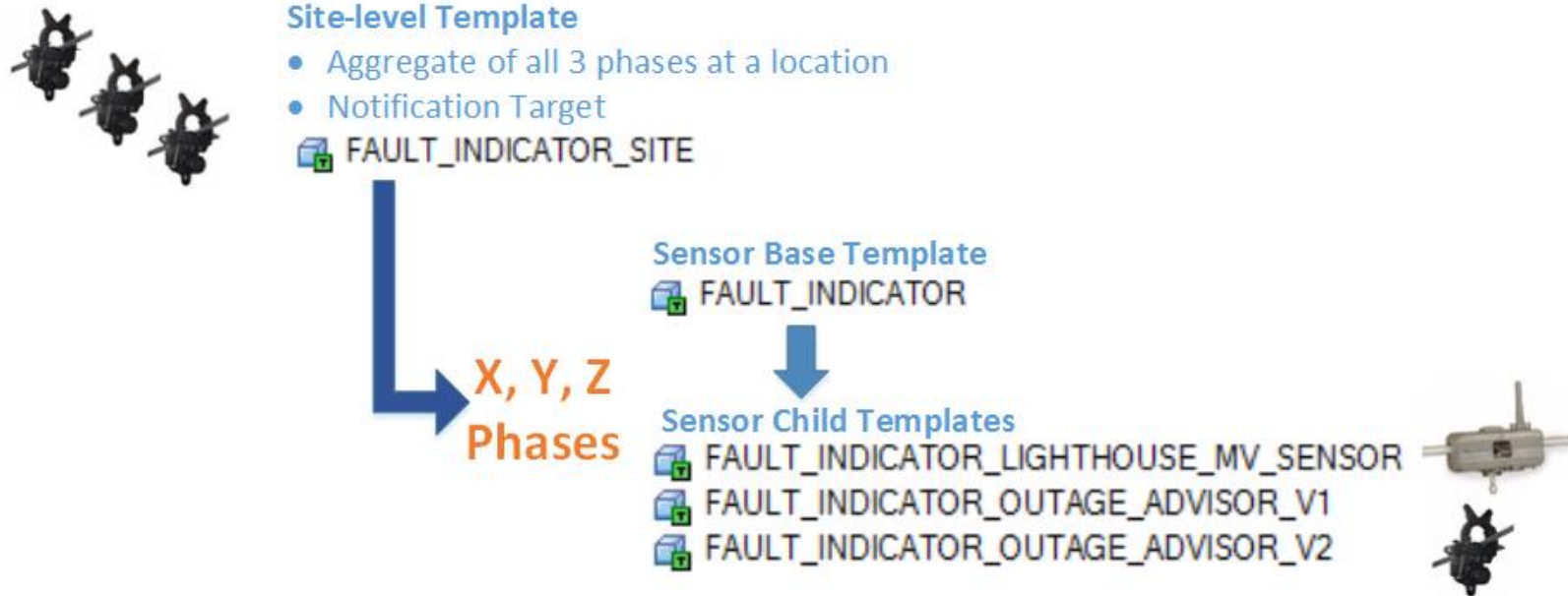
Asset Framework Details

Site-level Template

FAULT_INDICATOR_SITE

Attribute References:

Formulas:

A=Fault Current X;B=Fault Current Y;C=Fault Current Z;[max(max(A,B) , C)]

		Name	Value
		CIRCUIT	43T
		COMMUNICATIONS	CELLULAR
		Current X	240.19999694824219
		Current Y	225.30000305175781
		Current Z	192.60000610351563
		Device ID	MADSN43T
		DMS_REF	7
		Fault Current G	0
		Fault Current Max	0
		Fault Current N	0
		Fault Current X	0
		Fault Current Y	0
		Fault Current Z	0
		Fault Type	-1
		FEEDERMONITOR	No
		GLNXY	
		Latitude	42.335591
		LOCATION	NB 619
		Longitude	-83.042108
		Momentary Fault Status X	0
		Momentary Fault Status Y	0
		Momentary Fault Status Z	0
		OBJECTID	0
		OHUG	UG
		OUT_HOST_NAME	192.168.247.75
		OUT_PORT_NUM	6161
		Power Status X	0
		Power Status Y	0
		Power Status Z	0

SFI
- SFI-A0001
- SFI-A0002
- SFI-A0003
- SFI-A0004
- SFI-A0005
- SFI-A0006
- SFI-A0007
- SFI-A0008
- SFI-A0009
- SFI-A0010
- SFI-A0011
- SFI-A0012
- SFI-A0013
- SFI-A0014
- SFI-A0015
- SFI-A0016
- SFI-A0017
- SFI-A0018
- SFI-A0019
- SFI-A0022
- SFI-A0032
- SFI-A0033
- SFI-A0034
- SFI-A0035
- SFI-A0040
- SFI-A0041
- SFI-A0042
- SFI-A0043
- SFI-A0044
- SFI-A0048
- SFI-A0049
- SFI-A0050
- SFI-A0055
- SFI-A0056
- SFI-A0057
- SFI-A0058
- SFI-A0059
- SFI-A0060
- SFI-A0063
- SFI-A0064
- SFI-A0071

Elements

Event Frames

Asset Framework Details

Sensor-level Templates

Building Tag References:

Visualizing Data Using PI Client Tools

PI client tools like ProcessBook and Coresight allow engineers to easily view sensor data for planning and analysis
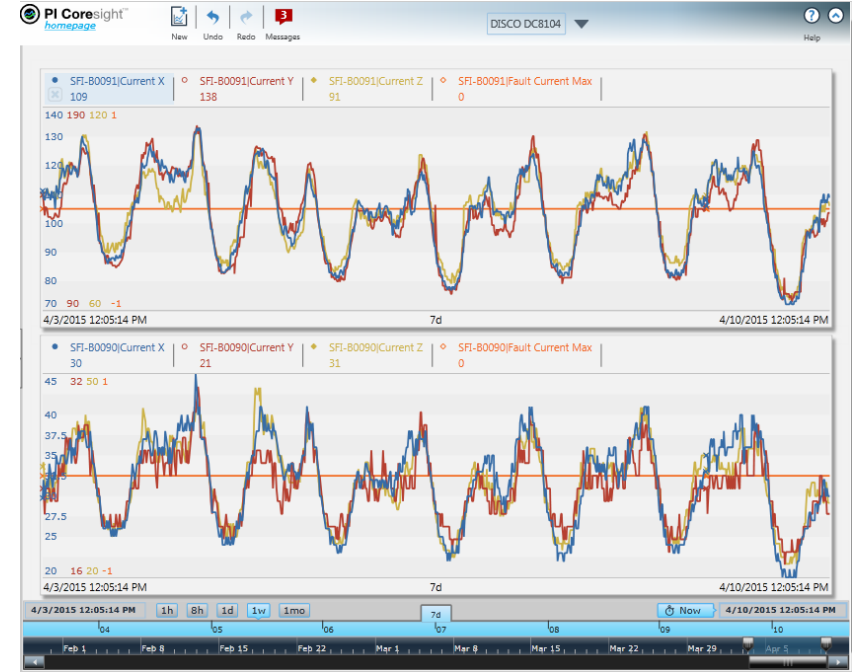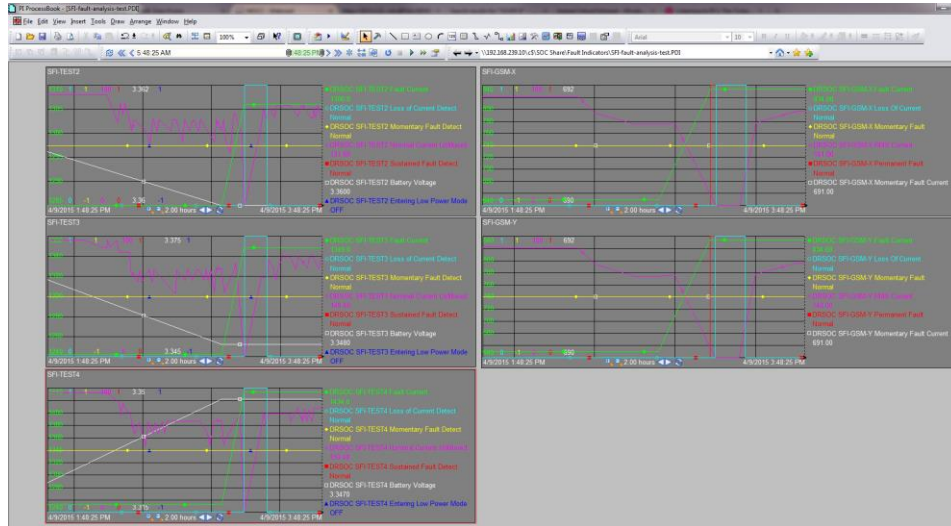
Visualizing Data Using PI Client Tools (cont'd)

- Web-based dashboard (AF-SDK) gives quick overview of circuits
- Element-relative displays allow users to drill-down into sensor data

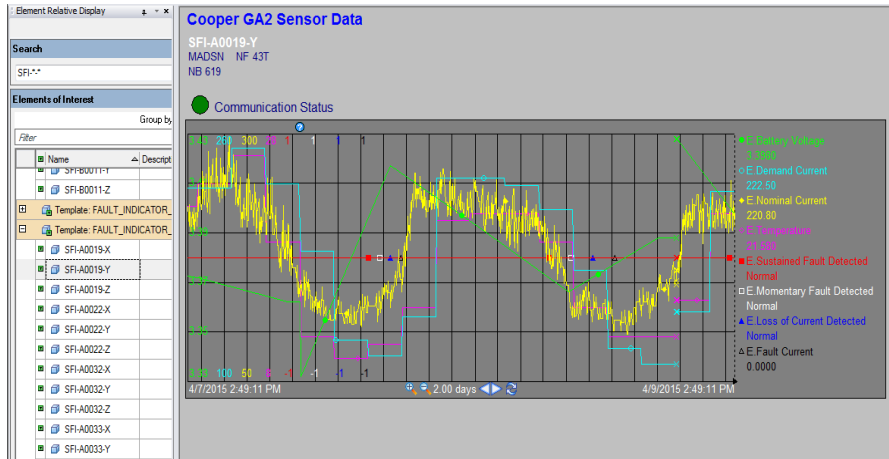| Circuit	SFI	objectid	Type	X Amps	Y Amps	Z Amps	Power Status	Fault Status	STATUS	Last Update
REDFD1064	SFI-A0001	5450	OUTAGE_ADVISOR_V1 CELLULAR OH	204	174	204	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
REDFD1064	SFI-A0002	5449	OUTAGE_ADVISOR_V1 CELLULAR OH	202	174	200	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
REDFD1064	SFI-A0003	5447	OUTAGE_ADVISOR_V1 CELLULAR OH	66	63	71	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
REDFD1064	SFI-A0004	5446	OUTAGE_ADVISOR_V1 CELLULAR OH	114	98	110	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
REDFD1064	SFI-A0005	5448	OUTAGE_ADVISOR_V1 CELLULAR OH	63	59	60	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
REDFD1064	SFI-A0006	5445	OUTAGE_ADVISOR_V1 CELLULAR OH	63	61	68	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
REDFD1064	SFI-A0007	5443	OUTAGE_ADVISOR_V1 CELLULAR OH	0	5	1	XYZ	XYZ	FAULTED	4/9/2015 2:23:15 PM
REDFD1064	SFI-A0008	9288	OUTAGE_ADVISOR_V1 CELLULAR OH	48	46	42	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VILLA1555	SFI-A0009	9289	OUTAGE_ADVISOR_V1 CELLULAR OH	69	65	55	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VILLA1555	SFI-A0010	9290	OUTAGE_ADVISOR_V1 CELLULAR OH	69	40	70	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VILLA1555	SFI-A0011	9291	OUTAGE_ADVISOR_V1 CELLULAR OH	39	63	42	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VILLA1555	SFI-A0012	9292	OUTAGE_ADVISOR_V1 CELLULAR OH	35	4	65	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VILLA1552	SFI-A0013	9295	OUTAGE_ADVISOR_V1 CELLULAR OH	63	122	118	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VILLA2161	SFI-A0014	9296	OUTAGE_ADVISOR_V1 CELLULAR OH	57	34	40	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VILLA2161	SFI-A0015	9922	OUTAGE_ADVISOR_V1 CELLULAR OH	39	37	34	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
HAYES1385	SFI-A0016	9923	OUTAGE_ADVISOR_V1 CELLULAR OH	128	128	118	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
HAYES1385	SFI-A0017	9924	OUTAGE_ADVISOR_V1 CELLULAR OH				XYZ	XYZ	POWER OUT	4/9/2015 2:23:15 PM
SYRAC2019	SFI-A0018	9925	OUTAGE_ADVISOR_V1 CELLULAR OH				XYZ	XYZ	POWER OUT	4/9/2015 2:23:15 PM
MADSN43T	SFI-A0019	0	GRID_ADVISOR_2 CELLULAR UG	229	221	211	XYZ	XYZ	NORMAL	4/9/2015 2:41:35 PM
TURNR1001	SFI-A0022	0	OUTAGE_ADVISOR_V2 CELLULAR OH	99	115	0	XYZ	XYZ	NORMAL	4/9/2015 2:34:22 PM
BLTMR1395	SFI-A0032	0	OUTAGE_ADVISOR_V2 CELLULAR OH	80	88	93	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM
JUPTR8352	SFI-A0033	0	OUTAGE_ADVISOR_V2 CELLULAR OH	58	74	0	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM
JUPTR8352	SFI-A0034	0	OUTAGE_ADVISOR_V2 CELLULAR OH	38	65	74	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM
SYRAC2019	SFI-A0035	0	OUTAGE_ADVISOR_V2 CELLULAR OH	175	192	201	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM
JUPTR8373	SFI-A0040	0	OUTAGE_ADVISOR_V2 CELLULAR OH	184	173	189	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM
JUPTR8373	SFI-A0041	0	OUTAGE_ADVISOR_V2 CELLULAR OH	50	49	45	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM
JUPTR8373	SFI-A0042	0	OUTAGE_ADVISOR_V2 CELLULAR OH	0	0	47	XYZ	XYZ	ABNORMAL	4/9/2015 2:34:21 PM
JUPTR8373	SFI-A0043	0	OUTAGE_ADVISOR_V2 CELLULAR OH	41	53	77	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM
JUPTR8373	SFI-A0044	0	OUTAGE_ADVISOR_V2 CELLULAR OH	8	18	50	XYZ	XYZ	NORMAL	4/9/2015 2:34:21 PM

Visualizing Data Using PI Client Tools (cont'd)
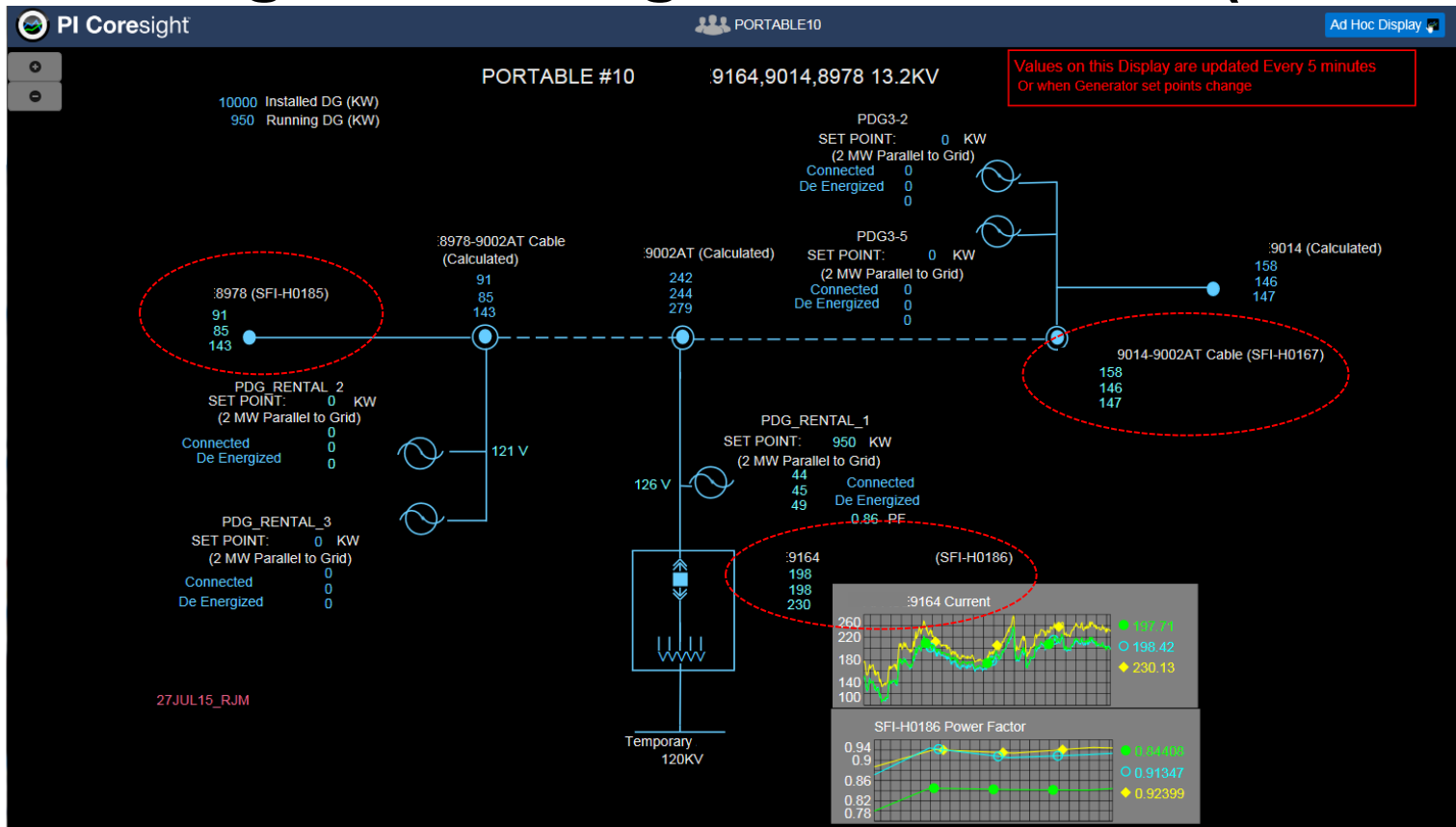
PI Notifications

Email notifications

PI Notifications

SOAP XML notifications

```
<soapenv:Body>
    <dms_ref>13</dms_ref>
    <device_id>REDFD1064</device_id>
    <fault_current_g>243</fault_current_g>
    <fault_current_max>1617</fault_current_max>
    <fault_current_n>1617</fault_current_n>
    <fault_current_x>1617</fault_current_x>
    <fault_current_y>0</fault_current_y>
    <fault_current_z>0</fault_current_z>
    <fault_type>0</fault_type>
    <priority>0</priority>
    <type>FAULT_INDICATOR_OUTAGE_ADVISOR_V1</type>
    <notification_trigger_time>2015-03-25 01:05:19
    </notification_trigger_time>
</soapenv:Body>
```
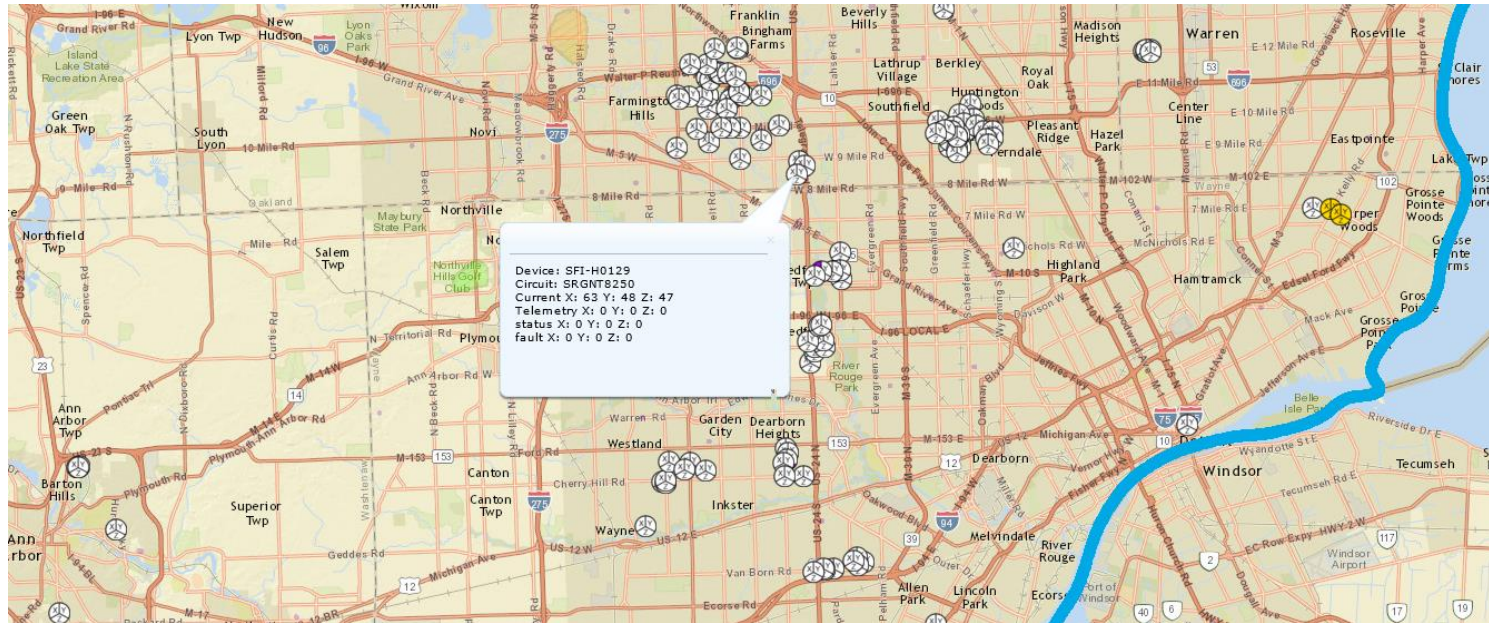
Mapping Fault Status

- Initial proof of concept: Developed Windows service using AF-SDK to push fault events into the GIS database
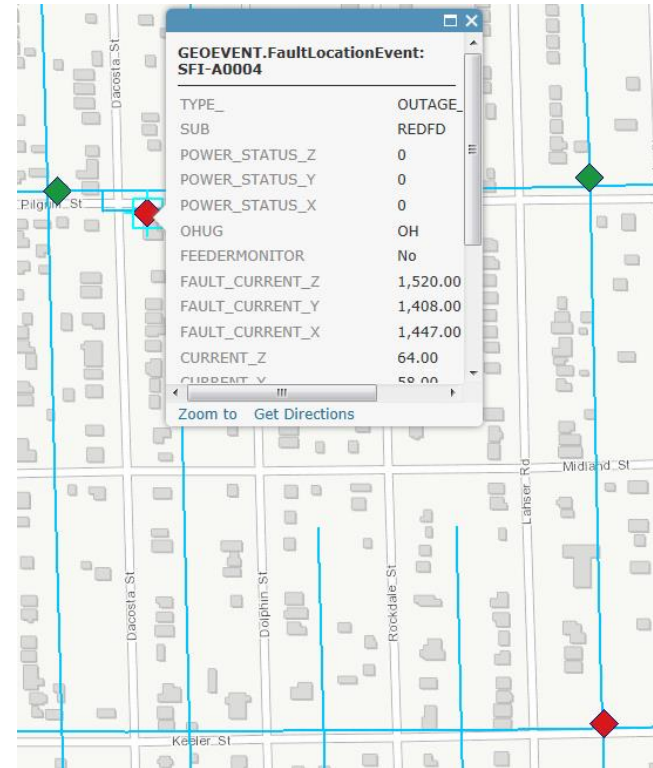
Mapping Fault Status (cont'd)

- Next steps: Moving from AF-SDK service to PI Integrator for Esri ArcGIS

- This has also been through proof-of-concept phase

- Expecting full roll-out Q4

Normal   Abnormal

GEOEVENT.FaultLocationEvent: SFI-A0004

TYPE_	OUTAGE_
SUB	REDFD
POWER_STATUS_Z	0
POWER_STATUS_Y	0
POWER_STATUS_X	0
OHUG	OH
FEEDERMONITOR	No
FAULT_CURRENT_Z	1,520.00
FAULT_CURRENT_Y	1,408.00
FAULT_CURRENT_X	1,447.00
CURRENT_Z	64.00
CURRENT_Y	58.00

Zoom to   Get Directions

PI Integrator for ArcGIS Configuration

- Template and root element is selected in PI Integrator
- Key fields are identified (key, Latitude, Longitude)
- StreamServer is created and started

Operationalizing the Data

- Circuit Level outage on MANDY0308 at 6 AM

- Based on previous circuit history, initial response from SOC was to treat circuit outage as a cable fault

- Overhead supervisor had access to data from a rapid experiment utilizing mobile map overlaid with fault data from intelligent field devices

- Overhead supervisor guided crew to the section of the circuit impacted by the fault, reducing patrol time

- Cause was a tree taking down XY phase on overhead

- Determination could have been made within 5 minutes of initial outage to send crew to do restore before repair

Fault Indicator

AMI Meters

DTE Energy: Reliability Through Innovation

"As an innovative utility, we were looking for solutions to get more real-time reliability data out of our distribution grid, particularly on older legacy and poorly performing circuits."

"Now that we have better real-time visibility into our grid, we can safely restore power faster and better plan our capital investments around aging assets before they cause outages."

Vince Dow
Vice President, Distribution Operations, DTE Energy

DTE Energy®
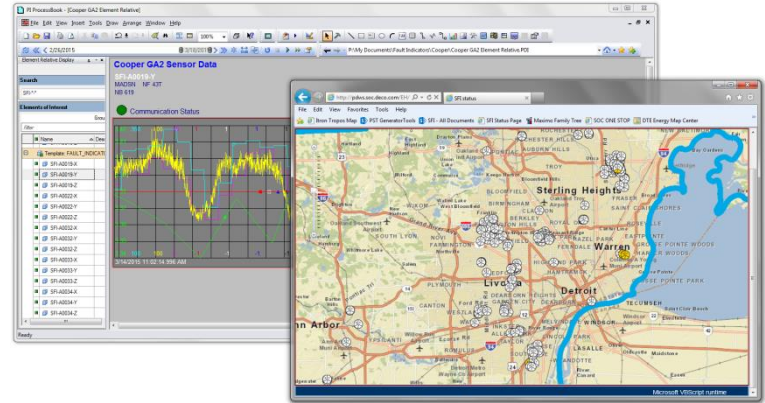
Business Challenges

- Determining where to send crews during outages to minimize patrol time

- Integrating data from different types of sensors with multiple backend systems

- Allow crews to visualize real-time sensor data in the field and engineers to visualize historical data in the office

Solution(s)

- Feed all sensor data into PI System using PI DNP3 interface

- Utilize PI AF and PI Notifications to push events to field and DMS

- Coresight and ProcessBook to visualize historical data

- Utilize PI integrator for Esri ArcGIS

Results and Benefits

- Visualization of sensor status on circuit map allows crews to divide circuit into segments and narrow search for faults. Expecting to eliminate at least **500k customer outage minutes** annually

- History of device operation and circuit data gives valuable visibility into legacy parts of the system. Savings estimated at **$25k per circuit**.

Cameron D. Sherding

sherdingc@dteenergy.com

Sr. Software Engineer

Power Systems Technology

DTE Electric Company

THANK YOU

Brought to you by OSIsoft.