



Improving Distribution Reliability with Smart Fault Indicators and the PI System

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DTE Energy is an Integrated Energy Company

Strong, Stable and Growing Utilities



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

Complementary Non-Utility Businesses



Gas Storage & Pipelines (GSP)

Transport and store natural gas



Power & Industrial Projects (P&I)

Own and operate energy related assets



Energy Trading

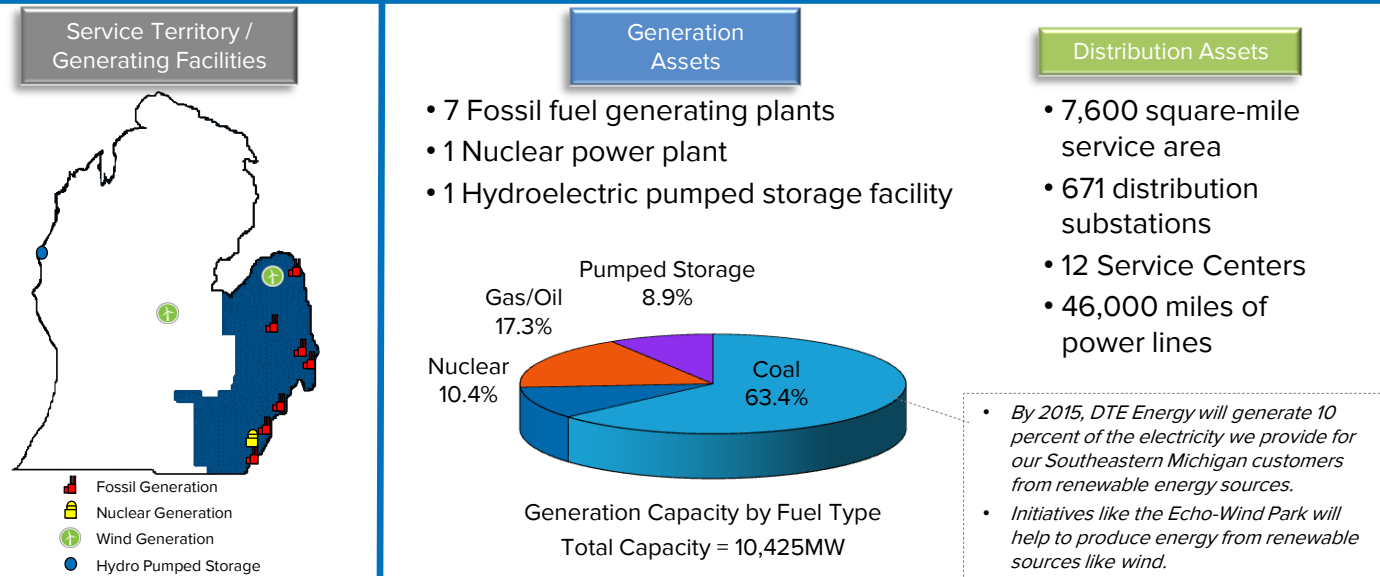
Generate economic value and provide strategic benefits

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

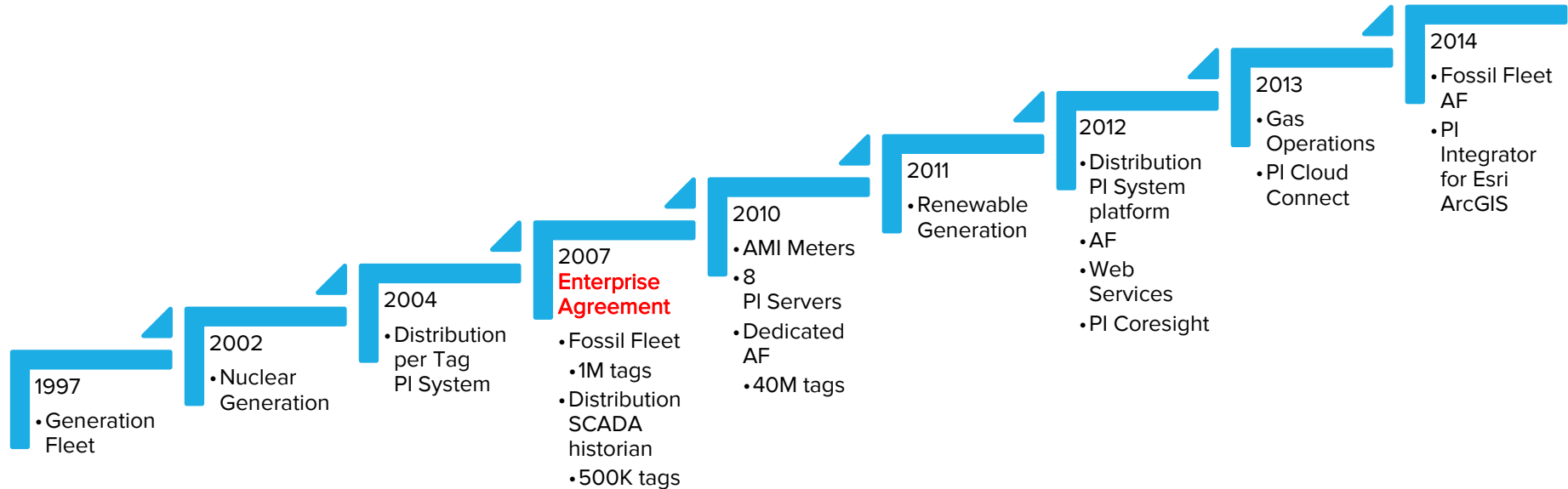
Profile of DTE Electric

- 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%



History of the PI System at DTE



Business Challenge

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

1. Fault Locating

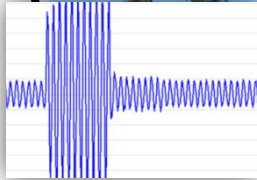
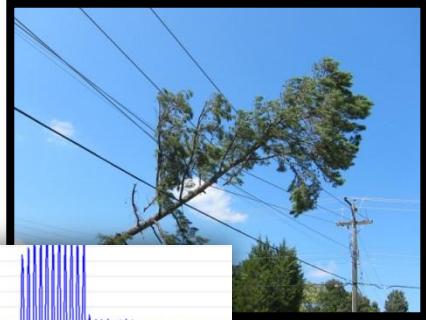
- Many outages are result of faults on the line caused by vegetation, animals, cable, or equipment failures
- Quickly locating the source of these faults is critical to minimizing restoration time

2. Low Cost Monitoring

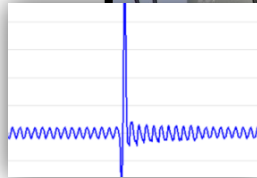
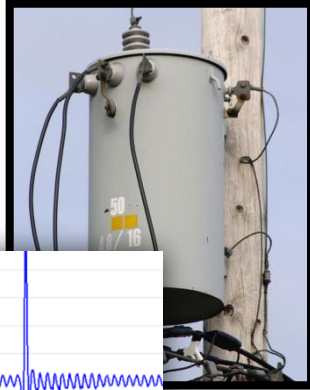
- Aging substations aren't cost-effective to install full SCADA. Basic load data can provide valuable visibility into the system at these locations.

Fault Locating

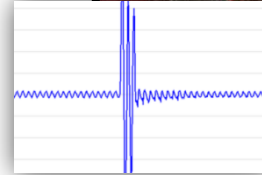
Wire Contact



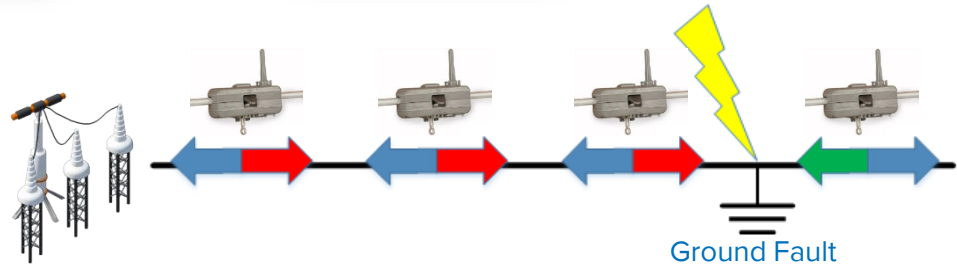
Failing Pole Top Transformer



Failing Underground Cable



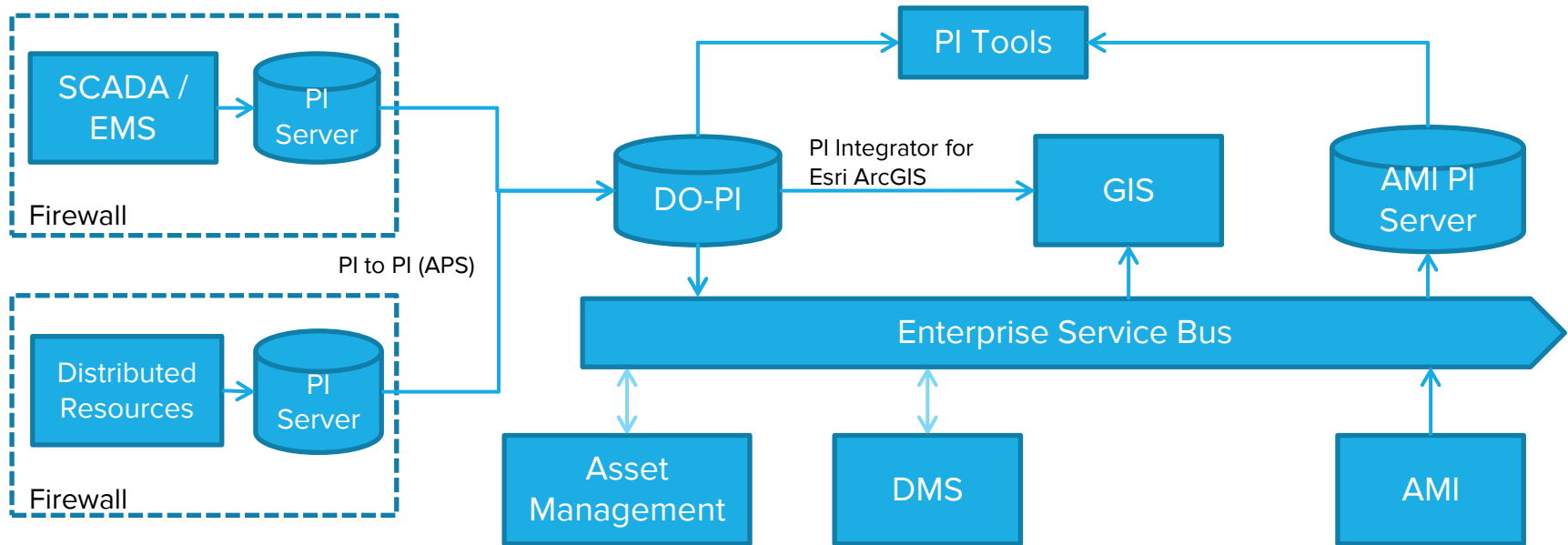
Minimizing patrol distances
can improve restore time



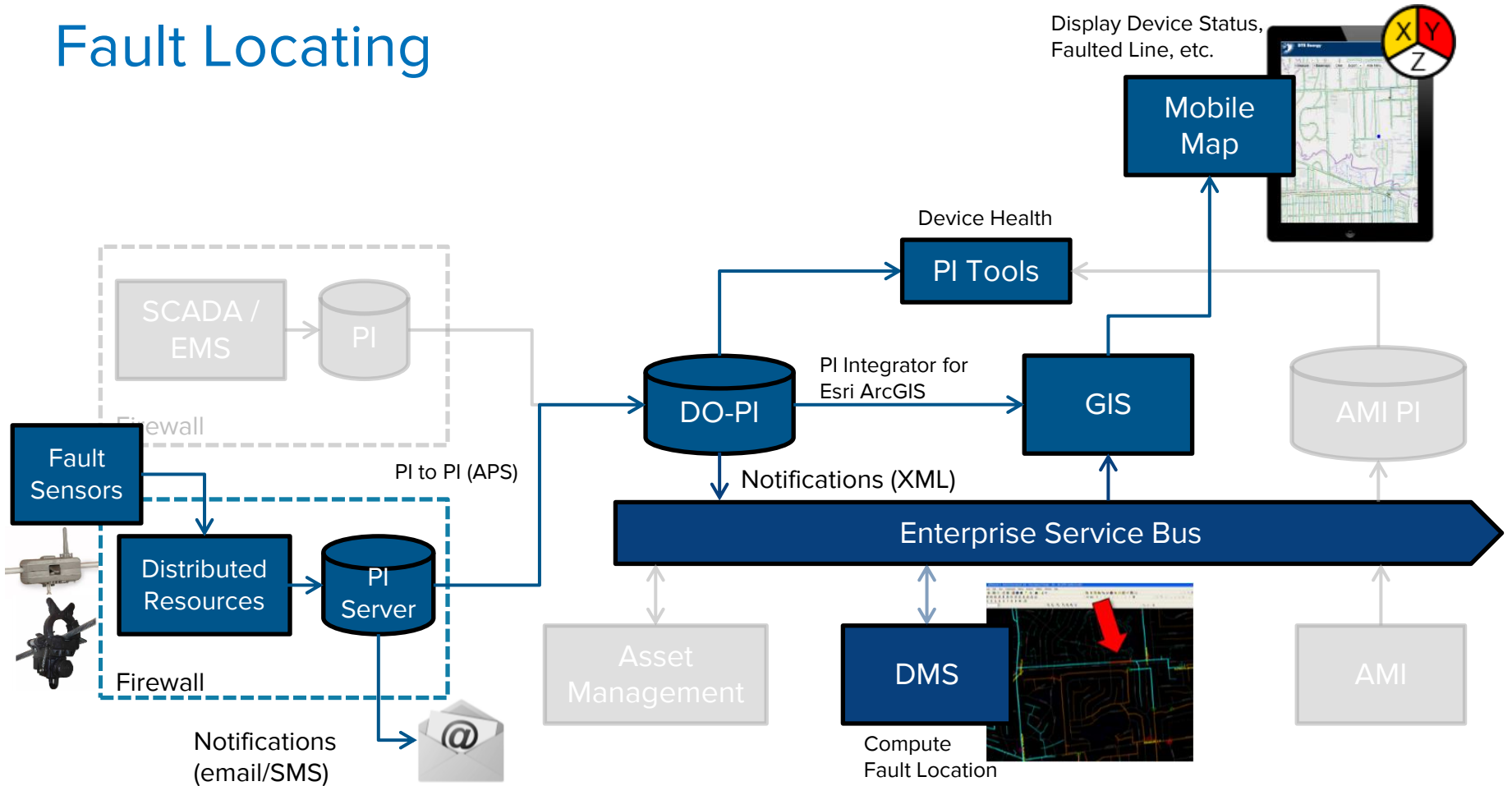
DTE Electric's Distribution Operations

- 450,000+ tags in SCADA historian
- 29,000,000 tags and growing in AMI PI System
- PI to PI APS SCADA and DR historian to DO-PI
- PI Server 2012 HA configuration
- AF 2012 (upgrading to 2014)
- PI Coresight 2013 (upgrading to 2014)

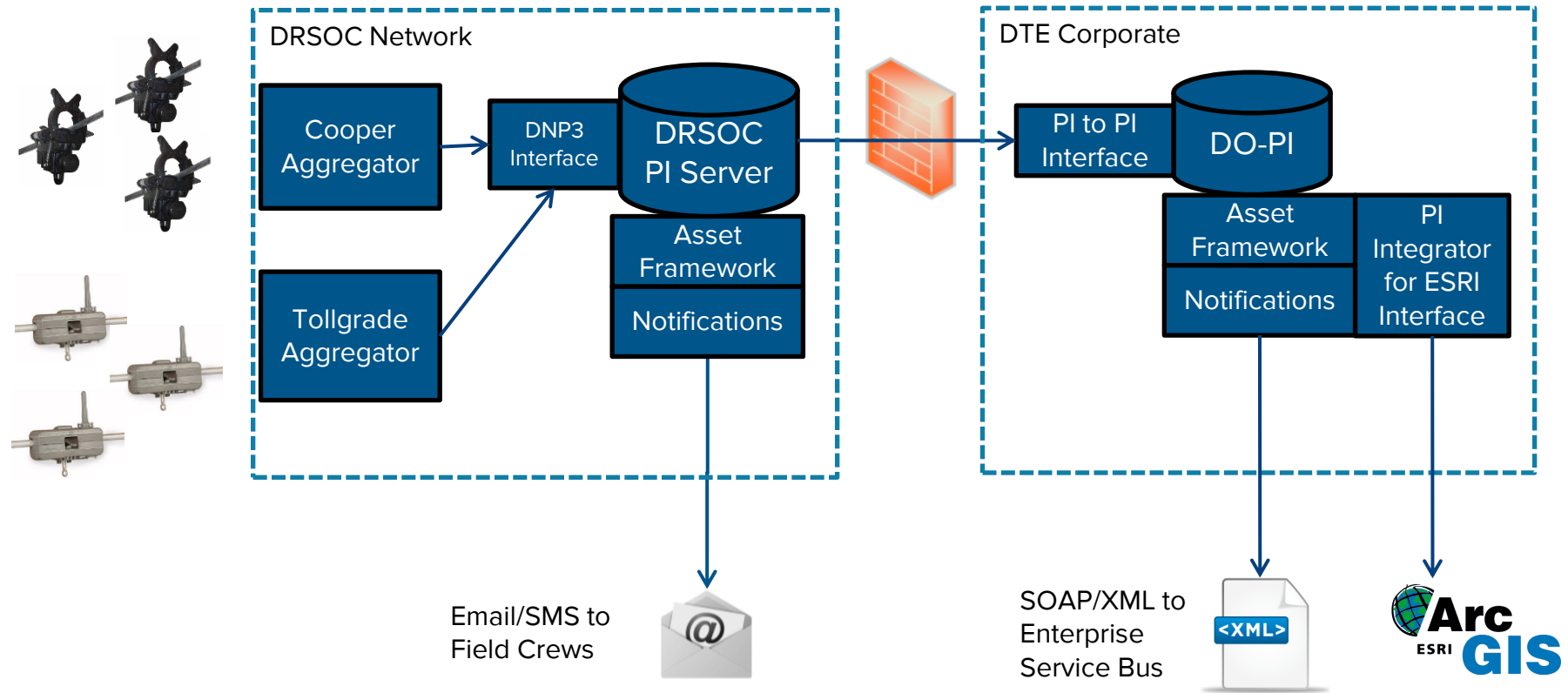
Distribution PI System



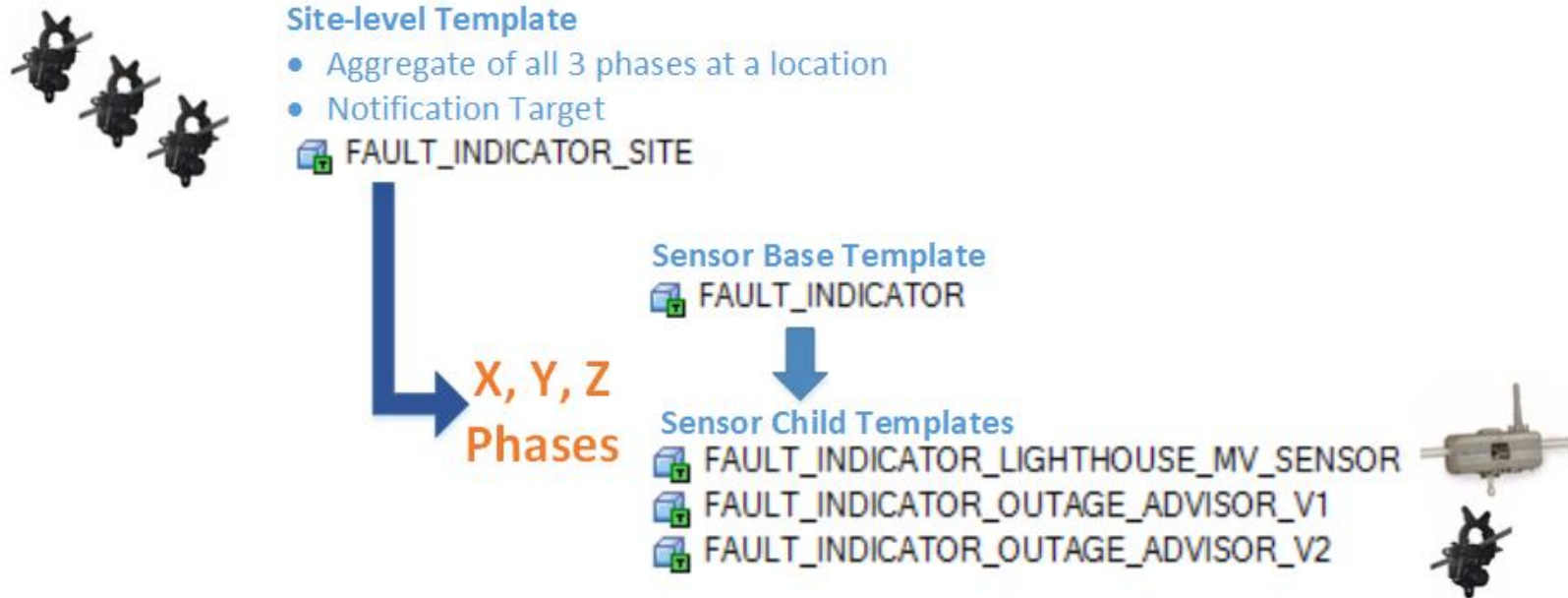
Fault Locating



PI System Solution Architecture

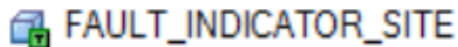


Asset Framework



Asset Framework Details

Site-level Template



Attribute References:

Current X	263.5	Default UOM:	<None>
Current Y	245.80000305...	Value Type:	Double
Current Z	220.40000915...	Value:	263.5
Device ID	MADSN43T	Data Reference:	Formula
DMS_REF	7		
Fault Current G	0		

A=\DEVICES\FAULT INDICATOR\%Element%-X(Current;[A]

Formulas:

Fault Current Max	0	Default UOM:	<None>
Fault Current N	0	Value Type:	Int32
Fault Current X	0	Value:	0
Fault Current Y	0	Data Reference:	Formula
Fault Current Z	0		
Fault Type	-1		
FEEDERMONITOR	No		

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

Asset Framework Details

Sensor-level Templates

FAULT_INDICATOR



FAULT_INDICATOR_LIGHTHOUSE_MV_SENSOR

FAULT_INDICATOR_OUTAGE_ADVISOR_V1

FAULT_INDICATOR_OUTAGE_ADVISOR_V2

Building Tag References:

Entering Low Power Mode	Data Reference: PI Point
Entering Normal Mode	Settings...
Fault Current	\\\\SERVER%\\%@SUBSTATION% %@CIRCUIT PREFIX%@CIRCUIT% SFI-%@REGION CODE%@SEQUENCE%-%@PHASE% Fault Current

Entering Normal Mode	True	Settings...
Fault Current	4936 A	\\\\DOPI\\SOFLD DC9010 SFI-H0027-Z Fault Current

- BREAKER
- BUS
- CABLE POLE
- CAPACITOR
- CIRCUIT
- CIRCUIT SWITCHER
- FAULT INDICATOR

SFI-A0001-X

SFI-A0001-Y

SFI-A0001-Z

SFI-A0002-X

SFI-A0002-Y

SFI-A0002-Z

SFI-A0003-X

SFI-A0003-Y

SFI-A0003-Z

SFI-A0004-X

SFI-A0004-Y

SFI-A0004-Z

SFI-A0005-X

SFI-A0005-Y

SFI-A0005-Z

SFI-A0006-X

SFI-A0006-Y

SFI-A0006-Z

SFI-A0007-X

SFI-A0007-Y

SFI-A0007-Z

SFI-A0008-X

SFI-A0008-Y

SFI-A0008-Z

SFI-A0009-X

SFI-A0009-Y

SFI-A0009-Z

SFI-A0010-X

SFI-A0010-Y

SFI-A0010-Z

SFI-A0011-X

SFI-A0011-Y

SFI-A0011-Z

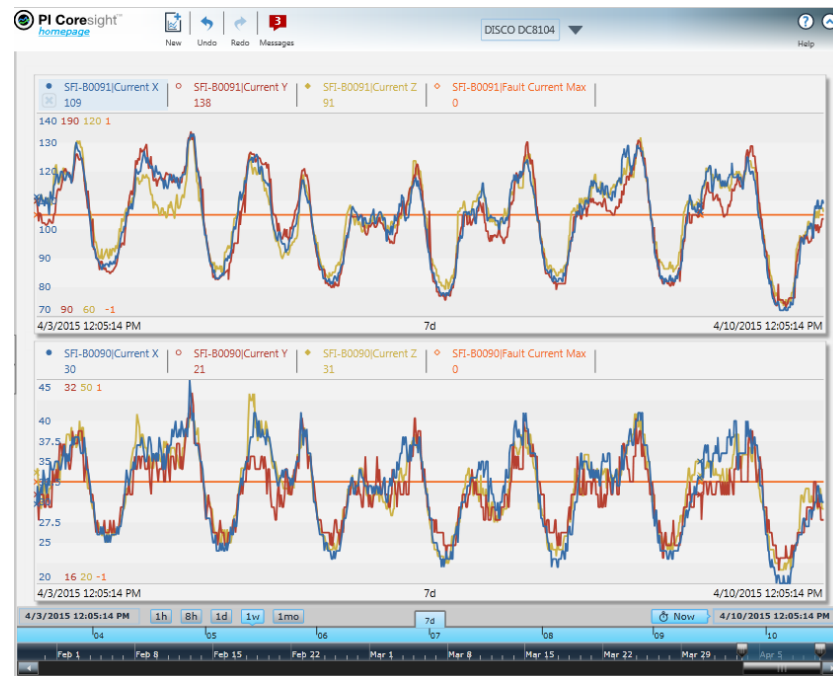
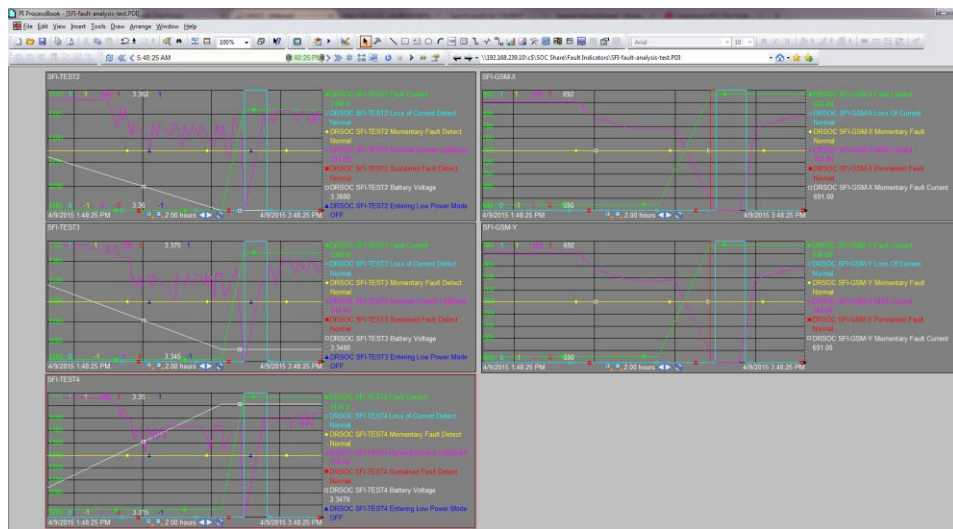
SFI-A0012-X

Name	Value
Fault Indication	Normal
Feeder Monitor	No
GLNX	290623
GLNY	335044
GSID	3
Latitude	42.414307
Location	LS W MCNICHOLS 2PE LAHSER
Longitude	-83.256508
Manufacturer	COOPER
Max Current	204 A
Min Current	170 A
Model	OUTAGE_ADVISOR_V1
Momentary Count	1 count
Momentary Count 24hr	0 count
Nominal Current	182 A
ObjectID	5450
OH-UG	OH
Operating Status	OPERATING
Outage Count	5 count
Over Current	Alarm
Phase	X
Phase Number	1
Power Status	On
Region Code	A
SCADA Fault Status	Normal.TE
SCADA Power Status	On.TE
Sequence	0001



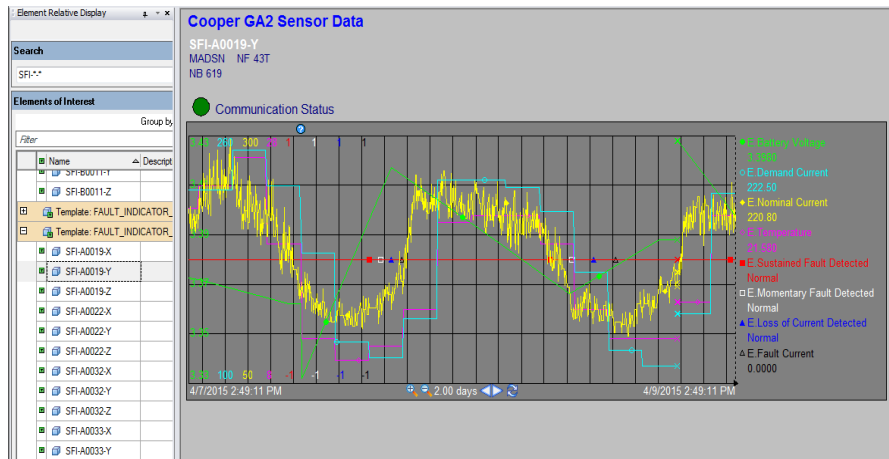
Visualizing Data Using PI System Tools

PI System Tools like PI ProcessBook and PI Coresight allow engineers to easily view sensor data for planning and analysis



Visualizing Data Using PI System Tools (cont'd)

- Web-based dashboard (PI 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
VLLA1555	SFI-A0009	9289	OUTAGE_ADVISOR_V1 CELLULAR OH	69	65	55	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VLLA1555	SFI-A0010	9290	OUTAGE_ADVISOR_V1 CELLULAR OH	69	40	70	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VLLA1555	SFI-A0011	9291	OUTAGE_ADVISOR_V1 CELLULAR OH	39	63	42	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VLLA1555	SFI-A0012	9292	OUTAGE_ADVISOR_V1 CELLULAR OH	35	4	65	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VLLA1552	SFI-A0013	9295	OUTAGE_ADVISOR_V1 CELLULAR OH	63	122	118	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VLLA2161	SFI-A0014	9296	OUTAGE_ADVISOR_V1 CELLULAR OH	57	34	40	XYZ	XYZ	NORMAL	4/9/2015 2:23:15 PM
VLLA2161	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
MAOSN437	SFI-A0017	9914	OUTAGE_ADVISOR_V1 CELLULAR OH	0	0	0	XYZ	XYZ	FAULTED	4/9/2015 2:23:15 PM
MAOSN437	SFI-A0018	9922	OUTAGE_ADVISOR_V1 CELLULAR OH	0	0	0	XYZ	XYZ	FAULTED	4/9/2015 2:23:15 PM
MADSN437	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

Notifications

Email notifications

From: drsoc@load-watch.com
To: sherdingc@load-watch.com
Subject: ALERT! SUSTAINED FAULT detected: REDFD1064
Date: 2015-04-09 01:40 PM
Priority: Low
Character encoding: Western European (ISO-8859-1)

ALERT! Sustained Fault Detected

4/9/2015 1:40:45 PM Eastern Daylight Time (GMT-04:00:00)

Station: REDFD
Circuit: 1064
Location: LW HAZELTON 1PN PILGRIM
OH/UG: OH

Fault Status X: 1
Fault Status Y: 0
Fault Status Z: 0
Fault Current: 1617 Amps

Lat/Long: 42.405733, -83.268618
Sensor Type: FAULT_INDICATOR_OUTAGE_ADVISOR_V1

Library

- DRSOC PI-AF
 - Categories
 - Analysis Categories
 - Attribute Categories
 - Element Categories
 - Reference Type Categories
 - Table Categories
 - Templates
 - Element Templates
 - DEFAULT
 - FAULT_INDICATOR
 - FAULT_INDICATOR_LIGHTNING
 - FAULT_INDICATOR_OUTAGE
 - FAULT_INDICATOR_OUTAGE
 - FAULT_INDICATOR_SITE
 - PI Server PerfMon Template
 - Event Frame Templates
 - Model Templates
 - Notification Templates
 - SFI SITE - Momentary Fault
 - SFI SITE - Sustained Fault
 - Transfer Templates
 - Enumeration Sets
 - Reference Types
 - Tables
 - Table Connections

SFI SITE - Sustained Fault

Overview | Trigger | Message | Subscriptions

Delivery Formats

Name	Delivery Channel
Global Default Email	Email
Sustained Fault Email	Email

Design | HTML Preview | Plain Text Preview

Tahoma 11

Subject

ALERT! SUSTAINED FAULT detected: Device ID:Value

Attachments

Body

ALERT! Sustained Fault Detected

Notification:Trigger Time

Station: SUB:Value
Circuit: CIRCUIT:Value
Location: LOCATION:Value
OH/UG: OHUG:Value

Fault Status X: Sustained Fault Status X:Value
Fault Status Y: Sustained Fault Status Y:Value
Fault Status Z: Sustained Fault Status Z:Value
Fault Current: Fault Current Max:Value Amps

Lat/Long: Latitude:Value, Longitude:Value
Sensor Type: TYPE:Value

Notifications

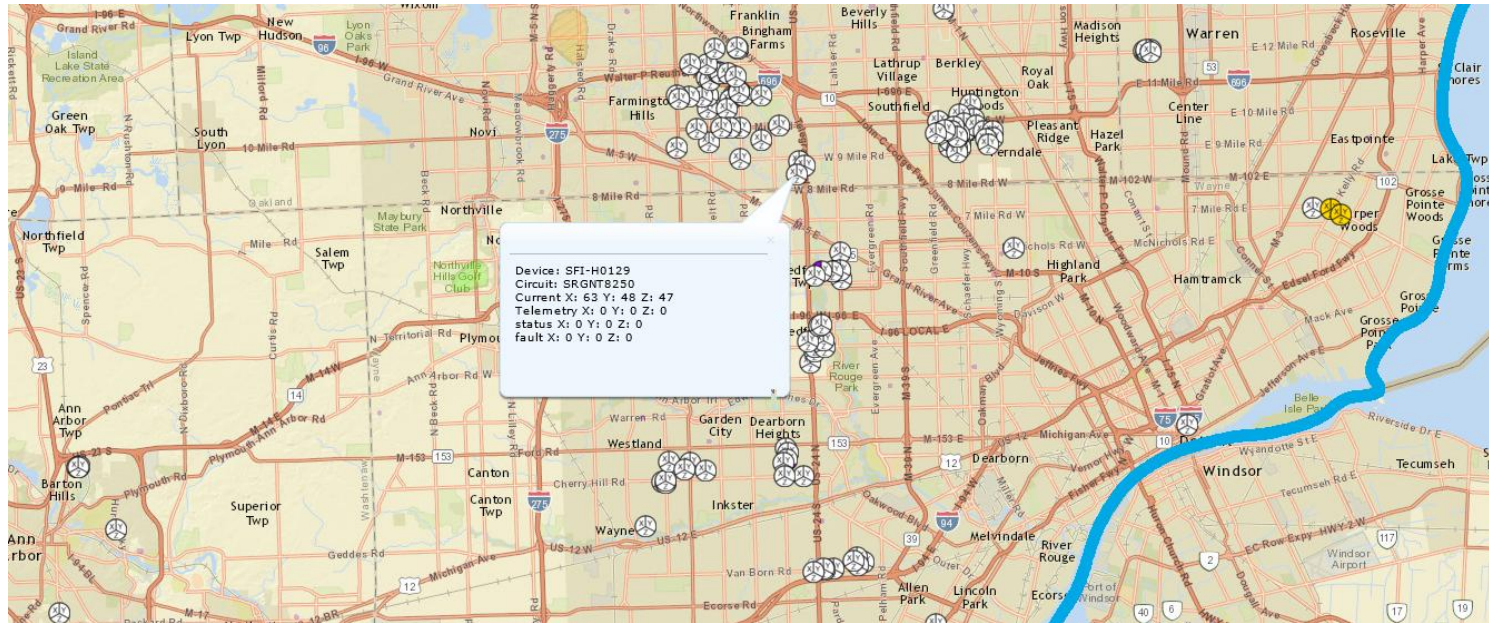
SOAP XML notifications

```
<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>
```

The screenshot displays the OSIsoft software interface for configuring notifications. The 'Library' pane on the left shows the hierarchy: DOPI AF Acc > Templates > Notification Templates > DMS_Fault_Input_XML. The 'DMS_Fault_Input_XML' pane on the right shows the 'Trigger Input' section with a list of attributes under 'Attribute Value', including various fault indicators and current values. The 'Contacts' pane at the bottom left shows a list of contacts, with 'XML_TCP_Fault' selected. The 'XML_TCP_Fault' pane at the bottom center shows the 'Delivery channel' set to 'XML_TCP'. The 'Delivery Channel Plug-In Properties' dialog box is open, showing the 'General' tab with 'Name' set to 'XML_TCP', 'Description' set to 'Sends notification contents over TCP/IP', and 'Assembly' set to 'XML_TCP_DeliveryChannel.dll'. The 'File' table at the bottom of the dialog shows the file 'XML_TCP_DeliveryChannel.dll' with version '1.0.0.0' and date '3/24/2015 6:46:42 AM'.

Mapping Fault Status

- Initial proof of concept: Developed Windows service using PI AF SDK to push fault events into the GIS database



Mapping Fault Status (cont'd)

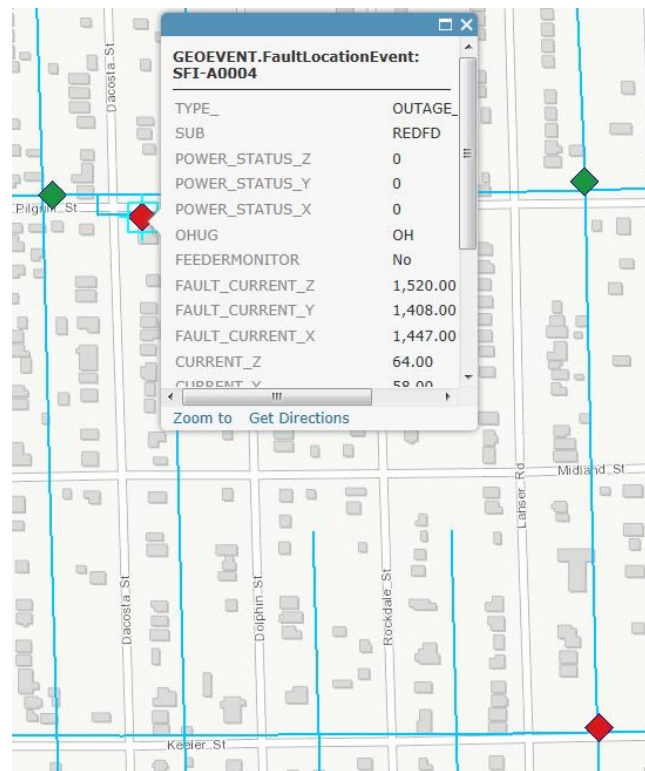
- Next steps: Moving from PI AF SDK service to PI Integrator for Esri ArcGIS
- This has also been through proof-of-concept phase
- Expecting full roll-out Q2 or Q3



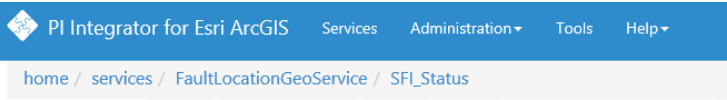
Normal



Abnormal



PI Integrator for ArcGIS Configuration



Layer SFI_Status

SFI Status

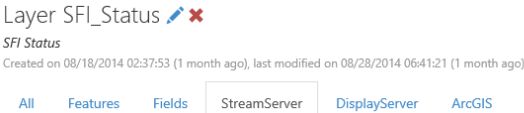
Created on 08/18/2014 02:37:53 (1 month ago), last modified on 08/28/2014 06:41:21 (1 month ago)

All Features Fields StreamServer DisplayServer ArcGIS

This layer exposes the following fields

Name	Attribute Name
TYPE	TYPE
SUB	SUB
Power_Status_Z	Power Status Z
Power_Status_Y	Power Status Y
Power_Status_X	Power Status X
OHUG	OHUG
LOCATION	LOCATION
GLNXY	GLNXY
FEEDERMONITOR	FEEDERMONITOR

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



This layer is exposed as a StreamServer within the [services directory](#)

Layer connections

Show: All Time: *1d Automatic refresh Clear

Status	Updates	Total data	Host	Address	Secure	Created	Updated	Total time	Time since last	Avg update rate	Avg data rate
✓ Opened	143	151.3 kB	162.9.162.252	162.9.162.252	✓	just now	just now	00:00:07	00:00:21	18.15 updates/s	19.2 kB/s

Stream Service Layer SFI_Status (0)

Connect Disconnect Clear Receiving data (169 features received)

☒ Use secure web socket



☐ Use bulk mode (JSON array)

```
{
  "attributes": {
    "objectId": "1419103957",
    "type": "LIGHTHOUSE_MV_SENSOR",
    "sub": "MACMB",
    "power_status_z": null,
    "power_status_y": null,
    "power_status_x": null,
    "ohug": "OH",
    "location": "",
    "glaxy": "",
    "feedermonitor": "Yes",
    "fault_current_z": 0,
    "fault_current_y": 0,
    "fault_current_x": 0,
    "current_z": 78,
    "current_y": 115,
    "current_x": 90,
    "communications": "CELLULAR",
    "circuit": "8409",
    "latitude": 42.50172
  }
}
```

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
- Sensors currently installed on 95 circuits as part of efficient frontier fault locating program



 Fault Indicator
 AMI Meters

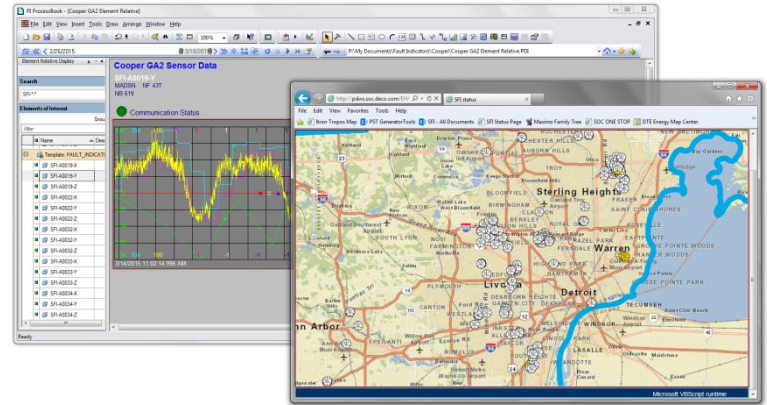
DTE Energy: Reliability Through Innovation

“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



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 Interface for DNP3
- Utilize Asset Framework and Notifications to push events to field and DMS
- PI Coresight and PI 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.

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DTE Energy

Questions

Please wait for the **microphone**
before asking your questions

State your
name & company





THANK YOU

