



Improving the Asset Reliability for Manufacturing the World's Most Advanced Fighter Jet, Lockheed Martin's F-35 Lightning II

Adam Whiting | Chris Gilman



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Project Manager
Lockheed Martin Aeronautics



Chris Gilman
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Strategic Maintenance Solutions (SMS)

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Transforming Data into *Operational Intelligence*



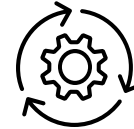
**Real-time
Monitoring**



**Diagnostics and
Troubleshooting**



**Maximo
Integration**



**Predictive
Maintenance**

**Kepware
to
Metrics**

**SMS App
for
Maximo**

**Search &
Reporting**

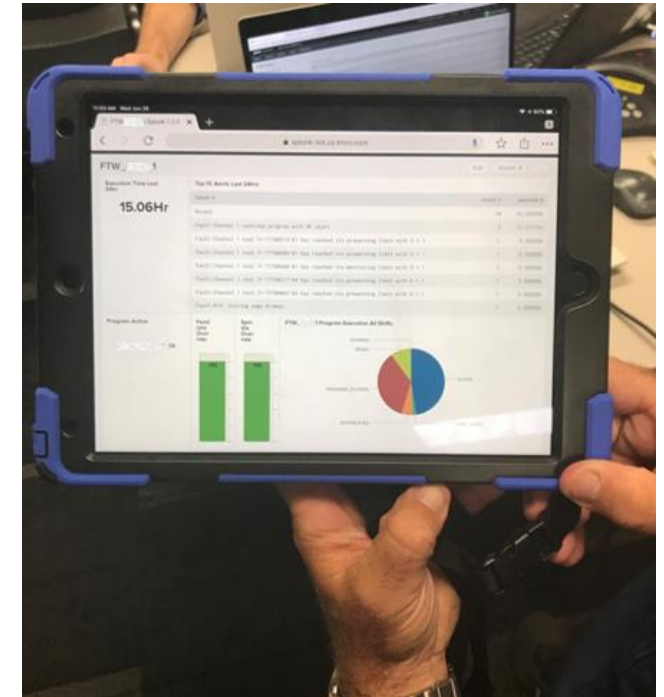
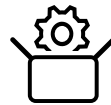
**Aero
IIoT**

**Industrial
Asset
Intelligence**

**Machine
Learning**

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Data Integrations (OPC, Kepware, Maximo, etc.)



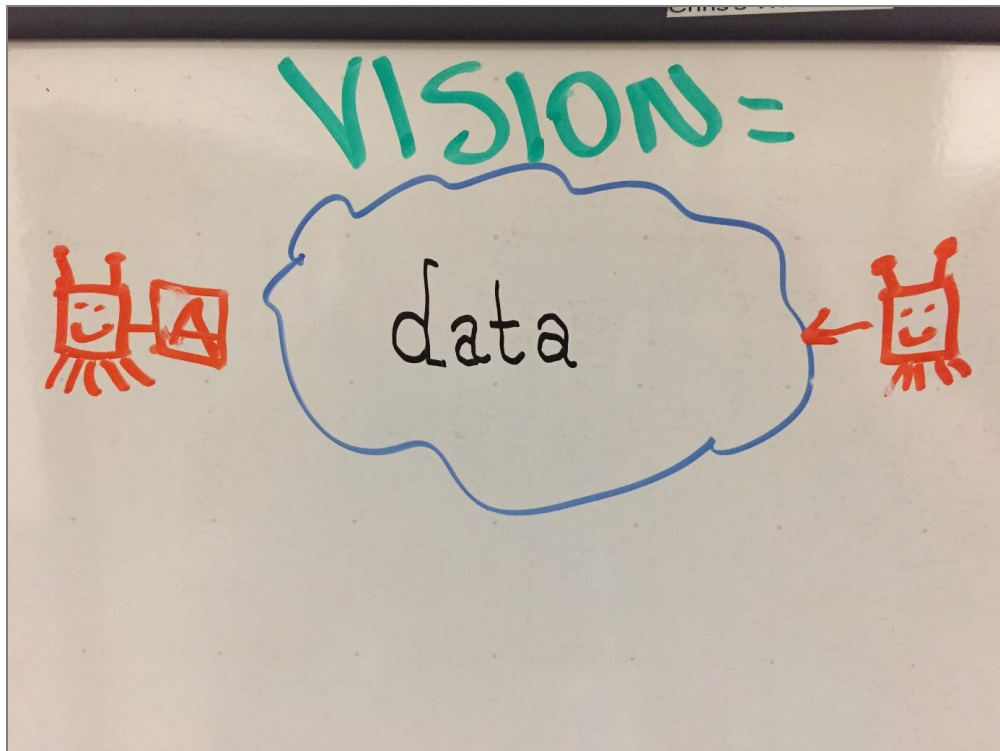
Strategic Maintenance Solutions

Industrial IoT Partner

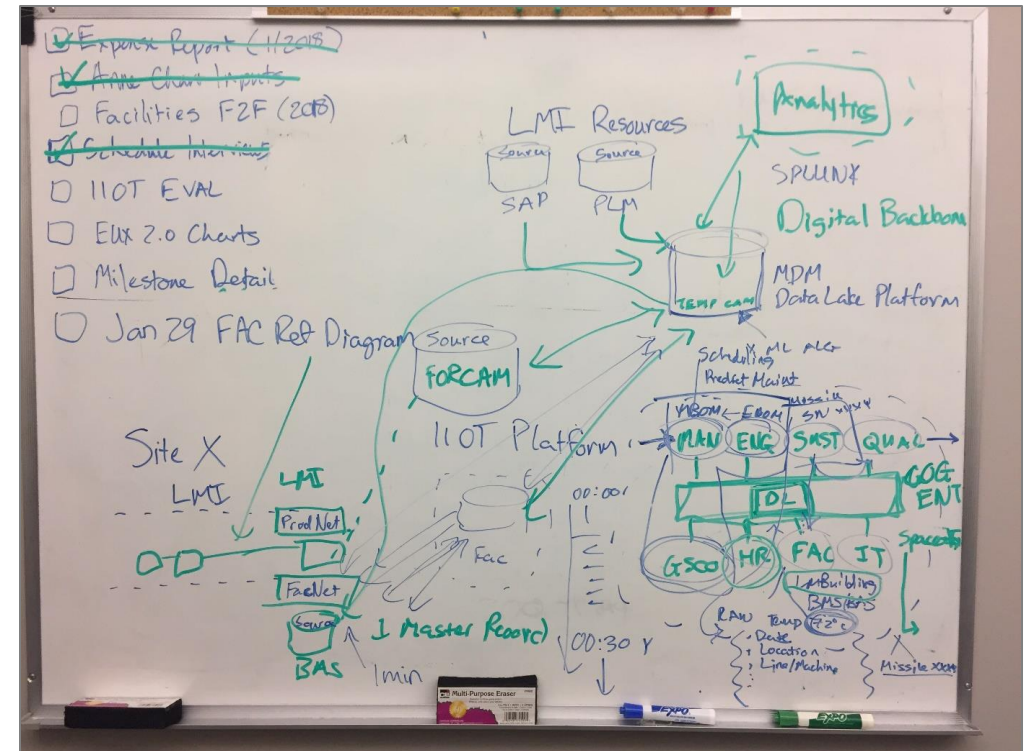


Lockheed Martin Introduction

Vision for Digitization of Facilities



Facilities / ESH Manager



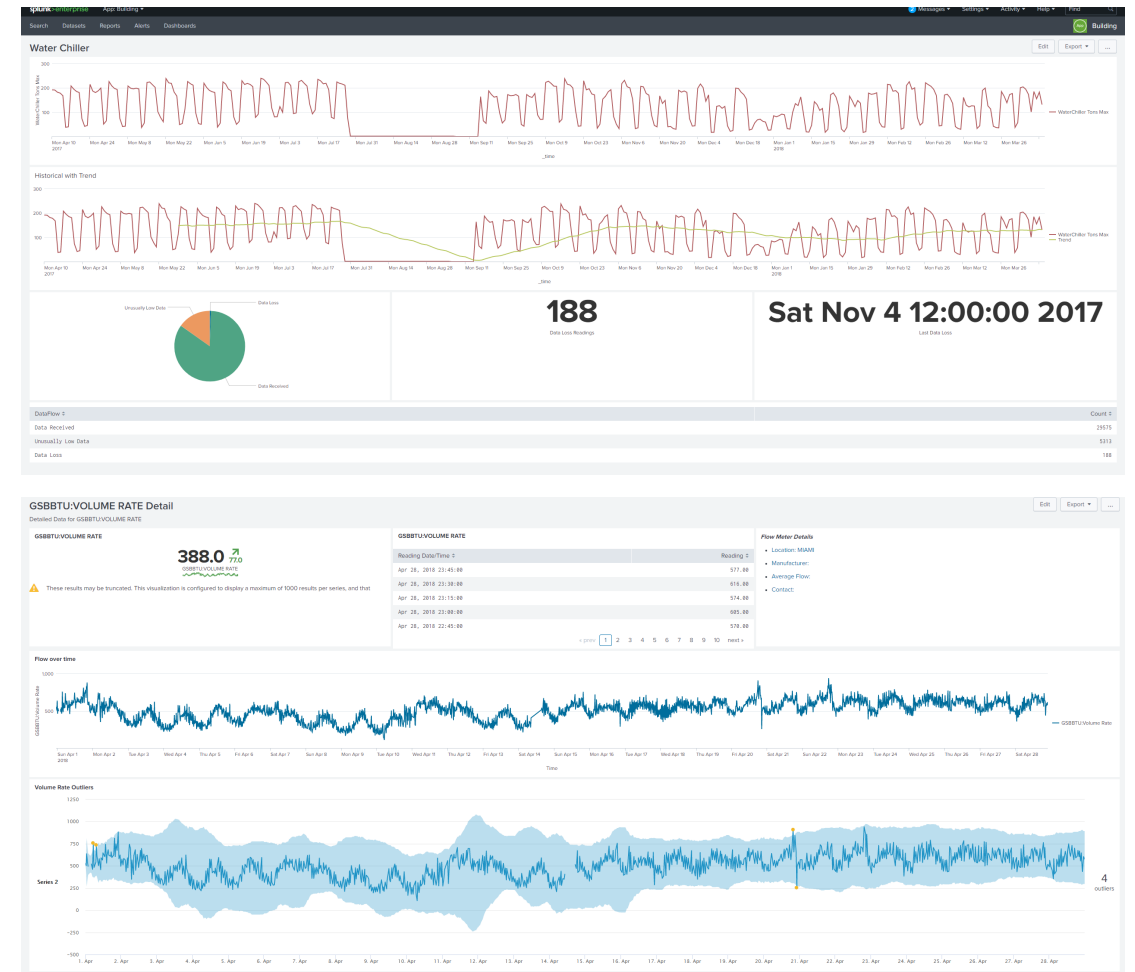
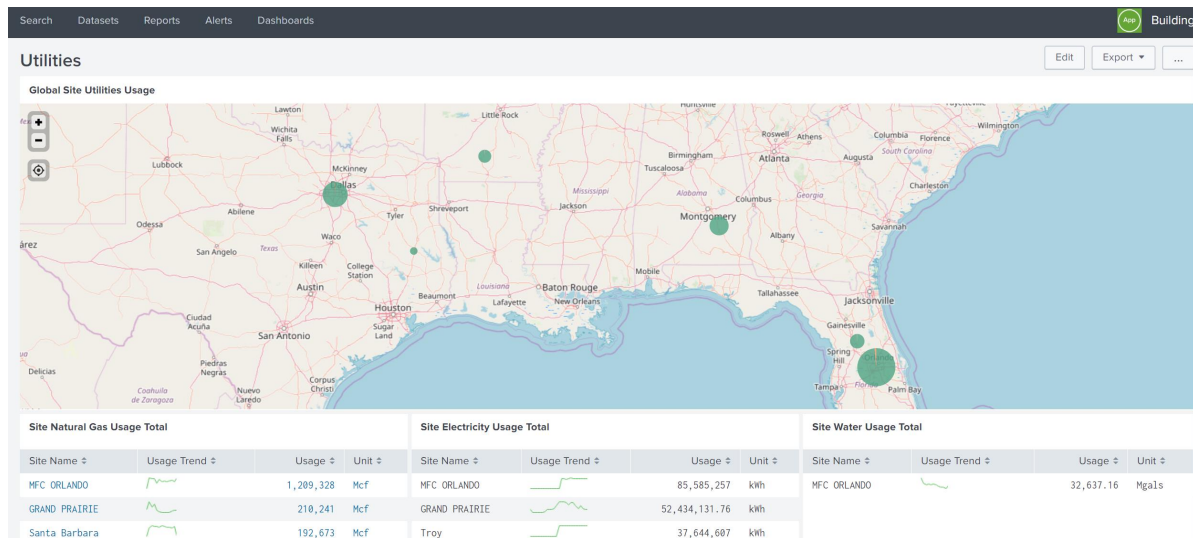
IT Manager

Where To Go From There?

November
2017

March 2018

January 2018

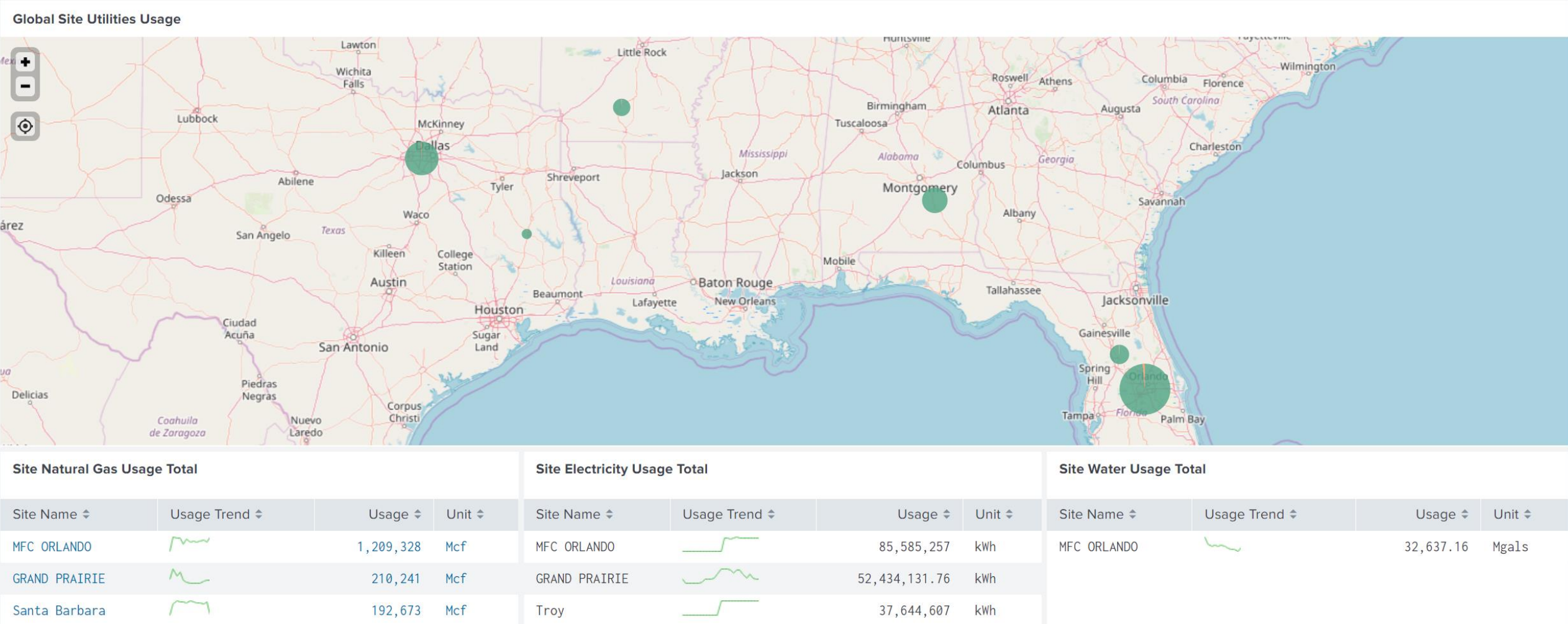


Utilities

Edit

Export

...



Detailed Data for GSB BTU:VOLUME RATE

GSBBTU:VOLUME RATE

388.0 ↑
77.0
GSBBTU:VOLUME RATE

⚠ These results may be truncated. This visualization is configured to display a maximum of 1000 results per series, and that

GSBBTU:VOLUME RATE

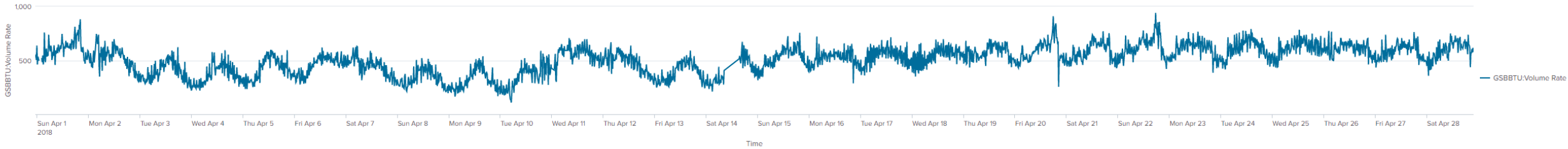
Reading Date/Time ↕	Reading ↕
Apr 28, 2018 23:45:00	577.00
Apr 28, 2018 23:30:00	616.00
Apr 28, 2018 23:15:00	574.00
Apr 28, 2018 23:00:00	605.00
Apr 28, 2018 22:45:00	570.00

« prev 1 2 3 4 5 6 7 8 9 10 next »

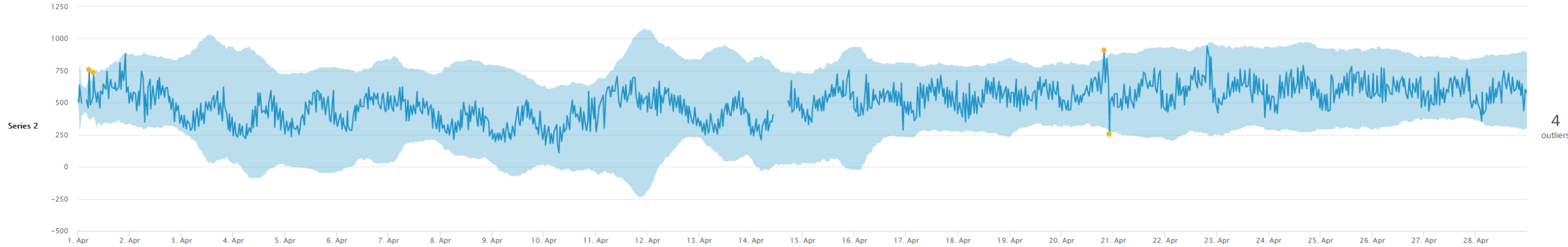
Flow Meter Details

- Location: MIAMI
- Manufacturer:
- Average Flow:
- Contact:

Flow over time



Volume Rate Outliers

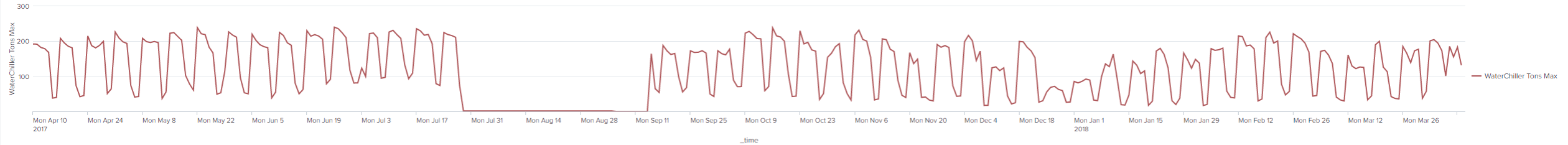


Water Chiller

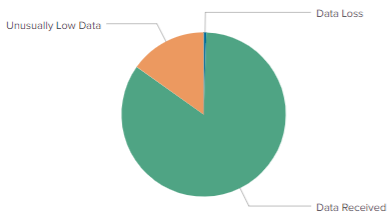
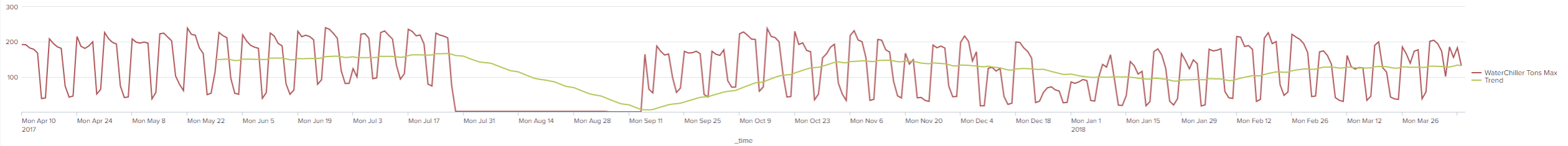
Edit

Export

...



Historical with Trend



188

Data Loss Readings

Sat Nov 4 12:00:00 2017

Last Data Loss

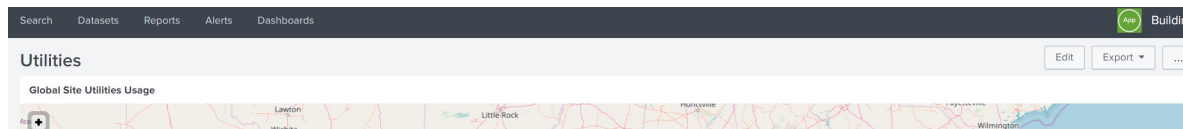
DataFlow	Count
Data Received	29575
Unusually Low Data	5313
Data Loss	188

Where To Go From There?

November
2017

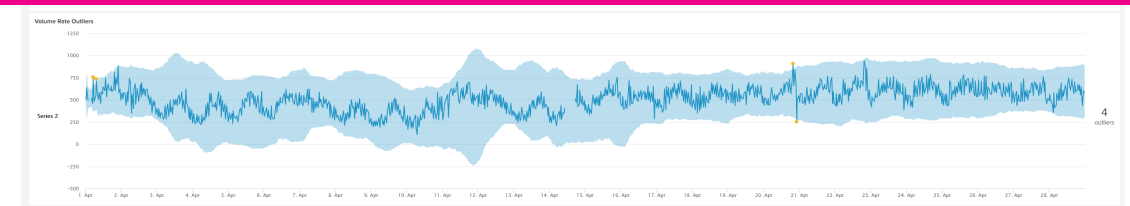
March 2018

January 2018



John Completed this on his Flight home (3.5 hours)
TIME TO VALUE

Site Natural Gas Usage Total				Site Electricity Usage Total				Site Water Usage Total			
Site Name	Usage Trend	Usage	Unit	Site Name	Usage Trend	Usage	Unit	Site Name	Usage Trend	Usage	Unit
MFC ORLANDO		1,289,328	Mcf	MFC ORLANDO		85,585,257	kWh	MFC ORLANDO		32,637.16	Mgals
GRAND PRAIRIE		210,241	Mcf	GRAND PRAIRIE		52,434,131.76	kWh				
Santa Barbara		192,673	Mcf	Troy		37,644,607	kWh				



Where To Go From There?

November 2017

- “Finally somebody in Facilities is doing this.” – Robert Frazier

March 2018

- F2F w/ John Gonzales (Splunk Staff Sales Engineer)
- Complete Initial POC on his flight home

January 2018

- Introduction to Splunk
- Introduction to Tony Bass & LM Splunk Team

October 2018

- Introduction to Aeronautics

Lockheed Martin F-35 Lightning II

Increasing Production, Decreasing Cost

splunk> .conf19

Business Goals

Align with Facilities

- Increase asset reliability & availability
- Automate a work order in Maximo from machine data
- Improve and track Asset Availability
- Anticipate catastrophic failures utilizing machine learning
- Access data from assets in near real-time
- Integrate with Maximo data
- Provide Technicians with the ability to visualize & create dashboards on their tablets without coding or programming



Where To Go From There?

November 2017

- “Finally somebody in Facilities is doing this.” – Robert Frazier

March 2018

- F2F w/ John Gonzales (Splunk Staff Sales Engineer)
- Complete Initial POC on his flight home

December 2018

- SMS began Splunk Proof of Concept

January 2018

- Introduction to Splunk
- Introduction to Tony Bass & LM Splunk Team

October 2018

- Introduction to Aeronautics
- SMS working on Maximo upgrade with Aeronautics

Making machine data accessible, usable and valuable to everyone

- Transform Facilities' operations by utilizing data from connected devices and systems
- Simplify the way information is communicated to enable all personnel in Facilities to monitor, analyze, and ensure operational excellence



Transform Machine Data into Operational Intelligence

Real-time Visibility & Predictive Analytics



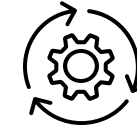
**Real-time
Monitoring**



**Diagnostics and
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**Maximo
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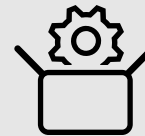
splunk>

Data Integrations (OPC, Kepware, Maximo, etc.)



Machine Data

What data are we using?



Machine Data

What data are we using?

26 Critical Assets across multiple US sites

- Mills, Drills, Autoclaves

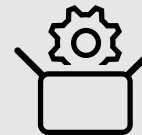
Maintenance

- Work Orders, Job Plans, PMs, Assets

Sensor (Metric) Data



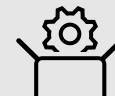
Unstructured (Event) Data



Machine Data

How do we use this data?

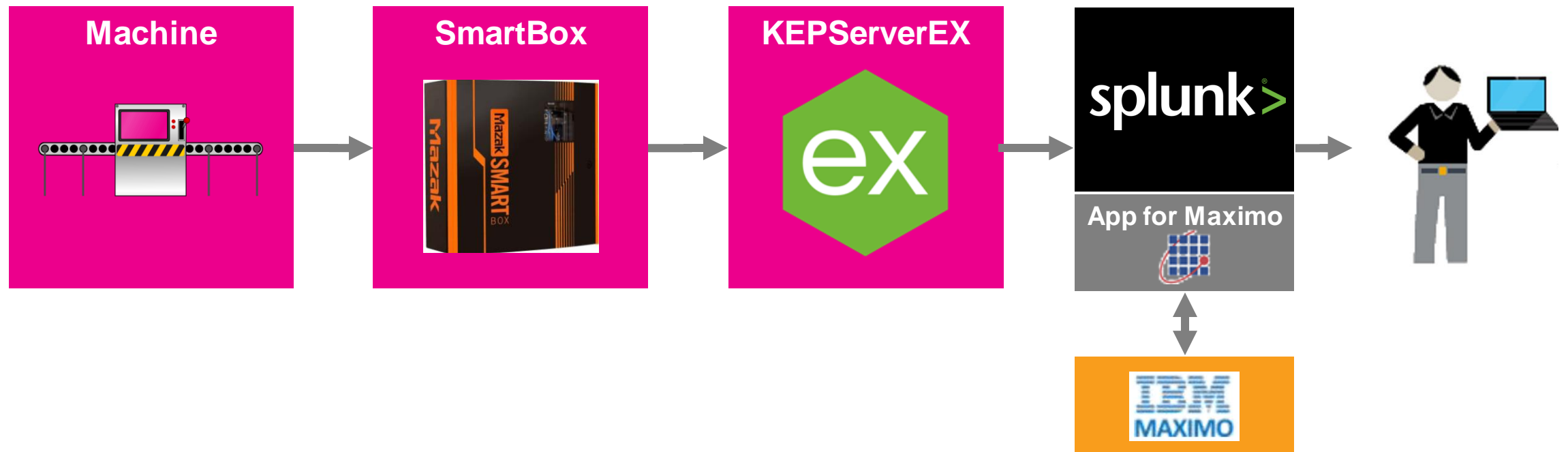
Data Integrations (OPC, Kepware, Maximo, etc.)



Machine Data

How do we Access this data?

Integrations (OPC, Kepware, Maximo, etc.)



Apps

How do we use the data in Splunk?



Apps

Add-ons

**Kepware to
Metrics**

splunkbase.splunk.com/app/3963/

**SMS App for
Maximo**

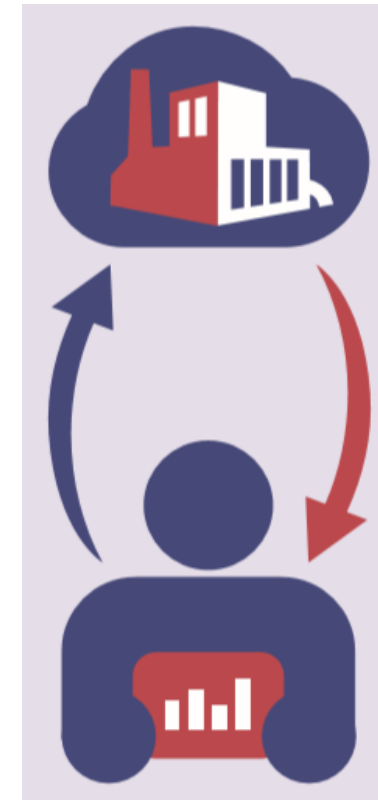
splunkbase.splunk.com/app/4410/

SMS App for Maximo

Data Ingest from IBM Maximo

- Ingesting Maximo Business Objects:
 - Assets, Locations, Work Orders, Job Plans, PMs, Items, Inventory, etc.

Work Order Generation from Splunk into Maximo



SMS App for Maximo

Generating a Work Order from Alert Action

Alert: Test WO Gen from Motor Start/Stop with Kepware

Description: Test WO Gen from Motor Start/Stop with Kepware

Search: `index="kepwaremotordemo" source="kepware:IDF" Tag="motor.motor1.starts_stops" Value="1"`
`| rename Tag as tagName, Value as tagValue`
`| head 1`

Alert type: ☐ Scheduled ☒ Real-time

Trigger Conditions

Trigger alert when: Per-Result ▼

Throttle? ☐

Trigger Actions

+ Add Actions ▼

When triggered

▼ SMS - Create Maximo Work Order Remove

ASSET Select... ▼

Use the above if the ASSET already exists in Splunk. If not, use the fields below.

ASSETNUM	11211
SITEID	BEDFORD
LOCATION	BR210

1001,BEDFORD,MOFLOOR1
1002,BEDFORD,MOFLOOR2
1003,BEDFORD,MOFLOOR3
1004,BEDFORD,MOFLOOR4
1006,BEDFORD,OFF401
1007,BEDFORD,OFF402
1008,BEDFORD,OFF301
1009,BEDFORD,OFF301
1010,BEDFORD,SWSTOCK
1011,BEDFORD,SWSTOCK
1012,BEDFORD,SWSTOCK
1013,BEDFORD,SWSTOCK
1014,BEDFORD,SWSTOCK
1015,BEDFORD,SWSTOCK
1016,BEDFORD,SWSTOCK
1017,BEDFORD,SWSTOCK
1018,BEDFORD,SWSTOCK
1019,BEDFORD,SWSTOCK

filter

ASSET Select... ▼

Use the above if the ASSET already exists in Splunk. If not, use the fields below.

ASSETNUM	11211
SITEID	BEDFORD
LOCATION	BR210



SMS App for Maximo

Work Order into Maintenance Workflow

Work Order Tracking

Query Find Work Order Select Action

List View | Work Order | Plans | Assignments | Related Records | Actuals | Safety Plan | Log | Failure Reporting

Work Order: 1397 motor.motor1.starts_stops=1

Location: BR210 » Circulation Fan #1- Main Office HVAC

Asset: 11211 » Motor Starter- Size 2/440v/3ph/60cy

Configuration Item: »

Parent WO: »

Classification: »

Class Description: »

Launch Entry Name: »

Site: BEDFORD

Class: WORKORDEF

Work Type: ALARM

GL Account: 6210-350-???

Failure Class: »

Problem Code: »

Storeroom Material Status: »

Direct Issue Material Status: »

Attachments

Status: WAPPR

Status Date: 2/13/19 12:19 PM

Inherit Status Changes? ☒

Accepts Charges? ☒

Is Task? ☐

Under Flow Control? ☐

Suspend Flow Control? ☐

Responsibility

Reported By: SPLUNK » Supervisor

Reported Date: 2/11/19 11:48 AM » Crew:

On Behalf Of: » Lead:

SMS App
for
Maximo



Real-time
Monitoring



Diagnostics and
Troubleshooting



Maximo
Integration



Predictive
Maintenance

Apps

Core

Kepware
to
Metrics

SMS App
for
Maximo

Search &
Reporting

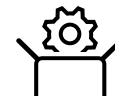
Aero
IIoT

Industrial
Asset
Intelligence

Machine
Learning

splunk>

Data Integrations (OPC, Kepware, Maximo, etc.)





Data

Metrics

Search Datasets Reports Alerts Dashboards				Aero IoT	
New Search				Save As ▾	Close
1 <code>mstats avg(_value) where metric_name="*_load" AND asset=FTW_ AND index=iiot_analytics_aero_mtx by asset metric_name index</code>				Last 24 hours ▾	
✓ 832,780 events (8/14/19 2:00:00.000 AM to 8/15/19 2:04:05.000 AM) No Event Sampling ▾				Job ▾ Verbose Mode ▾	
Events (832,780) Patterns Statistics (33) Visualization					
100 Per Page ▾ Format Preview ▾					
asset ↕	metric_name ↕	index ↕	avg(_value) ↕		
FTW_ .Axes_Axes.Linear_QM6	qm6_load	iiot_analytics_aero_mtx	0.07764274676070847		
FTW_ .Axes_Axes.Linear_QM6.Actuator_QM6_Drive	qm6_motor_load	iiot_analytics_aero_mtx	0.029049053015294403		
FTW_ .Axes_Axes.Linear_QMD	qmd_load	iiot_analytics_aero_mtx	0.9289297460078443		
FTW_ .Axes_Axes.Linear_QMD.Actuator_QMD_Drive	qmd_motor_load	iiot_analytics_aero_mtx	0.030889566905733645		
FTW_ .Axes_Axes.Linear_QW8	qw8_load	iiot_analytics_aero_mtx	8.282682569243567		
FTW_ .Axes_Axes.Linear_QW8.Actuator_QW8_Drive	qw8_motor_load	iiot_analytics_aero_mtx	0.7046297103459215		
FTW_ .Axes_Axes.Linear_QW9	qw9_load	iiot_analytics_aero_mtx	21.073868130126417		
FTW_ .Axes_Axes.Linear_QW9.Actuator_QW9_Drive	qw9_motor_load	iiot_analytics_aero_mtx	6.038624242184097		
FTW_ .Axes_Axes.Linear_VAM	vam_load	iiot_analytics_aero_mtx	0.5405599144079893		
FTW_ .Axes_Axes.Linear_XM	xm_load	iiot_analytics_aero_mtx	8.91371136471706		
FTW_ .Axes_Axes.Linear_XM.Actuator_XM_Drive	xm_motor_load	iiot_analytics_aero_mtx	8.768124356027599		
FTW_ .Axes_Axes.Linear_XM1	xm1_load	iiot_analytics_aero_mtx	11.760325725154532		



Data

Simple Visualization

Search

Datasets

Reports

Alerts

Dashboards

4

Aero IoT

New Search

Save As

Close

1 | mstats prestats=t avg(_value) where metric_name="*_motor_temp" AND asset=FTW_ AND index=iiot_analytics_aero_mtx

2 | stats avg(_value)

Last 24 hours

✓ 418,785 events (8/14/19 10:00:00.000 AM to 8/15/19 10:55:12.000 AM) No Event Sampling

Job

Fast Mode

Events

Patterns

Statistics (1)

Visualization

42 Single Value

Format

Trellis

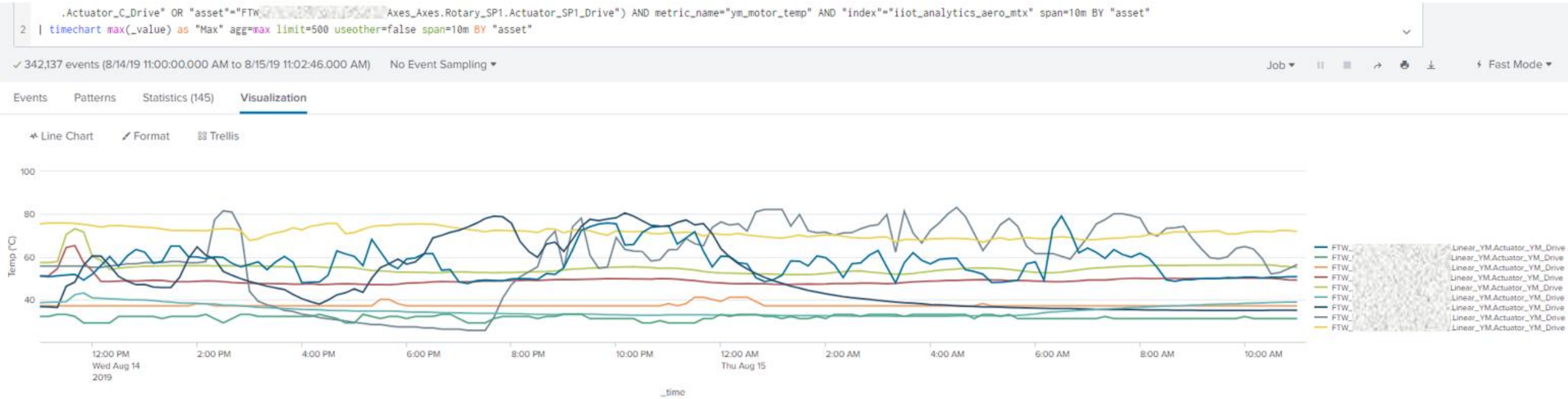
39.5 °C

avg(_value)

39.521776090356624

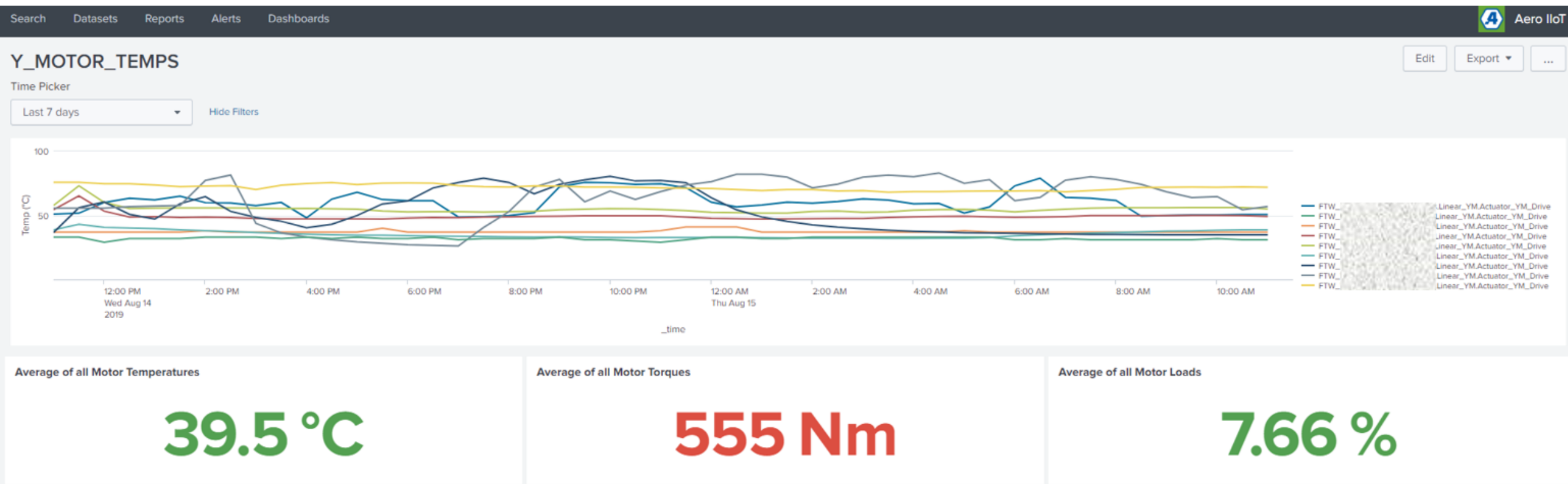
Data

Complex Visualization



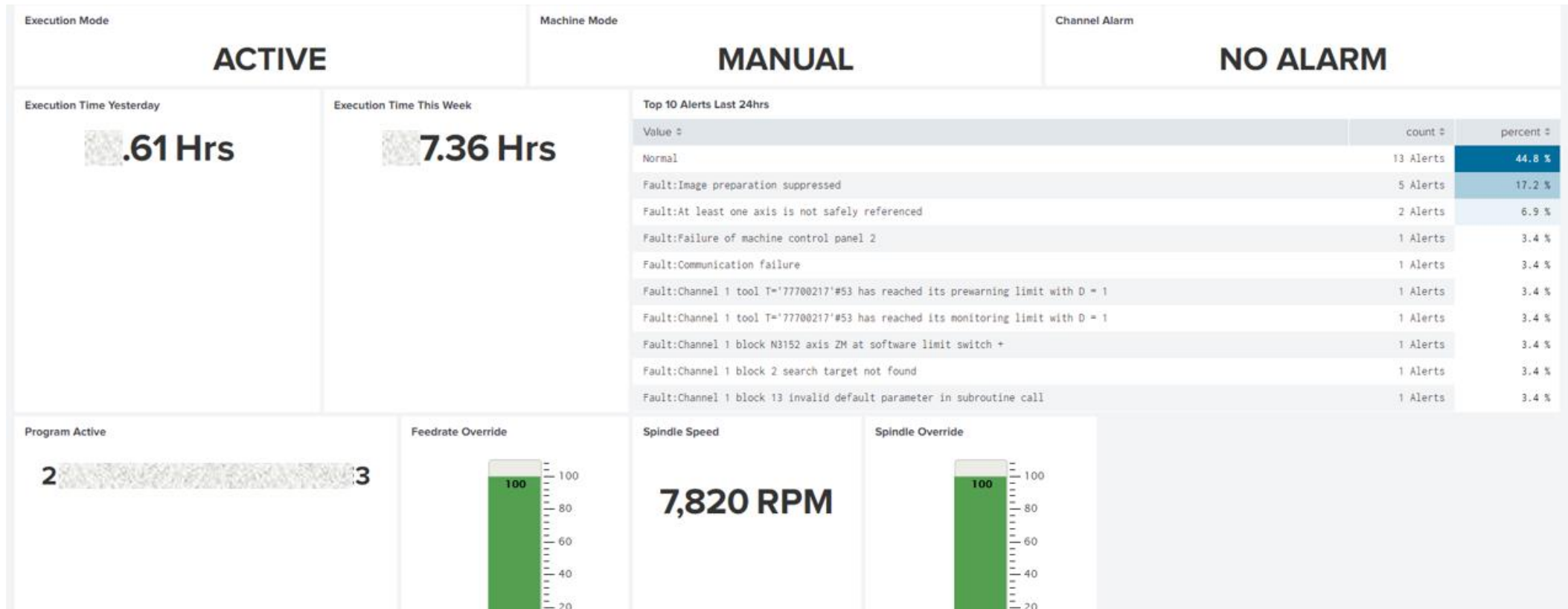
Data

Combining panels to create dashboards



Data

Focusing real-time panels for monitoring

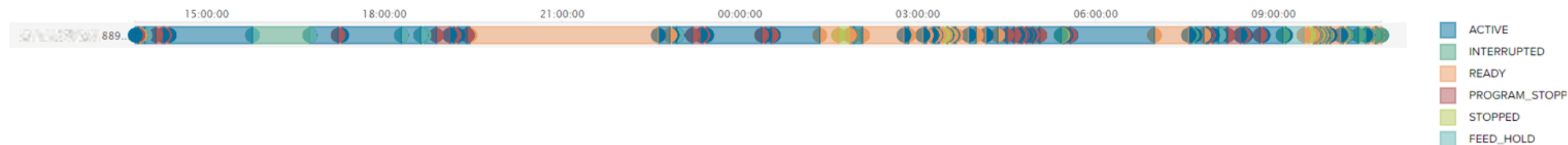


Save As ▾ Close

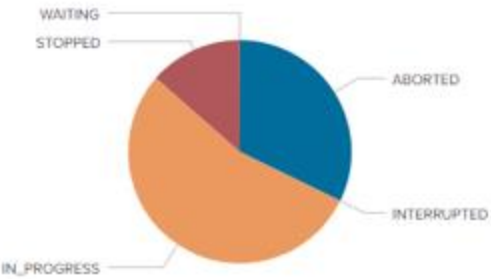
Last 24 hours ▾

Job ⚡ Fast Mode

Timeline Format Trellis



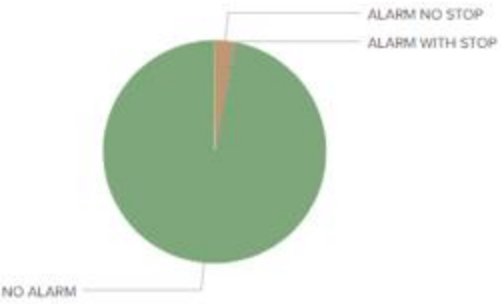
Program Status



Program Execution All Shifts

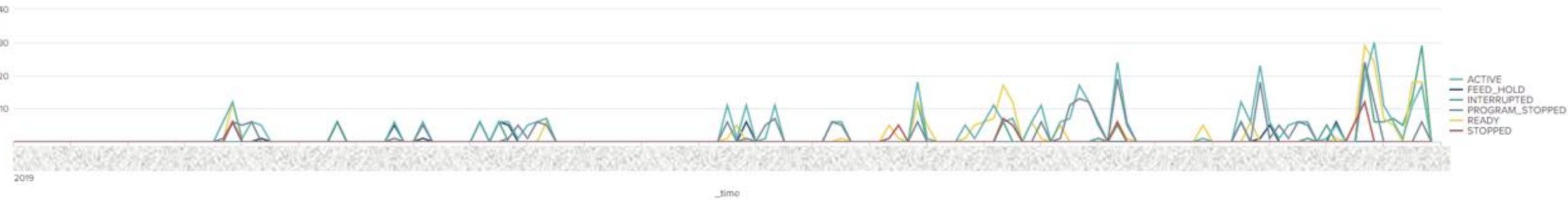


Alarm State



Bin Span (minutes)

Path 1 Execution - Status Counts



Path 1 Execution



Data – Actions

Sensor Data Discovery

Edit

Export ▾

...

Time

Asset(s)

Sensor(s)

Value(s)

Bin Span (seconds)

Hide Filters

Date time range ▾

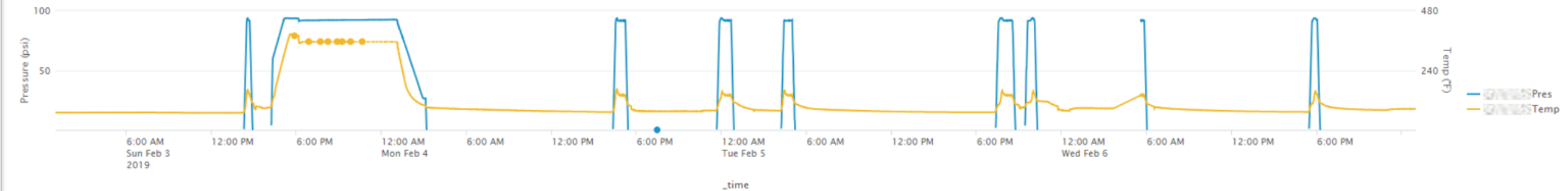
Asset(s)

Could not create search.

Pres ✕

Temp ✕

60

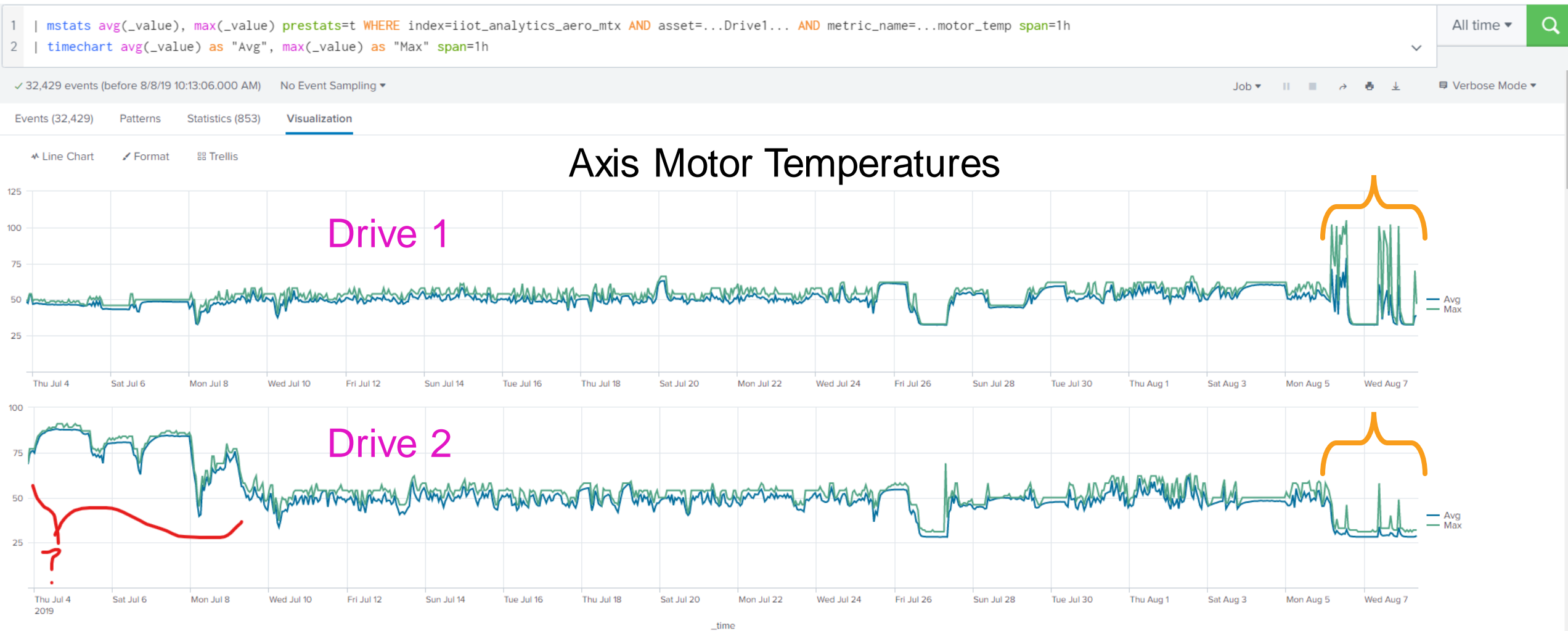


_time	dataitemid	value
2019-02-05 20:31.25.307	Temp	138.9
2019-02-05 20:31.33.791	Pres	91.75
2019-02-05 06:10.07.177	Temp	87.2
2019-02-05 22:17.52.196	Pres	0
2019-02-05 14:35.33.587	Temp	72.4
2019-02-05 17:51.48.152	Temp	71.3
2019-02-05 09:28.13.936	Temp	77.8
2019-02-05 05:11.52.426	Pres	0
2019-02-05 22:03.24.025	Temp	146.5
2019-02-05 11:47.25.660	Temp	74.5

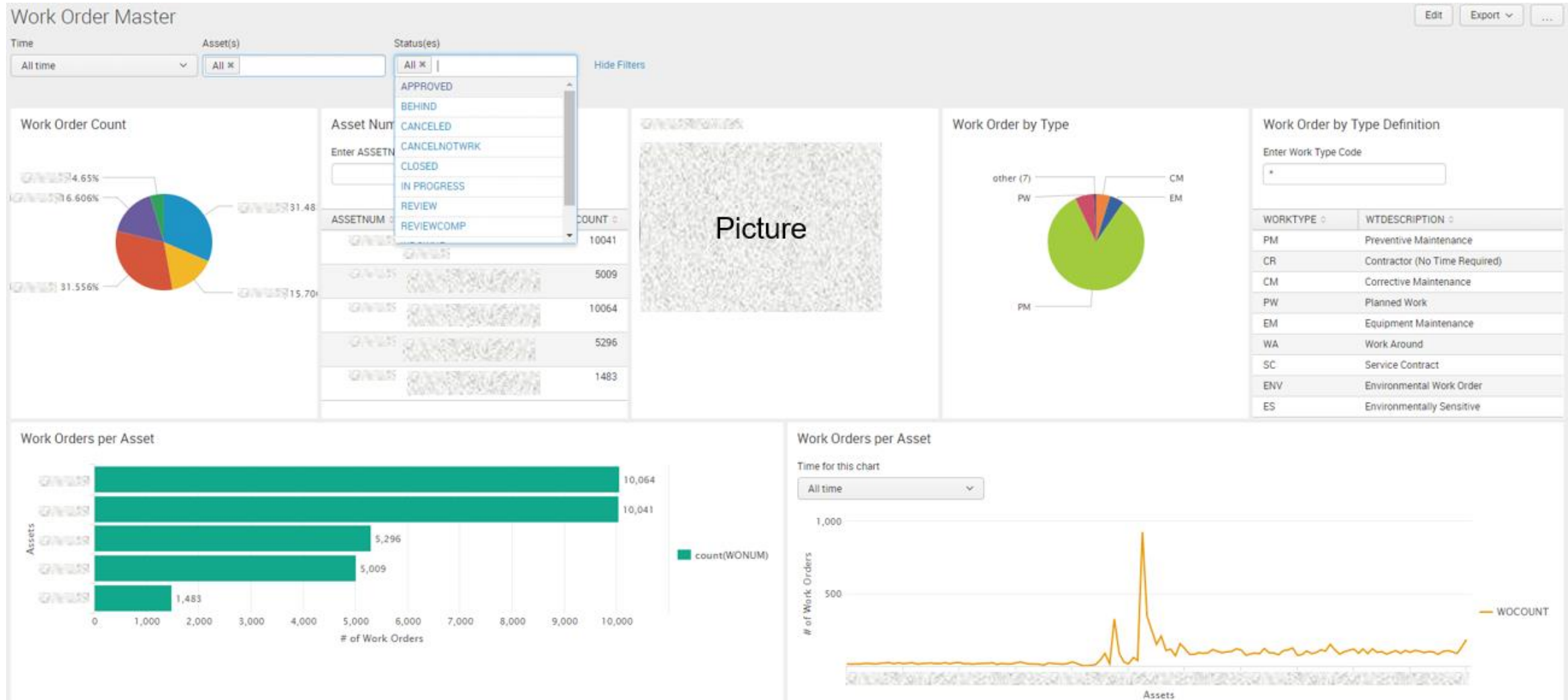
Search & Reporting

Aero
IoTReal-time
Monitoring

Data – Actions



Work Order Data





Alerts

Alert **DATA MISSING**

Description

Search

```
1 | mstats latest(_value) where metric_name="*" AND index
=iiot_analytics_aero_mtx AND asset="FTW_*" AND sourcetype
="keeware:idf" by asset, metric_name, index
```

Alert type ☒ Scheduled ☐ Real-time

Run on Cron Schedule ▼

Time Range

Cron Expression
e.g. 00 18 * * * (every day at 6PM). [Learn More](#)

Expires

Trigger Conditions

Trigger alert when

Trigger ☒ Once ☐ For each result

Throttle ? ☒

Suppress triggering for



Alerts

Suppress triggering for

12

hour(s) ▼

Trigger Actions

+ Add Actions ▼

When triggered



✉ Send email

Remove

To

christopher.m.gilman@lmco.com

Comma separated list of email addresses.

[Show CC and BCC](#)

Priority

Normal ▼

Subject

LMPI:Splunk IIOT Email Notification

The email subject, recipients and message can include tokens that insert text based on the results of the search.

[Learn More](#)

Message

There has been no data from FTW_ the past 1 hour.

Include



Link to Alert



Link to Results



Search String



Inline [Table](#) ▼



Trigger Condition



Attach CSV



Trigger Time



Attach PDF

Type

HTML & Plain Text

Plain Text



Apps

Splunk for IoT – IAI

Kepware
to
Metrics

SMS App
for
Maximo

Search &
Reporting

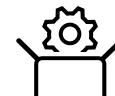
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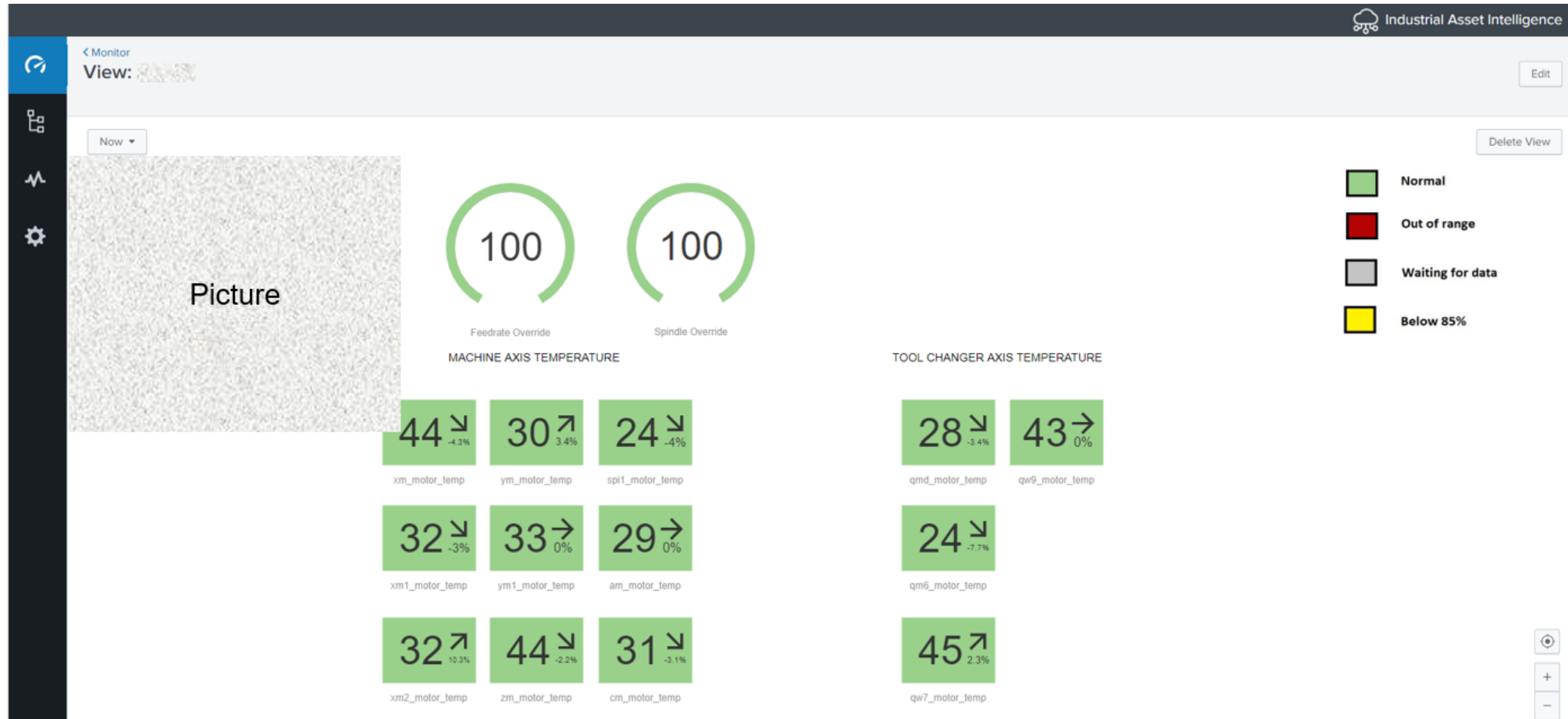
Machine
Learning

splunk>

Data Integrations (OPC, Kepware, Maximo, etc.)



Monitor View



Monitor View



Analyze View

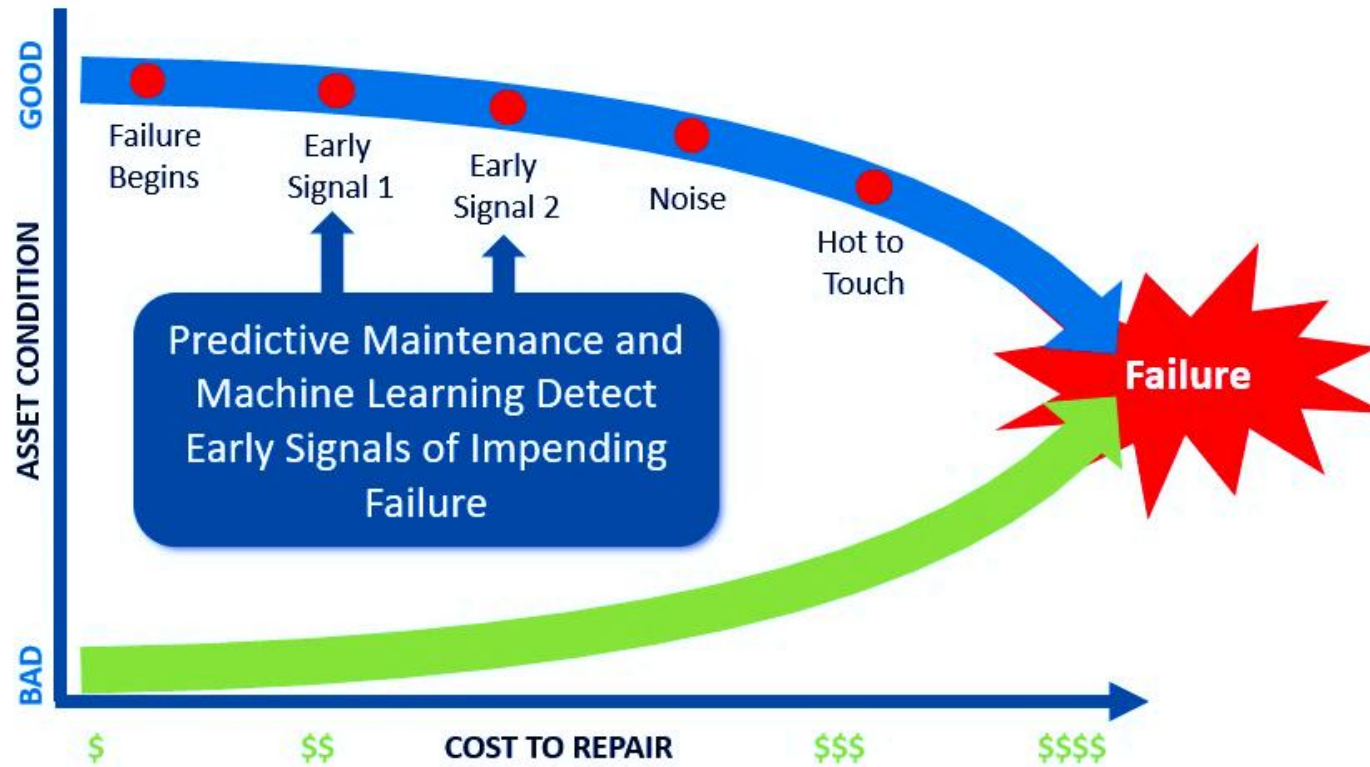


Apps

Machine Learning – Predictive Maintenance



Machine Learning



Predict machine failure and prescribe a remedy before failure

Transforming Data into Operational Intelligence

Full stack



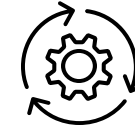
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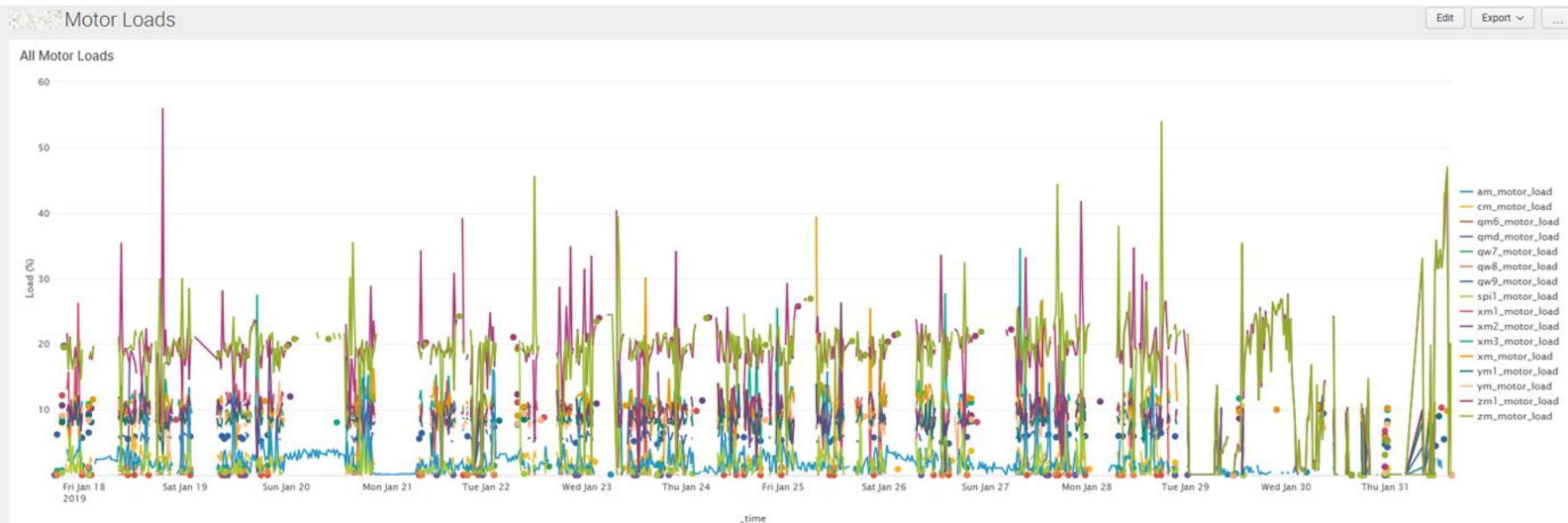
Machine
Learning

splunk>

Data Integrations (OPC, Kepware, Maximo, etc.)



Machine – Comparing Motor Loads



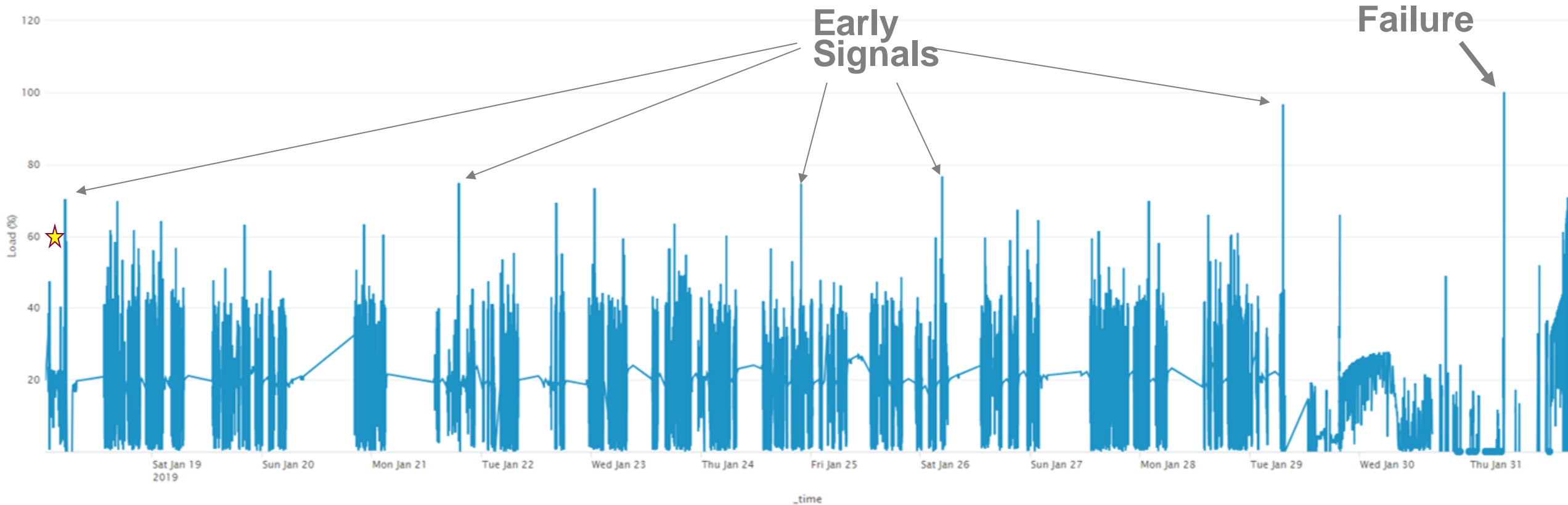
Machine – Comparing Motor Loads

Good Axis

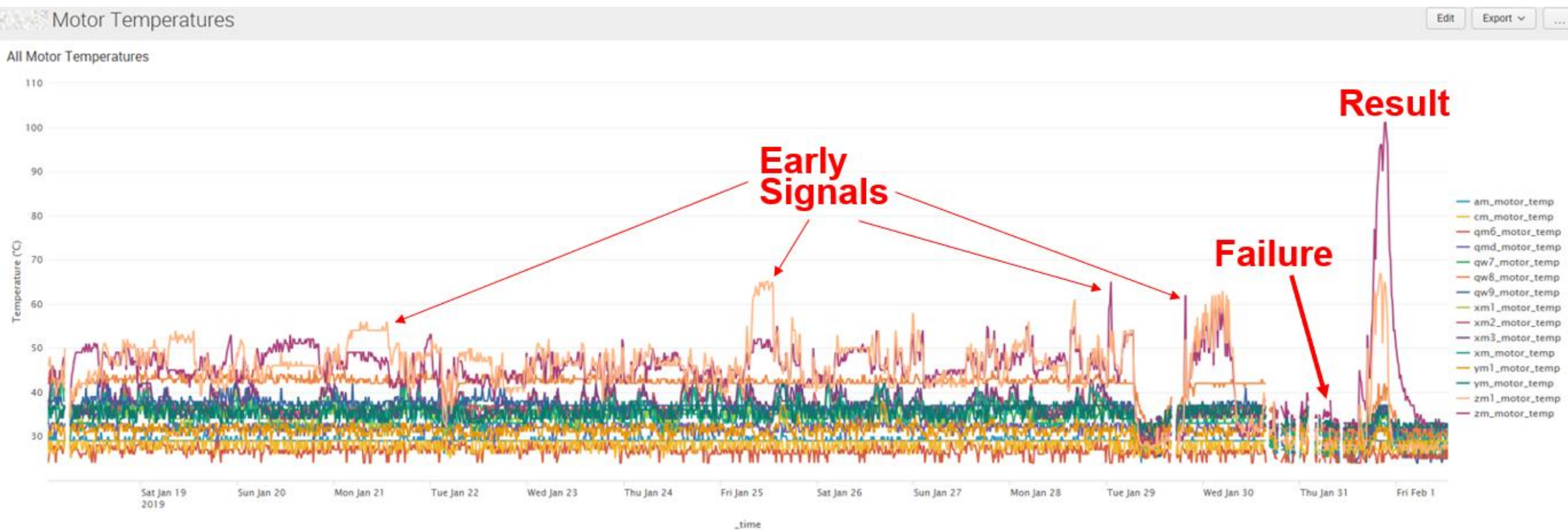


Machine – Comparing Motor Loads

Bad Axis



Machine – Comparing Motor Temperatures



Transforming Data into *Operational Intelligence*



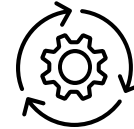
**Real-time
Monitoring**



**Diagnostics and
Troubleshooting**



**Maximo
Integration**



**Predictive
Maintenance**

**Kepware
to
Metrics**

**SMS App
for
Maximo**

**Search &
Reporting**

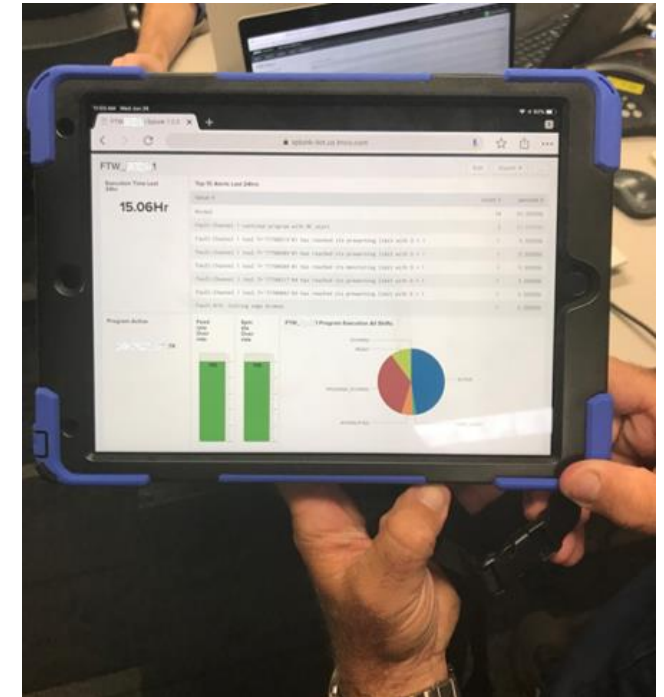
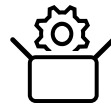
**Aero
IIoT**

**Industrial
Asset
Intelligence**

**Machine
Learning**

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Data Integrations (OPC, Kepware, Maximo, etc.)



Business Goals

Align with Facilities

- Increase asset reliability & availability
- Automate a work order in Maximo from machine data
- Improve and track Asset Availability
- Anticipate catastrophic failures utilizing machine learning
- Access data from assets in near real-time
- Integrate with Maximo data
- Provide Technicians with the ability to visualize & create dashboards on their tablets without coding or programming



The people

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Q&A

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Thank You!

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