OSIsoft®

USERS CONFERENCE 2016

April 4-8, 2016 | San Francisco

TRANSFORM YOUR WORLD

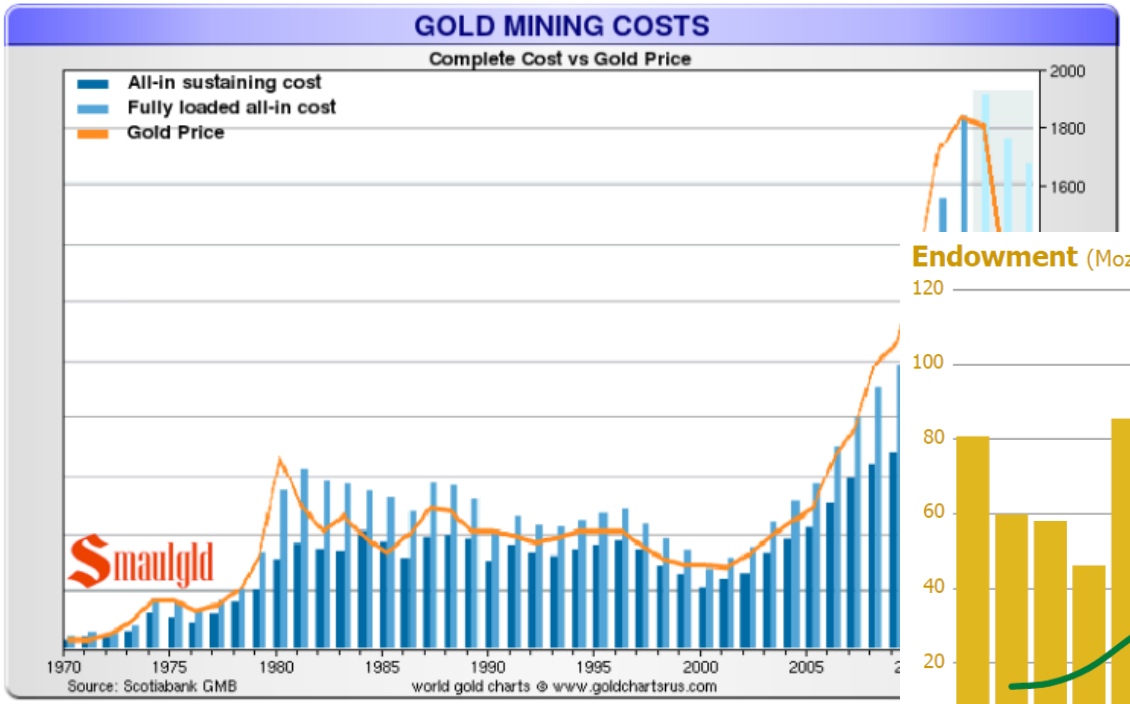
Get More From Your PI System Data With Advanced Analytics

Presented by **Iain Allen, Senior Manager, Mining IT, Barrick Gold**
Sameer Kalwani, Co-Founder & VP of Product, Element Analytics

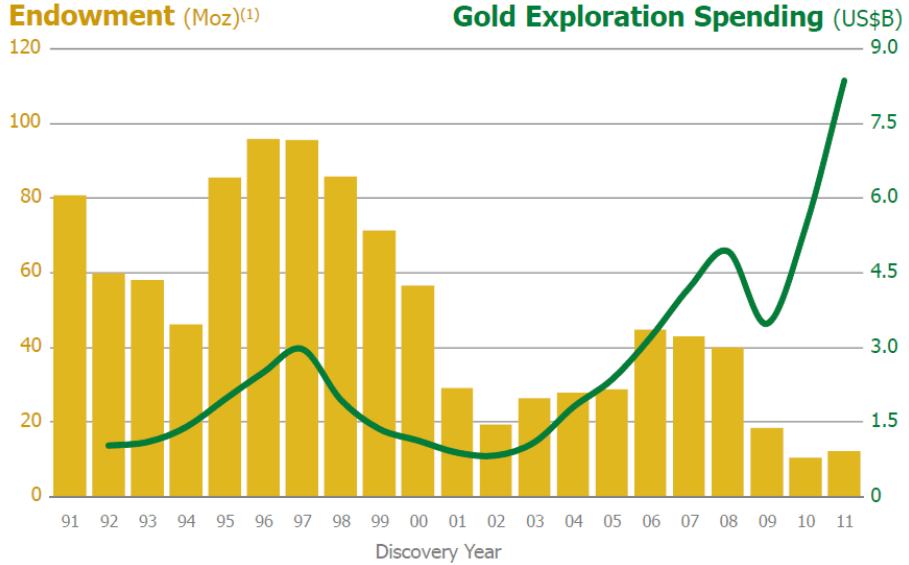
BARRICK

ELEMENT ANALYTICS™

The Gold Mining Business



Less and less bang
for the Exploration buck!



Tough and getting tougher
Cost control is paramount

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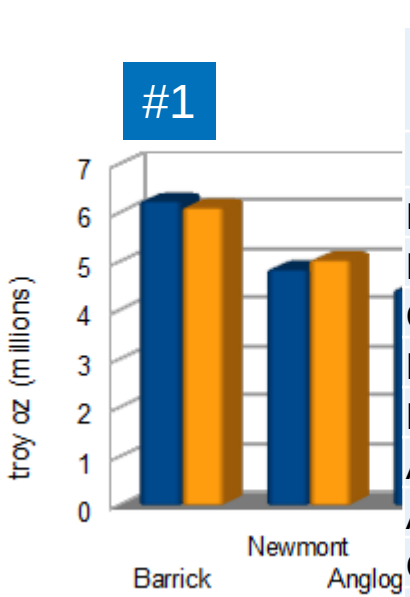
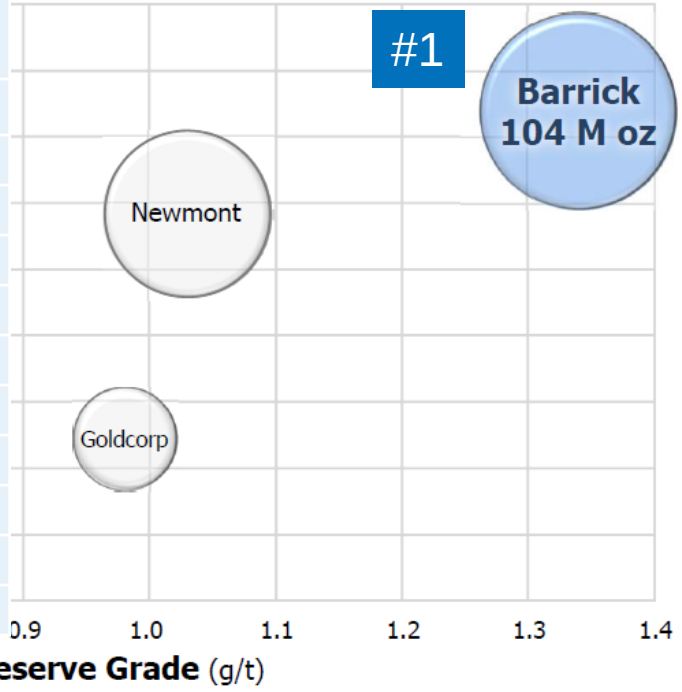
Barrick in the Gold Mining Business



Company	Market Cap (US$Bn)	
	2015	2014
Barrick	15.7	7.4
Newmont	14	8.57
Goldcorp	13.19	10.99
Newcrest	9.93	6.44
Polyus	8.79	8.64
Agnico	7.93	5.45
Anglogold Ashanti	5.58	3.48
Gold Fields	3.25	2.13
Yamana	2.91	1.63
Eldorado	2.25	2.21

#1



(1) Source: Company filings. See final slide #4.

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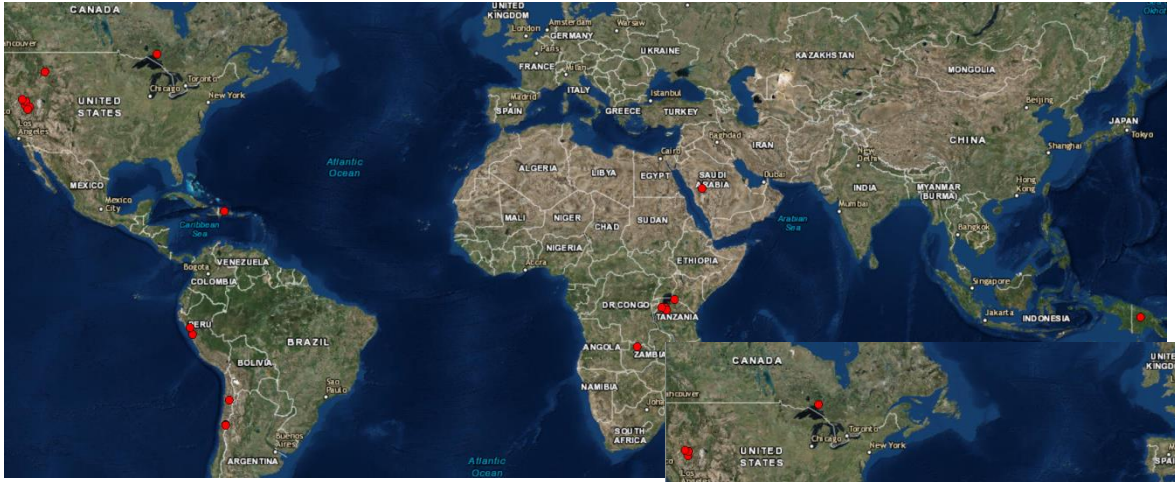
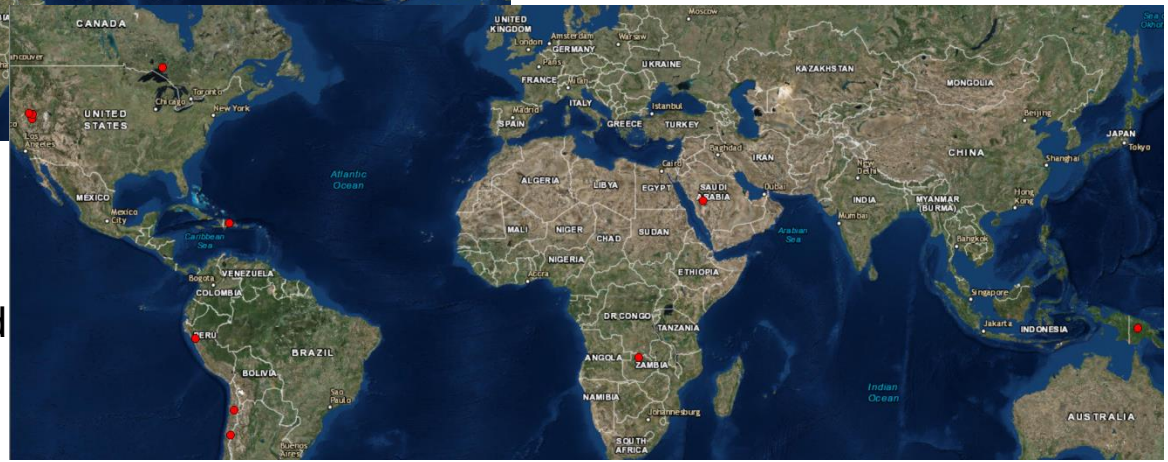
How Did Barrick Become #1 Again?



2012

- 25 operating mines
- ~7.5 million ounces produced
- AISC US$915
- Reserves 104.1 million ounces



2015

- 12 operating mines
- ~6.25 million ounces produced
- AISC US$831
- Reserves 93 million ounces

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All In Sustaining Costs (AISC)

	Cash Costs	AISC
Direct Production Cost	✓	✓
Onsite Admin and Regulatory Costs	✓	✓
Royalties and Production Taxes	✓	✓
Smelting, refining and transport	✓	✓
By-product Credits	✓	✓
Corporate General and Admin Costs	×	✓
Reclamation and Remediation	×	✓
Exploration (Sustaining)	×	✓
Stripping and Mine Development (Sustaining)	×	✓
Sustaining Capex	×	✓

- Does not include
- Capex for new mine construction
- Debt repayment

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Barrick's Goal – Gold Price Agnostic

"Our aspiration is to achieve all-in sustaining costs **below $700** per ounce by 2019."

2013	
Actual	$915

2014	
Guidance	920-980

2015	
Guidance	830-860

The Law of Diminishing Returns

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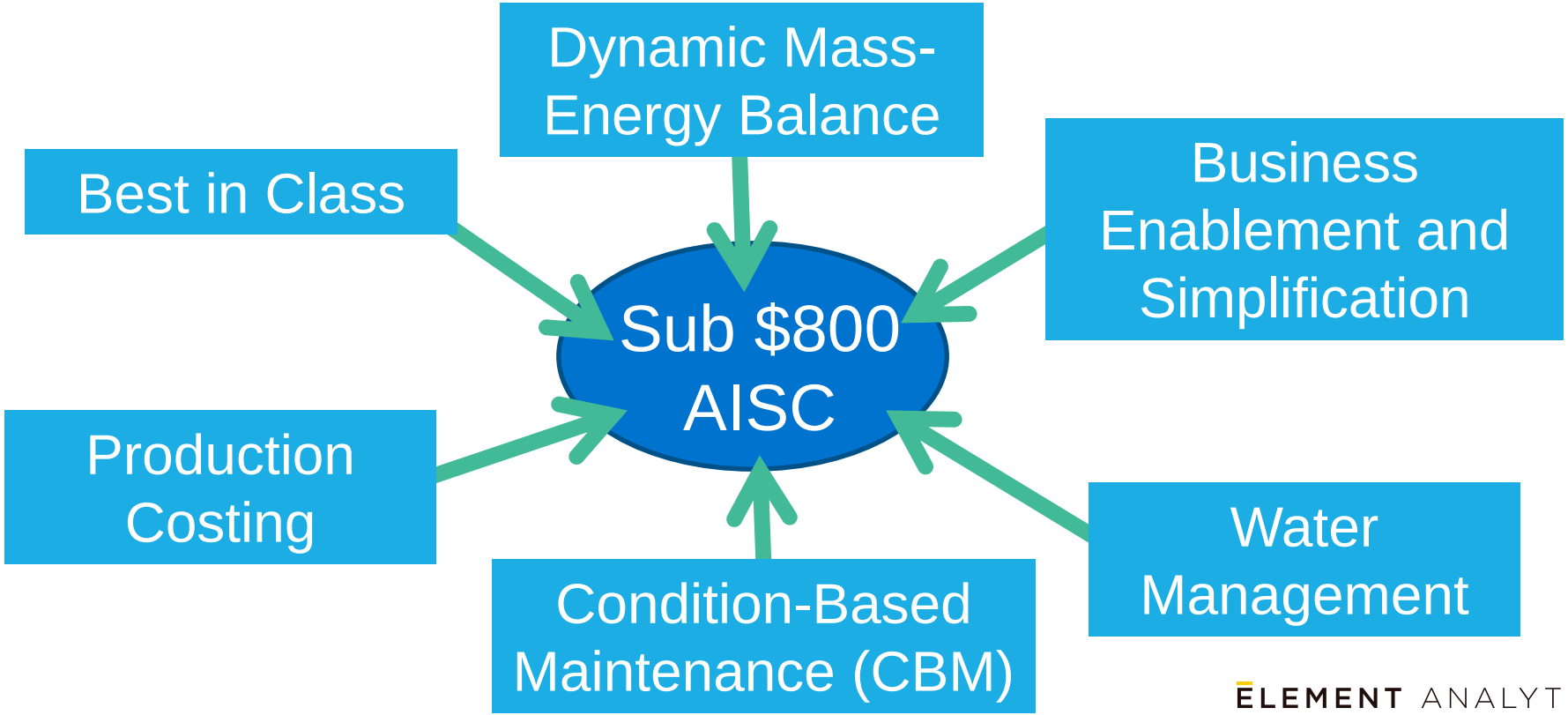
"It is crucial to the future of the company that Barrick become a **Data-Driven** Decision-making Organization"

Jim Gowans, Chief Operating Officer, 2014

The Digitization of Barrick



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“Our aspiration is to achieve all-in sustaining costs **below $700** per ounce by 2019.”

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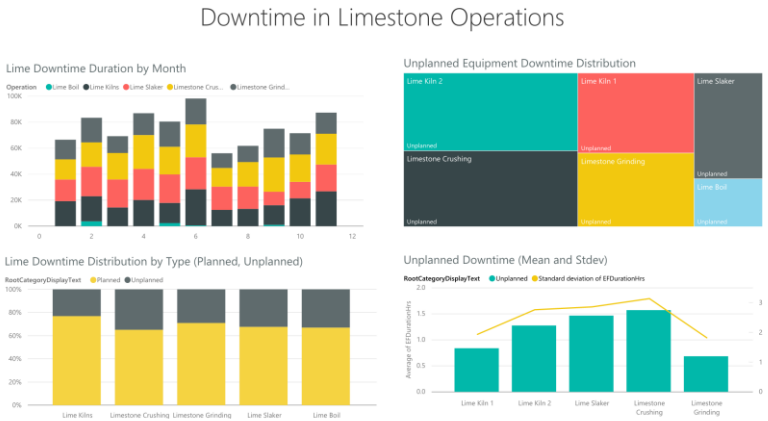
Pueblo Viejo Mine

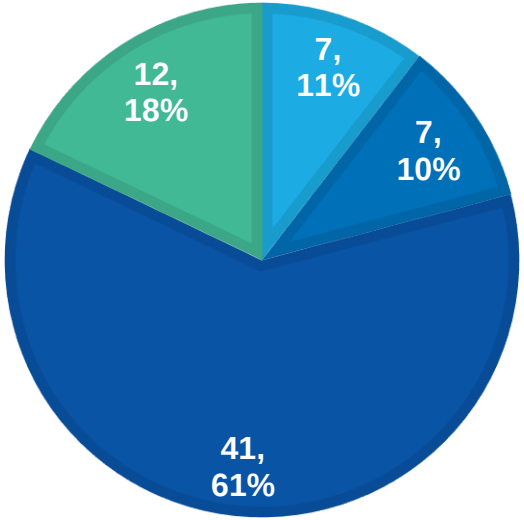
- Barrick's newest mine
- Produces 800k ounces of gold per year
- Most advanced PI site
- Doing very innovative work with PI on Energy and CBM
- Have a positive attitude toward new ideas

Producing Analytics

Descriptive Analytics



Predictive Analytics



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Demo: Descriptive Analytics

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How we got to Descriptive Analytics Quickly

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Emerging Categories Create a lot of Noise

Internet of Things

Industrial Internet

Big Data

IT/OT Convergence

Industry 4.0

Looking for Solutions That Make Our People and Equipment More Effective

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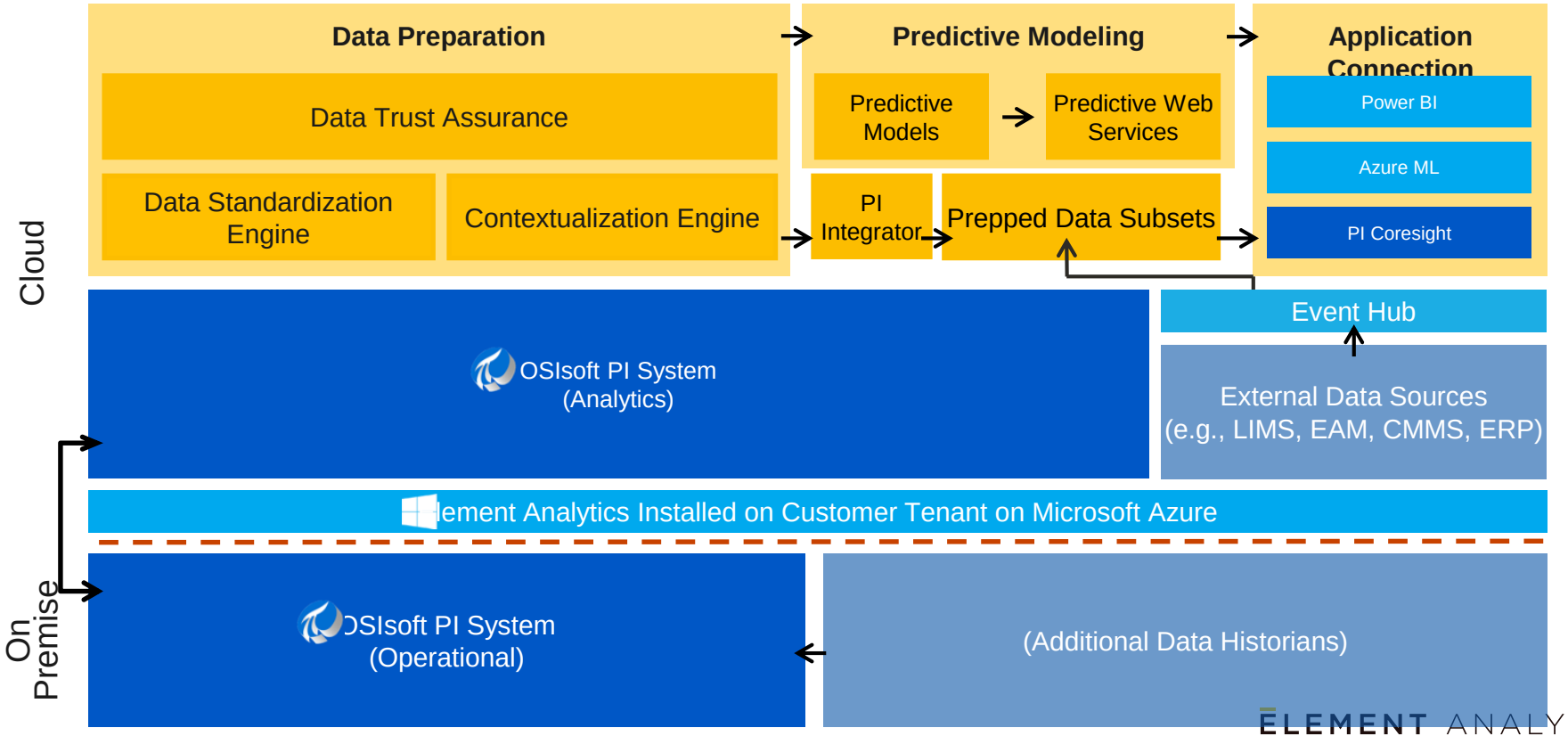
Element Analytics Platform Architecture (an OSIsoft ConnectedApp)



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Demo: Element Platform

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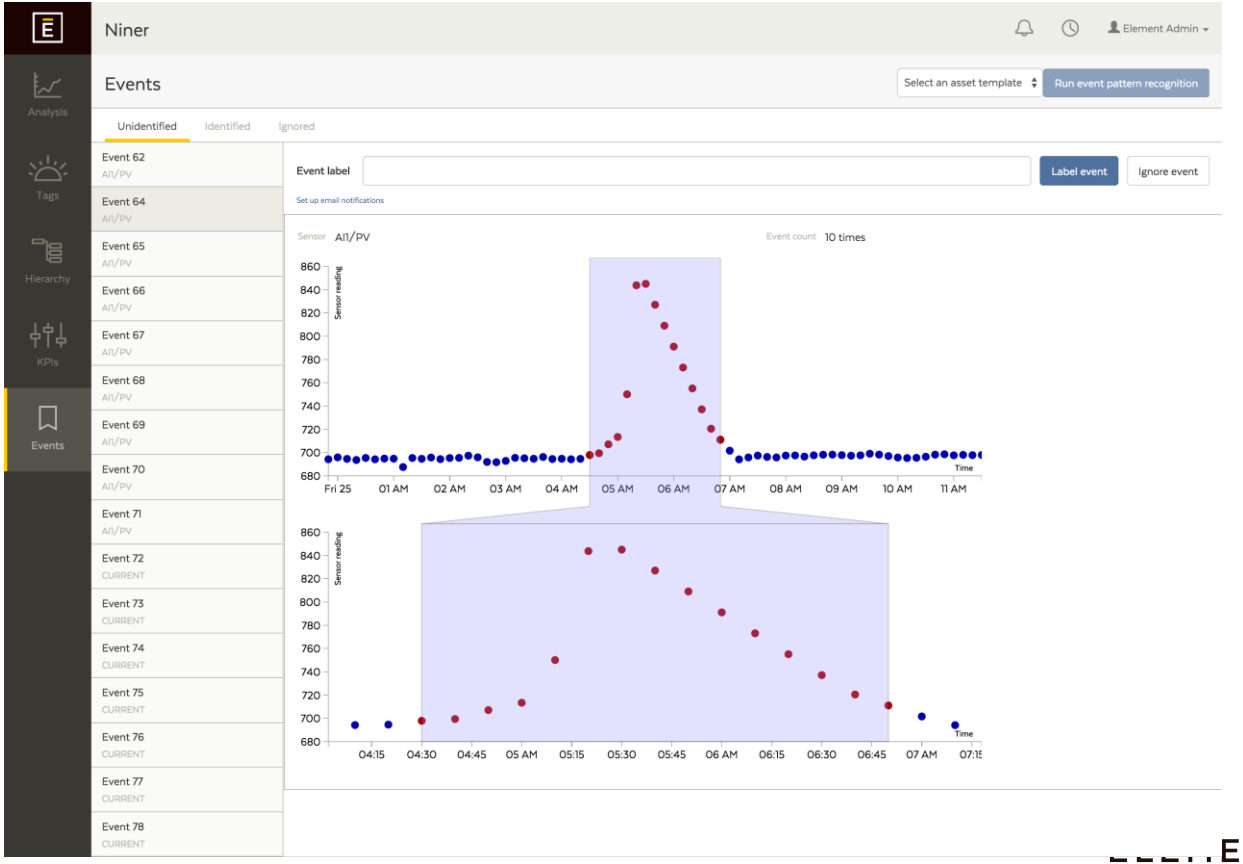
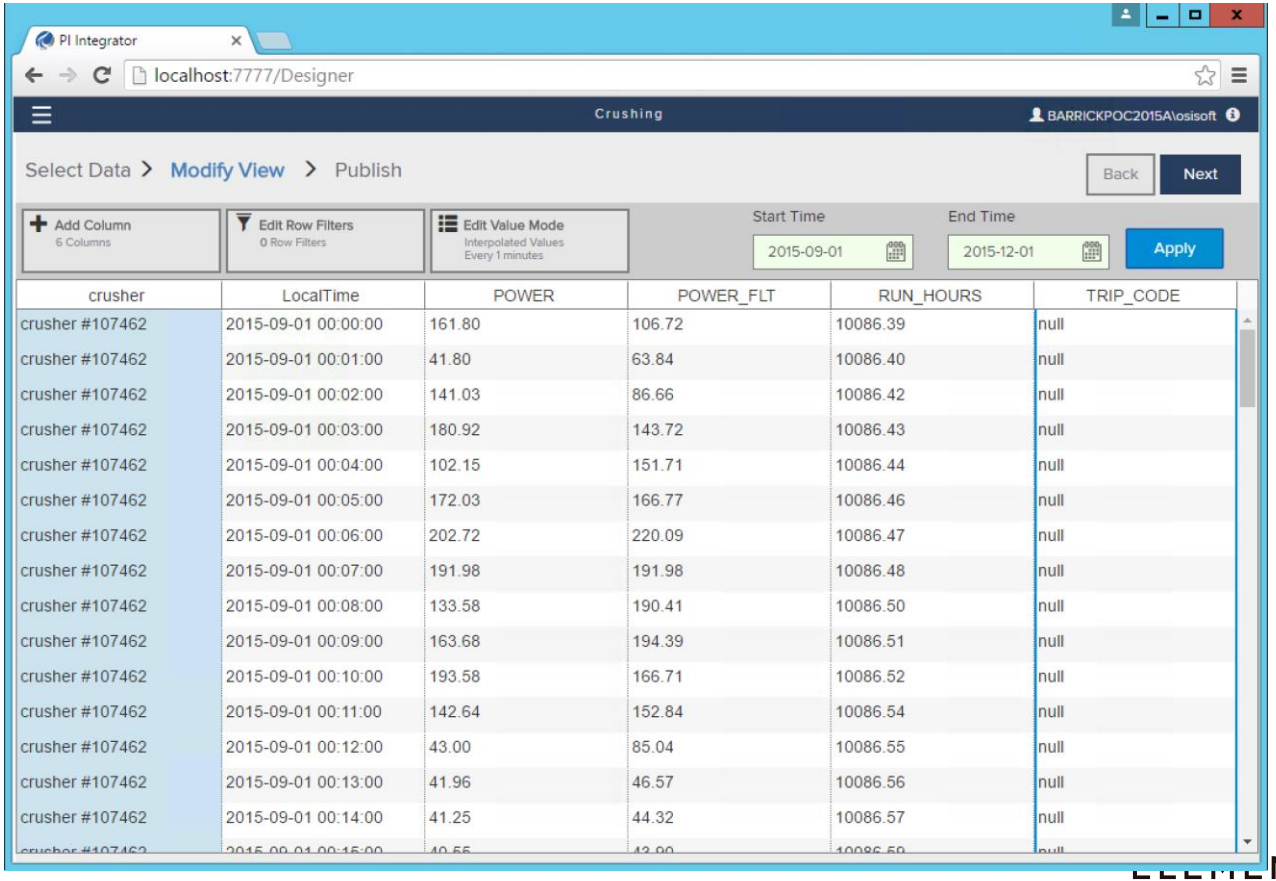
Contextualization – Easily Surface Events, and Label them as Event Frames. We Use All Assets of an Asset Template + All Historical Data to Surface Events



PI Integrator



crusher	LocalTime	POWER	POWER_FLT	RUN_HOURS	TRIP_CODE
crusher #107462	2015-09-01 00:00:00	161.80	106.72	10086.39	null
crusher #107462	2015-09-01 00:01:00	41.80	63.84	10086.40	null
crusher #107462	2015-09-01 00:02:00	141.03	86.66	10086.42	null
crusher #107462	2015-09-01 00:03:00	180.92	143.72	10086.43	null
crusher #107462	2015-09-01 00:04:00	102.15	151.71	10086.44	null
crusher #107462	2015-09-01 00:05:00	172.03	166.77	10086.46	null
crusher #107462	2015-09-01 00:06:00	202.72	220.09	10086.47	null
crusher #107462	2015-09-01 00:07:00	191.98	191.98	10086.48	null
crusher #107462	2015-09-01 00:08:00	133.58	190.41	10086.50	null
crusher #107462	2015-09-01 00:09:00	163.68	194.39	10086.51	null
crusher #107462	2015-09-01 00:10:00	193.58	166.71	10086.52	null
crusher #107462	2015-09-01 00:11:00	142.64	152.84	10086.54	null
crusher #107462	2015-09-01 00:12:00	43.00	85.04	10086.55	null
crusher #107462	2015-09-01 00:13:00	41.96	46.57	10086.56	null
crusher #107462	2015-09-01 00:14:00	41.25	44.32	10086.57	null

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Getting Predictive Results

Every Minute Counts!
Now That We Can Measure It And See It, We Can Do Something About It

Identifying the Opportunity

- With PowerBI, we identified downtime issues with the limestone crushing system.

- The biggest 3 systems on that circuit are:
  - Limestone crushers
  - Lubrication system
  - Conveyor

How to Solve the Problem

- Requirement:
  - need at least 1 week notification in advance to predict potential faults
- Challenge:
  - Scheduling more frequent maintenance doesn't scale.
- Solution:
  - Need to catch faults before they happen
  - Need Data Science to create predictive models

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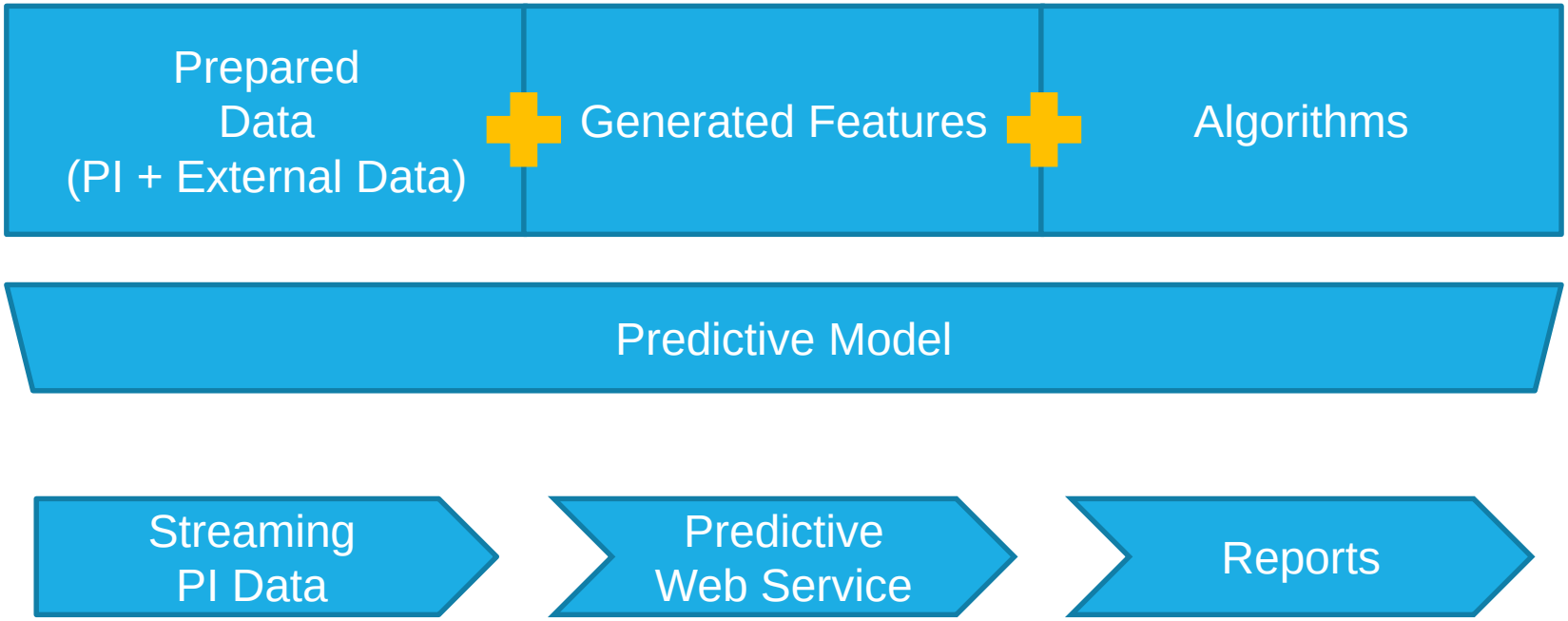
Approach to build a model to predict unplanned failures in limestone circuit a week in advance



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Identifying Features

- Dynamic Features
  - Traditional tags that change based off the conditions of the system it is monitoring

- Alarm Features
  - Binary status/state tags that indicate on/off conditions of the system it is monitoring

Dynamic Features

Crusher

- Current
- Main Drive Coupling Zero Speed
- Power Used
- Area Receiver Pressure
- Pulse Air Receiver Pressure
- MPS Pressure

Lubrication System

- Discharge Pressure
- Backup Pump Pressure
- Oil Res Temperature
- Oil Rtn Line Temperature
- Primary Pump Pressure
- Centrifugal Filter Pump
- Cooling Fan
- Pump

Conveyor

- Head Temperature
- Weight Scale
- Conveyor Current

Std Dev. | Min | Max | … | Mean

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Alarm Features

Crusher

- Blower Filter Warning
- UPS Alarm
- Dirty Filter Warning
- Plugged Filter Warning
- Screen Diverter Feed Chute Level

Lubrication System

- Oil filter Valves Closed
- High Oil Temp Alarm
- Low Oil Temp Alarm
- Low Oil Level Alarm
- Oil Filter Valve Open
- Filter Plugged

Conveyor

- Conveyor RIP Detect
- Conveyor Tail Speed
- Conveyor Misalign
- Conveyor Pullcord

Daily Counts

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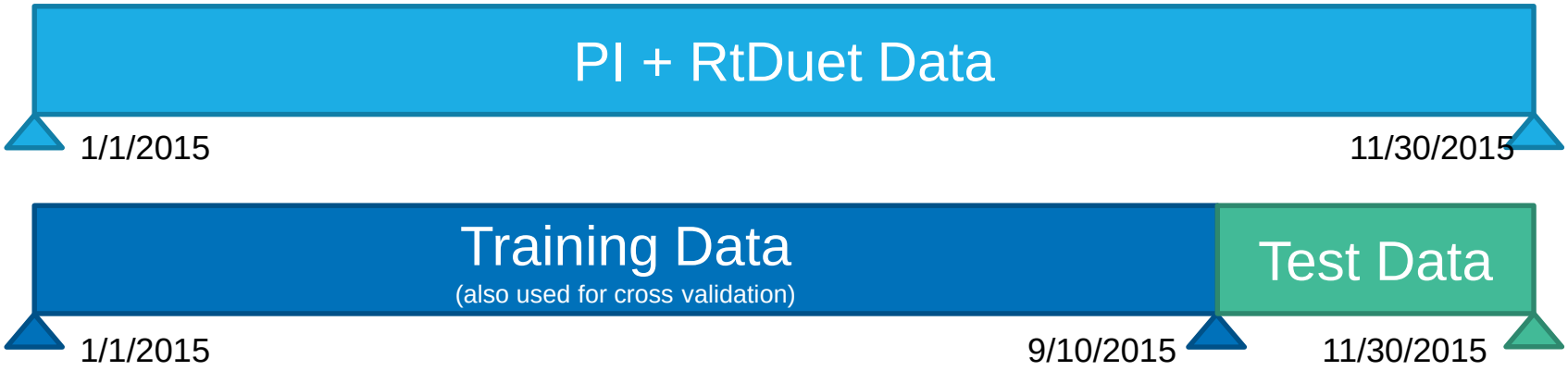
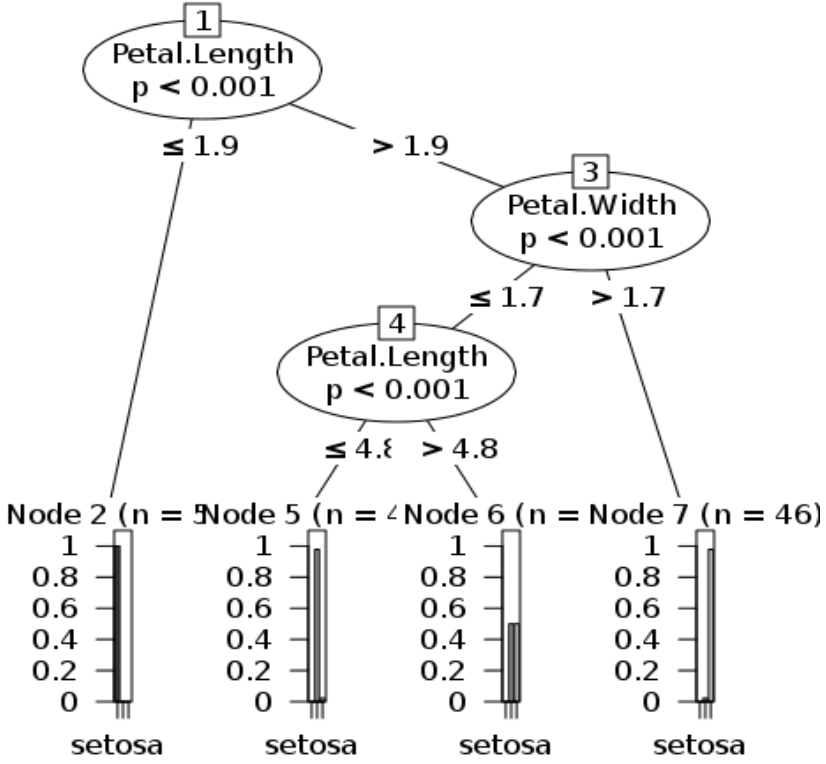
Splitting the Data to Build the Model



Decision Trees

Automatically identify ways to divide data.



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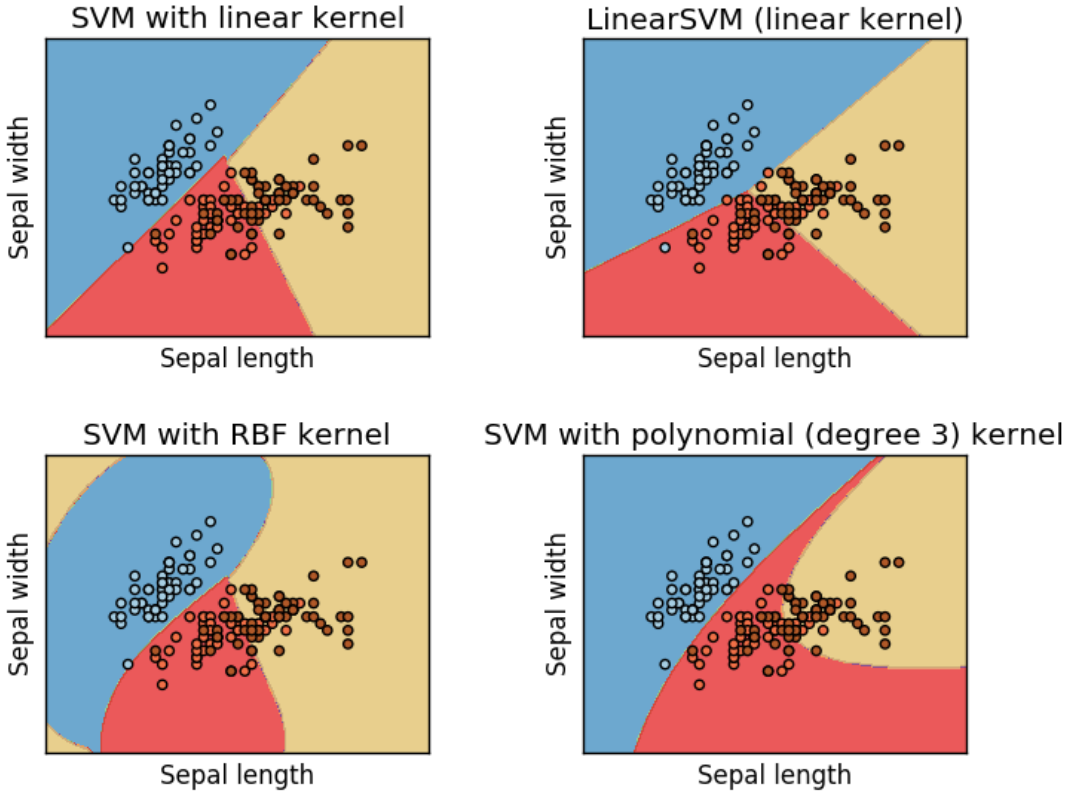
Support Vector Machines

Finds Non-linear separation in data



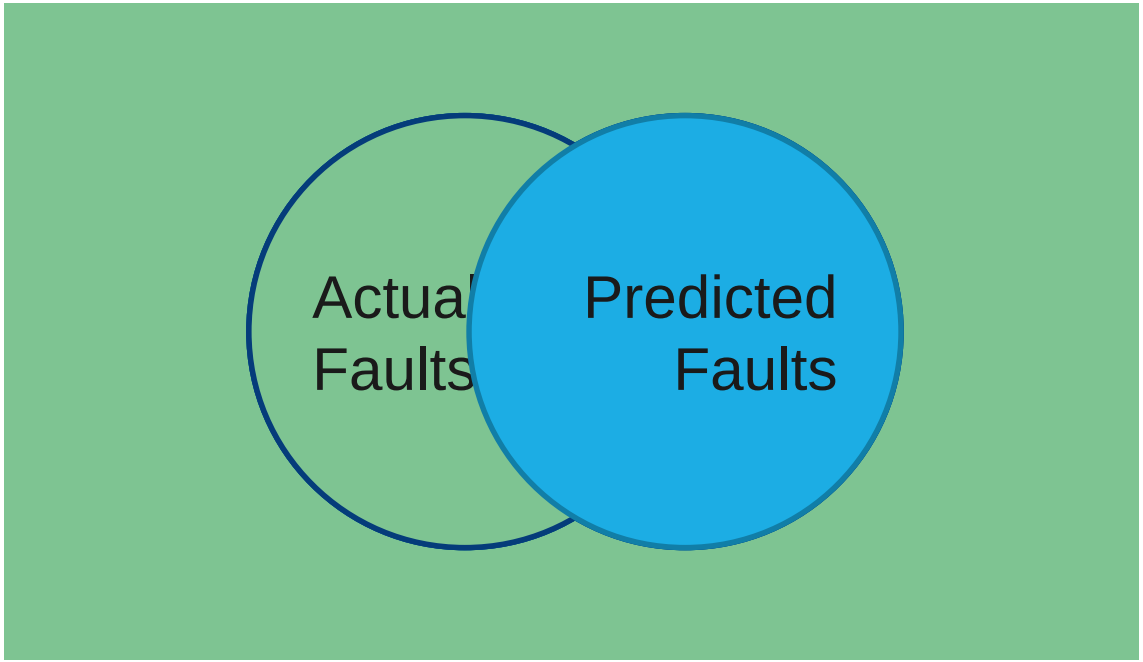
ICS™

How to Measure Predictive Model Performance

The Ecosystem of a Predictive Mode

- True Positive
- True Negative
- False Positive
- False Negative

- Precision
  - TP/(TP+FP)
- Recall
  - TP/(TP+FN)



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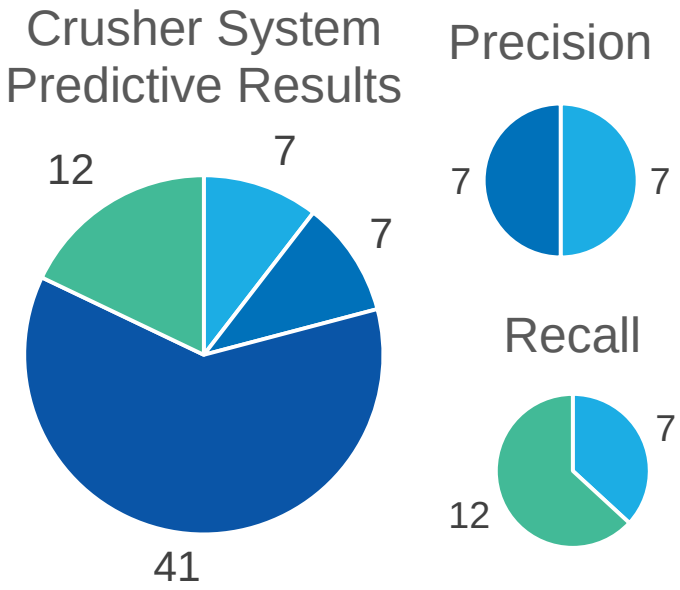
Crusher Predictive Initial Results



Number of assets trained upon	1
Actual number of days that are predictive of faults	19
Actual number of days that are predicted of non-faults	48
Number of faults predicted by model	14
% predicted faults that actually occur	7 (50%)
% of predicted faults that are non-faults	7 (50%)
% of total faults that were predicted	7 (37%)

TP - Correctly predicted faults

FP - Incorrectly predicted faults

TN - Correctly predicted non-faults

FN - Actual fault, but not predicted

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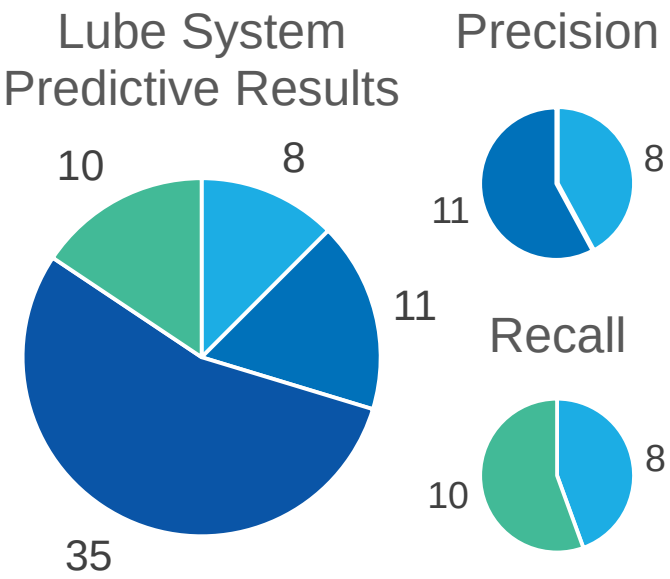
Lube System Predictive Initial Results



Number of assets trained upon	1
Actual number of days that are predictive of faults	18
Actual number of days that are predictive of non-faults	46
Number of faults predicted by model	19
% predicted faults that actually occur	8 (42%)
% of predicted faults that are non-faults	11 (58%)
% of total faults that were predicted	8 (44%)

TP - Correctly predicted faults

FP - Incorrectly predicted faults

TN - Correctly predicted non-faults

FN - Actual fault, but not predicted

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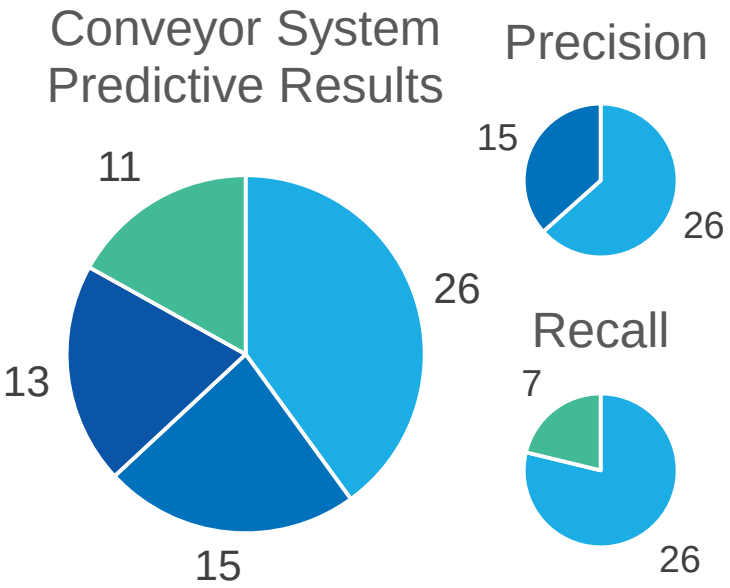
Conveyor Predictive Initial Results



Number of assets trained upon	1
Actual number of days that are predictive of faults	33
Actual number of days that are predictive of non-faults	28
Number of faults predicted by model	41
% predicted faults that actually occur	23 (67%)
% of predicted faults that are non-faults	17 (33%)
% of total faults that were predicted	26 (79%)

TP - Correctly predicted faults

FP - Incorrectly predicted faults

TN - Correctly predicted non-faults

FN - Actual fault, but not predicted

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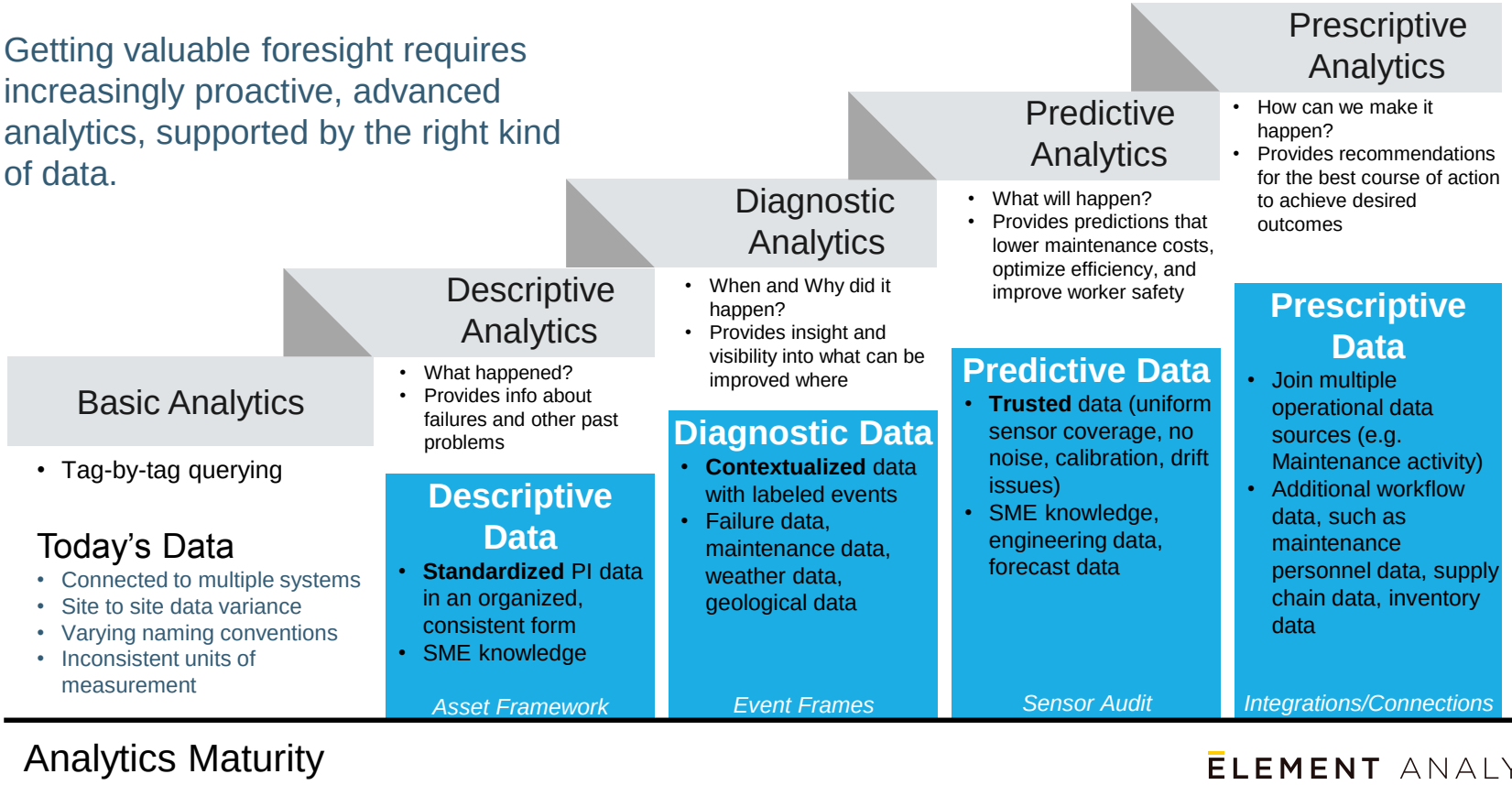
Recap

Recap: The Analytics Journey Requires the Right Data to Enable it

Getting valuable foresight requires increasingly proactive, advanced analytics, supported by the right kind of data.



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Lessons Learned

- Involve the site team from the beginning
- Provide as much PI data as possible
- Provide detailed descriptions of your PI tags
- Provide any supporting data – RtDuet, Ivara
- Have a follow-up workshop to present and discuss the results

Contact Information

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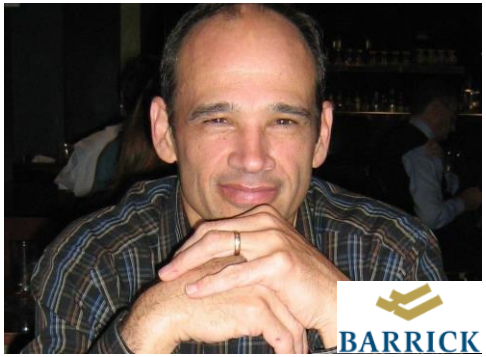
Barrick Gold



Sameer Kalwani
sameer@elementanalytics.com
Co-Founder & VP of Product
Element Analytics

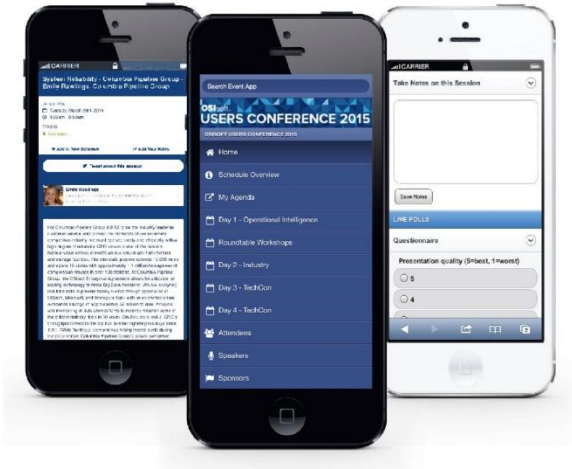
Questions

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

State your **name & company**

Please don't forget to…

Complete the Online Survey for this session



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감사합니다

谢谢

Danke

Gracias

Merci

Thank You

ありがとう

Спасибо

Obrigado

Talk to us about:

Predictive Analytics for Industry - http://bit.ly/1UfGnPt

The Future of Industrial Big Data and Its Data Tech Stack - http://bit.ly/1mg2CsY

Downtime Overview

Minutes Waiting for Trucks	Minutes Waiting for Stone	Downtimes w/o Comments
9,543	28,161	65

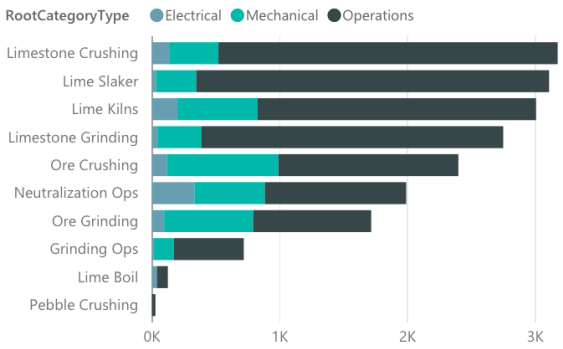
Operations

- [ ] Grinding Ops
- [ ] Lime Boil
- [ ] Lime Kilns
- [ ] Lime Slaker
- [ ] Limestone Crushing
- [ ] Limestone Grinding
- [ ] Neutralization Ops
- [ ] Ore Crushing
- [ ] Ore Grinding
- [ ] Pebble Crushing

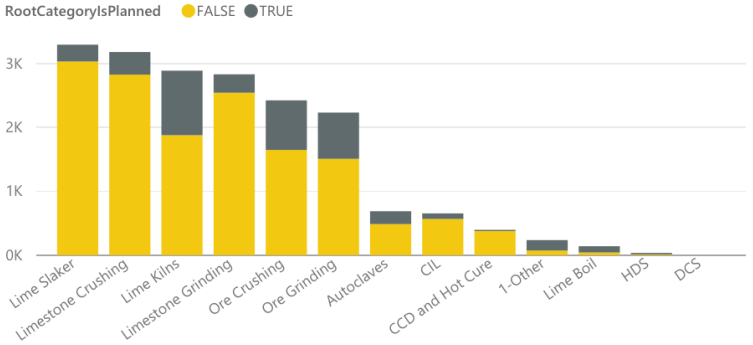
Month

- [ ] April
- [ ] August
- [ ] December
- [ ] February
- [ ] January
- [ ] July
- [ ] June
- [ ] March
- [ ] May
- [ ] November
- [ ] October
- [ ] September

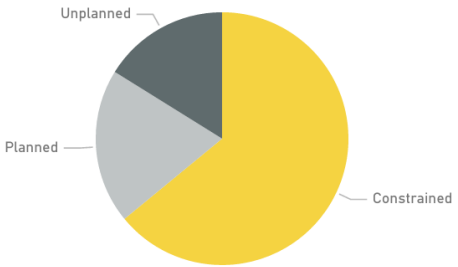
Downtime Duration by Source Site



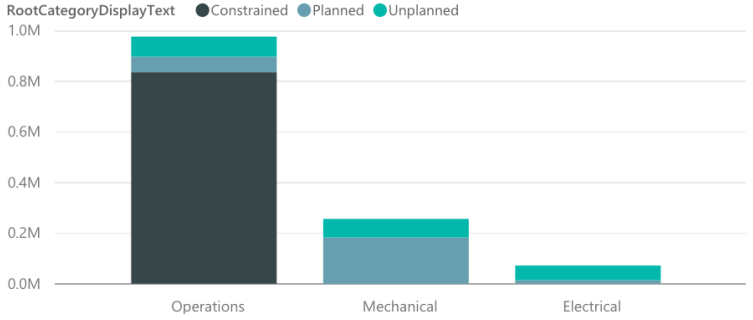
Downtime Duration by Source Site (Planned vs. Unplanned)



% Downtime (Planned, Unplanned, Constrained)

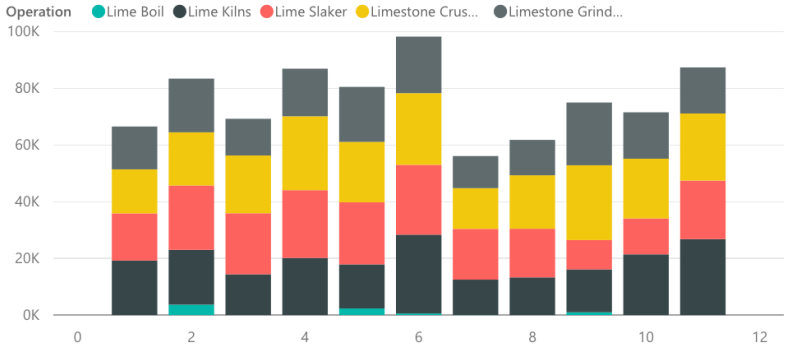


Downtime Duration by Type (Planned, Unplanned, Constrained)



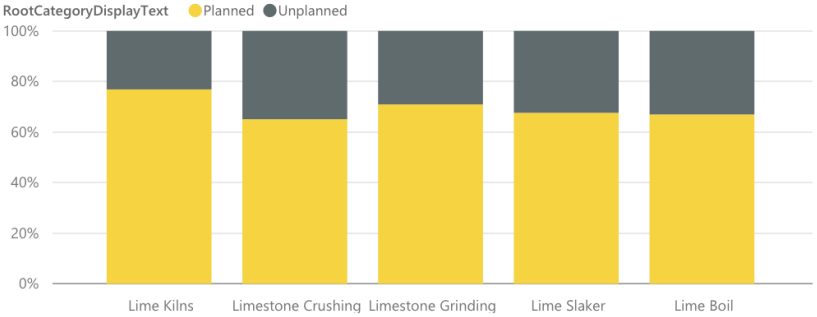
Downtime in Limestone Operations

Lime Downtime Duration by Month

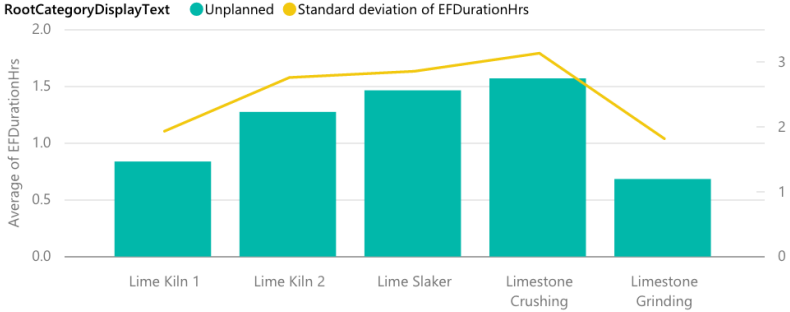


Unplanned Equipment Downtime Distribution

Lime Downtime Distribution by Type (Planned, Unplanned)



Unplanned Downtime (Mean and Stdev)



Crusher Downtime

Crusher Equipment

- [ ] Blower
- [ ] Crusher
- [ ] Fan
- [ ] Flow Rate Indicator

Machine

- [ ] Lime Boil
- [ ] Lime Kiln 1
- [ ] Lime Kiln 2
- [ ] Lime Slaker
- [ ] Limestone Crushi...
- [ ] Limestone Grindi...

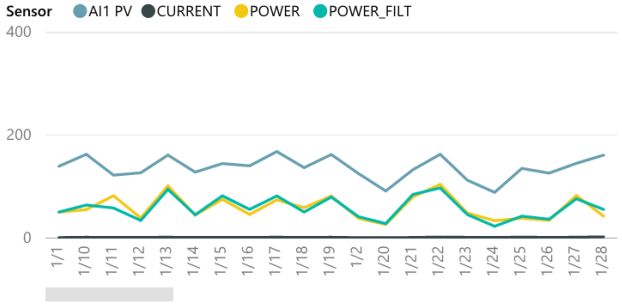
Downtime Type

- [ ] Constrained
- [ ] Planned
- [x] Unplanned

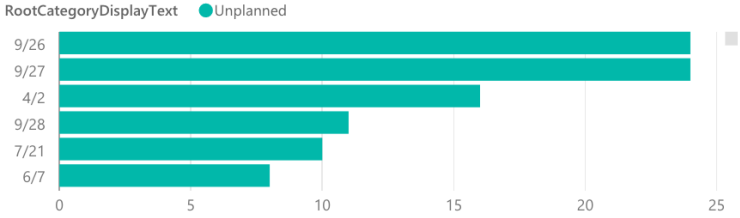
Date

- [ ] 1/1
- [ ] 1/10
- [ ] 1/13
- [ ] 1/14
- [ ] 1/17
- [ ] 1/2
- [ ] 1/20
- [ ] 1/21

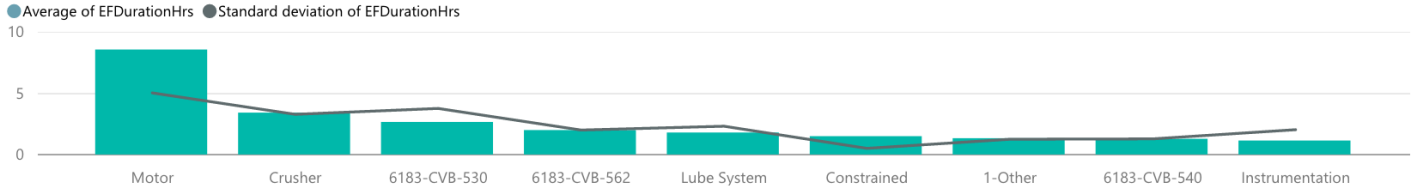
Energy Consumption



Crusher Daily Unplanned Downtime



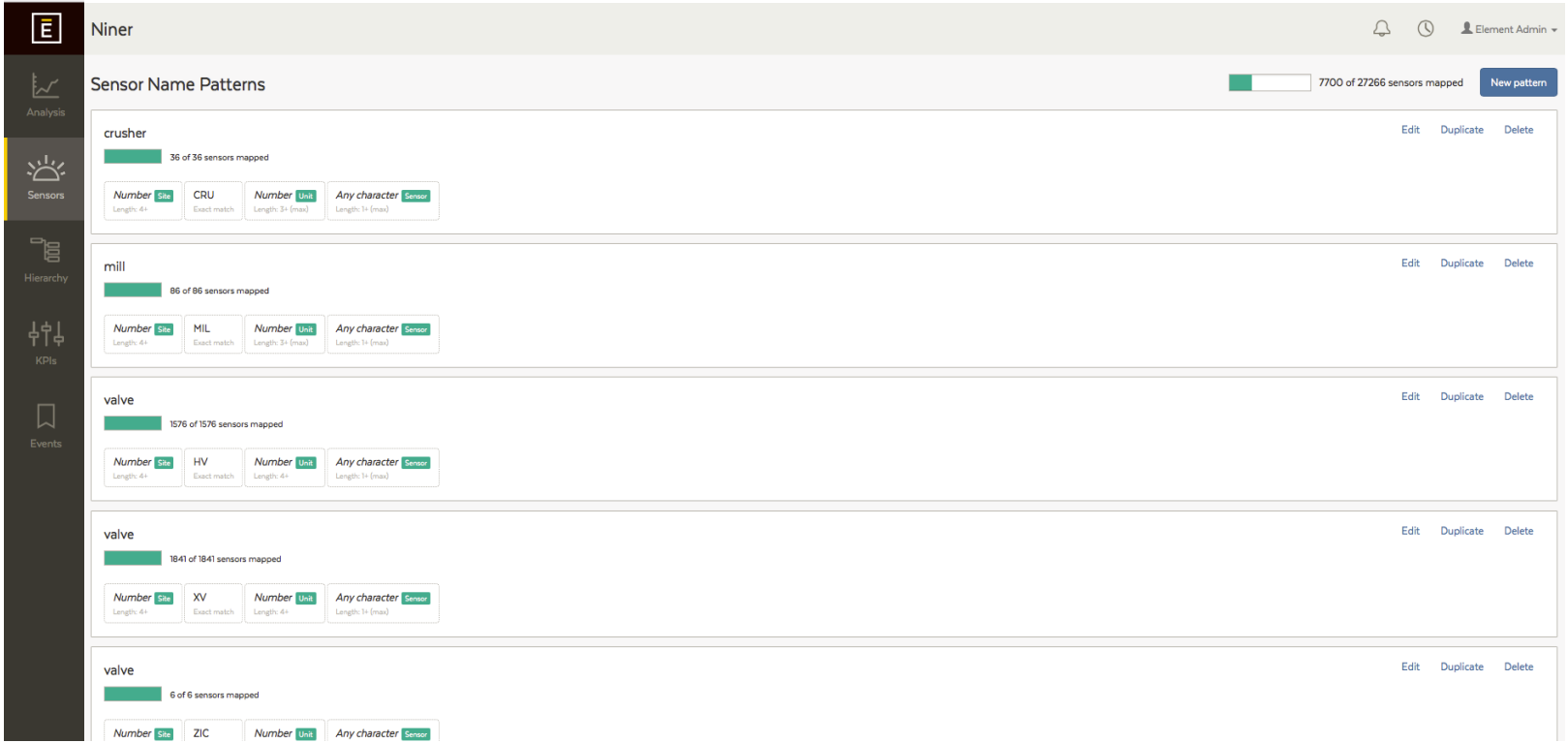
Top 10 Reasons for Crusher Downtime (Mean and Standard Deviation)



Maintenance Logs

Date_Mont...	Reason	Comment
1/1	\Lime Kilns\Kiln 1	chequeo de valvula de vapor
1/10	\Limestone Grinding\Mill\6186-MIL-570 (Ball Mill)	limpieza en la canaleta de los ciclones
1/10	\Lime Slaker	sordadura de soporte del alimentador o screen , estaba roto
1/13	\Limestone Crushing\Conveyor\6183-CVB-540	6183-CVB-540 Fault
1/13	\Lime Kilns\Kiln 2	Change filters in the Blowers
1/13	\Lime Slaker\Constrained	Change of Spring in the Screen

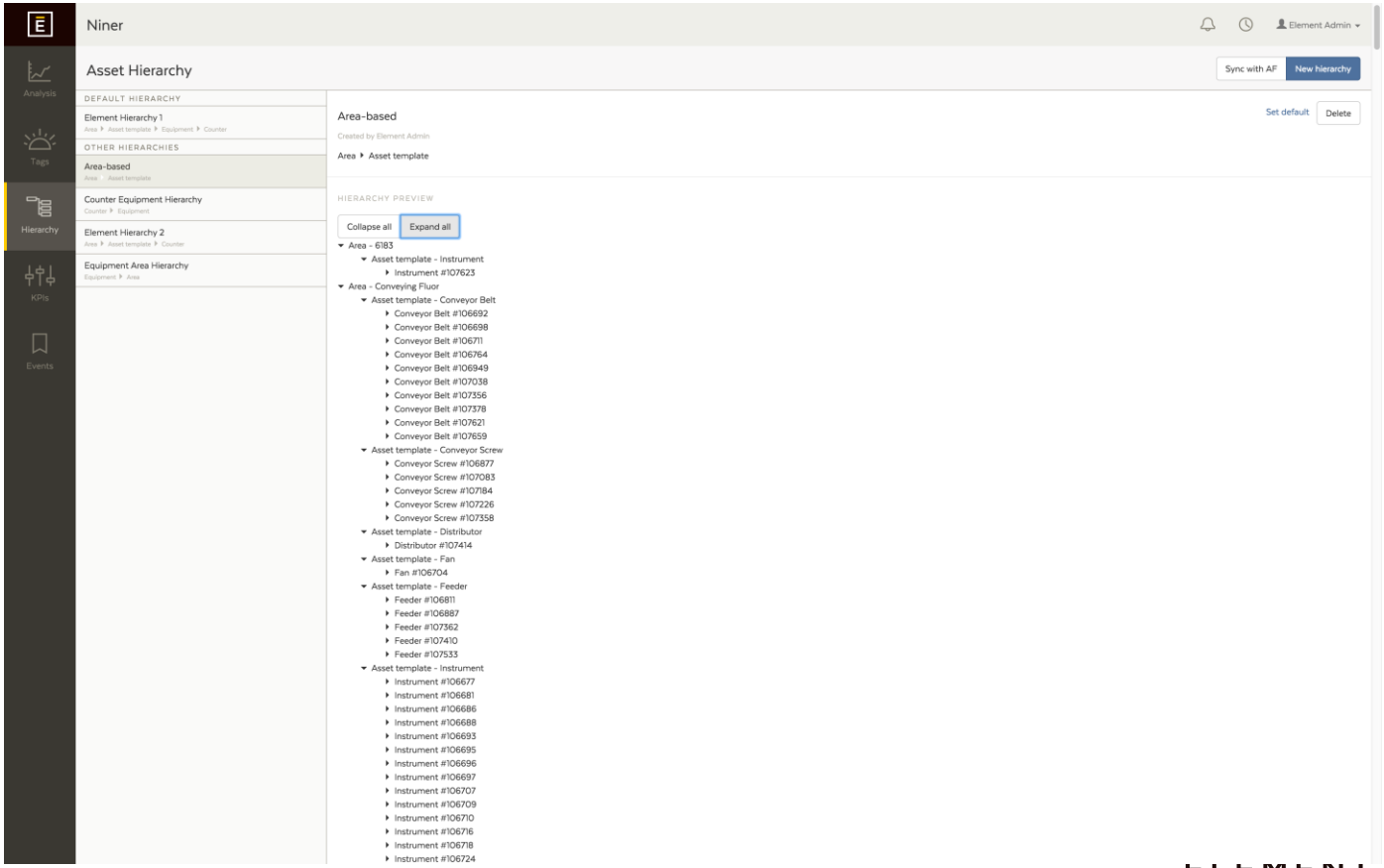
Getting Ready for Analytics:
Moved PI Tags into Consistent Asset Templates



We were able to get 7700 tags across 11 asset templates completed in 3 hours, using the Element Analytics Platform

LYTICS™

Created Asset Hierarchies



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Questions

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

State your **name & company**

Please remember to…

Complete the Online Survey for this session

http://ddut.ch/osisoft

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감사합니다

谢谢

Danke

Gracias

Merci

Thank You

ありがとう

Спасибо

Obrigado

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