Time Series AI for Anomaly Detection and Diagnosis

AI-driven plant performance & visibility

Crick Waters
SVP Enterprise
falkonry

Abstract

Artificial Intelligence (AI) and Machine Learning (ML) techniques have been used to solve complex manufacturing operations problems. Applying ML and AI to anomaly detection and diagnosis at scale, however, has been a significant challenge. This paper discusses how Falkonry's Time Series AI platform leverages ML/AI for automated detection and diagnosis of equipment in steelmaking, detecting precursor conditions to critical equipment failures 3-10 weeks in advance of breakdowns. This methodology is scalable across use cases without the need for data scientists. Precedent detection of novel equipment conditions provides insight into maintenance operations that would otherwise have been missed. Such insights lead to proactive maintenance interventions, thus avoiding loss of production due to unexpected downtime events.

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Artificial Intelligence (AI) and Machine Learning (ML) techniques have been used to solve complex manufacturing operations problems. Applying ML and AI to anomaly detection and diagnosis at scale, however, has been a significant challenge. This paper discusses how Falkonry's Time Series AI platform leverages ML/AI for automated detection and diagnosis of equipment in steelmaking, detecting precursor conditions to critical equipment failures 3-10 weeks in advance of breakdowns. This methodology is scalable across use cases without the need for data scientists. Precedent detection of novel equipment conditions provides insight into maintenance operations that would otherwise have been missed. Such insights lead to proactive maintenance interventions, thus avoiding loss of production due to unexpected downtime events.

Falkonry serves Industrials, Defense, Pharmaceuticals, more

Industrials

Defense

Pharmaceuticals

Ternium

HESS

NLMK

NAS

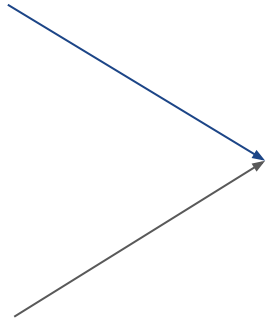
ArcelorMittal

teva

Metals Manufacturing Challenge

60% of downtime is unplanned

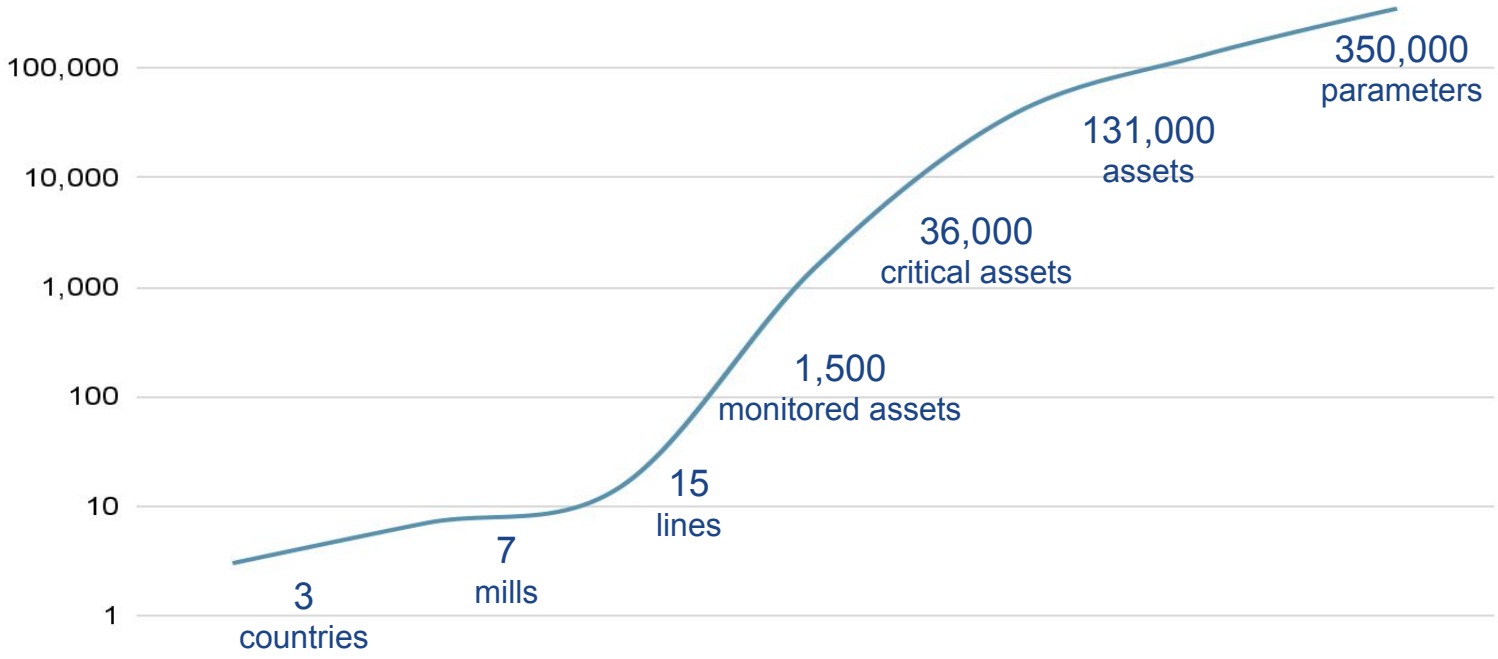
60-70% of malfunctions are due to improper maintenance



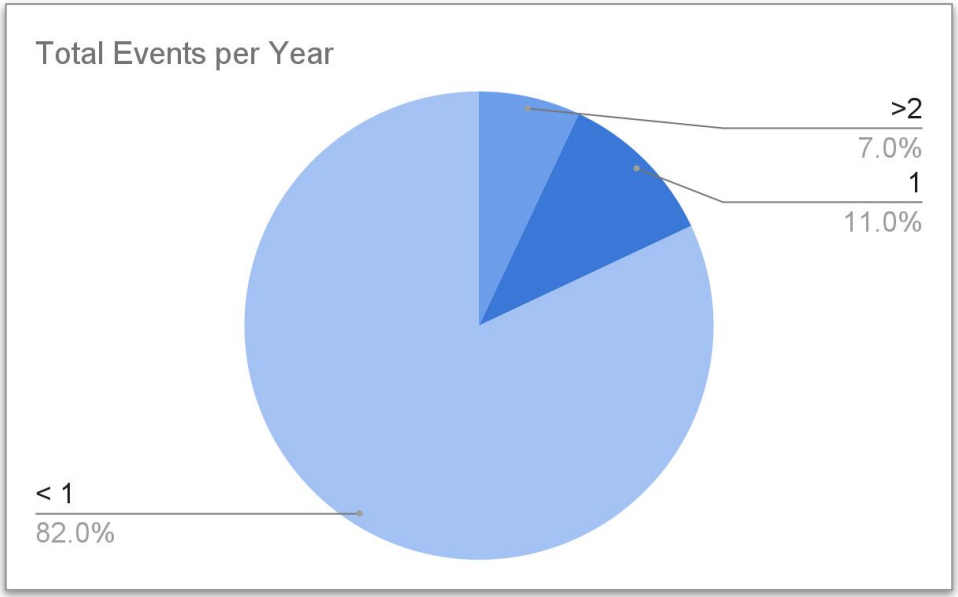
$500,000 per day
(average loss from unscheduled downtime)

Knowing When and What needs attention - an exponential problem

A typical steel manufacturer might have:



Scarcity Exacerbates this High-Value, High-Complexity Problem



Time Series AI Platform

Automated Time Series AI

Guided Time Series AI

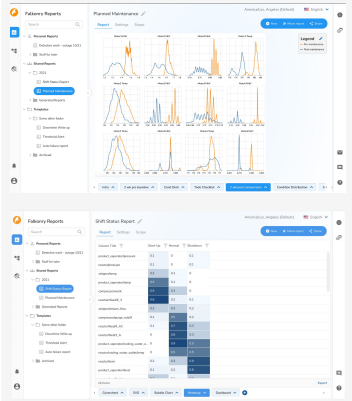
Applications

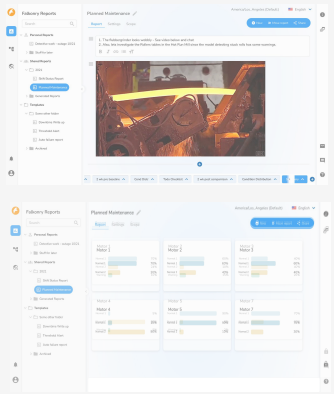
IoT Sensor

Process Control

SCADA

Manufacturing Execution System





Digital Analyst

Engineers

Operations

Public Cloud

Private Cloud

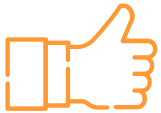
Air Gap

Edge

Falkonry makes the *physical* world's information accessible and useful

FINDS IMPORTANT EVENTS

We focus human attention on important signals in fast moving and noisy data



WORKS FOR END-USERS

We do not need data scientists or data engineers

RECOGNIZED & RESPECTED

Forbes AI50 TOP AI FIRMS TO WATCH 2021

Highest private AI company recognition

AFWERX

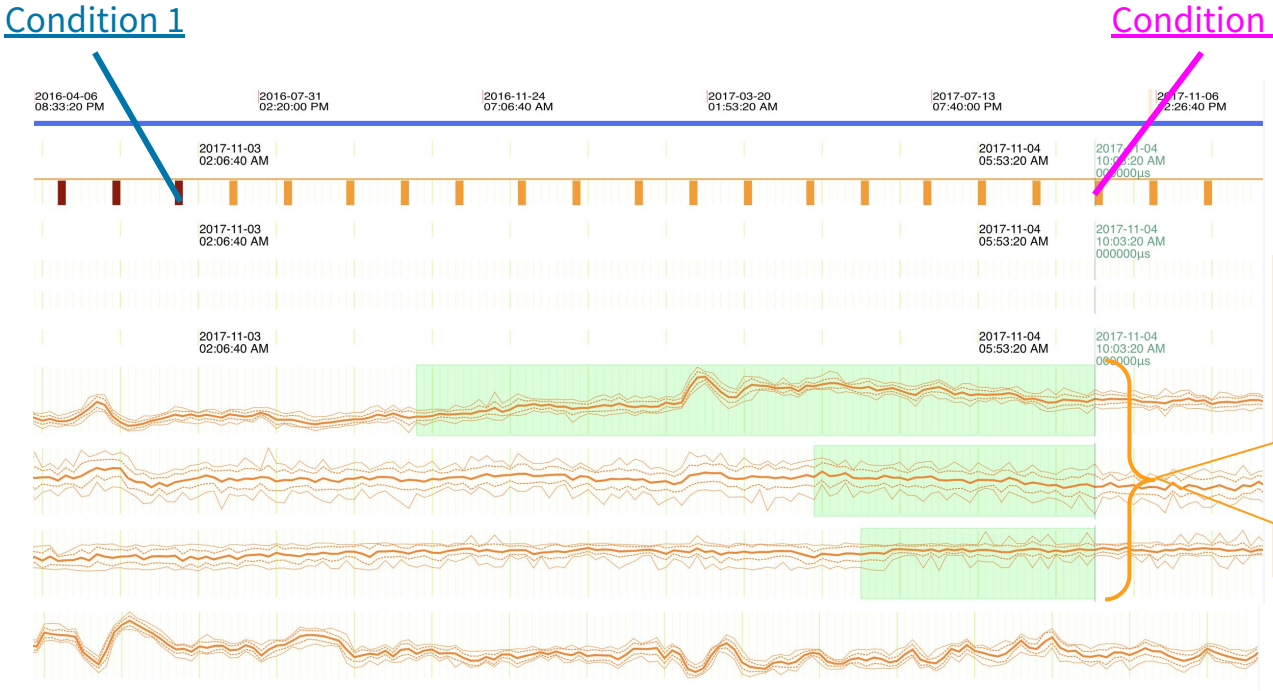
First large-scale strategic sensor DoD AI capability

AI 100 CBINSIGHTS 2020

Selected from 5,000 companies globally

21 Patents issued and pending globally

Time series AI: Mining & organizing multivariate, temporal patterns



Pattern:

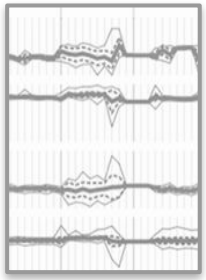
- Uniqueness
- Important parameters
- Relative weights
- History duration
- Shapes or waveforms

AI automatically discovers and distinguishes between conditions

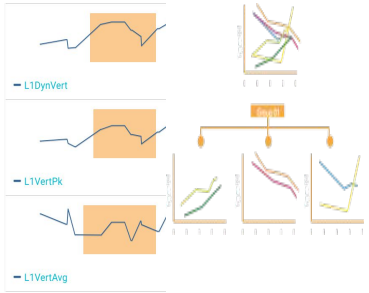
Without requiring data scientists or data engineers

Analysis pipeline inside an ML application

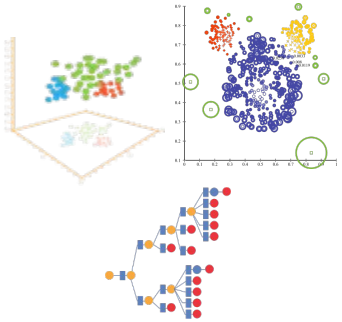
Multi-source Operational Data



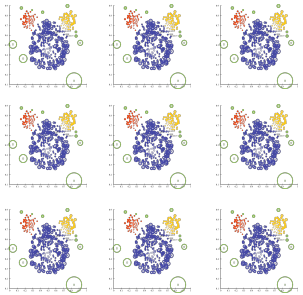
Automated Feature Extraction



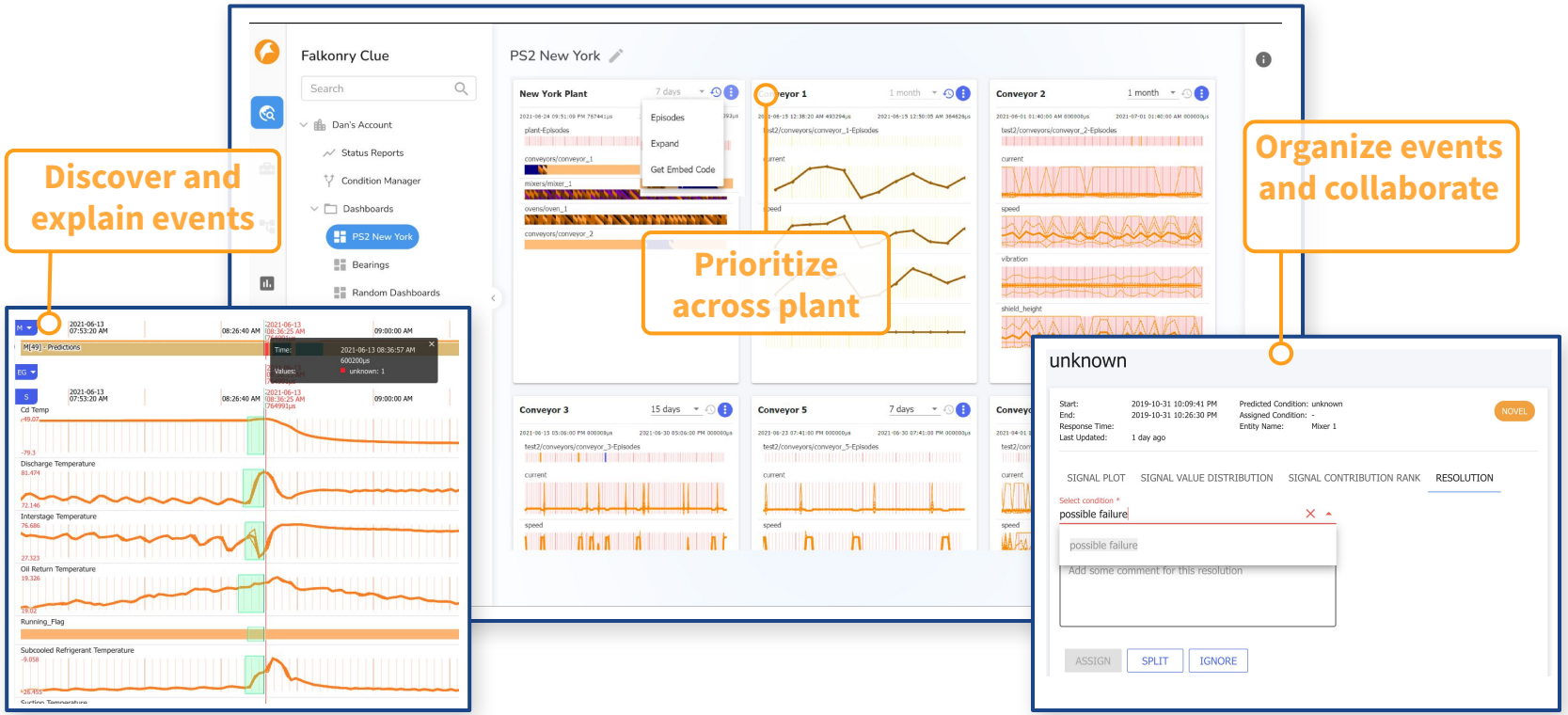
Condition Detection



Root Cause Explanation



Enable smarter decisions with AI on time series data



Time Series AI Application Suite & Platform

Application Suite

WORKBENCH
For targeted conditions

CLUE
Multivariate pattern detection

INSIGHT
Univariate anomaly detection

Approach

Look for specific conditions you know you need to act on.

Automatically identify patterns worth investigating that may lead to failure

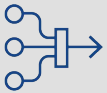
Explore, organize, and analyze all signals & anomalies.

User Roles

Digital/Reliability Engineer

Analyst

Time Series AI Platform


OT Data Pipeline


Time Series Database

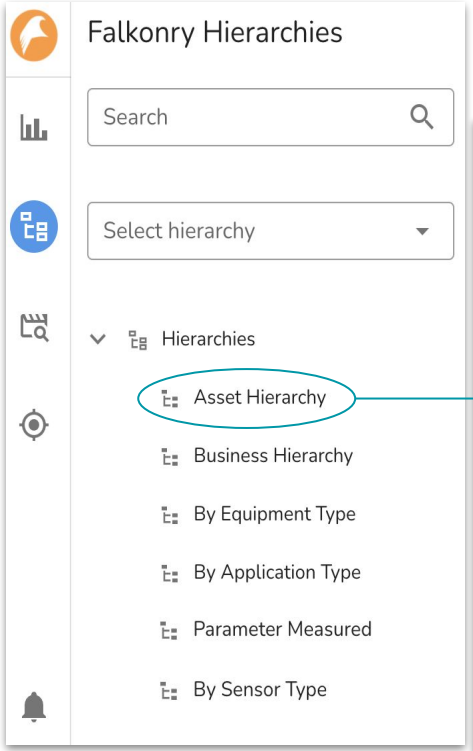

Signal Manager

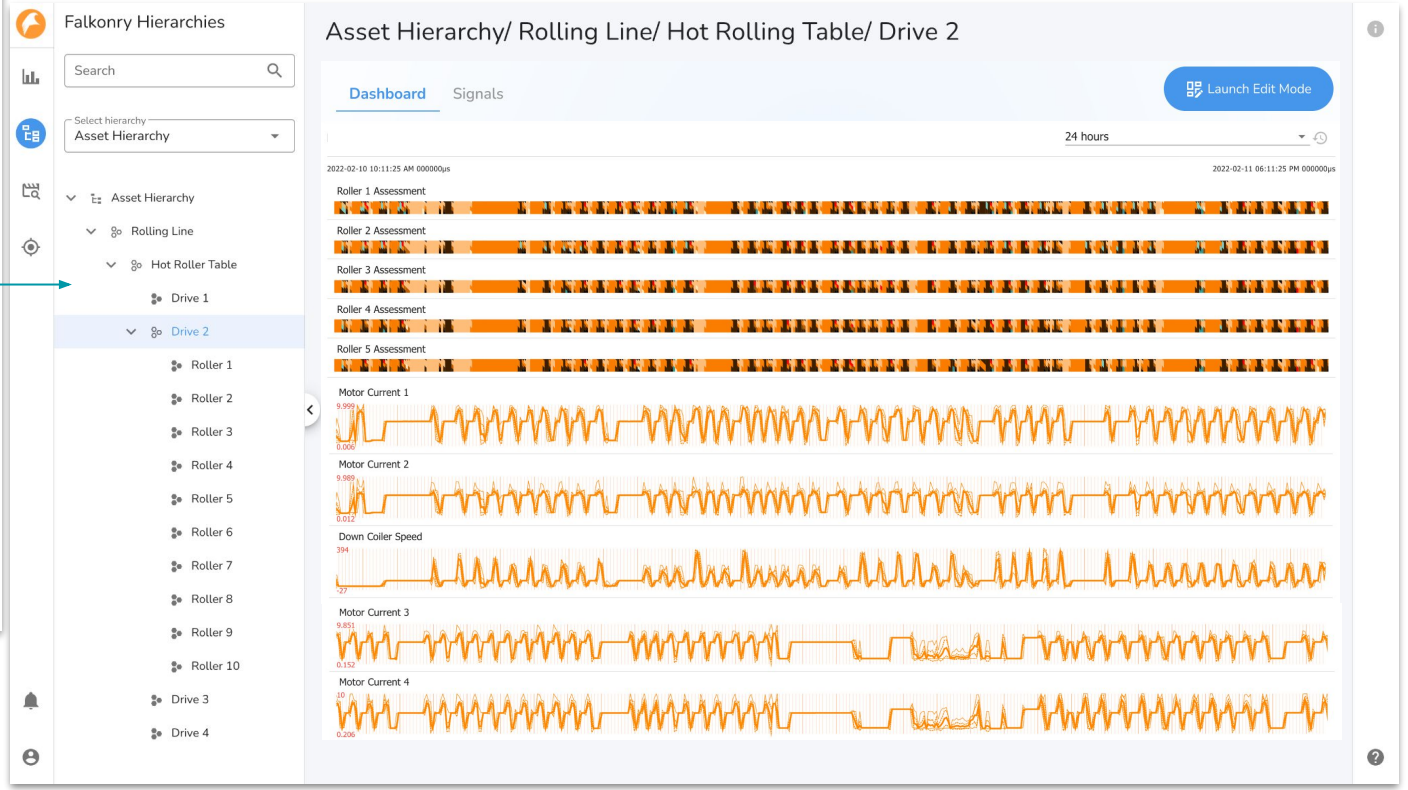

Case Reports


EAM/ CMMS Integration

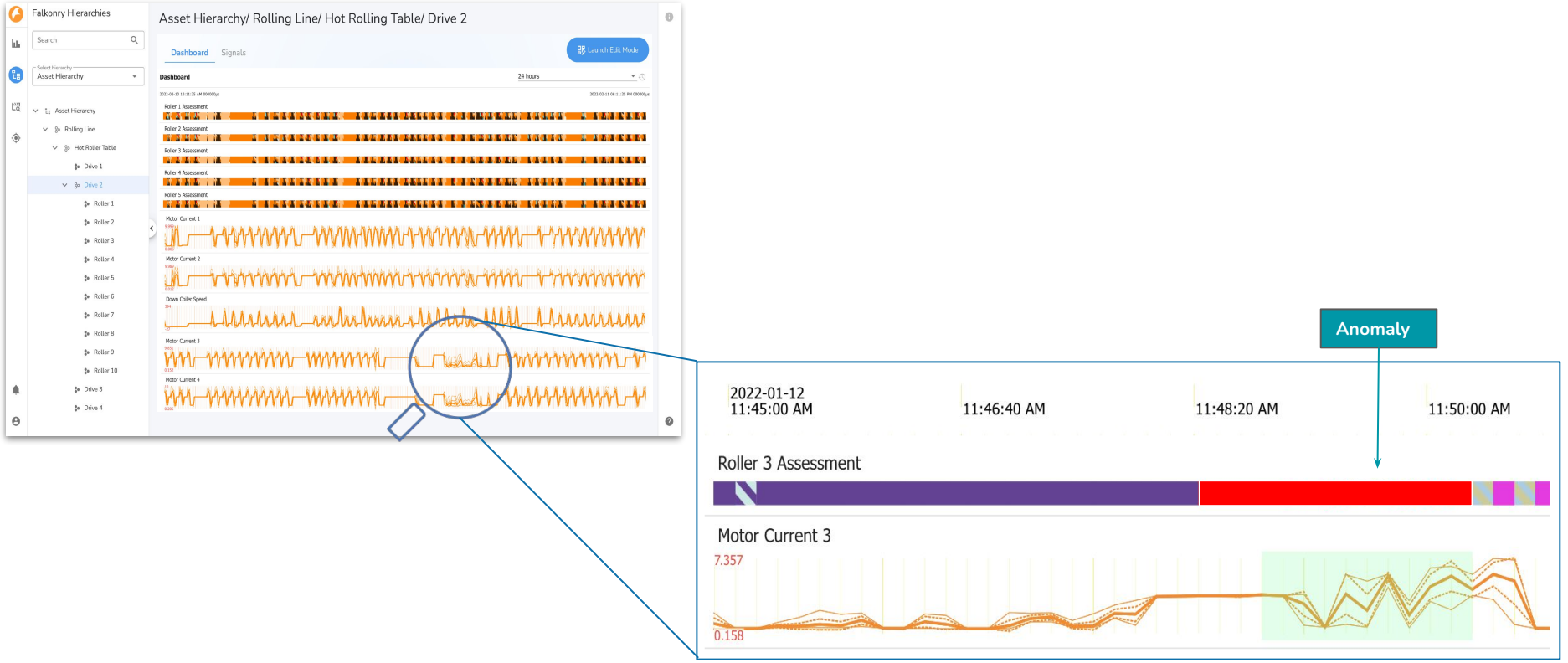

Decision Knowledge Capture & Search

Explore plant-scale data using Hierarchies

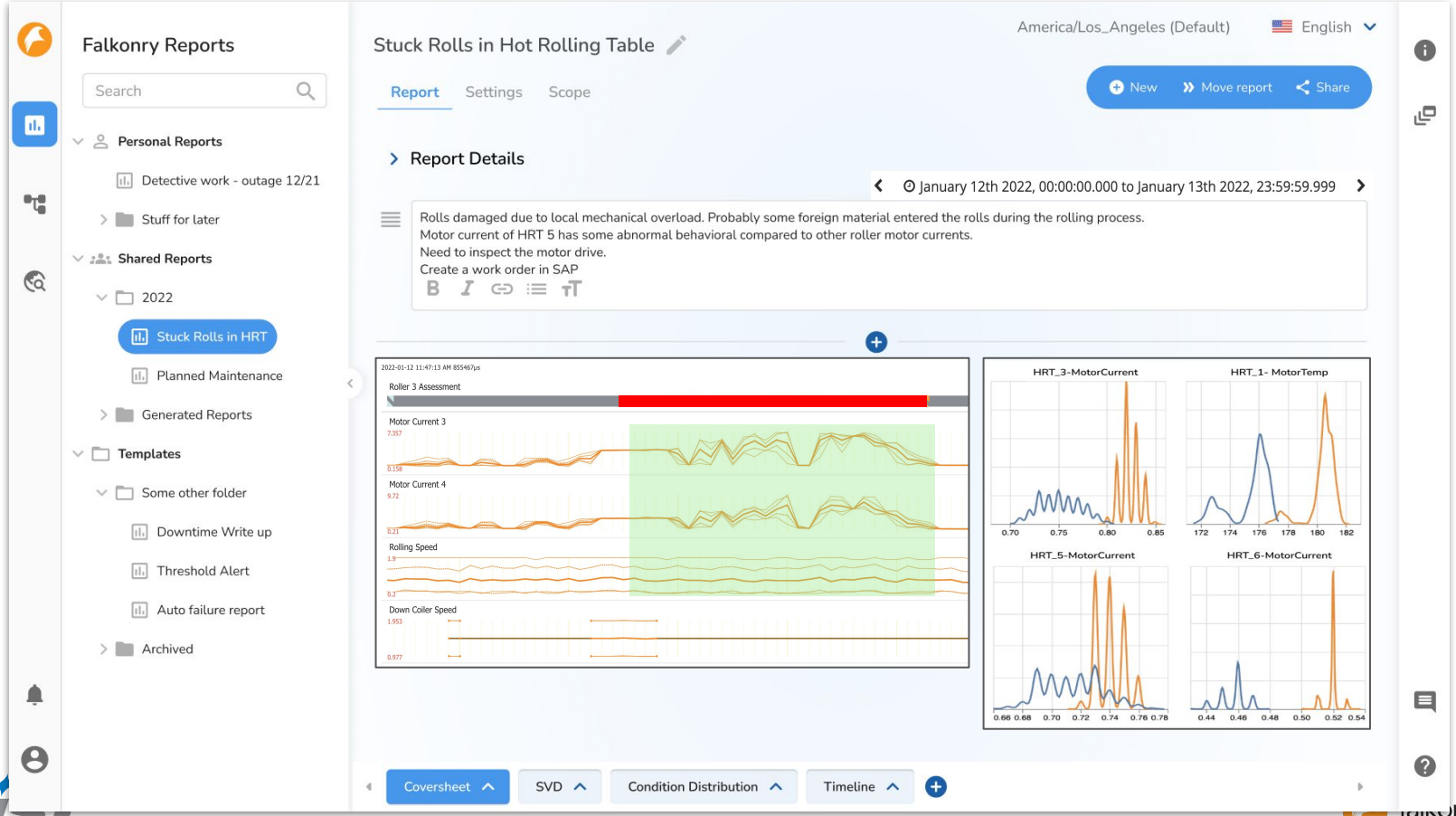




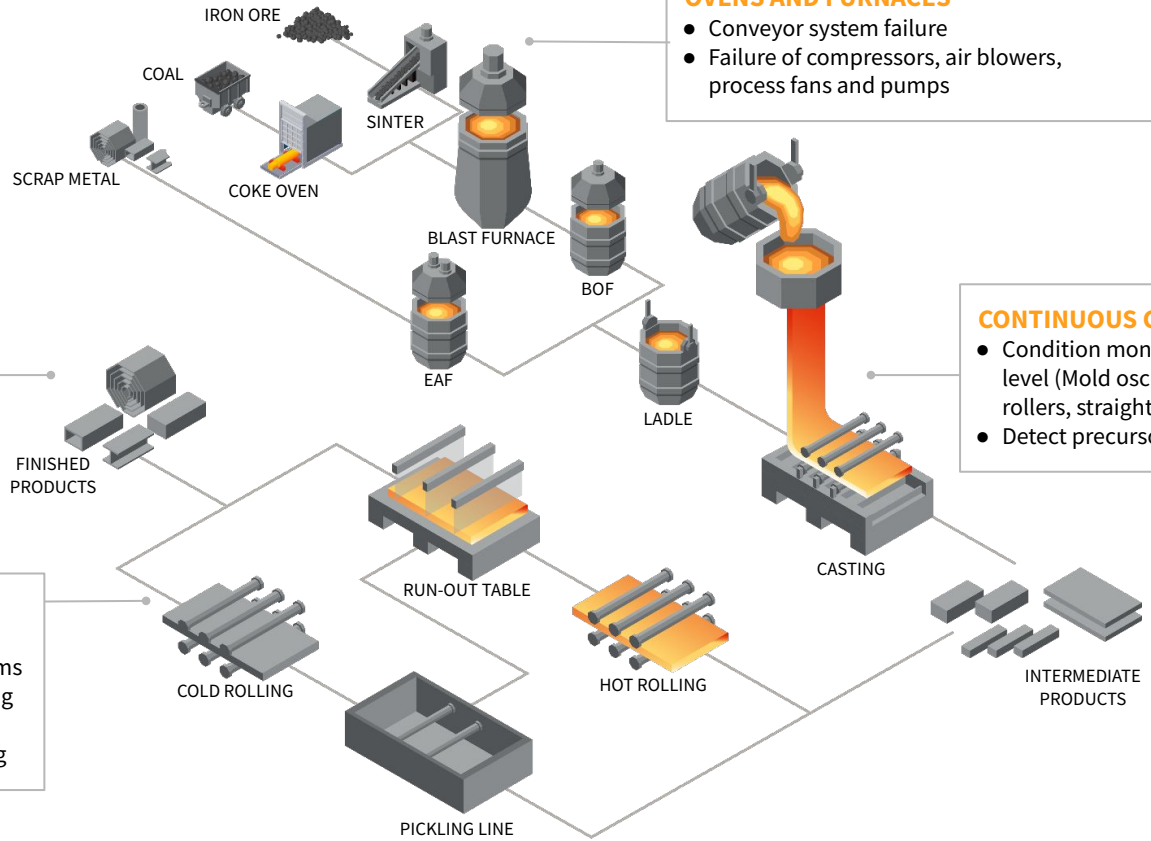
Automatic detection of anomalies in the now



Create a detailed report for diagnosis and RCAs



Sample of monitored assets



OVENS AND FURNACES
- Conveyor system failure
- Failure of compressors, air blowers, process fans and pumps

FINAL GOODS HANDLING
- Predictive Maintenance of coil carrying cars and laminators

CONTINUOUS CASTER
- Condition monitoring at component level (Mold oscillator, segment and pinch rollers, straighteners, shears)
- Detect precursor to failures

ROLLING MILLS
- Detect motor and bearing failures
- Monitor hydraulic and lubrication systems
- Component-level monitoring of roughing mills, tandem mills & finishing mills
- Strip break classification in strip welding

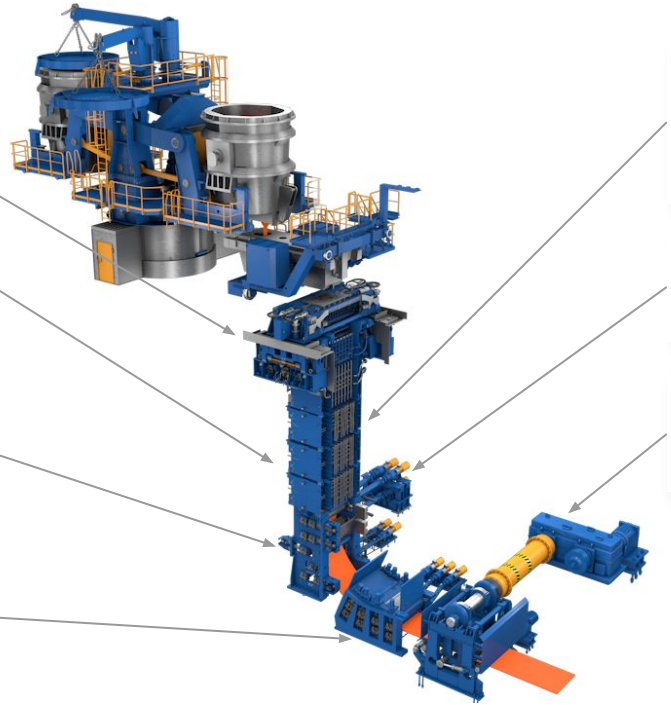
Time series AI in continuous casting

Mold Oscillator
Warning of oscillator failure

Bending Rolls
Predicted bending roll failures

Dummy Bar
Predict dummy bar misalignment and disengagement failures

Straightener
Provide early warning of stuck rollers

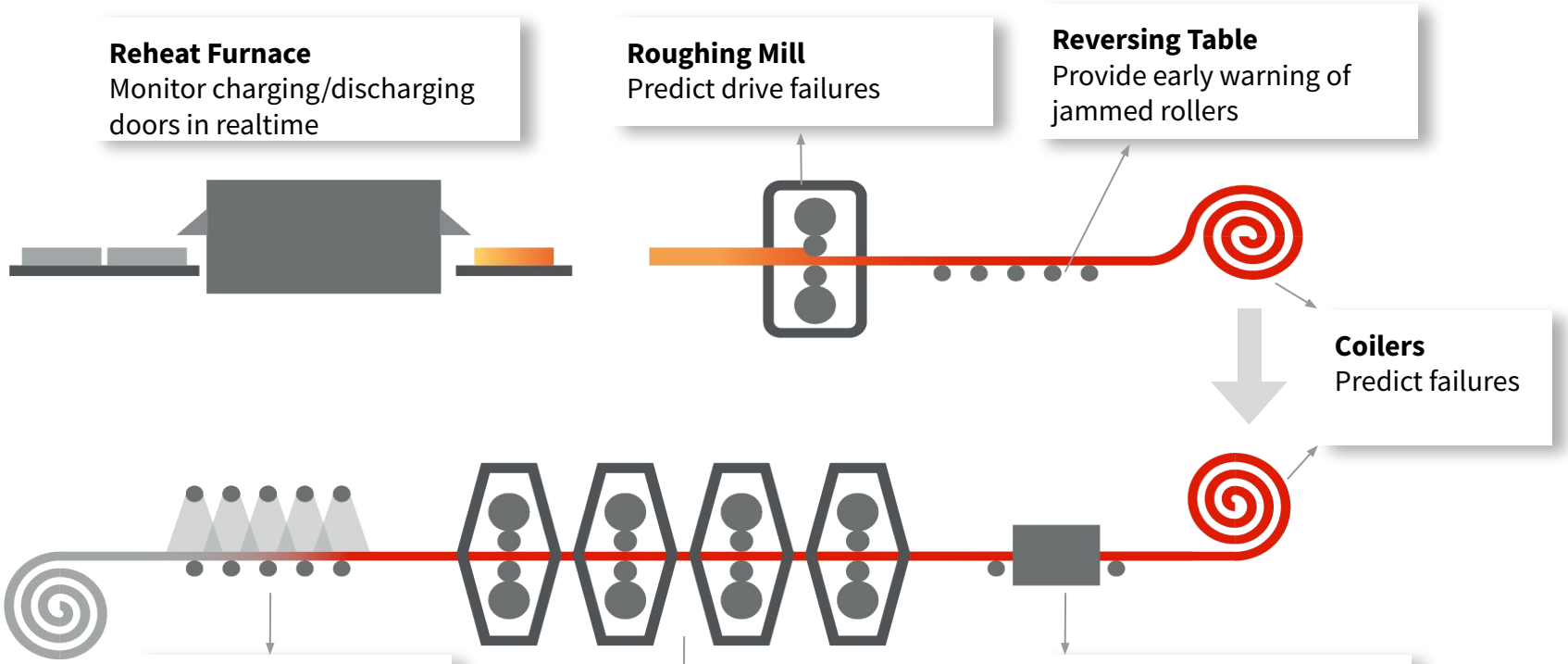


Segment Rollers
Failures, misalignments and high stress

Pinch Rollers
Predict failures

Shears
Predict failures

Time series AI in hot rolling mills



Time Series AI in Hot Run Table (HRT)

Situation: HRT or cooling table, driven by hundreds of rollers, moves steel plates and strips from one point to another in the mill. Unidentified motor failure or jammed rollers causes surface defects on steel plate / strip

Challenge(s):

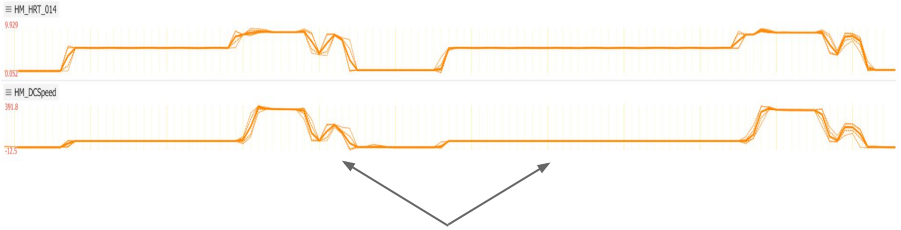
- Univariate signal for each motor: motor current.
- Limited available information and data precision for the classification engine.
- Varying widths and grades

Workflow

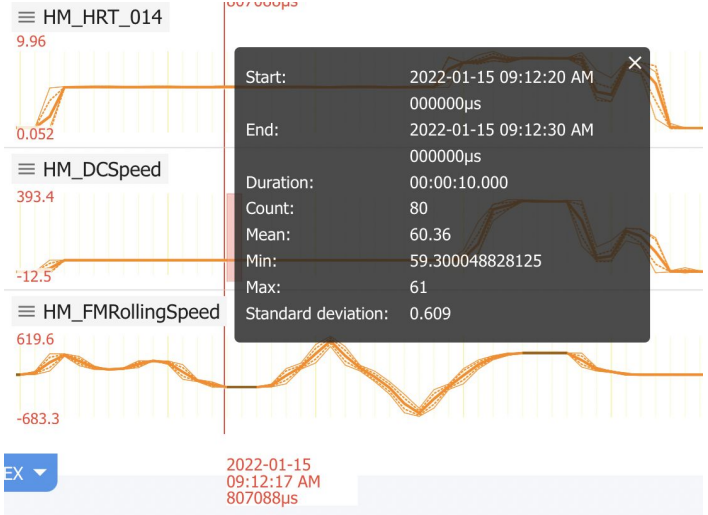
1. Identify available signals
2. Establish a stream of real time data to the time series AI platform
3. Let the AI observe asset operation over a period of time
4. Observe that the AI “learns” the expected patterns of operation
5. Compare detected operating anomalies and observed equipment failure events
6. Explanation and Resolution
7. Monitor for anomalous events

Available signals and Data stream visualization

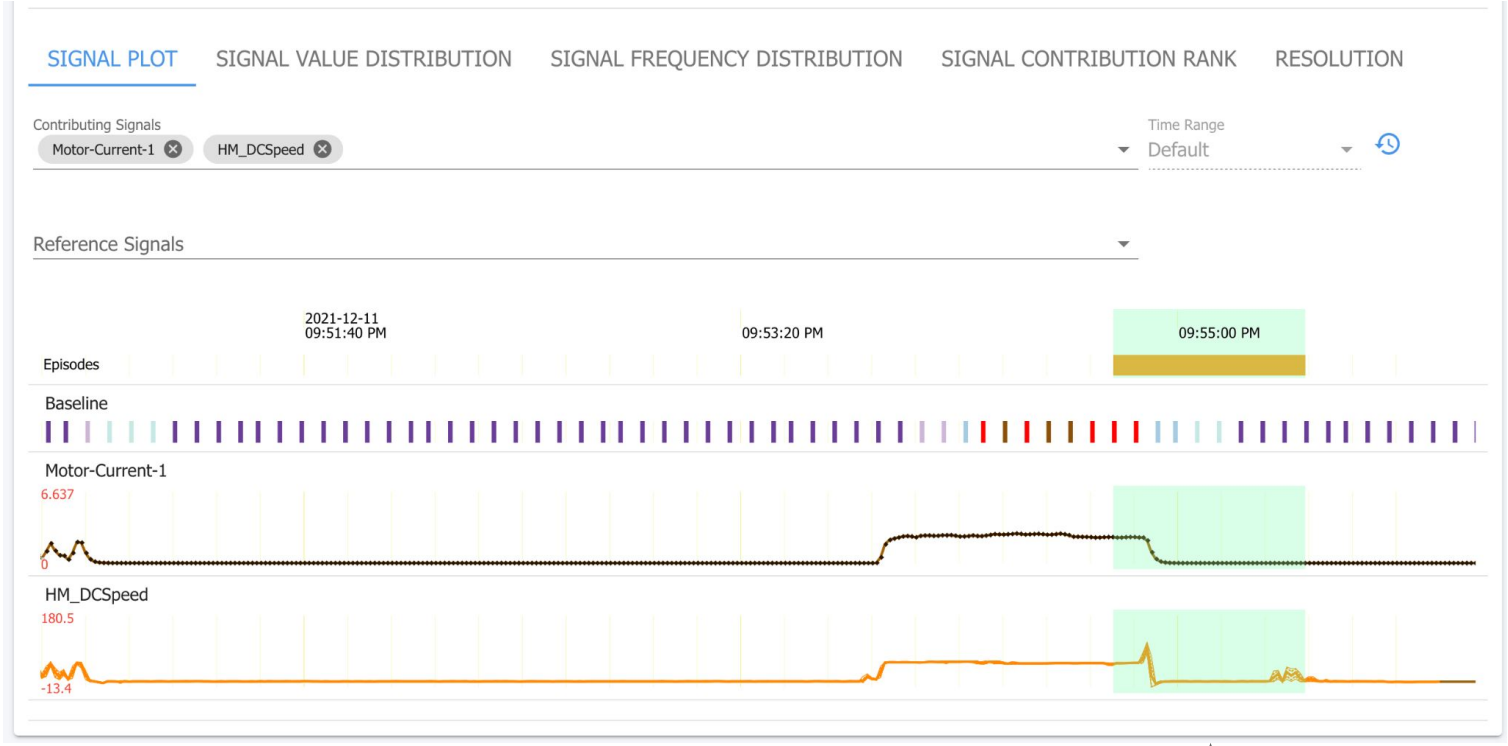
Parameter	Sampling Rate
Motor current	1 second
Electric drive speed	100 ms, sample and hold



Two plates passing an HRT motor



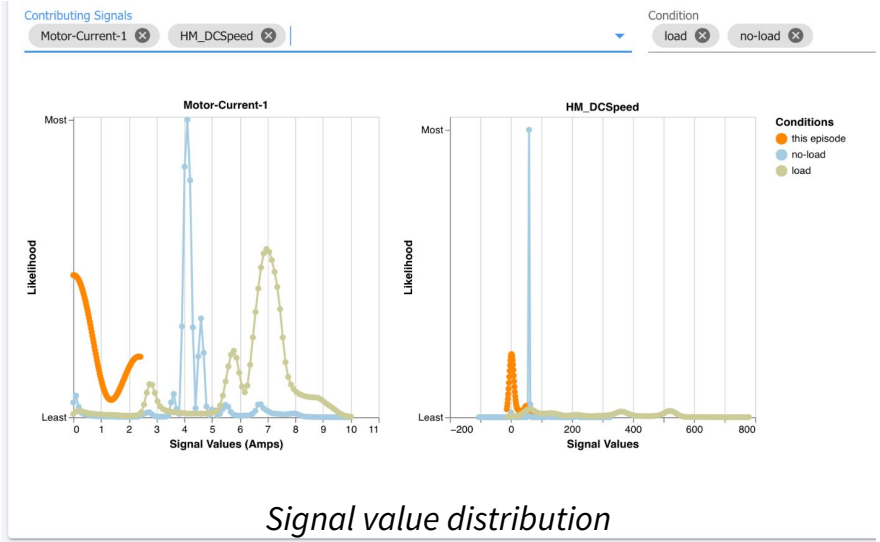
Anomaly detection



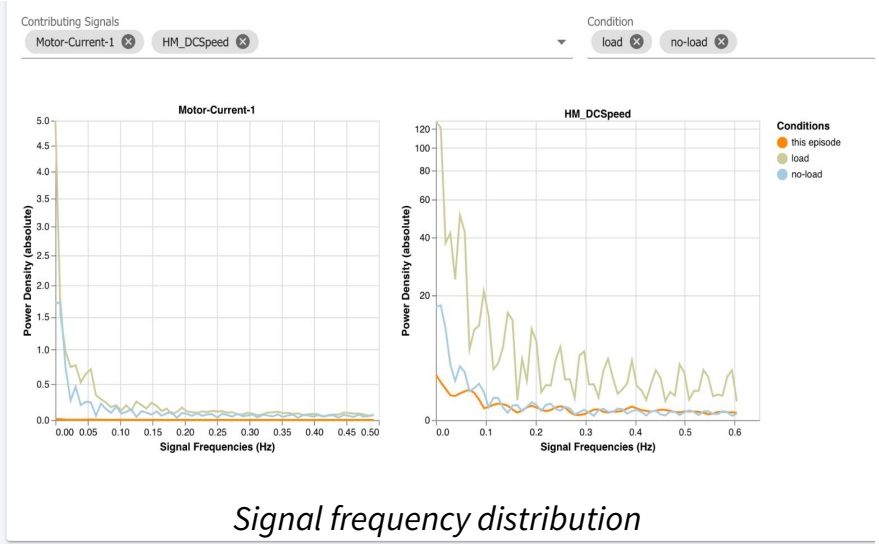
Novel event

Explanations and root cause analysis

Compare the novel event with ‘known’ operating conditions



Signal value distribution



Signal frequency distribution

One Motor is Not Enough

Only a single unique signal per motor: current

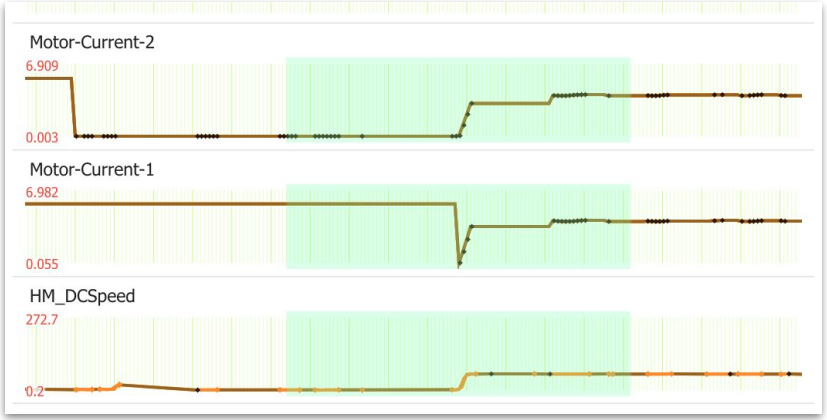
Only other signal is “shared”: downcoiler speed

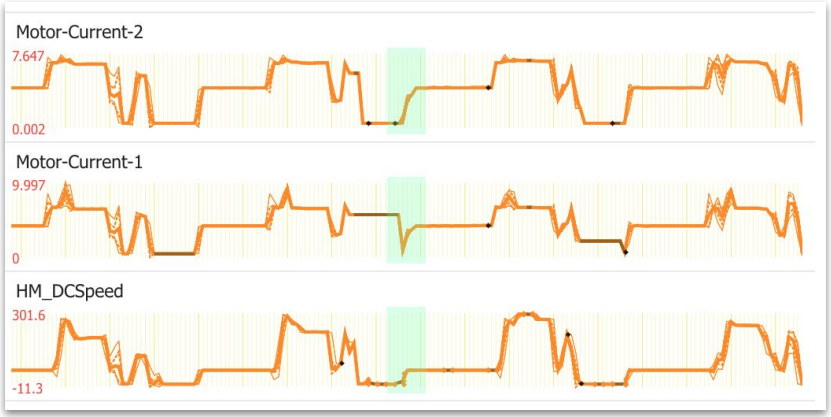
Motors are mechanically coupled

Slab and coil mass and rigidity mechanically couple adjacent rollers

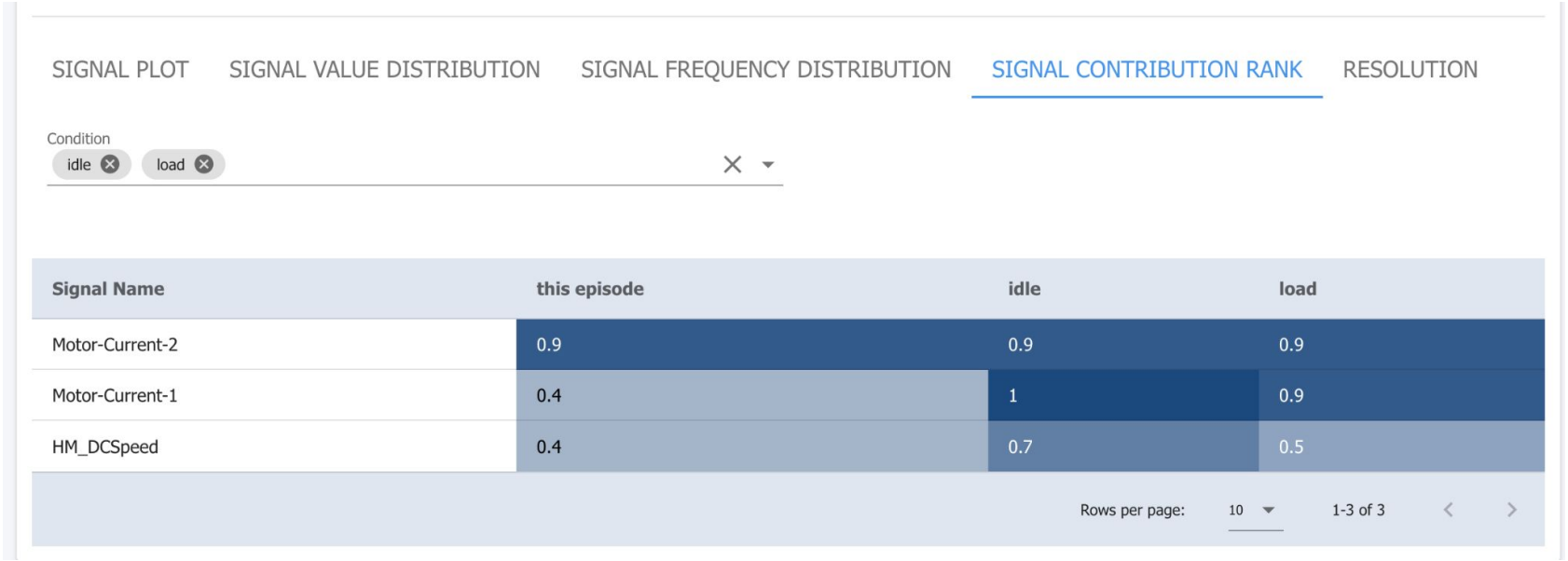
Motor current waveforms are influenced by adjacent motors

Bi-motor analysis signal plots



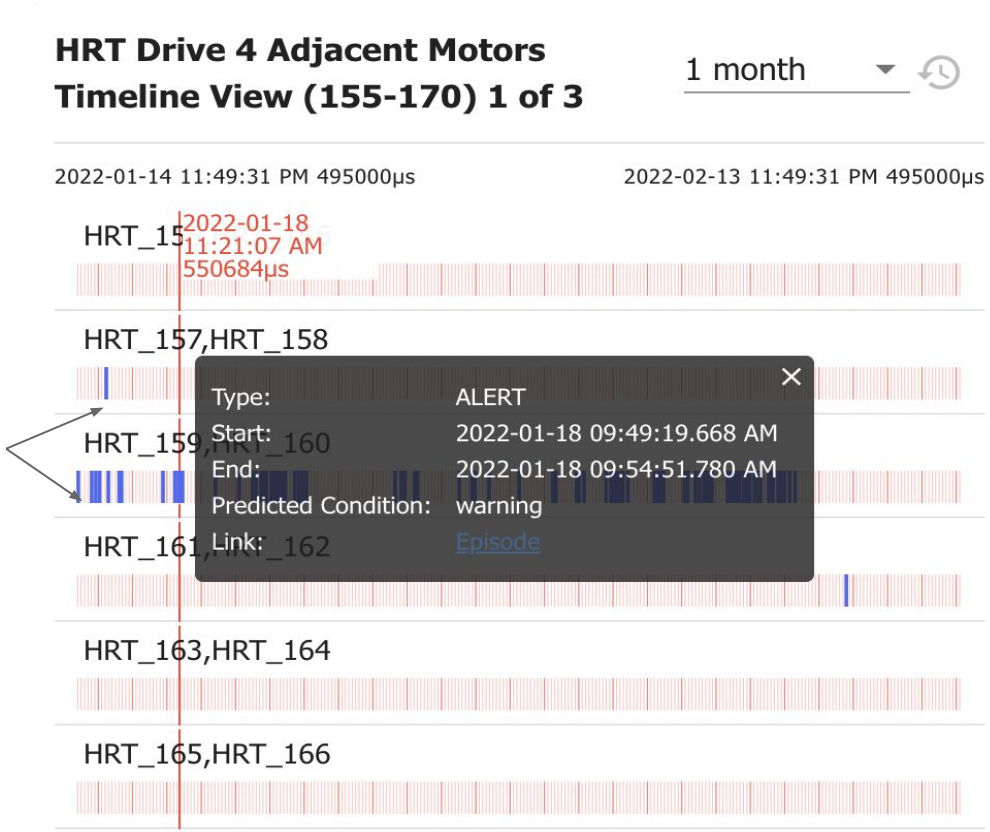


Signal Contribution Rank of an HRT novel event



Learn and Monitor for subsequent anomalies

Known warning conditions



Application and parameters used

Process	Equipment Type	Application	Parameters Available	Parameters Used by the AI	Digital Twin Development Time	Detection to Failure Interval
Finishing Mill	Hot Rolling Table Motors	• Detect motor events: decoupling, trip, stuck	200 (total across rollers)	189	4 live twins, 4-6 weeks, 11-49 iterations	60+ days, 25-8 hours, ~20 minutes (depending on failure mode)
	Steckel Mill	• Detect abnormal operations (e.g. high vibration) • Detect misalignment/ position deviation	38	10	3 weeks	
	Entry Steckel	• Detect abnormal operation (temperature spikes, improper slotting)	30	4	13 iterations, 3 weeks	
	Delivery steckel		30	4		

Hot Run Table Time Series AI Performance

HRT: Electric Drive 4

Time range: Last 3 months

18	17	6	11
Total Events	Detected Events	Events With Named Alerts	Events Without Named Alerts

20	24
Named Alerts with No Event	Novel Alerts

38.6 minutes

Average Lead Time To Warning

Total Events : Total number of events experienced in a given time range

Detected Events : Out of total events how many did Falkonry Clue detect?

Events with Named Alerts : Count of events with forewarnings

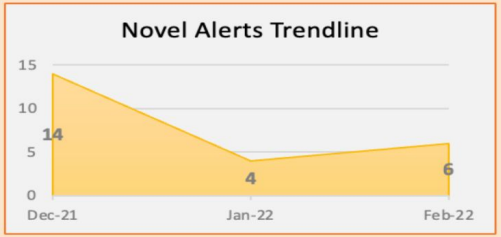
Events without Named Alerts : Count of events detected without forewarnings

Named Alerts with No Event : Alerts with no associated events but action may have been taken

Novel Alerts : Alerts associated with new/unique conditions detected

Executive Summary:

- 94.44% of total events were detected by Falkonry Clue.
- 35% of detected events were alerted by Falkonry and 65% of detected events were not alerted.
- Warning patterns detected for Motor 160 (ED4) with average lead time of ~70 days and 368 alerts. Due to this insight, it was discovered that an incorrect motor had been installed.
- Range of forewarning lead time is from 5 min to 154 min.

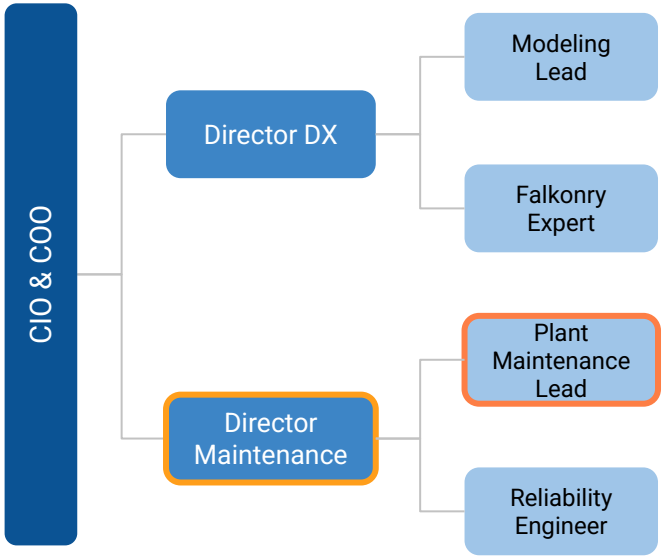


Maintenance Teams are Empowered

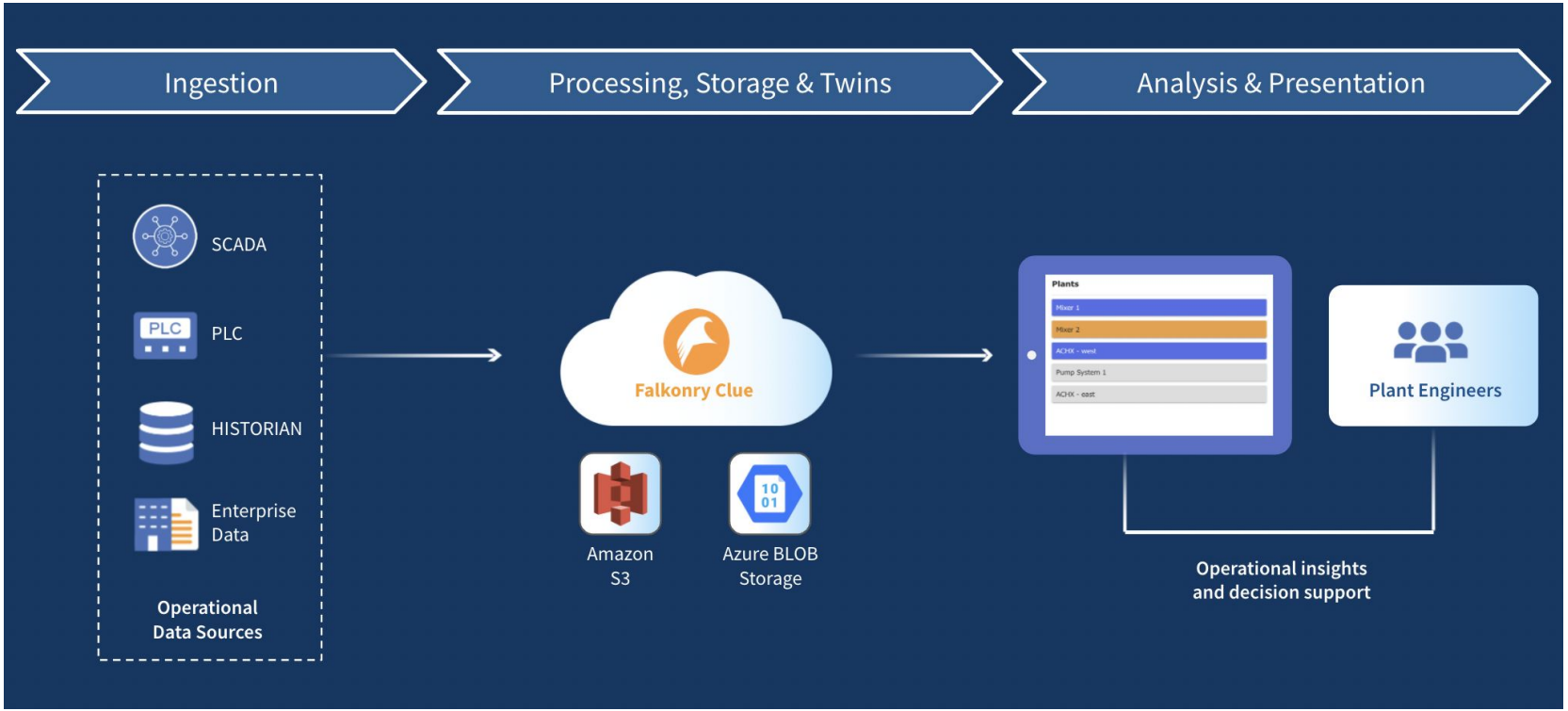
Notification of discovered events everywhere the software finds them.

Explanation of anomalies.

Diagnostic tools to determine what actions to take.

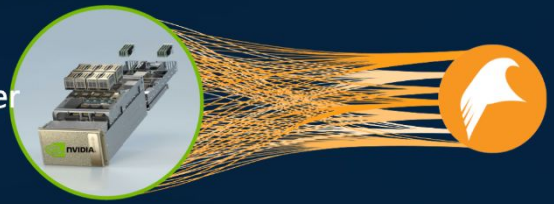


Solution deployment architecture



FALKONRY + NVIDIA ACCELERATES AI

NVIDIA's DGX and Falkonry's Time Series AI provides higher speed, at scale



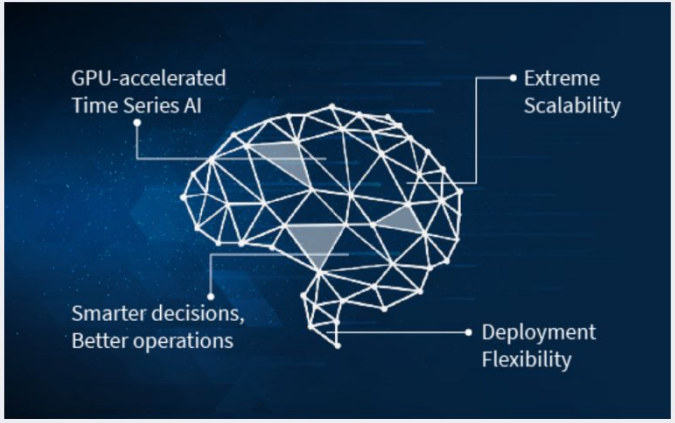
REQUEST A DEMO

NVIDIA. | falkonry

AI for defense and industrial operations has been constrained by 2 factors: speed & scale. Falkonry's focus on ease of use and AI automation, combined with NVIDIA's expertise in parallel computation, has changed the game. Falkonry's AI, supported by **NVIDIA's Triton inference server and DGX architecture**, applies the computational power of GPUs to provide real-time insights against trillions of high-speed data points.

This breakthrough in AI scaling makes possible information dominance in defense and real-time AI at plant-scale for large industrial verticals such as metals manufacturing — all as a complete time-series AI "platform-in-a-box" for on-site, in-the-field, deployment.

NVIDIA DGX™ A100 is the universal system for all AI workloads, offering unprecedented compute density, performance, and flexibility in the world's first 5 petaFLOPS AI system. NVIDIA DGX A100 features the world's most advanced accelerator, the NVIDIA A100 Tensor Core GPU, enabling enterprises to consolidate training, inference, and analytics into a unified, easy-to-deploy AI infrastructure that includes direct access to NVIDIA AI experts.



Conclusions

- **Automated unsupervised learning** is the suggested method when dealing with **huge amounts of data** and can deliver alerts of “novel” conditions as they emerge in operating equipment

- The time series AI platform becomes enhanced with the ability to recognize **emergence of named conditions as well as unknown and ‘novel’ conditions**

- **Real-tim**e pattern recognition enables **early detection** of novel conditions, resulting in proactive maintenance interventions before substantial production losses are incurred

- The flexibility of an automated multivariate pattern recognition approach to machine learning enables **deployment at scale**, across processes and lines without the need for specialized operational or data science knowledge.

Crick Waters
SVP Industrials

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Thank you

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