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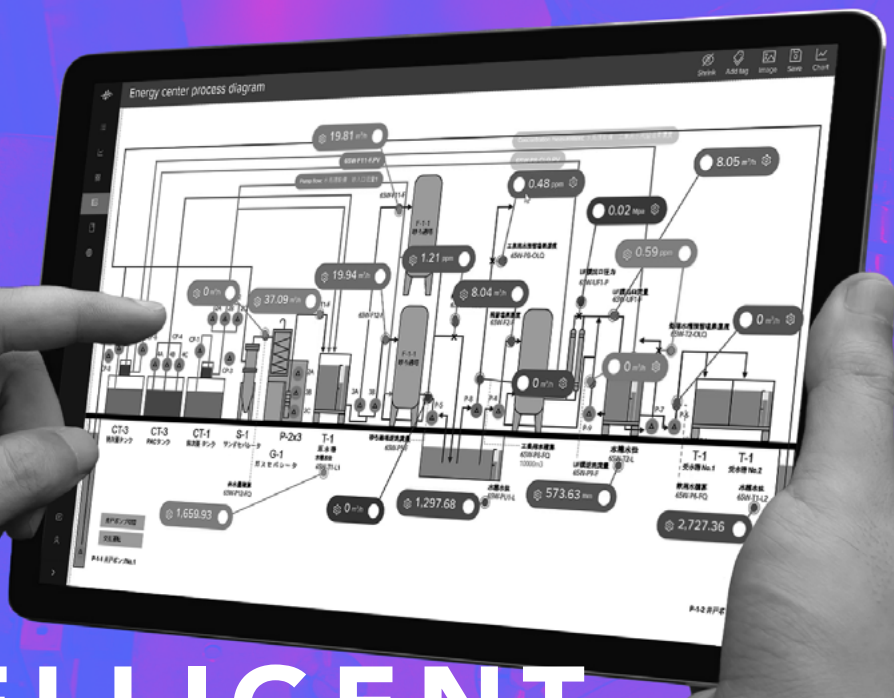

INTELLIGENT FACTORIES:

THE DATA-DRIVEN FUTURE OF THE MANUFACTURING INDUSTRY

CONTENT

5 Introduction

5 Key Drivers For The Digitalization Of The Global Manufacturing Industry

8 Accessible Data

9 Cognite Data Fusion (CDF)

11 Cognite in Action

INTRODUCTION

We believe data, algorithms, and software should power industry, freeing human creativity to shape a profitable, safe, and sustainable future. Today, heavy-asset industries like oil and gas, manufacturing, shipping, and power have reached a digitalization tipping point. Increasing access to data has made data handling a key differentiator.

Competitiveness in the digital industrial future will equate to data deftness. Companies must put their data to work. Must adopt software solutions to solve traditional pain points and answer the needs of their workforce. Quickly, creatively, progressively. The companies who seize the mantle as digital frontrunners will have the greatest influence over their respective fields.

Cognite helps manufacturing companies reach that future and capture value along the way with technological solutions such as **Cognite Data Fusion (CDF)**, a software package that supplies contextualized data as a service (CDaaS); **services** that enable real-time data access, condition monitoring, and machine learning hosting; and **applications** such as Asset Data Insight and Operation Support, which make data available and accessible to users.

This paper explains how.

KEY DRIVERS FOR THE DIGITALIZATION OF THE GLOBAL MANUFACTURING INDUSTRY

Manufacturing companies face an uncertain business environment filled with trade conflicts, fluctuating raw material costs, and evolving consumer demands. This uncertainty is driving business leaders to look inward, where investments in information and operational technologies could bolster their bottom lines. In 2019, 81% of industrial manufacturing CEOs claimed they will rely on operational efficiencies to bolster competitiveness and growth, PwC reports.[1]

Intelligent, interconnected, and automated factories allow manufacturers to scale and adapt capabilities as they seize new opportunities and respond to changing demands. In this way, new digital technologies deliver tangible solutions for manufacturers facing unpredictable market realities. "Accelerated technology innovation in recent years opens opportunities for extraordinary product and process innovation," according to Gartner. "Manufacturers [must] identify opportunities to use these tools to jump ahead of competitors and accelerate digitalization.[2]"

Now, manufacturers are pursuing next-generation digital tools -- including artificial intelligence

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(AI), Internet of Things (IoT) sensors, and digital twins -- that are changing competitive dynamics in their fields. They will look to optimize the way information technology (IT) and operational technology (OT) investments work together to produce business value. Connected technologies will strengthen the links between OEMs and other segments of their supply chains -- including end customers -- as well.

Digitalization Trends and Opportunities in Manufacturing

"The future of manufacturing connects factories that synchronize processes, data and human ingenuity with customer value." [3]

Modern manufacturing is about realizing possibilities through technology -- and while half of manufacturers are piloting or implementing new technology investments, roughly one-third are still "knowledge gathering, investigating, and developing their strategies," Gartner reports. [4]

But few companies can afford to wait on business-critical investments if they want to remain competitive. Modernizing production systems is critical as digital technologies reshape the manufacturing sector and drive game-changing performance improvements among early adopters.

Cognite took a closer look at the key technologies behind digitalization in manufacturing today. We discovered not only how these technologies transform manufacturing, but how they fit into a workforce management model that future-proofs manufacturing environments and drives long-term business value as well.

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Internet of Things (IoT) Sensors: Connecting IT and OT Infrastructure

IoT technologies are proliferating among manufacturers as real-time dataflow and analysis revolutionize productivity, ROI, and preventative maintenance. Nearly 70% of manufacturers credit IoT with profit growth; manufacturers will have invested $267 billion in IoT technologies by 2020, Forbes reports. [5]

IoT will only grow in its importance as it converges with AI and other cognitive systems, "improving performance transparency and access to real-time information through more user-friendly visualization for operators and managers," as McKinsey describes. [6] Use of IoT will continue to expand in the 2020s as manufacturers find more operational applications, effectively spanning the gap between their IT and OT investments.

Artificial Intelligence: Boosting Value, Productivity, and Cost Savings

Thinking machines are rapidly evolving, allowing manufacturers and their partners to build, train, and test neural networks with applications across verticals and departments. Analysts at McKinsey believe that manufacturers that implement AI now can expect a 122% increase in cash flow over the next five to seven years -- companies that do not can expect only 10% growth.

Predictive analytics is perhaps one of the most critical AI applications in manufacturing. Intelligent predictive models allow manufacturers to consistently prevent the downtime once common to the industry -- where a single hour of downtime can equate to $100,000 in losses in a manufacturing environment, according to Forbes: "Using data, AI, and predictive analytics, some say manufacturers can reduce planned outages by 50%."

But AI has dozens of operational applications as well. German manufacturer Bosch uses automated tools to support workers managing its internal operations -- from procurement to shipment logistics. They anticipated €1 billion (US$1.13 billion) in cost savings from this effort by 2020, PwC reports. The application of machine learning to manual and mechanical processes dramatically reduces the need for human intervention, boosting productivity and freeing human workers to add value in other ways. Manufacturers will find even more applications for AI as it enhances capabilities within other digital systems.

Digital Twin: Visualizing OT Possibilities in Strategic and Scalable Ways

While creating digital models to simulate real-world machinery is not a new concept, the "digital twin" is a practical approach of this kind for a new Industrial Age. "Digital twins allow the creation of digital models marrying physical and digital data to provide a better understanding of an object's performance or to provide a better end-user experience," Forrester writes. [7]

Thanks to IoT sensors, manufacturers can leverage real-world data in near real-time to plan and anticipate future applications and events with their machinery. They needn't disrupt physical processes when experimenting, either

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-- digital twins allow manufacturers to optimize OT environments with minimal risk, cost, and equipment downtime, even for transformative changes.

Optimizing the Digital Workforce

McKinsey estimates that between $1.2 and $3.7 trillion in global productivity gains are "up for grabs" in the manufacturing sector by 2025. Manufacturers who stay ahead of the curve on evolving digital technologies -- and find applications that add value at scale -- are best equipped to achieve a long-term competitive edge.

But as technologies evolve, workforces must evolve with them. Even though an estimated 60% of today's manufacturing jobs could in theory be automated with available technology, the transition will take decades -- and companies will still need skilled people to manage, maintain, and utilize those digital technologies successfully when those transitions are complete. [8]

At Cognite, we believe digital tools should power industry, freeing human creativity to shape a profitable, safe, and sustainable future. The companies who seize the mantle as digital front-runners will have the greatest influence over their respective fields, but it's the companies who successfully prepare their workforces that will sustain that influence for decades.

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ACCESSIBLE DATA:

The Key to Efficient Digitalization

Today many manufacturing companies are still in the early stages of the data science journey, exploring the troves of data at their disposal and identifying business problems that could become data science use cases.

This is also the stage where the potential of digitalization enters a technical bottleneck. Companies might find that the time to deployment is lengthy and costly. That scalability across assets or equipment is low. And that connecting different sources of data together to create meaningful insight requires many areas of expertise.

These and other challenges are why 80-90% of the time it takes to complete a data science project today isn't actually spent on creating models, but on gathering, cleaning, and contextualizing data.

The lack of access to liberated, usable, and shareable industrial data is a major source of inefficiencies within manufacturing companies, requiring workers to complete time-consuming manual processes to find the information they need to do their jobs. Examples include:

- **Business analysts:** "I want to have all customer data in one place, so that I can avoid wasting time running around to collect it. I also want to be able to export reports, which would free up time that I can spend on other tasks, and get up-to-update critical equipment data so that I can review developments shortly after they are reported."
- **Data scientists:** "I need access to all our data in one place, in context. That way I won't have to gather, clean, and collect data for every new analysis. I also want to be able to quickly visualize my results in a naturally consumable interface to end-users to ensure my advice is acted on."
- **Quality control specialists:** "I want to know when and where quality deviations happen reported in a dashboard, so that I can more effectively determine the cause of and correct for quality issues."
- **Equipment engineers:** "I need to be notified when the data flow has stopped, so that I can investigate if a sensor has failed."
- **Maintenance experts:** "I want to be able to review alarms from all our machines on the factory floor in one place, instead of having to manually pull a local log from each machine. I also want critical machine values flagged and the ones that are not reviewed yet presented on top, so that I do not have to search for it."

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COGNITE DATA FUSION (CDF):

Cognite Data Fusion (CDF) was developed specifically to tackle the technical challenges that original equipment manufacturers (OEMs), engineering, procurement, and construction (EPC) companies and discrete and process-based manufacturers face.

Cognite Data Fusion integrates seamlessly with existing IT and OT infrastructures to liberate a wide variety of industrial data from separate, siloed source systems, collecting it all as a comprehensive set in the cloud, securely and without space limitations. It then automatically structures the sensor data in relation to other relevant data (e.g., process diagrams, 3D models, event data, and more). This contextualization process effectively creates an operational digital twin of an asset or system.

With contextualized data as a service (CDaaS), manufacturing companies no longer need to collect, clean, and contextualize data for every new data science project. This enables companies to scale beyond pilot projects and create solutions that generate real value, from more robust and reliable machine learning applications for optimization and automatization to human-facing applications such as advanced visualizations and apps for the digital factory worker.

By maximizing their own capabilities with data, manufacturing companies can sharpen their competitive edge.

Features

Cognite's goal is to accelerate your existing digitalization or AI team with rapid and easy access to the operational data they need, and connect you with the best tools in the market. This includes offerings from our expanding ecosystem of specialist partners. There is no lock-in, only options.

Cognite Data Fusion (CDF) is deployed enterprise-wide, and our subject-matter experts (SMEs) will collaborate with your own team to establish the best way to deliver value and improve your manufacturing operations. Using our accompanying suite of applications and services, we'll put you in immediate contact with live data and work in an iterative manner toward operationalized value.

Selected capabilities of CDF include:

Data Extraction and Integration: Cognite Data Fusion supports a range of flexible data integration patterns, emphasizing security and governance at every step of the process. Easy-to-integrate extractors for protocols such as OPC-UA, MTConnect, and MQTT, as well as support for systems such as SAP, Product Lifecycle Management (PLM) software and Distributed Control Systems (DCS), help companies extract operational data directly from source systems and contextually integrate it with data from data warehouses and data lakes.

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EMPOWER PEOPLE

Make it securely accessible to developers based on their use cases

CONTEXTUALIZE DATA

Connect OT data with IT data in a way that mirrors the physical world

LIBERATE DATA

Break OT data free from siloed source systems

Machine Learning Hosting: Machine learning is most effective when the models can run constantly, alerting the right people when necessary and advising on what steps need to be taken. With Cognite's model hosting environment, companies can deploy, schedule, and manage models in one place, tightly integrated with Cognite Data Fusion. Deploy models in a minute, scale up quickly by separating code and input data, script deployment for large-scale rollout, and easily set up monitoring by fetching logs with the API.

Integration with Analytics and Visualization Tools: Cognite Data Fusion also interacts seamlessly with modern software (e.g. Python, Scala, Spark, Spotfire, Grafana, Databricks, Tableau, and Power BI, among others). This provides the ideal environment for users and domain experts to efficiently organize, explore, and accelerate the development of models — and visualize the results in real time. With CDF, the path and time to solution is significantly reduced.

Digital Twins: Manufacturing companies can enhance their understanding of their own operations by putting all OT and IT data through our contextualization pipeline to create an operational digital twin. Combining that data with a 3D model, for example one created using photogrammetry technology, creates a foundation for authorized users, whether internal or external, to streamline the creation of models for individual components, equipment, and processes.

The operational digital twin allows for data consumption based on the use case. Any model created can live off the streaming live data that exists there, enriching the space by feeding its own insights or derived information (e.g., synthetic temperature or vibration information created by a simulator for equipment where no real sensor exists) back into the twin. Combined with live and historical data, these insights on equipment behavior shore up the operational digital twin, making it even more complete and useful for the future.

Low-code Development Integrations: Cognite

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Data Fusion (CDF) enables domain experts and citizen developers to quickly and easily create simple dashboards and visualizations through an intuitive drag-and-drop interface. CDF works with the tools manufacturing companies already use, such as OutSystems, Grafana, Sharepoint, PowerApps, and Microsoft Forms and Power BI. Gearbox, Cognite's library of reusable UI components, further frees up development time, letting companies focus their efforts on building solutions that deliver value.

Interactive Diagrams: Paper documents can be unwieldy on the factory floor, and by themselves, they don't tell the full story about plant operations. Asset Data Insight, Cognite's flagship application for smart maintenance, lets users easily build infographics by combining different data sources contained in Cognite Data Fusion. For example, users can assign labels to individual components in a diagram, and by clicking on one of the labels, the user is taken to an asset explorer page. The user can then view asset metadata, and search and filter time series, events, and other documents such as instruction manuals.

Asset Data Insight is developed for handheld devices and computers. This means factory workers — no matter where they are located — can look at the same interactive diagrams to make data-driven decisions that improve operations.

COGNITE IN ACTION

Contextualized data from Cognite Data Fusion (CDF) can heighten your analysts' and engineers' understanding of their own operations and empower your teams to maximize daily production.

With real-time access to the right data in context, your teams can remove unnecessary production constraints and take actions to release more production, increase production capacity by process debottlenecking, mitigate production deferral, and take actions to close the gap between production capacity and actual production.

How Cognite Data Fusion (CDF) reduces unplanned failures and maintenance costs

Challenge: Many manufacturing companies run their maintenance operations on a schedule, tasking workers to conduct routine inspections of equipment at set intervals. In addition to scheduled maintenance, workers also conduct reactive maintenance, such as when a sensor alerts them to a potential issue involving equipment.

This approach to maintenance means that workers may spend several hours of their day inspecting equipment that is in good working condition – hours that could instead be spent performing other tasks that generate value for the company.

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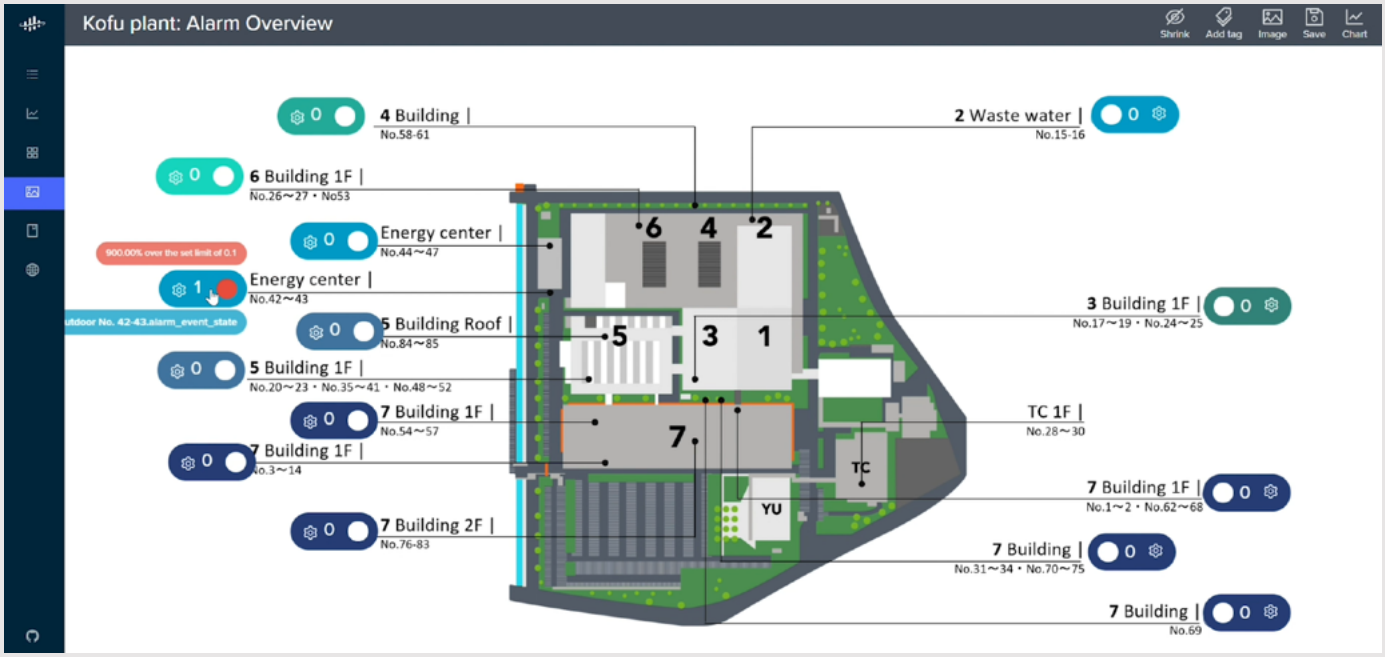
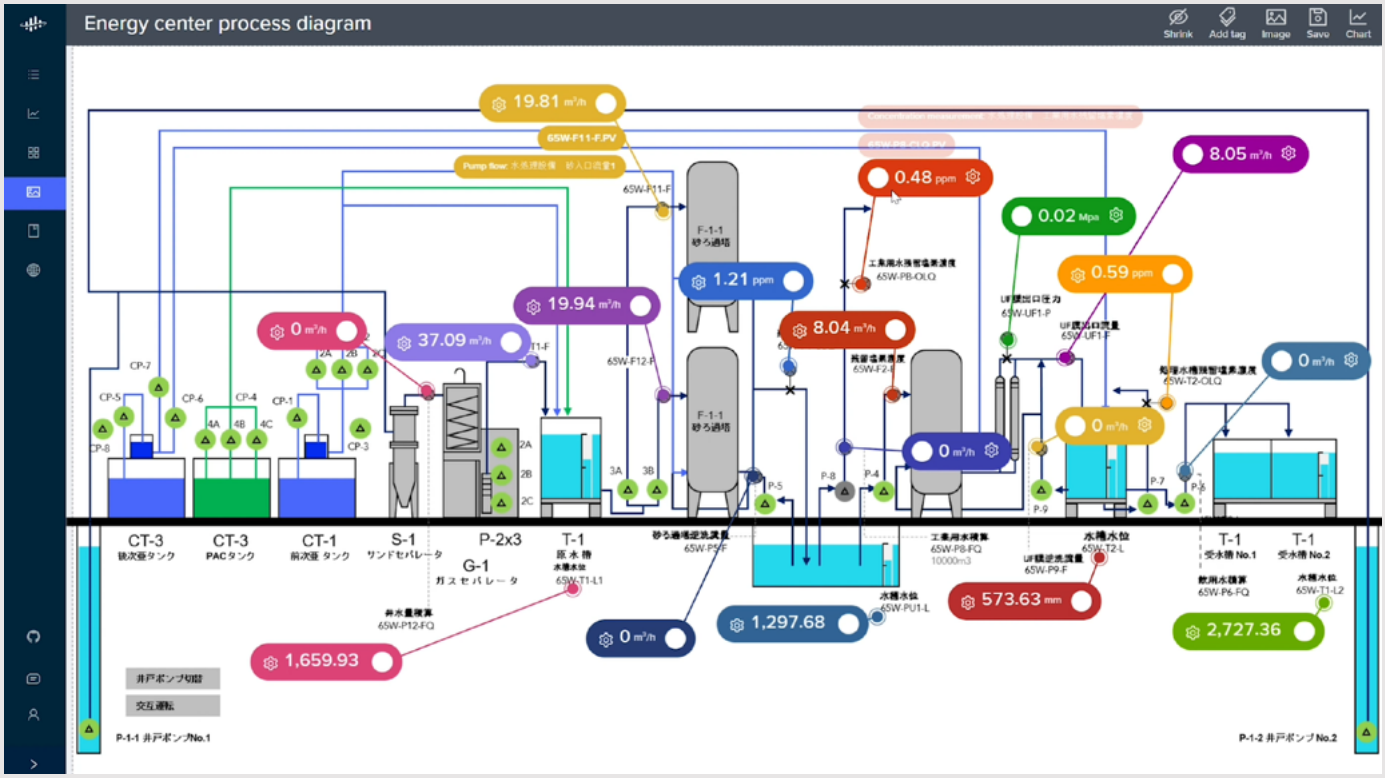


Solution: Yokogawa and Cognite used the liberated, contextualized industrial data stored in Cognite Data Fusion (CDF) to build maintenance solutions in Asset Data Insight, Cognite's flagship application for smart maintenance.

One such solution is an alarm overview that reduces unnecessary inspection of equipment. The overview shows a bird's-eye view of the manufacturing plant and live sensor data from the pumps on-site. If a pump's vibration exceeds a predetermined threshold, one of Yokogawa's systems will send a signal to CDF, which will visualize it as an alert. When a user clicks an overlaid label associated with a pump on the infographic, the user is taken to an asset explorer page. The user can then view asset metadata, search and filter time series, events, and documents such as the instruction manual. This enables workers responsible for the plant operation to diagnose the issue and decide whether it needs to be corrected immediately.



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Another solution combines the process diagram of the plant's energy center with live sensor data. By clicking on the individual components that together form the energy center, workers can easily view all the information about the equipment available in Yokogawa's maintenance system. The information can also be displayed in convenient charts that reveal how different factors may be connected, for example pump flow rate, temperature, and vibration.

Impact: Instant access to data allows companies to conduct maintenance on equipment based on its actual condition, as opposed to running its maintenance program on a set schedule.

How Cognite Data Fusion (CDF) improves the efficiency of manufacturing plant maintenance workers

Challenge: Large-scale digitalization of the manufacturing industry will only be possible if companies make all the data they collect available in a way that's intuitive to human users and machines. However, for many manufacturing companies, data is trapped in complex, siloed systems. This makes it more complicated for workers to use the data in their day-to-day activities; data scientists must build point-to-point integrations every time they want to develop a new application, and maintenance workers have to access multiple systems to find the information they need.

Solution: In less than two days, Cognite liberated data from Yokogawa's source systems, including time series, equipment information, historical events, and instruction manuals, collecting it all as a comprehensive set in Cognite Data Fusion (CDF).

Yokogawa and Cognite then identified two specific ways of getting the liberated, contextualized data into the hands of maintenance workers.

The first is Operation Support, Cognite's flagship application for digital field workers. Available

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on computers and handheld devices, Operation Support streams data from CDF. By scanning a tag on any piece of equipment in the manufacturing plant, Yokogawa's maintenance workers can now pull up all real-time and historical data, documentation, maintenance records, pictures, and more information relevant to that equipment.

The second is a digital twin that combines the liberated, contextualized data with a 3D model. After taking about 400 pictures of the Kofu plant, Cognite used photogrammetry to make a 3D model of it in about 30 minutes. Cognite then overlaid the 3D model with real-time and historical sensor data, giving users a powerful visualization tool to explore the plant.

Contextualized data can also enable easier creation and deployment of analytics models powered by artificial intelligence and machine learning. Historically fault finding, analysis, and diagnosis is done based on data from standalone systems. This means that it is not possible to correlate various signals and systems across a plant. With large amounts of historical data about pump flow, vibration, and events, however, companies can detect anomalies and fault conditions that were previously not possible to diagnose.

Impact: Operation Support enables field workers to collaborate with remote experts looking at the same data. Working together, they can more quickly diagnose errors and conduct maintenance work more efficiently.

The 3D model with contextualized data enables field workers to more efficiently search for and locate equipment and plan remote operations, and also improves off-site planning and support.

How Aarbakke and Cognite are extending the lifetime of CNC machines

Challenge: Aarbakke has dozens of computer numerical control (CNC) machines at its factory in Bryne, Norway. The machines complete complex operations on sometimes rare materials to achieve highly precise product requirements that its customers in the oil and gas industry demands.

Historically, the CNC machines have sometimes been unknowingly operated in a suboptimal way, and there have been no alerts or warnings prior to them breaking down. Issues include high temperatures in coolants or oils, which leads to wear and tear; wrong pH and salinity in the coolant, which can cause corrosion or bacterial or fungal growth; incorrect lube oil consumption; and missed maintenance on the machines.

Aarbakke lacked a master log of these machine alarms, as well as a system to filter out less critical ones. Service managers previously depended on operators to send them a note every time a critical issue occurred. Otherwise the service managers needed to physically go to each individual machine and manually pull a local log to view the alarms.

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Solution: Aarbakke and Cognite first liberated the data about machine alarms from its source system, ingesting it into Cognite Data Fusion (CDF). With all the data streaming from one place, the developers then created a dashboard that shows an overview of all alarms but also groups alarms by machine and issue. This helps service engineers pinpoint specific issues and machines and take targeted maintenance actions to address them.

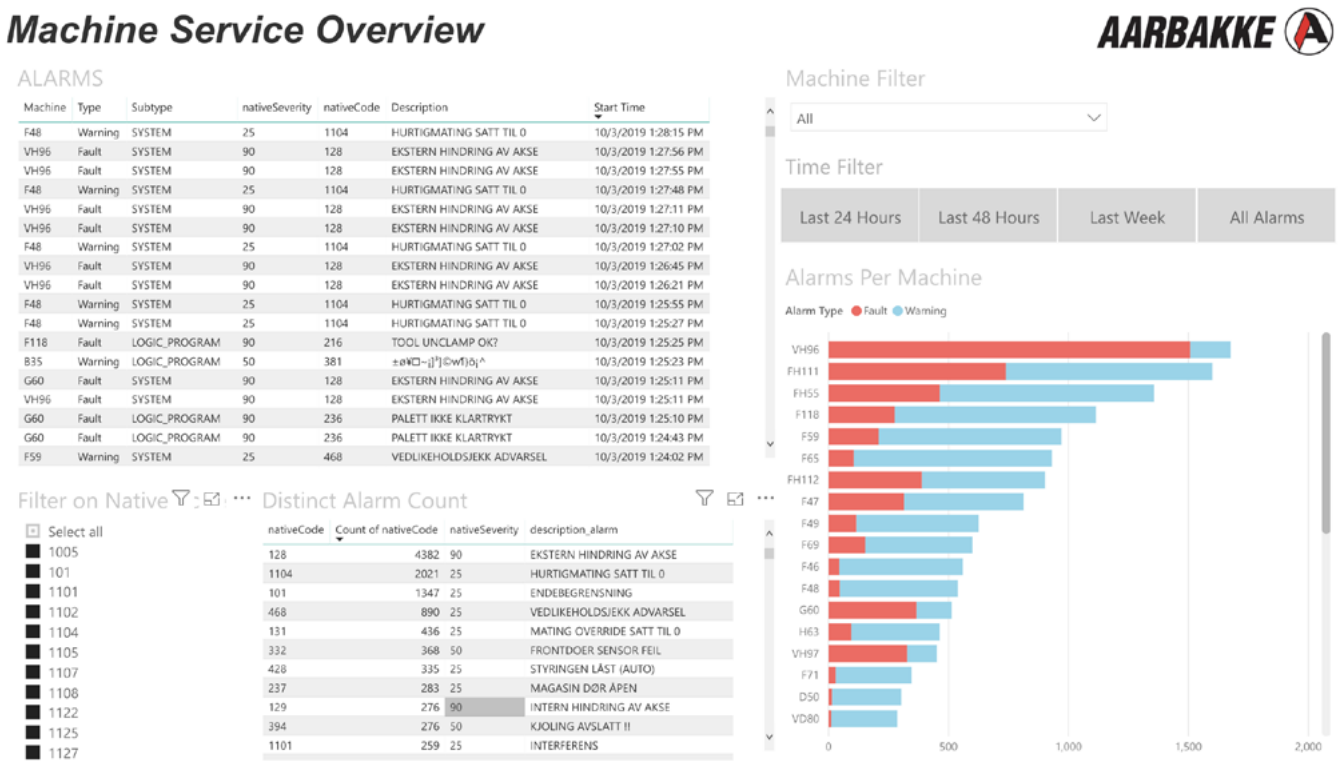
Aarbakke and Cognite plan to add more functionality to the dashboard in the future, including a feature that lets service managers assign levels of criticality to alarms, ensuring that the alarms they deem most important will always be featured at the top of the list.

Impact: Improved monitoring of operational parameters and the ability to look at records of alarms and warnings centrally will reduce the number of breakdowns and extend the lifetime of the machines. Beyond that, collecting cleaned, contextualized data about alarms will help drive Aarbakke toward a future in which the company can predict potential failures before they happen.

Aarbakke estimates that the dashboard will reduce service costs by 20-30%, reduce downtime, and avoid unplanned stops due to mechanical reasons.

How Aarbakke and Cognite are optimizing the use of cutting tools

Challenge: Aarbakke's computer numerical control (CNC) machines use more than 22,000 unique cutting tools to complete complex operations on sometimes rare materials. However, due to old numerical control programs, lack of operator experience, and other reasons, these tools are sometimes used in an inefficient way, and operators and production managers are only aware of a suboptimal cutting process once the part is finished.



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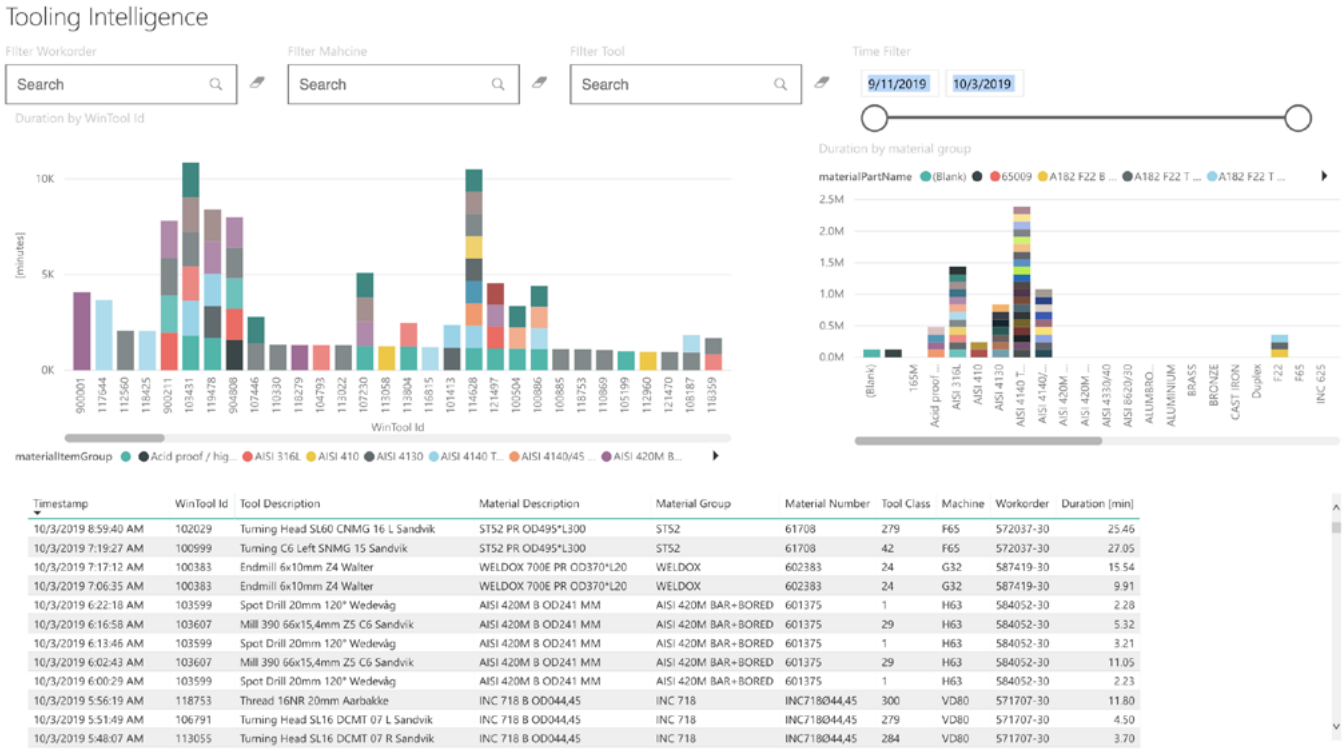
It is also difficult to get an overview of tool usage and performance. Some tools may be in use for hundreds of minutes in a single day, while others may hardly be used at all.

Solution: Aarbakke already had in place separate systems that tracked machine operation data and work orders – the systems just didn't communicate with each other. Cognite and Aarbakke therefore liberated the data from the systems and collected it all in Cognite Data Fusion (CDF), and then visualized it in a dashboard.

The dashboard gives production managers, team leaders, and operators an overview of which tools are most frequently in use and color-codes the usage based on the material that the tool is cutting into. Aarbakke can use this information to optimize tool usage during cutting and reduce cutting time.

Impact: By analyzing historical use of tool assemblies and their performance, Aarbakke aims to reduce tool assemblies by up to 60% and boost the efficiency of the remaining tools by 10%.



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ALL ABOUT COGNITE

Our Vision

An industrial world powered by data and algorithms, freeing human creativity to shape a productive and sustainable future

Our Team

Cognite is a global software company supporting the full-scale digital transformation of heavy-asset industries around the world, from the U.S. to Japan to Austria to New Zealand. Our impressive interdisciplinary team includes more than 250 of the best software developers, data scientists, designers, 3D specialists, and industry professionals.

Together, we have built Cognite Data Fusion (CDF), a software package that empowers companies in industries like Oil & Gas, Energy, Shipping, and Manufacturing to extract value from their wealth of existing data by transforming it into useful information. CDF supplies data contextualization as a service, delivering reliable, meaningful data to industrial applications that increase safety and efficiency and drive revenue.

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