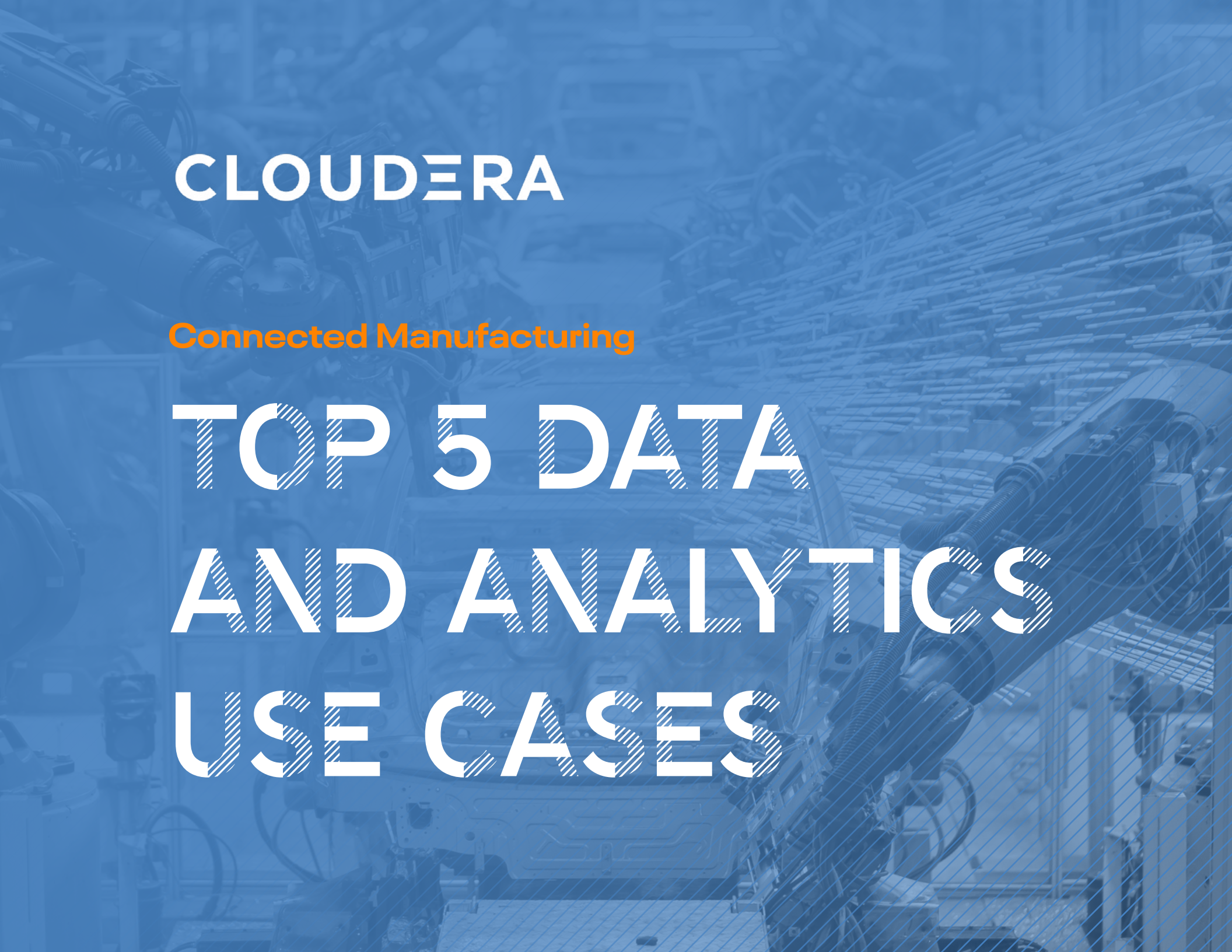

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Connected Manufacturing

TOP 5 DATA AND ANALYTICS USE CASES

Connected Manufacturing

The manufacturing industry today is experiencing transformation like never before. With the ubiquitous rise of instrumentation, connectivity, and Internet of Things (IoT) technologies powered by data and analytics, today's manufacturing industry is witnessing the creation of a fourth industrial revolution: Industry 4.0.

Industry 4.0, enabled by smart or connected manufacturing, brings together physical production and operations with digital technologies, machine learning, and big data analytics. It creates a more connected and holistic ecosystem of machines, assets, and processes capable of autonomously exchanging information, identifying anomalies, and triggering actions.

The move to smart manufacturing is enabled by several factors including:

- The drastic reduction in the cost of sensors, coupled with the astonishing rise in computational power and stable connectivity
- The emergence of cutting-edge data analytics and machine learning capabilities
- New forms of human-to-machine interactions
- Improvements in transferring digital instructions to the physical world

The convergence of these trends creates a mandate that requires manufacturers to unlock value from their data.

Digitalization, a key tenet of connected manufacturing, must be underpinned by data. By harnessing data and using it in new and innovative ways, manufacturers can enable innovative use cases such as real-time asset and process monitoring, predictive maintenance, quality and yield optimization, supply chain optimization, and more.

The Role of Analytics in Manufacturing

The proliferation of machines and sensors, generating torrents of data, is disrupting the manufacturing industry. Data volumes from both inside production factories, as well as outside the manufacturing process continue to grow. In addition, the makeup of manufacturing data is changing as it becomes increasingly unstructured and is streamed in real time.

Despite being historically slow to adopt new technologies, manufacturers are eagerly implementing IoT initiatives, leveraging real-time data flows and machine learning to solve age-old problems. Research shows that the total cost of poor quality amounts to **20%** of sales revenues,[2] and unplanned downtime costs approximately **$50 billion** per year.[3] Data has the ability to drive the process improvements needed to reverse these statistics.

However, managing these new and real-time data flows becomes challenging and cost prohibitive with existing legacy manufacturing systems, data infrastructure, and processes. To innovate, remain competitive, and differentiate themselves, manufacturing organizations must fundamentally relook at their approach to how they collect, manage, and drive intelligence from all of this data. With a modern approach to data management, they can gain the insight they need and optimize their businesses

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Industrial products lead all industries in IoT adoption at **45%**.[1]

[1] Forrester, "Internet-Of-Things Heat Map 2018; Prioritize IoT Use Cases Based On Value To Your Company Operations," April 23, 2018.
[2] ASQ, Cost of Quality
[3] Aberdeen Group, "Asset Performance Management: Blazing a Better Path to Operational Excellence," November 2017.

with an actionable view of their operations, products, customers, and supply chain.

Tapping into existing and emerging data sources enables manufacturers to:

- Gain **360-degree views** into products, processes, suppliers, customers, and assets
- Analyze performance data and get early alerts that can **predict equipment failure** and enable proactive equipment maintenance
- Integrate and analyze data from connected machines
- Use IoT analytics to **reduce downtime** and meet zero-defect goals
- Gain insight into the supply chain to **reduce supply disruptions**
- Utilize image and video analytics for **quality monitoring**

Manufacturers can implement data analysis and machine learning across all aspects of the product lifecycle, including the way products are engineered, produced, and serviced in the field. With greater visibility and insights, they can make data foundational to connected manufacturing initiatives.

Predictive maintenance can reduce factory equipment maintenance costs by

12%

and improve uptime by

9%.[4]

Machine learning can reduce supply chain forecasting errors by

50%

and reduce lost sales by

65%

with better product availability.[5]

[4] PwC, "Predictive Maintenance 4.0 Beyond the Hype: PDM 4.0 Delivers Results," September 2018.
[5] McKinsey & Co., "Smartening Up with Artificial Intelligence."

Top 5 Analytics Use Cases in Manufacturing

Analytics, machine learning, and artificial intelligence are reshaping the manufacturing landscape. The most innovative manufacturing companies are applying industrial IoT concepts, coupled with data and analytics, to transform their product development, supply chains, and manufacturing operations.

However in order to capitalize on this fundamental shift, manufacturers need the ability to ingest, process, store, and analyze all types of data (structured, unstructured, and semi-structured data) regardless of where it lands—at the edge, on the factory floor, in the data center, in any public cloud, or in a hybrid cloud.

Today's manufacturers need to be able to generate insights and use cases not only from data at rest, but also from data in motion and streaming data sources in real time. They are starting to utilize machine learning, advanced analytics, and artificial intelligence to identify patterns from petabytes of data, detect anomalies, and predict potential outcomes for their businesses.

With greater visibility and insights at the point of decision, manufacturers can use the data they generate every day to gain real-time visibility into their operations and supply chain, improve operational performance, enable predictive maintenance, and help drive new revenue streams.

Here are the top five areas where manufacturers are using the power of analytics and machine learning to drive business success.

1. Real-time Process Monitoring

Real-time process monitoring and operational dashboards provide a consistent, real-time view into the state of operations. The data offers insights into key sensor parameters and KPIs and measures production targets like cycle time, production rates, and defect rates.

By analyzing the full ecosystem of processes, manufacturers can easily identify problem areas, model bottlenecks and failures, and spot inefficiencies, particularly as manufacturing processes increase in complexity. For example, process monitoring dashboards reduce non-conformance, downtime, scrap, and late shipment costs.

The most significant challenge in real-time process monitoring is acquiring real-time data from a variety of sources and performing streaming analytics to drive insights quickly, securely, and with clear traceability.

With Cloudera, manufacturers gain a scalable, real-time streaming analytics platform that ingests, curates, and analyzes data for key insights and provides immediate actionable intelligence. The end-to-end platform addresses the key challenges enterprises face with data in motion including:

- Collecting and processing **real-time data** streaming at high volume and high scale
- Tracking **data provenance** and lineage of streaming data
- Managing and monitoring diverse **edge applications** and streaming sources
- Enabling **streaming analytics** to derive intelligence and action in real time
- Providing data scientists with tools to build, test, refine, and deploy **machine learning** models

These capabilities enable manufacturers to react immediately to non-conforming processes and make appropriate adjustments in real time.

Unplanned downtime costs an estimated

$50B

per year.[6]

[6] Deloitte, "Making Maintenance Smarter: Predictive Maintenance and the Digital Supply Network," May 9, 2017.

2. Predictive Maintenance

One of the most significant ways that data is playing a role in manufacturing is in the repair and maintenance of equipment. With a reactive maintenance process, valuable uptime can be lost. In fact, studies indicate that unplanned downtime costs an estimated $50 billion per year.[7] In auto manufacturing specifically, downtime can cost a staggering $1.3 million per hour.[8]

Traditional *corrective maintenance* is performed only after a piece of equipment fails, which results in unplanned downtime, schedule disruption, and reduced quality. In contrast, *preventative maintenance* is performed on a set schedule based on time or usage. However, this approach results in unnecessary downtime and expense with maintenance being performed regardless of the equipment's actual condition. Much more efficiently, *predictive maintenance*, is based on monitoring the actual, real-time condition of the equipment and maintenance is performed only when needed.

In automotive manufacturing, unplanned machine downtime can cost up to

$1.3M

per hour in lost productivity.[8]

[7] Deloitte, "Making Maintenance Smarter: Predictive Maintenance and the Digital Supply Network," May 9, 2017.
[8] PTC, "IoT Slashes Downtime with Predictive Maintenance," March 4, 2016.

With IoT and sensor data streaming from equipment, predictive maintenance enables organizations to effectively predict machine outages. The data detects variances, understands warning signals, and identifies any patterns that may indicate a potential breakdown. Manufacturers can use analytics and machine learning to accurately predict the odds of a machine going down. This enables early and corrective measures to be planned (i.e., spare parts ordering, repair scheduling, etc.) and introduced in the most effective way, thereby avoiding unplanned downtime and costly staff and resources.

With Cloudera, manufacturers can ingest, process, and analyze streaming and operational data, gaining performance and maintenance insights across the asset lifecycle. They can integrate data from multiple connected machines and other enterprise data sources such as maintenance and quality management systems to build predictive models. Data scientists can build, test, and deploy machine learning models, utilizing this data to predict when and how an equipment failure or outage might happen. They can even push these models out to the edge to make intelligent decisions, in real time, close to where the data is generated.

With this visibility, manufacturing organizations can identify issues before they occur, take corrective actions, and optimize production schedules according to machine availability—reducing the downtime that can significantly impact the bottom line.

Using IoT and data analytics to predict and prevent breakdowns can reduce overall downtime by

50%[9]

[9] McKinsey & Co., "The Internet of Things: Mapping the Value Beyond the Hype," June 2015.

3. Computer Vision for Quality Assurance

Quality assurance and control in manufacturing is an absolutely critical process as it has a direct impact on customer satisfaction and overall costs. Quality assurance best practices focus on identification and prevention of defects at every stage during the manufacturing process. And data analytics, machine learning, and AI are revolutionizing how we approach and manage quality control and assurance today. In fact, *Forbes* notes that automating quality testing using machine learning can increase defect detection rates by up to 90%.[10]

Computer vision is the field of science that enables computers to see, identify, and process images in the same way that human vision does and then provide appropriate output. The technology is being increasingly utilized today in manufacturing to carry out automated visual inspections for quality assurance.

Harnessing the power of image recognition and machine learning, computer vision can be used to effectively manage quality assurance while reducing the cost of quality control. Armed with a large repository of images for model

Automating quality testing using machine learning can increase defect detection rates by up to 90%.[10]

[10] *Forbes*, "10 Ways Machine Learning Is Revolutionizing Manufacturing In 2018," March 11, 2018.

training, manufacturers can build, train, and refine machine learning models for image recognition and classification that identifies defects more quickly and inexpensively than manual methods.

- **Image processing and machine learning** detect and distinguish good versus defective production outcomes
- **Camera and sensor data**, coupled with deep learning, enables automated visual inspection and the detection of surface imperfections
- **Machine learning algorithms** detect potential aberrations or faults that would otherwise be missed

With Cloudera, manufacturers can easily deploy a scalable and effective solution for quality assurance using computer vision by leveraging image processing and machine learning. Cloudera offers a next-generation platform, services, and tools that enable manufacturers to effectively ingest, aggregate, process, and store billions of images, automate annotation and labeling, enable semantic search and enrichment, and build and refine machine learning models. Cloudera Data Science Workbench provides an easy and efficient way for data scientists to **build, test, and iterate on machine learning models** for conducting image recognition at scale on petabytes of image data.

Ultimately, computer vision can identify and address quality issues faster and at the source, allowing for a more compliant product that meets the expectations of customers. Manufacturers can then feed this data into the audit trail and perform advanced analytics to prevent the issues from happening again.

4. Throughput Optimization

To drive profitability, manufacturers must continuously optimize manufacturing throughput and production levels across their plants. Finding effective ways to increase throughput helps manufacturers meet production schedules, stay on pace with delivery timelines, and keep satisfied customers. To do so, however, requires timely identification and resolution of bottlenecks, which can take the form of labor, equipment, inventory, or other resources. Regrettably, identifying bottlenecks in complex manufacturing organizations is a time-consuming, manual, and often neglected task with negative impacts across the manufacturing value chain. Data, analytics, and machine learning can help optimize throughput by dynamically identifying and eliminating bottlenecks, improving production rates, reducing inventory, and increasing asset utilization, all of which significantly impact manufacturers' top and bottom lines.

- **Data-driven algorithms** dynamically identify throughput bottlenecks
- **Dynamic calculations** identify and rank the most critical bottlenecks from an ROI perspective

Cloudera can help manufacturers utilize data to automatically detect, rank, quantify, and eliminate costly bottlenecks in real time. Actionable analytics enable them to quickly identify and take action against constraints and bottlenecks that slow production volumes.

Working with key partners, Cloudera drives significant business impacts to leading manufacturers, through throughput optimization including:

- 90-100% improvement in their inventory allocation strategy
- 600x improvement in analysis time versus existing methods
- Up to 30% improvement on cash conversion cycles
- Up to 15% reduction in inventory levels

With Cloudera, manufacturers can harness the power of data and analytics to get answers to important throughput-related questions, identify systemic patterns in the data, and act on those patterns by improving processes. Analytics and machine learning help identify the variables and key patterns that have the greatest impact on production yields. They can then build those patterns and any anomalies into future analysis to better understand and forecast future volumes and inventory levels.

5. Supply Chain Optimization

The influx of real-time data and high-performance analytics is enabling new levels of supply chain performance—underpinned by supply chain visibility, performance monitoring, and the ability to optimize current and future actions based on lessons learned from the past.

Supply chain use cases range from the simple, offering visibility into inventory levels, to more complex ones related to supply chain optimization and transformation. Often, gaining basic visibility into supply chain information (e.g., process monitoring or inventory location tracking) can provide immense value, without the need to resort to more complex transformation use cases (e.g., real-time inventory optimization or logistics routing optimization).

In terms of preliminary use cases, sensors replace RFID tags to monitor both the location and condition of the goods and provide real-time feedback of processes. For example, IoT devices embedded within refrigerated trucks carrying perishable foods can help in cold-chain monitoring by measuring temperature and humidity inside the truck and alerting the driver to abnormal temperature changes.

The more complex and transformative use cases such as real-time inventory optimization require manufacturers to collect and curate histories of inventory data over a period of time and correlate historic inventory shortages with contextual variables (such as click-streams, POS data, inventory locations/levels, weather, etc). They can then use machine learning models to identify critical variables, monitor them in real time, predict impending disruptions, and correct them before they occur.

Cloudera offers an end-to-end data management and analytics platform that enables manufacturing organizations to ingest, process, analyze, and model both real-time and historical data to drive supply chain insights. Machine learning models can be developed and tested natively, using the full corpus of data, in full fidelity, using Cloudera Data Science Workbench, and deployed back to the edge, for real-time decision making.

[11] BCG, "Turning Visibility into Value in Digital Supply Chains," January 25, 2018.

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Digital supply chains and improved visibility into the supply chain yield reductions of

in manufacturing, warehousing, and distribution costs.[11]

Big data analytics leads to a

4.25X

improvement in order-to-delivery cycle time and a

2.6X

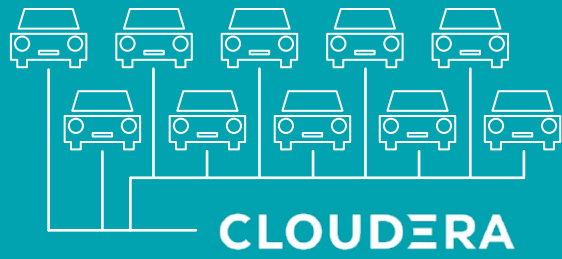
improvement in supply chain efficiency

- Accenture

Manufacturing Analytics in Action

Today, a number of leading manufacturers across the globe use the Cloudera data management and analytics platform to drive connected manufacturing processes, enable predictive maintenance, improve quality assurance, optimize supply chain and inventory processes, and improve manufacturing yield and throughput.

10 of the **world's top 10** auto manufacturers run on Cloudera.



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Case Study: Micron Technology

Micron Technology, Inc. is one of the largest memory manufacturers in the world, producing many semiconductor devices, including dynamic random-access memory, flash memory, and solid state drives. Because semiconductor manufacturing is a highly complex and intricate process, data and analytics offer significant value.

Micron is utilizing the power of Cloudera DataFlow, powered by Apache NiFi, to build and gain visibility into data ingestion pipelines. Cloudera also provided an end-to-end data management platform that enabled Micron to focus more on data analytics and less on data management. The company is using the power of the platform to run computer vision for quality assurance, and it helped reduce the time it took to identify misprocessed die from **seven days** to **under an hour.**

"Hadoop and big data are our technology focus. We chose Hortonworks [now Cloudera] because of its commitment to open source, its collaborative approach to development, and because it is a leader in the Hadoop space."

-Greg Kincade
Senior Ecosystem Enablement Program Manager, Micron Technology, Inc.

Case Study: Navistar

Navistar is a leading manufacturer of commercial trucks, buses, defense vehicles, and engines, widely known for its International® Truck and IC Bus® brands. The company uses Cloudera to deliver IoT-enabled predictive maintenance, vehicle diagnostics and management, and route optimization to help fleet and truck owners minimize vehicle downtime.

Navistar built an IoT-enabled remote diagnostics platform, called OnCommand® Connection, on Cloudera Enterprise Data Hub with SDX. The platform brings in over 70 telematics and sensor data feeds from more than 375,000 connected vehicles—including engine performance, truck speed, acceleration, coolant temperature, and brake wear. This data is then correlated with other Navistar and third-party data sources including meteorological, geolocation, vehicle usage, traffic, historical warranty, and parts inventory information. The platform uses machine learning and advanced analytics to automatically detect engine problems early and predict maintenance requirements.

With OnCommand Connection, Navistar has helped fleet and vehicle owners reduce maintenance costs by more than **30%**. One specific Navistar customer was able to reduce the maintenance cost per mile for its vehicles, previously 12 to 15 cents, to less than **three cents**.

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"The results are overwhelmingly positive. Using real-time big data to frame business decisions and deploy proactive maintenance has opened new revenue streams and delivered additional customer value."

-Troy Clarke
CEO, Navistar

Case Study: Nissan

Nissan Motor Company, Ltd. is a Japanese multinational auto manufacturer that sells its cars under the Nissan, Infiniti, and Datsun brands. In its production of connected cars, the company struggled with creating an infrastructure capable of storing, processing, and analyzing huge volumes of vehicle driving data and production quality data on a long-term basis.

Cloudera (then Hortonworks) delivered an open source data lake solution that helped store and analyze over **500 terabytes** of data while enabling the flexibility to pivot if circumstances change in the future.

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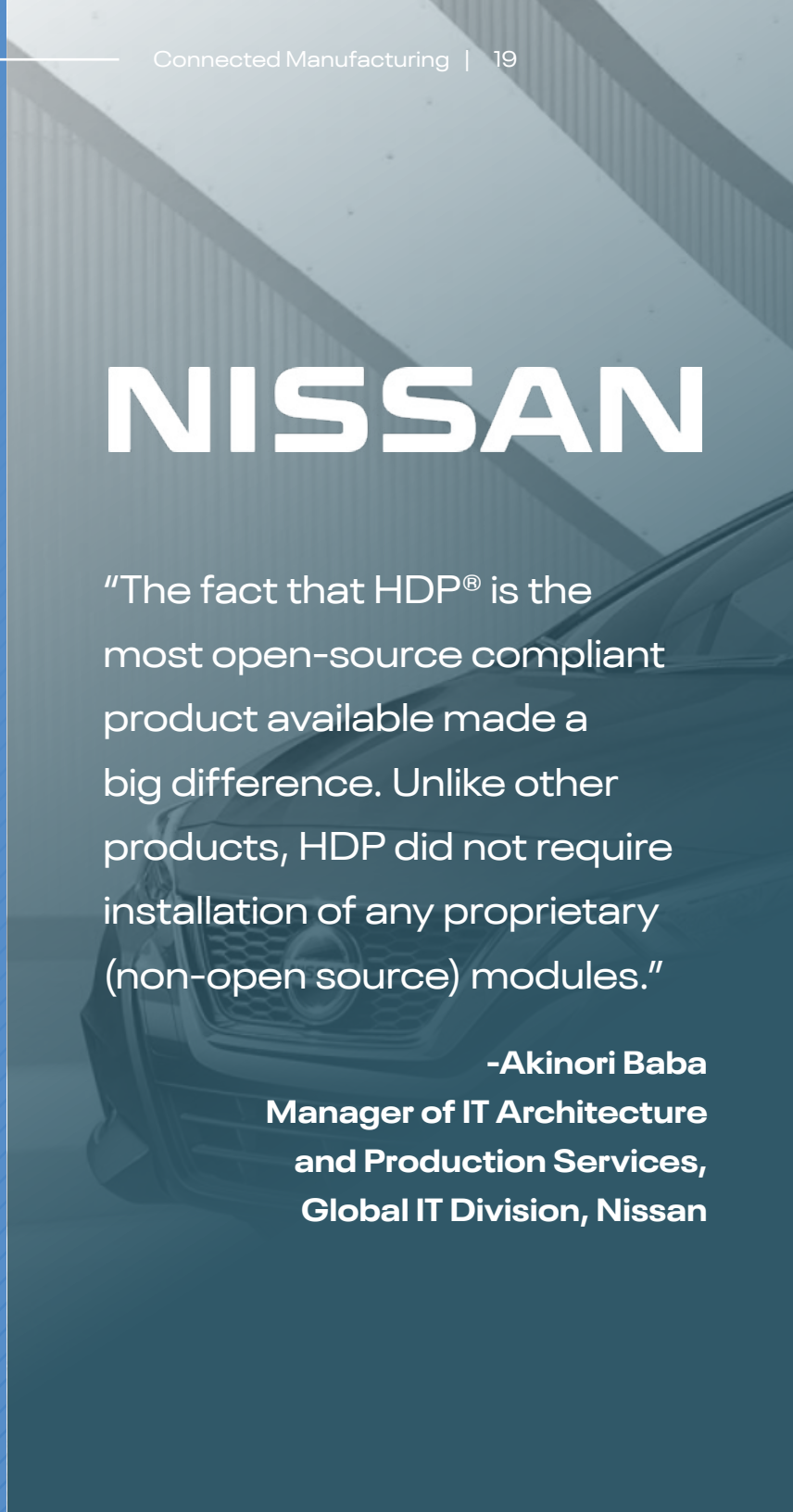

"The fact that HDP® is the most open-source compliant product available made a big difference. Unlike other products, HDP did not require installation of any proprietary (non-open source) modules."

-Akinori Baba
Manager of IT Architecture and Production Services, Global IT Division, Nissan

Case Study: Faurecia

Faurecia is a tier-one automotive supplier specializing in automotive seating, interior systems, and emission control technologies. With relational databases that couldn't provide the scalability or performance needed, the company looked to Cloudera to create an enterprise data hub for its IoT data. The company can now collect, analyze, and track more than **300** sensor data feeds and combine them with production and quality data to provide a comprehensive picture of operations.

Working with Cloudera, Faurecia created an enterprise data hub for IoT that brings together and analyzes data from a variety of sources, including thousands of machines and millions of sensors, to help drive predictive maintenance and improve product quality.

The move to IoT-enabled predictive maintenance has helped Faurecia reduce unplanned production downtime and maintenance costs.The company has also been able to improve product quality and move closer to its goal of **zero defects**.

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faurecia

"We can visualize machine operations from any worldwide location in real time and analyze the data to predict potential problems."

-Jose Gascon
Manager of Faurecia's Core System Team

"The cost of plant downtime can be significant, depending on the minutes of stoppage and every minute counts. With predictive maintenance, we are identifying correlations and patterns, and can take action before a breakdown occurs, avoiding unplanned production stoppage."

-Jose Gascon
Manager of Faurecia's Core System Team

Data-driven Manufacturing with Cloudera

Given the complexity and variety of manufacturing and IoT data, many organizations are reinventing their data management and analytics strategy—transitioning to an open platform that is optimized for the massive scale and complexity of the data that the industry demands.

Today, leading manufacturing organizations worldwide are adopting an enterprise data cloud strategy using the Cloudera Data Platform. The platform offers manufacturers the ability to ingest, process, store, and analyze any type of data (structured, unstructured, or semi-structured data), regardless of where it lands — at the edge, on premise at the factory floor, in the data center, or in any public, private or hybrid cloud. The platform offers an integrated suite of proven open source data management and analytics engines, enabling data storage, management, and processing, while driving insights and analytics from all data. With Cloudera, organizations can easily ingest data from multiple sources, combining and correlating IoT sensor data streams with activity logs, historian data, ERP and MES data, customer data, external data, and much more. Any type of data can be loaded into Cloudera without altering its format or fidelity, while preserving data integrity and enabling security and governance.

More importantly, Cloudera offers the flexibility to run a variety of analytical workloads to drive insights, intelligence, and action from all data. Depending on the business needs, organizations can analyze data in a variety of ways including interactive SQL, text search, integration with leading BI and visualization tools, advanced analytics, and machine learning—all with the robust security, governance, data protection, and management that manufacturers require. Data scientists can build, test, iterate, and deploy machine learning models and perform advanced analytics and AI on petabytes of data to identify patterns, detect anomalies, and predict potential outcomes.

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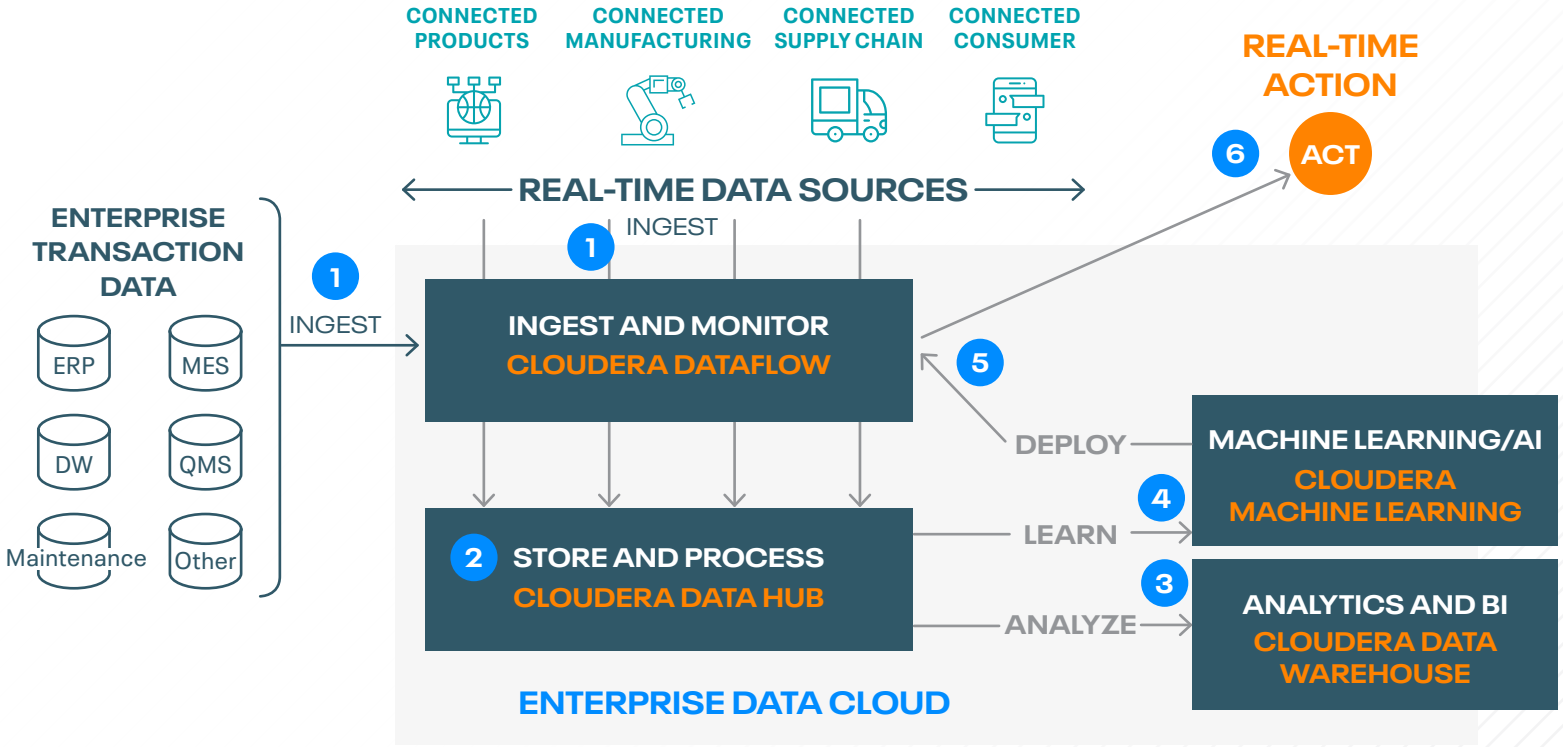
End-to-End Manufacturing Data Flow with Cloudera

With Cloudera, manufacturers can ingest data from a variety of sources including both streaming and enterprise data sources, store and process it across a hybrid infrastructure, and run analytics or apply machine learning algorithms to all data, all while maintaining strict enterprise data security, governance, and control across all environments.



Cloudera DataFlow provides a scalable, real-time streaming analytics platform that ingests, curates, and analyzes data for key insights and immediate actionable intelligence. It can ingest and process real-time data from streaming data sources (such as connected machines and connected products) and also from traditional enterprise data sources such as ERP, MES, and QMS systems.

It also addresses the key challenges enterprises face with data in motion including:

- Processing real-time data streaming at high volume and high scale
- Driving stream processing and analytics on data in motion
- Tracking data provenance and lineage of streaming data
- Managing and monitoring edge applications and streaming sources

Cloudera Data Hub provides massively distributed storage and processing engines for large data sets across clusters. It can store and process of any kind of data including unstructured data, semi-structured data (i.e., sensor data) and structured data (i.e., transactional data from ERP, maintenance, SCM, CRM data, etc.) and provides the ability to execute a wide range of data processing workloads in an extremely high-performance manner. It enables real-time data processing on batch and streaming data using Apache Spark and Spark Streaming, supported by storage options like Apache HBase and Apache Kudu.

Traditional data warehouses are inadequate to meet the increased scale, economics, and analytics demands that today's manufacturers are experiencing. Cloudera Data Warehouse is an enterprise-grade, hybrid cloud solution designed for self-service analytics — enabling organizations to share petabytes of data to drive analytics and BI with the security, governance, and availability that large enterprises demand.

Cloudera Data Science Workbench helps accelerate data science at scale to build, test, iterate, and deploy machine learning models in production using by taking advantage of massively parallel compute and expanded data streams. Using Python, R, and Scala directly in the web browser, CDSW delivers a self-service experience to data scientists to develop and prototype new machine learning projects and easily deploy them to production.

Data scientists can even push these models out to the edge to continuously monitor digital signatures from connected data sources and drive action in real time.

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Enterprise Data Cloud

Enterprise Data Cloud empowers organizations to get clear and actionable insights from complex data anywhere, from the edge to AI. It provides the flexibility to run modern analytic workloads anywhere, regardless of where the data resides. It offers the ability to move those workloads to different cloud environments—public or private—to avoid lock-in. And it has the agility, elasticity, and ease of use of public clouds and a common security and governance framework to enable data privacy and regulatory compliance by design.

With the ability to analyze data at rest, data in motion, and streaming data, manufacturers can use machine learning, advanced analytics, and AI technologies to drive insights and action in real time.

Any Cloud

Multi-Function

Secure & Governed

Open

CLOUDERA

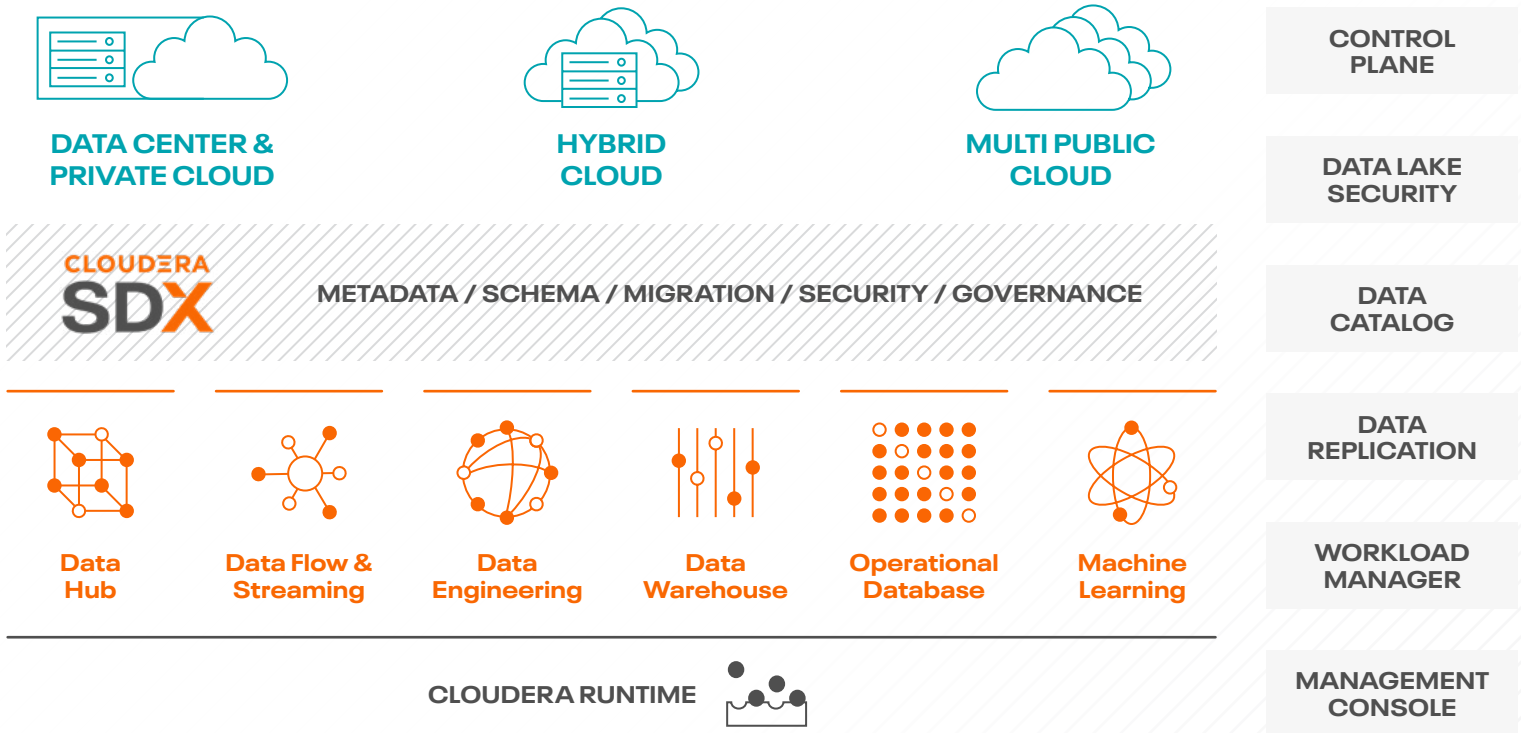
70%

of the global top 100 global manufacturers run on Cloudera

200

of the world's leading manufacturing companies rely on Cloudera

The Cloudera Data Platform



The Cloudera Data Platform delivers the industry's first enterprise data cloud. Providing powerful self-service analytics across hybrid and multi-cloud environments, the CDP offers sophisticated, granular security and governance policies that IT and data leaders demand.

The platform offers data warehouse and machine learning services, a data hub service for building custom business applications, and a unified control plane to manage infrastructure, data, and analytic workloads across hybrid and multi-cloud environments. This includes consistent data security, governance, and control with SDX to safeguard data privacy, ensure regulatory compliance, and prevent cybersecurity threats. It all lives on an open source foundation that avoids vendor lock-in and accelerates enterprise innovation.

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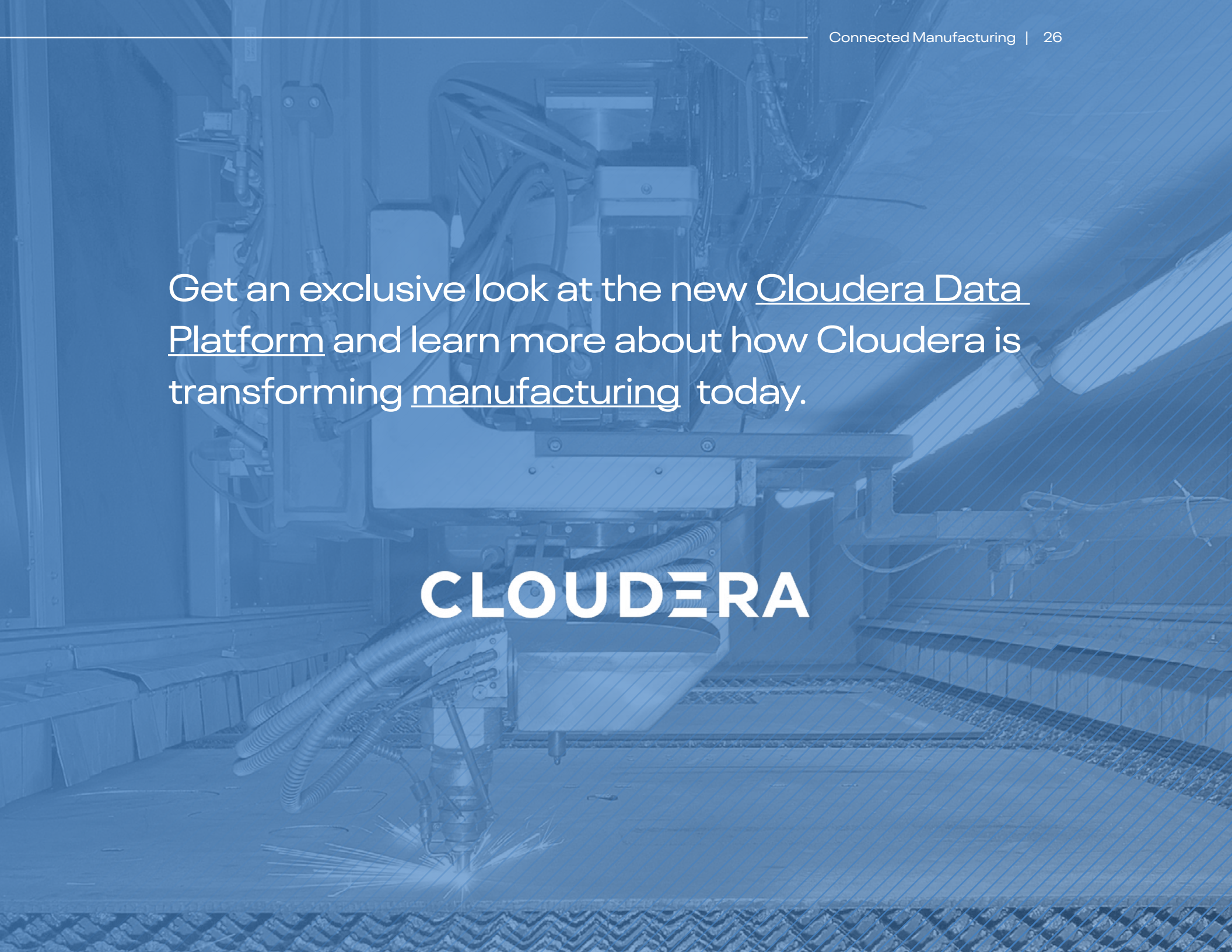

Get an exclusive look at the new Cloudera Data Platform and learn more about how Cloudera is transforming manufacturing today.

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About Cloudera

At Cloudera, we believe that data can make what is impossible today, possible tomorrow. We empower people to transform complex data into clear and actionable insights. Cloudera delivers an enterprise data cloud for any data, anywhere, from the Edge to AI. Powered by the relentless innovation of the open source community, Cloudera advances digital transformation for the world's largest enterprises. Learn more at Cloudera.com.