



A NEW ERA IN Mill Analytics

*How a Data Infrastructure Can Improve Pulp & Paper
Production Management and Asset Performance*

INTRODUCTION

WE LIVE IN AN AGE OF ACCESSIBLE INFORMATION. BETWEEN POCKET-SIZED SMARTPHONES, GOOGLE, AND WIKIPEDIA, WE CAN ALMOST INSTANTLY FIND ANSWERS TO ANY QUESTION. AFTER ALL, WHO HASN'T PULLED OUT A SMARTPHONE TO USE GOOGLE OR SIRI TO SETTLE A DINNER DEBATE?

But it hasn't always been that way. Not long ago, access to the internet was limited to specific locations and devices. Users had to be at a desktop computer that was hardwired to connect, login to a machine profile and then run queries. Now, all of that information is available in someone's pocket, giving unparalleled access to massive amounts of information from anywhere — without the complexity associated with programming.

Access to information has been democratized, and it's changing more than just dinner conversations. It's setting the stage for true digital transformation and revolutionizing entire industries, including pulp and paper mills.

Every pulp and paper mill faces the same challenge: optimizing production at the lowest possible cost. Decisions, such as rationalizing grade structures and enabling the supply chain to respond to shorter product life cycles, can have a critical impact on the bottom line. It can also mean the difference between efficient operations or shutting their doors.



Now, thanks to complex solutions that are overlaid with user-friendly interfaces, even the most novice of users have a wealth of rich operational insights that can drive business change right at their fingertips. From bleaching to recovery processes to optimizing digesters, winders and other mill equipment, operators can make data-driven decisions that ensure that all parts of the production process are running at optimal levels.

The key to optimizing production with no additional capital investment is a digital infrastructure that enables self-service access to operational data. With the help of real-time data from sensors, assets, and control systems, users can understand both process and equipment performance and make critical changes that prevent production losses, increase output and preserve equipment health — all without complex technical knowledge of the data technology behind it.

When operators are empowered with data, they can take ownership over their areas of the business and make decisions that directly affect the health of the mill and the bottom line.

Benefits of a Digital Infrastructure:



Decreased
Energy
Consumption



Process
Optimization



Root Cause
Analysis



Quality Control



Condition-based
Maintenance
or predictive
maintenance

INTEGRATION AND AUTOMATION LEAD TO CRITICAL INSIGHTS

As the pulp and paper industry has transitioned from analog and pneumatic controls to wireless sensors sending data into the cloud, the mill floor has become more integrated, both in terms of process flows and data. This expanded level of automation and integration has brought new challenges. Mills must learn how to use and integrate new sources of data for better situational awareness across the multiple operation units and asset types within the enterprise value chain. In addition, the production process is dynamic, and mills must constantly question actions taken in various operating scenarios.

The ability to make quality decisions is directly tied to the accessibility of insights gleaned from data generated across the supply chain. When stakeholders can ask questions and directly interact with that data, they can find the answers they need to optimize production processes.

If the price being paid for putting energy on the grid is high, should one shift the grade mix to grades that make it easier to shed power, or does the contribution margin of the current grade maximize profits?



A NEW ERA OF SELF-SERVICE ANALYTICS IN A PRODUCTION SETTING

A data infrastructure collects, aggregates and wraps manufacturing context around operational data from the various grades. With that context, mill supervisors, operators and process engineers can gain production insights without needing to understand the raw data streams or underpinning technology. Domain experts in production settings can give context to shop-floor data using systems that identify key relationships between data streams, capturing knowledge and industry best practices. They can also define the analytics required to filter and shape data, such as the shower flow needed for an optimal dilution ration at the washers based on variances of kappa number.

With the right hardware and software infrastructure in place, any stakeholder can get answers to these questions at any time without the help of an IT specialist or data scientist.

**But how do you know if you have the right infrastructure investments?
A good data infrastructure will:**



Integrate data from multiple systems within a model centered on how equipment is performing in relationship to one or more events



Add operational context to data naming conventions to optimize data governance



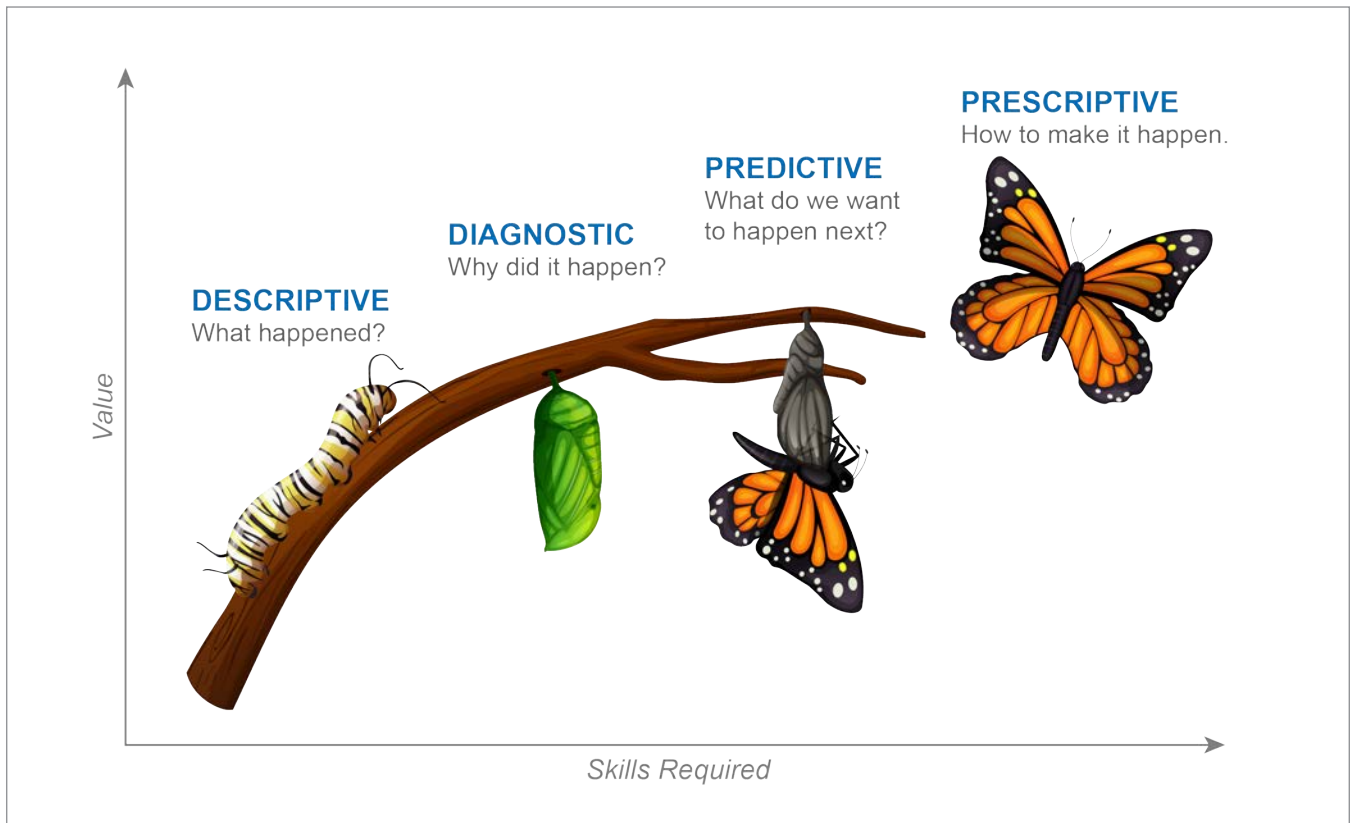
Embed domain expertise into the analysis of factors affecting production performance, as IT departments are generally ill-equipped to do this work



Create a common information infrastructure accessible by all stakeholders, from the mill to headquarters, in order to increase the level of collaboration within production teams

Once raw data streams have been integrated into a single infrastructure, overlaying the context embedded from an engineer's perspective and knowledge is what enables a self-service experience. For example, while the tradeoffs in fiber development between tear and tensile are well known, creating a model that captures the impact of subtle variations in zeta potential, changes in fiber length distribution (due to increases in fines loading), or variations in HPD/T refining loads, requires the insights from someone very familiar with the process. Some refer to this highly-integrated view of the science and art of papermaking as 'tribal knowledge'. With the right data infrastructure, a mill can apply, validate and preserve this tribal knowledge in an organized, auditable way.

If you can build a model, you can enable self-service.



Crawl, walk, fly: As self-service analytics become stronger with technology such as machine learning, stakeholders will be able to move from descriptive to prescriptive analytics, subsequently increasing their value to the organization.

THE KEYS TO SUCCESS: DATA-BASED COLLABORATION

Today, mills are at a turning point. The questions we need to ask about mill performance are multi-faceted. Asset performance relates to:

- **PROFITABILITY** by grade, by run, due to material substitution, supplier, type and customer
- **SUSTAINABILITY** by assuring we properly manage resources for profits, people and the planet

The infrastructure approach allows mills to identify areas of opportunity to optimize asset health and performance.

Successful enterprises must treat data like any other asset essential to operations. Just like information networks and telecommunications assets are required to support communication, a data infrastructure is critical for collaboration within the enterprise. Managing data through a common infrastructure as an enterprise asset will create new levels of collaboration within and across mills. Multidimensional models based on situational awareness across

unit operations create breakthroughs in innovation and operational efficiency. This makes the infrastructure extensible to many users, facilitates progress, enables discoveries and promotes collaboration to answer myriad questions.

The following section examines how a self-service data infrastructure approach can enable all stakeholders to make real-time decisions in a dynamic environment to optimize performance.



A STEP-BY-STEP GUIDE TO EXAMINING SHEET BREAKS

Operational technologies can help personnel use data across the enterprise value chain by offering one or more of four key functions:

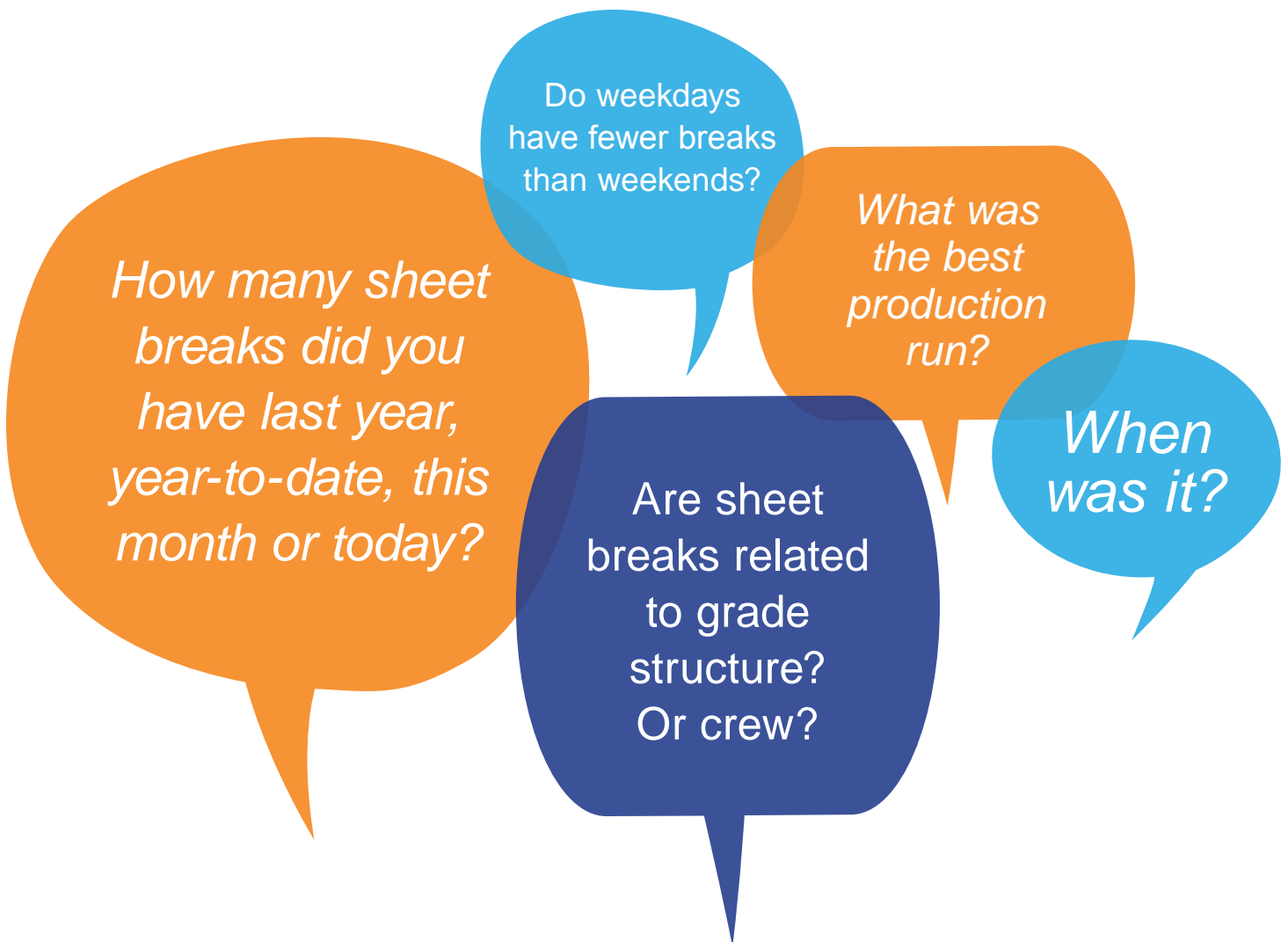
1. VISUAL DATA DISCOVERY
2. SELF-SERVICE ANALYTICS
3. DATA MINING AND COMPLEX ANALYTICS
4. IDENTIFICATION OF THE “GOLDEN” RUN

As an example, let’s look at how operations personnel could use a data infrastructure and self-service analytics to reduce the number of sheet breaks.

GETTING STARTED

Once the infrastructure aggregates and integrates data from diverse sources, domain experts establish the operational context around data streams. With

data organized by asset and process, the team can begin analyzing equipment performance in relation to specific events. From there, subject matter experts can create data models and ask questions to determine the root causes or factors that most affect performance.

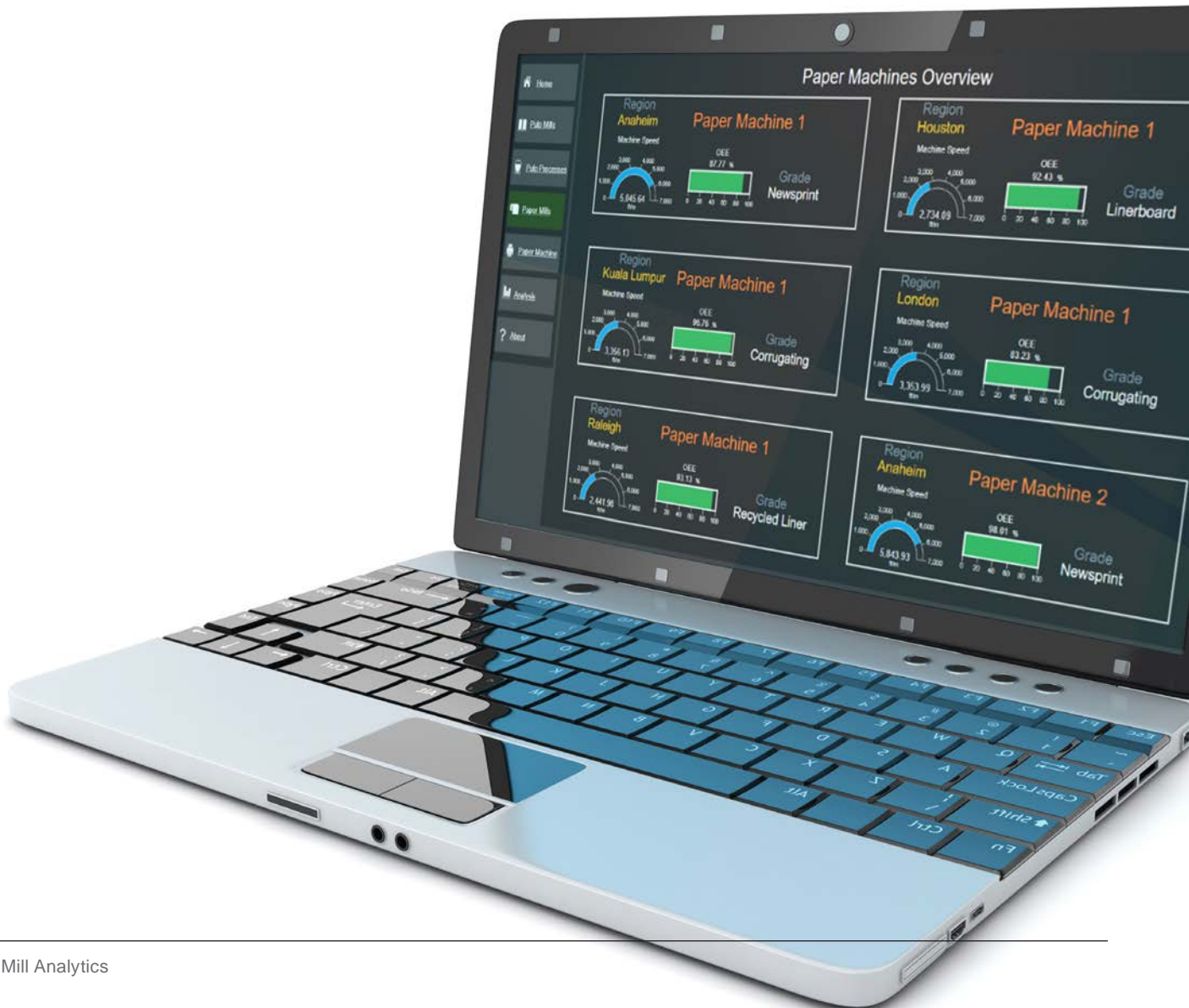


1. VISUAL DATA DISCOVERY

Visual data discovery enhances the user experience. It starts with a question, overlays domain expertise to gather the data, uses visual discovery to identify and validate relationships and then applies analytics to those findings.

A model that includes the context of the different sections within the paper machine will help tremendously in the analysis, and it's imperative to capture outliers for further analysis. For example, capturing the location of the first-off signal of a paper break can quickly provide the number of incidences.

The next step is to dive into the available data for each section of the paper machine and create KPIs that can be easily shared with the organization. OEE measured alongside cost, energy, steam and water consumption are easy wins for overall operational awareness and enable mills to prioritize areas of improvement.

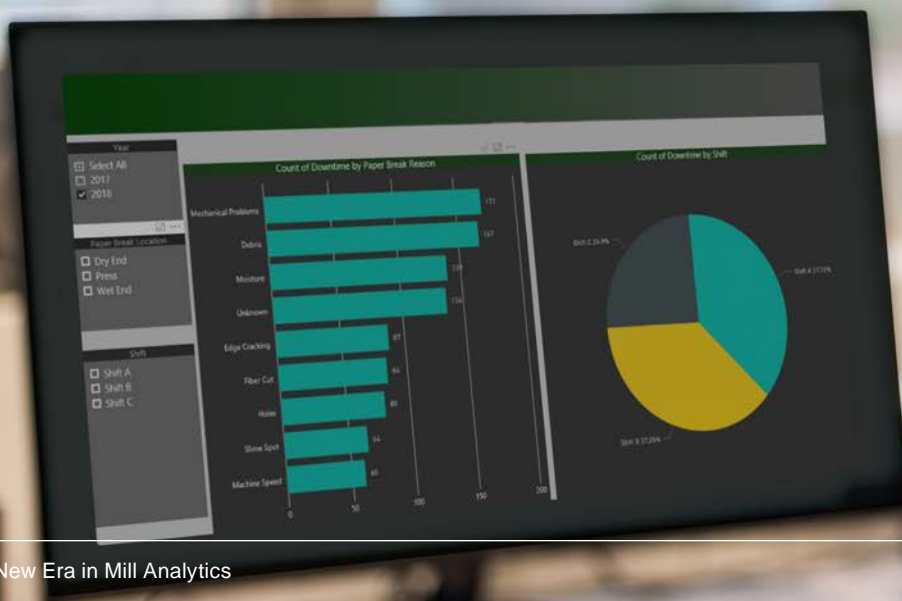


2. SELF-SERVICE ANALYSIS TOOLS

Process data models can be examined in more detail using self-service analysis tools, like Business Intelligence (BI) dashboards, that work with a data infrastructure. The model shown below contains over one hundred process variables from around the paper machine. It is common to have models that contain hundreds of process variables around the paper machine. In this use case, data is collected at one-minute resolutions for more than a year, equating to over 50 million raw data points. The data model also ties these variables to the analysis of thousands of data streams both upstream and downstream – from kappa numbers and pitch values in the pulp mill to zeta potential on the wet end. At first glance, these displays appear to be just bar-charts and trends, but there are a few key differences.

- The fundamental calculations are done close to the data sources, which optimizes the compute power for the users.
- The user has a much higher level of interaction with the information in the dashboards. This data model allows the user to slice and filter data without help from IT.
- It can be done very quickly. Self-service tools, in some cases, are an extension of the desktop environment, and most users are already running this level of inquiry.

The data infrastructure provides the foundation for collecting and integrating process and machine data, offers built-in analysis tools and connects to enterprise BI systems. With these self-service tools, the user makes machine data relevant by putting it in context of assets, systems and events.



3. DATA MINING AND COMPLEX ANALYTICS

In addition to creating models based on domain expertise, it is possible to apply statistics, such as frequency distribution, to hundreds of process variables and visually comprehend their effects. For example, we can examine ways to balance fiber developments for the paper properties of tear versus tensile.

The next step is to test the relative strength of the relationships among the collected data. A first pass, retention may indicate a strong relationship to sheet breaks. However, the user may feel that data more specific to wet end operations, like ash retention or zeta potential data, are even more important. Results may lead the user to collect more data or higher resolution data or data closely associated with previously gathered data.

Thanks to modern tools, setting up and interpreting these relationships does not require a degree in advanced mathematics. The solutions available today contain algorithms that allow users to easily test the strength of these relationships through visualization. Once the strength of relationships are confirmed, one can extract those same variables into the data model required for more advanced analytics, such as multivariate analysis (MVA), partial least square regression (PLS) or random forest algorithms.

This means correlating real-time data from the running parameters for different paper grades with test results from the laboratory. In addition, chemical properties of the pulp used as well as fillers quantity and quality should also be part of the analysis. The complexity of the calculations and finding relationships between these variables leads to multivariate analysis that can be grasped using current visualization tools. In many cases, the correlations are presented as a Pareto chart from strongest to weakest correlations among variables. In other cases, it is a list of priorities.

The technologies described here — self-service analytics, visual data discovery, data mining, and complex analytics — are interrelated and supported by infrastructure technologies, which help to validate and operationalize insights across different tools and parts of the organization.

4. BEST PRACTICES: GOLDEN RUNS

After the key variables or priorities are identified and their characteristics linked to production runs, mill personnel can define the ideal process and production data parameters that lead to a sheet break-free “golden run”. This means setting the acceptable ranges for running a product. Once a golden run is defined, automated notifications and real-time visualization can support consistently improved performance across production runs. The knowledge gained will accelerate the development of new products and new grades, and is the only way to continuously improve the quality and yield within operations.

For example, Paper Grade 10001 has different set-point parameters for the paper machine. Based

on the finding of MVA, these parameters may have changed, particularly because performance can change as machines get older. Set point parameters will dictate the high and low limits for current operational data, which will have to be monitored in real-time to track the variances for specifications. When this information gets within a certain range, a notification and events are created to track operations that are “in trouble” and compel supervisors and operators to take action before an event, such as a sheet break, occurs.

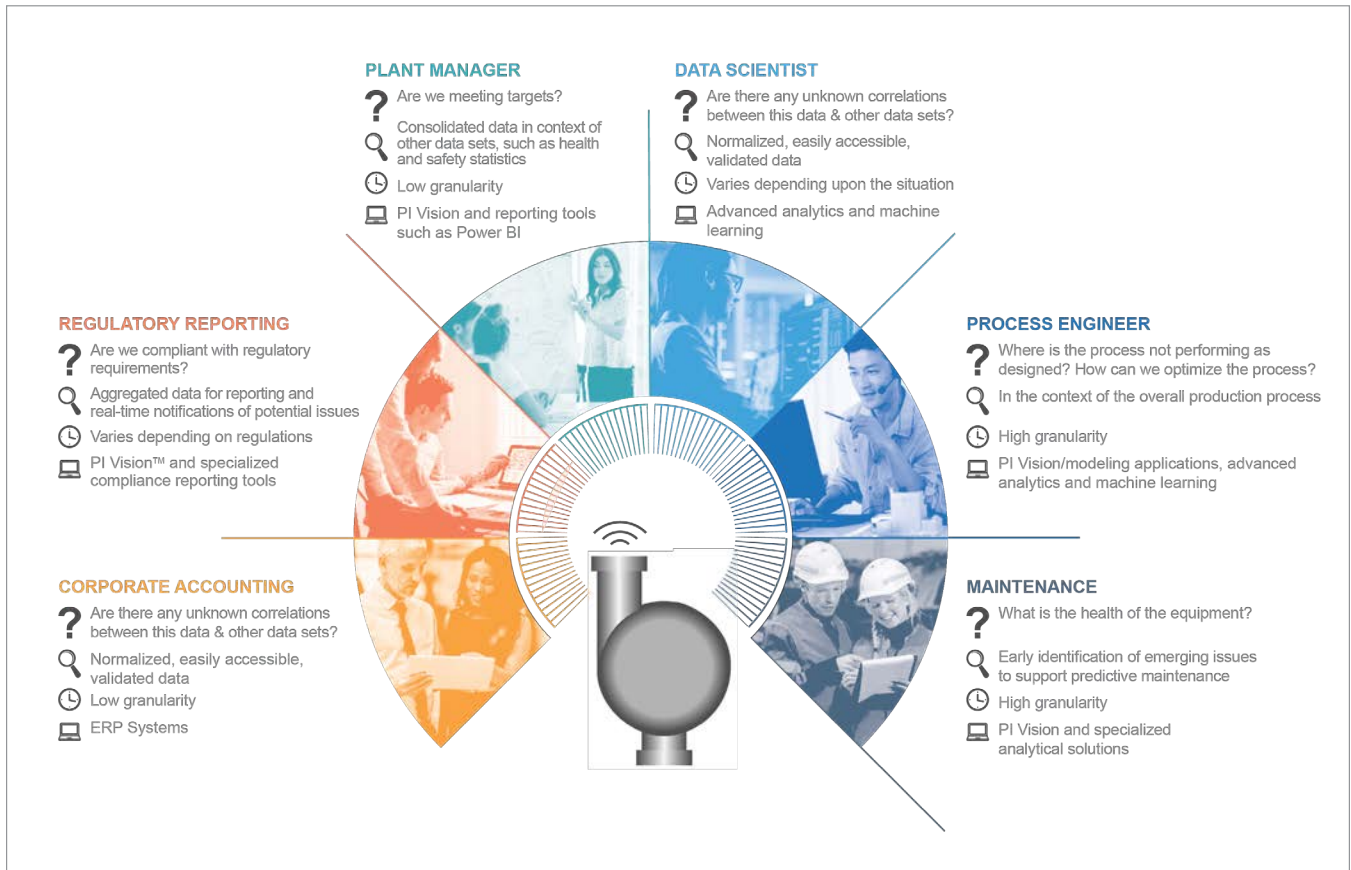
At the beginning, these events may elude a mill, but as operators become more familiar with set points and performance benchmarks, data-driven operations will run smoother.



THE PI SYSTEM™: INSIGHT ON DEMAND

The PI System is a data infrastructure that captures data from sensors, equipment, control systems, and other devices and transforms it into rich, real-time insights. Anyone, from pulp and paper engineers to executives and partners, can then use that insight to reduce costs, dramatically increase overall yield and productivity, improve quality, and make more strategic, data-driven decisions.

Data Should be an Asset Everyone Can Use



How Different Parts of the Organization Look at a Single Data Point

KLABIN: PAPER GETS A DIGITAL TWIN

Klabin is Brazil's largest producer and exporter of paper products and pulp. The company operates 17 plants in Brazil and Argentina and produces 3.5 million tons of pulp per year. Its Puma plant churns out 1.5 million tons of pulp per year and is energy self-sufficient, producing enough power for a city of one million people.

OSIsoft's PI System gave Klabin the power to create a real-time digital model of pulp production at Puma, from tree harvesting all the way through drying. As a result, Klabin can make faster, better decisions, automate notifications of abnormal production conditions, and trace products through the entire production process.

One of the most important aspects of Puma's PI System-based digital twin is the ability to trace batches from tree to finished product and analyze batch data on the fly and correlate important quality information. For instance, data on one pulp batch showed an unusually low point in the brightness of the pulp coming out of a drying machine on a particular day. By using the PI System to compare data at every step of the process, from the cutting of forest logs through chipping, bleaching and drying, Klabin engineers were able to quickly trace the problem with the pulp brightness to an issue with part of the bleaching process, upstream from the drying machine.

Having a digital twin of the Puma plant has also accelerated decision-making. Previously, a decision to adjust the production pace would take 1-2 hours. Now process coordinators can simulate decisions in real-time and react more quickly and effectively across the plant. As a result, they have added an additional 3400 air dry tons per year, equivalent to a day's worth of plant production.

Additionally, with real-time process monitoring, Klabin can better control water quality in their boilers and avoid expensive shutdowns. Each time a boiler has to be shutdown, it's 8 hours of lost production and an estimated \$4.8 million cost per incident. Using the PI System, Klabin created automated notifications that have already prevented two boiler shutdowns for \$9.6 million in cost savings.

But Klabin's digital transformation journey isn't over yet. Today, they are working on a daily management report that highlights lagging key performance indicators (KPIs) so management can focus on the most mission critical issues.

For me, transformation isn't in the collection of data. I assume the data is all there. For me, the transformation happens in turning that data to information, to knowledge, to action, to dollars and allowing people to draw conclusions using the Internet of Things data that's always been there. The power behind that, for me, comes with PI.

— Larry Shutzberg, CIO at Evergreen Packaging

CLEARWATER PAPER IDENTIFIES PRODUCTION DEVIATIONS WITH THE PI SYSTEM

As the largest provider of private label tissue to retail grocery stores in the United States, Clearwater Paper's operations span seven manufacturing sites, more than 10 paper machines and over 50 tissue converting lines, as well as pulp mills, recovery and power boilers. With a need for real-time operational intelligence, Clearwater uses the OSIsoft PI System, an open data infrastructure that gives users across the organization access to real-time and time-series data, to extract insights and optimize production.

After setting control limits and alarms to monitor asset performance across dozens of different grades, Clearwater was able to quickly identify performance deviations in the manufacturing process. When the average daily temperature of one of the mills began to slowly increase over time, they were able to distinguish it from regular day-to-night fluctuations and, upon inspection, determine that there was debris in the motor. Not only that, Clearwater was able to identify seemingly innocuous issues, such as small setting changes, and work with mill operators to ensure consistency to prevent interruptions or issues.

Much like smartphones have given consumers self-service access to the information on the internet, a digital infrastructure gives stakeholders across an enterprise access to the insights hidden within massive amounts of data. As the pulp and paper industry continues to change, this self-service access to information will be imperative for long-term survival. However, while the technology required is available, success lies in integrating changes in business practices with technological advancements. Ultimately, the full value of data is realized in the hands of human talent. The easier it is for people to access relevant data for decisions, the more mills can improve overall performance.





ABOUT OSISOFT

With the belief that people can improve process efficiency, manage assets and mitigate risk if they have access to the data they need, OSIsoft created the PI System as a common data infrastructure to capture and store real-time data and make it available however and wherever needed. For over 30 years, OSIsoft has delivered the PI System with the singular goal of creating a common data source to connect enterprise data with people making decisions and solving problems.

Today, the PI System is trusted to do just that. Processing over 2 billion data streams across 19,000 sites, the PI System is embedded in operations and critical infrastructure in over 125 countries. Our customer base includes Fortune 100 and Fortune 500 companies in power generation, oil and gas, utilities, metals and mining, transportation, critical facilities and other industries. Our customer base includes 65 percent of the Global 500 process industry companies, including all 10 of the top pulp & paper companies (as listed by PWC and RISI).

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