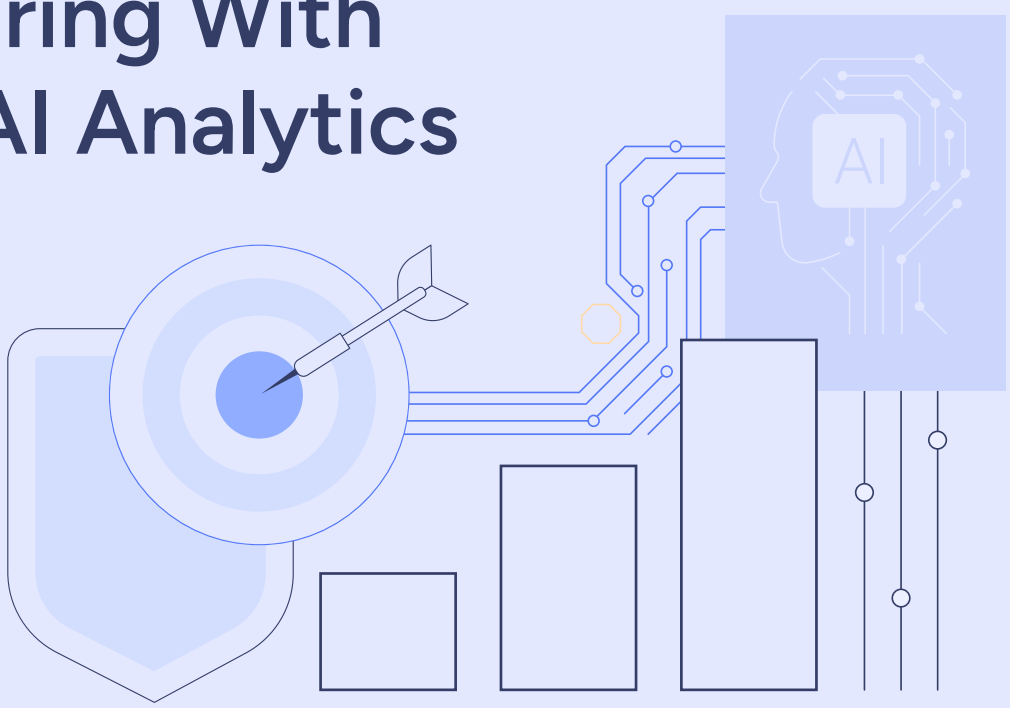
Precision Under Pressure

Accelerating Semiconductor Manufacturing With Industrial AI Analytics



Spotfire®

With the worldwide surge in AI adoption, the stakes in high-tech manufacturing (HTM) have never been higher.

Across the globe, fabrication plants (fabs) are seeing record demand. The rise in global AI usage means new players are entering the market every day, all of whom require hardware to support their operations. At the same time, most manufacturers face a massive backlog, with capacity booked out as far into the future as 2028.[1]

In that environment, the margin for error is razor-thin. Excursions that aren't rapidly resolved can easily balloon into inferior products, missed contract deadlines, reputational damage and accompanying penalties, and falling behind competitors that ship on target. Meanwhile, at a larger scale, the downstream effect of missed shipments is the disruption of crucial global supply chains.

To succeed under this pressure, manufacturers must be able to rapidly identify the key causes of production issues, in real time and across highly technical, heterogeneous data. Yet many teams still rely on fragmented systems and improvised, in-house solutions—tools that fail to provide the much-needed bigger picture and that were never built to handle this level of pressure.

In this ebook, we explore the role of a dedicated **visual industrial analytics platform**, augmented by AI, for unifying data and insights across systems, accelerating root cause analysis, and keeping production moving at the pace of demand. We show how this approach solves the key challenges manufacturers face today, and how the combination of expert-in-the-loop AI and analytics translates into measurable industry advantage.

An industry under pressure: key challenges in high-tech manufacturing

A combination of market demands and changing operational conditions means that today's manufacturers face a combined set of pressures unique in the history of HTM.

A growing workforce shortage

For the semiconductor industry alone, estimates suggest more than a million additional skilled workers will be needed by 2030.[2] At the same time, as older engineers age out, fewer qualified trainees are taking their place, making it difficult to meet that demand and ensure continuity of operations.

As a result, manufacturers are increasingly turning to automation and AI to fill the gap. Success with this approach, however, is not guaranteed. Making the most of AI and automation requires systems that provide clear visibility into production failures and that allow engineers to easily identify bottlenecks, improve productivity, and use their expertise to improve performance.

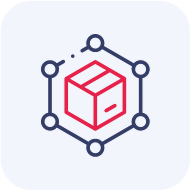
[1] TSMC's fabs are so in demand, they're sold out even before they've been built (Yahoo Finance, 2026). https://finance.yahoo.com/sectors/technology/articles/tsmcs-fabs-demand-theyre-sold-101834931.html

[2] The global semiconductor talent shortage (Deloitte, 2024). https://www.deloitte.com/us/en/industries/tmt/articles/global-semiconductor-talent-shortage.html

Significant overheads

A single, fully outfitted fab can easily cost $10–$20 billion.[3] Faced with those overheads, manufacturers need to guarantee a return on investment—or suffer massive financial fallout.

To achieve those returns, facilities and equipment *must* operate at maximum throughput, while still producing products to the technical specifications and quality standards needed by customers. Getting this right takes an unprecedented level of clarity and insight across the entire manufacturing process—and the ability to resolve excursions as fast as possible.



Short, complex product life cycles

Compounding the cost issue is the nature of the industry itself. Given the pace of technological innovation, product life cycles are inevitably short and complex. Manufacturers often need to turn out a new product in as little as six months. This requires rapid development of an optimized process across multiple steps, each with its own heterogeneous data and requirements.

Inflexible deadlines and high execution latency

In today's market, delivery deadlines are typically non-negotiable. The customers relying on manufacturer outputs have often locked in their own schedules years in advance. Any delay on the manufacturer's production floor has seismic impacts on the viability of the products those customers take to market.

For fab operators, this means that issues must be resolved with the lowest execution latency possible. Accomplishing that, however, requires insight across data spanning multiple systems—insight that can't be easily gained if the underlying data sources are fragmented and disparate.

Against this increasingly complex operational backdrop, the stakes for manufacturers have never been higher. Failure to deliver on time carries not only financial and reputational risk—it can easily be the catalyst for a permanent loss of ground against accelerating competition.

[3] New Manufacturing Plant Cost 2026: Full Breakdown by Industry (iFactory AI, 2026). https://ifactoryapp.com/greenfield-consulting/cost-to-build-manufacturing-plant-2026

Meeting the production challenge: criteria for success

Succeeding in the face of these industry pressures requires near-instantaneous access to production floor data, along with the ability to *connect and analyze data across the entire production cycle*. This includes being able to explore and enrich data, test out hypotheses, combine data on the fly and cross-functionally, and leverage AI for working through challenging problems. With those capabilities in place, it becomes possible to:

Maximize throughput and quality: Better data insights measurably improve quality, yield, and output. That, in turn, keeps production moving at pace and ensures fabs can meet their assigned targets.

Increase learning rates: With a more unified view of the production floor, engineers can find the root causes of problems faster and apply those learnings back into production—speeding up the rate at which learning contributes to optimization. Those findings can also be easily shared between teams and departments, speeding up optimization across the entire production line.

Develop differentiated product capabilities: Better insight into production data, along with shorter learning cycles, increases the likelihood of breakthroughs, and can have an outsized impact on market success. That includes being able to develop novel product features at speed, improve quality, and develop process innovations that translate directly into higher quality products.

Scale expertise with AI: As production data grows in volume and complexity, manual analysis alone can't keep pace. Systems using AI to aid data analysis can help surface patterns and the likely causes of production line issues faster. This allows engineers to narrow the search and focus their expertise where it matters most, even when dealing with large data volumes.

Empower teams to make fast, informed decisions: Finally, access to unified, multi-domain data empowers fab managers and on-site experts to make good calls quickly. It also allows engineers to investigate creative options for optimizing production or their hunches about where a process might be going wrong.

Despite the need for them, these capabilities are exactly where many operations come up short. As new challenges arise, a common solution in many fabs and assembly facilities is to jury-rig fixes, deploy outdated tools, or create custom systems to address pain points in their processes.

The unintended upshot is that their data becomes more fragmented across systems. And the end-to-end process visibility manufacturers need to keep operations running on time becomes buried under makeshift fixes and disconnected data silos.

The overall result is a high level of risk to operations from solutions that:

Optimized production from optimized data: the transformative potential of industrial analytics

Meeting the objectives listed above and overcoming the key challenges of modern HTM production require a fundamentally different approach to how process data is handled—one rooted in the idea that engineers, fab managers, and operations leaders must be able to:

- Easily connect data from different sources,
- Synthesize and explore that data for deeper, cross-functional insights, and
- Use those insights to bolster efficiency, yield, and product quality in real time.

This is the core concept behind sector-specific industrial analytics. **A comprehensive industrial analytics platform allows teams to extract insights across disciplines and business units within a single environment, and empowers them with AI-augmented decision-making capabilities and improved manufacturing analytics.** This allows them to quickly understand the causes of variations and excursions, and to streamline production processes to meet quality, yield, and timeline parameters.

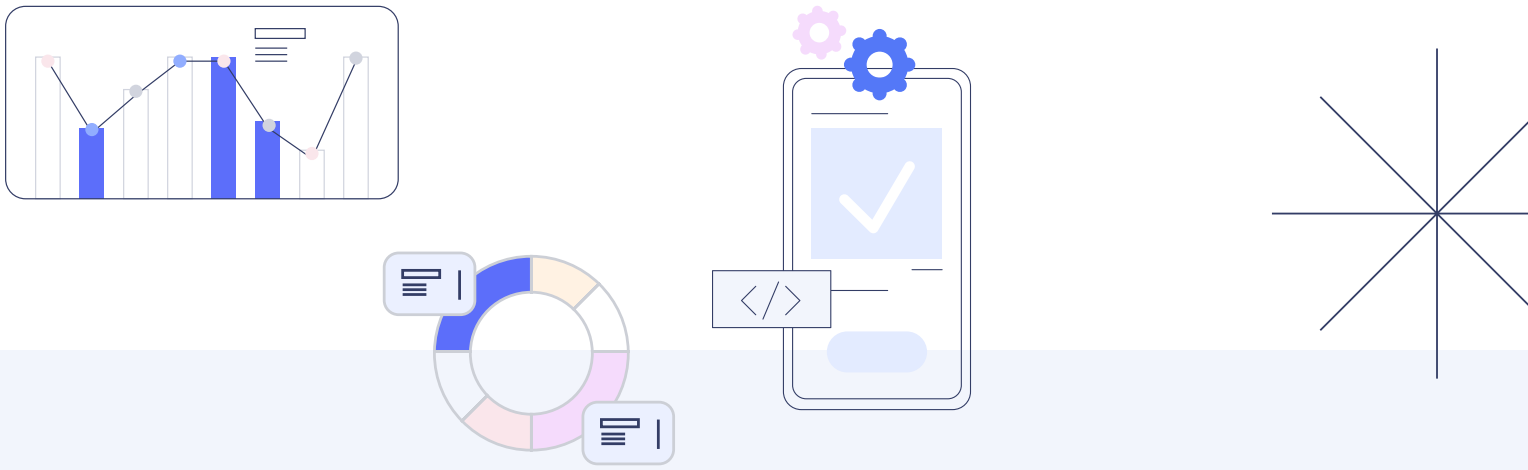
At a glance: What is industrial AI analytics and what does it enable?

Industrial analytics refers to data platforms natively designed to meet the core challenges of specific industries, like high-tech manufacturing. These platforms typically combine AI capabilities, advanced analytics, and industry-specific workflows that allow teams to turn complex, industrial data from multiple sources into actionable, shared intelligence. They are also designed to handle industrial-scale data volumes, and the specific file formats and data visualizations used by different domains within a given industry.

In the case of high-tech manufacturing, this means the following:

- Data from across the entire production process can be aggregated, viewed, compared, and analyzed in a single data environment—from MES and inspection data to metrology, test results, and machine performance.
- Teams can easily explore variations across spatial, temporal, and hierarchical relationships, allowing them to make measurable improvements to performance, quality, and yield.
- Fab managers and operations leaders can cut through the clutter of complex datasets, reaching crucial insights at the pace of business decision-making.

Within high-tech manufacturing specifically, these capabilities translate into distinct use cases across the production lifecycle: from operational efficiency and product performance to process control and yield optimization, each with its own data, workflows, and success metrics.



Pinpointing the causes of variation

To produce reliable, high-quality parts, engineers must be able to rapidly pinpoint and remove the causes of variation. For example, with a Process Capability Index (Cpk) of 0.67, failure rates run at 4.55%, unacceptably high for modern high-tech manufacturing fabs.

Using root cause analysis supported by industrial AI analytics can push that Cpk up to 2.00; yielding a failure rate of just 0.002 PPM. A result that would be exceedingly difficult to achieve with manual process analytics approaches.

The four pillars of industrial analytics

To be considered a true industrial analytics solution, platforms must meet four criteria:

1

AI augmentation

To increase data analysis efficiency across complex production datasets, platforms must come with *fully integrated* AI. This means:

- AI systems that are embedded directly into workflows, including context-aware AI agents
- Compatibility with large language models (LLMs) already being used across the organization
- Transparency in data sourcing and analysis
- Checkpoints and data exploration suggestions based on the knowledge and expertise of human engineers
- Full "expert-in-the-loop" functionality, with AI surfacing patterns and anomalies, but human experts making decisions based on that data

2

Industry-native functionality

Platform functionalities and workflows should be aligned with real operational processes and industry best practices. This includes having industry-specific visualization tools and analytical methods—such as wafer maps, fail pattern analysis, and defect classification—built in. It also means having workflows tailored to real-world investigative patterns (e.g., moving from wafer analysis to equipment logs and performance testing to understand an emerging issue).

Teams must also be able to:

- Build out custom workflows and tools to meet their exact challenges and needs, according to the unique context of their production line.
- Connect learnings and data across defect, equipment, process and yield engineering—shortening learning cycles, and speeding up correlation between metrology, defect data, and electrical testing.

3

Integrated analytics

The solution should support visual data exploration *and* advanced analytics in a single environment. This means engineers and other users should be able to move from visual observation directly to statistical validation *without needing to switch tools*. This requires built-in, industry-relevant statistical and modeling capabilities, along with support for end-to-end analytical workflows.

4

Scalable analysis

Platforms should be designed to execute analyses at scale, regardless of the complexity and size of their datasets. This is especially important for high-tech manufacturing, where analysis often includes datasets containing terabytes of data. In practical terms, this capability is supported by push-compute functionality, where data is analyzed at the source and the results updated in the shared platform environment.

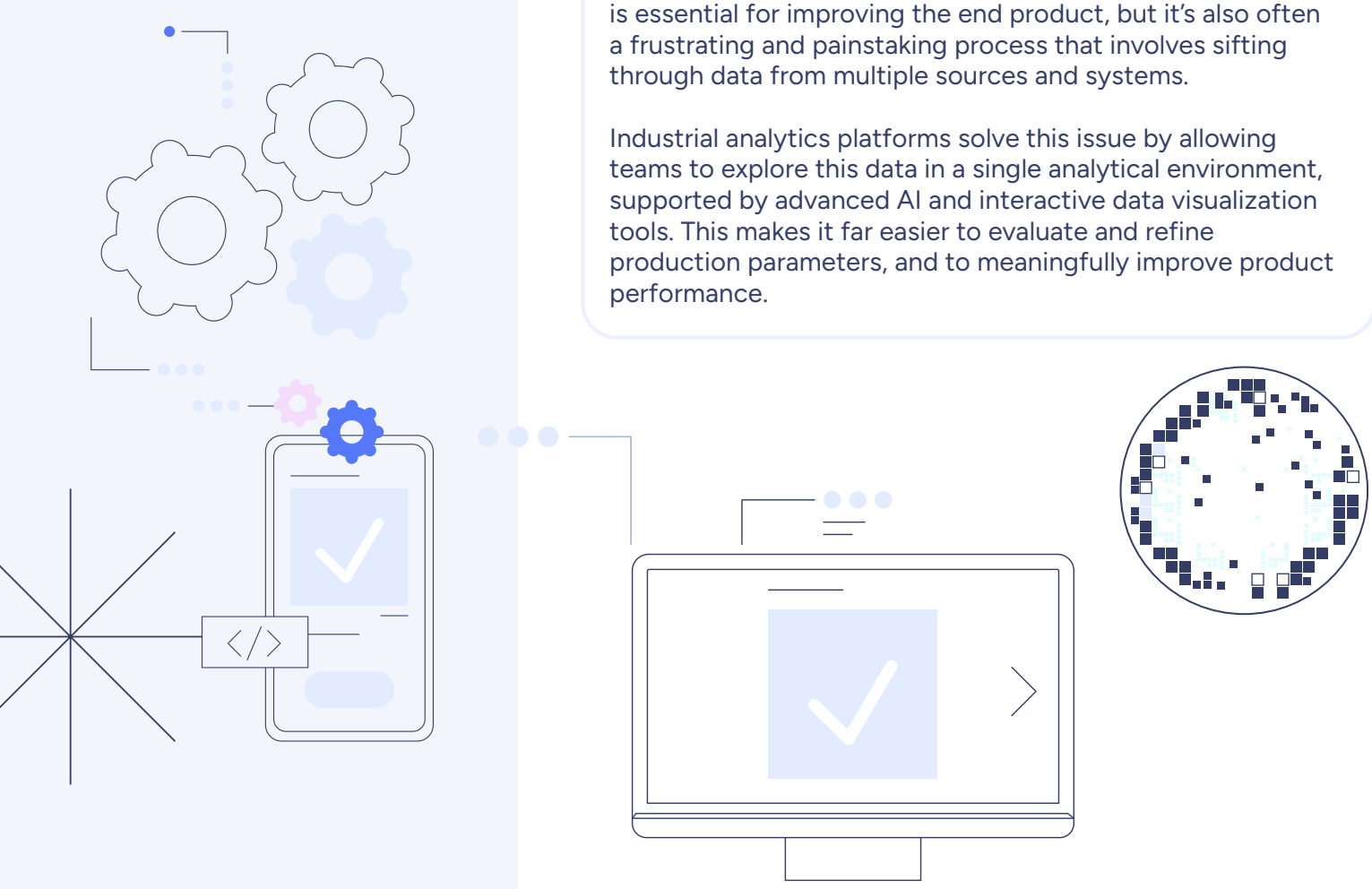
The industrial analytics advantage: supporting critical manufacturing decisions

With a fully realized industrial analytics platform in place, teams gain a measurable advantage across critical manufacturing processes and decision-making.

Optimized product performance

To optimize product performance, teams must understand the interaction of hundreds of variables. These span everything from the materials used to the production environment. This is essential for improving the end product, but it's also often a frustrating and painstaking process that involves sifting through data from multiple sources and systems.

Industrial analytics platforms solve this issue by allowing teams to explore this data in a single analytical environment, supported by advanced AI and interactive data visualization tools. This makes it far easier to evaluate and refine production parameters, and to meaningfully improve product performance.



Enhanced operational efficiency and resilience

In any fab, operational efficiency hinges on a number of complex factors. Clashes in production schedules, machine availability, maintenance, and process performance can all impact throughput and process performance, as well as dictate whether a manufacturer is able to meet their targets.

By providing deeper insights into these processes, industrial analytics tools empower teams to proactively monitor everything from production performance to equipment behavior—making it easier to both identify potential problems and to understand the impacts of operational decisions.

Higher process integrity and control

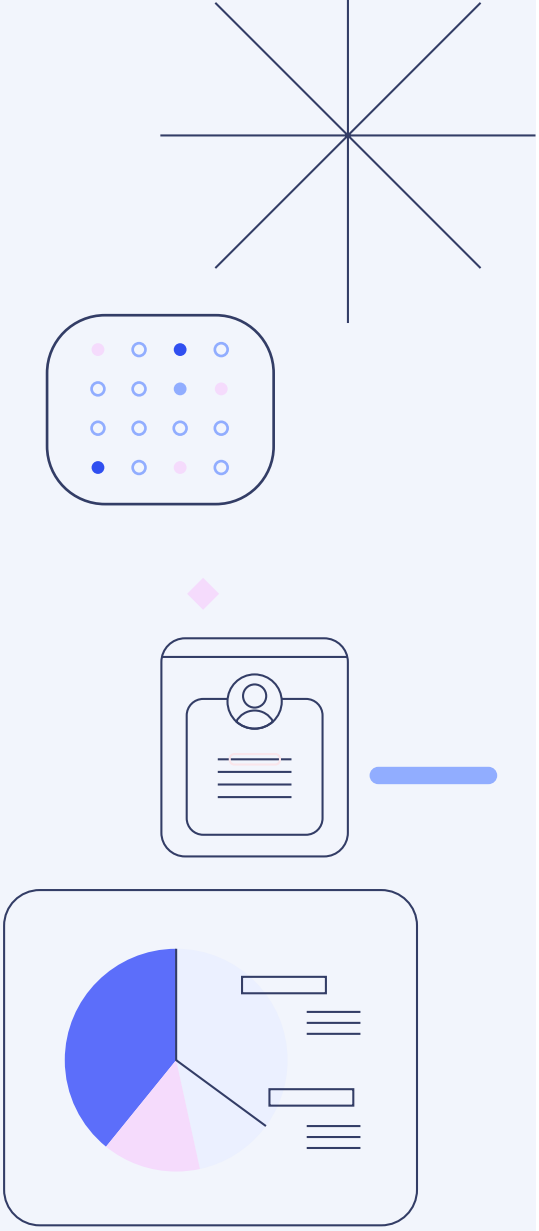
The gold standard for high throughput is stable, repeatable manufacturing processes. Achieving this requires continuous real-time monitoring of processes and test results, so that engineers can respond to changes in parameters before they seriously affect production.

Integrated industrial analytics equip teams with the statistical tools, spatial visualizations, and time-series data needed to explore process behavior and identify emergent deviations. This allows for rapid troubleshooting and root cause analysis that can prevent more significant excursions before they occur.

Improved yield and quality

To improve yield and quality, engineers must have an in-depth understanding of variation across products, tools, and processes. That includes being able to correlate data from multiple sources, such as metrology measurements, test data, and defect inspection results.

Using the data-rich, visual environment offered by industrial analytics, this process becomes far easier. Engineers can map relationships in a single platform, across spatial, temporal, and hierarchical dimensions. This, in turn, allows them to identify best practices, and improve both product and process outcomes.



At a glance: core operational benefits of industrial analytics

The ability to access, analyze, and visualize data from multiple sources in a single environment comes with several operational advantages. Manufacturers adopting industrial analytics see:

- **Accelerated root cause analysis:** Unified visual data and analysis in a single platform, across production steps, ensures faster identification of excursion causes.
- **Faster new product introduction:** Faster insights mean faster product development and the accompanying market advantage.
- **Improved Cpk (Process Capability Index):** Real-time visibility into process variation allows operations leaders to correct issues before processes drift out of specification.
- **Increased OEE (Overall Equipment Effectiveness):** Proactive management of equipment and downtime ensures teams can optimize performance and productivity.
- **Stronger individual equipment performance insights:** Rapid identification of BOB (Best of Best) and WOW (Worst of Worst) tools and chambers based on historical data. This allows teams to finetune performance across the entire production floor.
- **Higher daily turns:** Optimized processes and fewer stoppages mean that material moves through each production step faster.
- **Minimized material hold time:** Faster root cause analysis and clearer process visibility mean that lots spend less time on hold, whether due to excursions, equipment issues, or inspections.
- **Fewer scrapped wafers:** Early detection of process drift and deviations means fewer wafers lost to defects noticed too late.

Having these capabilities in place ensures that production lines continue to run optimally, even under sustained demand and tight delivery windows. That reliability under pressure becomes a competitive edge.

Industrial analytics in action: How Renesas improved yield, quality, and efficiency on their semiconductor line

In the case study below, we explore how semiconductor producer Renesas Electronics improved operational efficiency with Spotfire's industrial analytics.

Company context

For more than two decades, Renesas Electronics has been a leading provider of semiconductor solutions to industries worldwide. In that time, their reputation for engineering excellence, and a commitment to innovation, have seen them go from strength to strength. Today, Renesas is one of the world's largest providers of embedded semiconductor technology to the automotive, industrial automation, IoT, and infrastructure sectors.

The challenge

As with any semiconductor manufacturer, Renesas must meet the growing challenge of maintaining quality while improving their yield. In recent years, the company has faced several roadblocks to that goal, including how to handle and learn from massive datasets using legacy technology like spreadsheets and static reporting.

Worse still, Renesas teams around the globe have historically worked within disconnected systems. This has not only made collaboration difficult, it has also impacted the ability of the business as a whole to make agile decisions and respond to changing market conditions.

With these issues impacting time-to-market and profitability, Renesas leadership was looking for an industry-specific partner that could help them speed up production through data insights.

The Spotfire solution

In 2005, Renesas deployed Spotfire, which quickly became a cornerstone of their digital transformation strategy. Using Spotfire's unique blend of advanced analytics, industry-specific visualizations, and real-time data access, the company's engineers and analysts were able to build tailored solutions to their most pressing problems. Spotfire has also fostered secure collaboration between teams and facilities, speeding up the pace of company-wide, data-driven decision-making.

Today, Renesas uses Spotfire tools and analytics across dozens of use cases, including:

Spatial zone analysis: Renesas engineers now use Spotfire to analyze edge zones, center zones, and other wafer-specific regions to detect process deviations. The result is faster root cause identification and tuned processes across production lines.

Statistical bin and yield limit monitoring: Spotfire enables Renesas teams to evaluate materials against Statistical Bin Limits (SBL) and Statistical Yield Limits (SYL). By identifying deviations from optimal thresholds, engineers can tighten process windows and drive targeted yield improvements.

Limit management and specification tuning: Through Spotfire data applications, teams continuously evaluate the impact of specification changes on product yield, reliability, and cost—allowing Renesas to optimize the balance between customer requirements and manufacturing constraints.

Return material analysis: Spotfire supports wafer map reconstruction for returned customer material. Using this capability, Renesas engineers can quickly get to the root of product failure, enhancing their ability to solve issues and improving the company's relationships with affected customers.

With these and many other Spotfire-enabled capabilities in place, Renesas has been able to improve performance across their operations: boosting collaboration between teams, enhancing yield and quality, and shortening the time to investigate and resolve production issues.

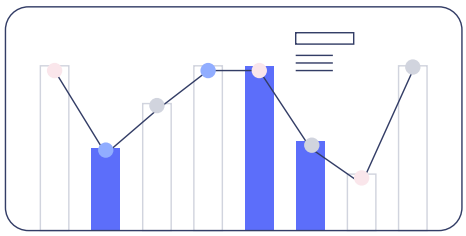
Looking ahead

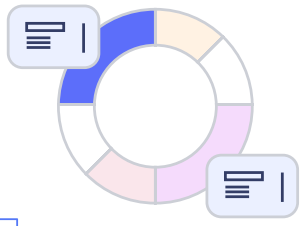
In the years to come, Renesas has even bigger ambitions for Spotfire's industrial analytics platform. Using built-in workflow capabilities, and Spotfire's onboard AI, the company plans to consolidate their enterprise analytics and reporting toolset, eliminating redundancy and cost. They also have an eye on enhancing their predictive analytics capabilities to improve yield prediction and anomaly detection.

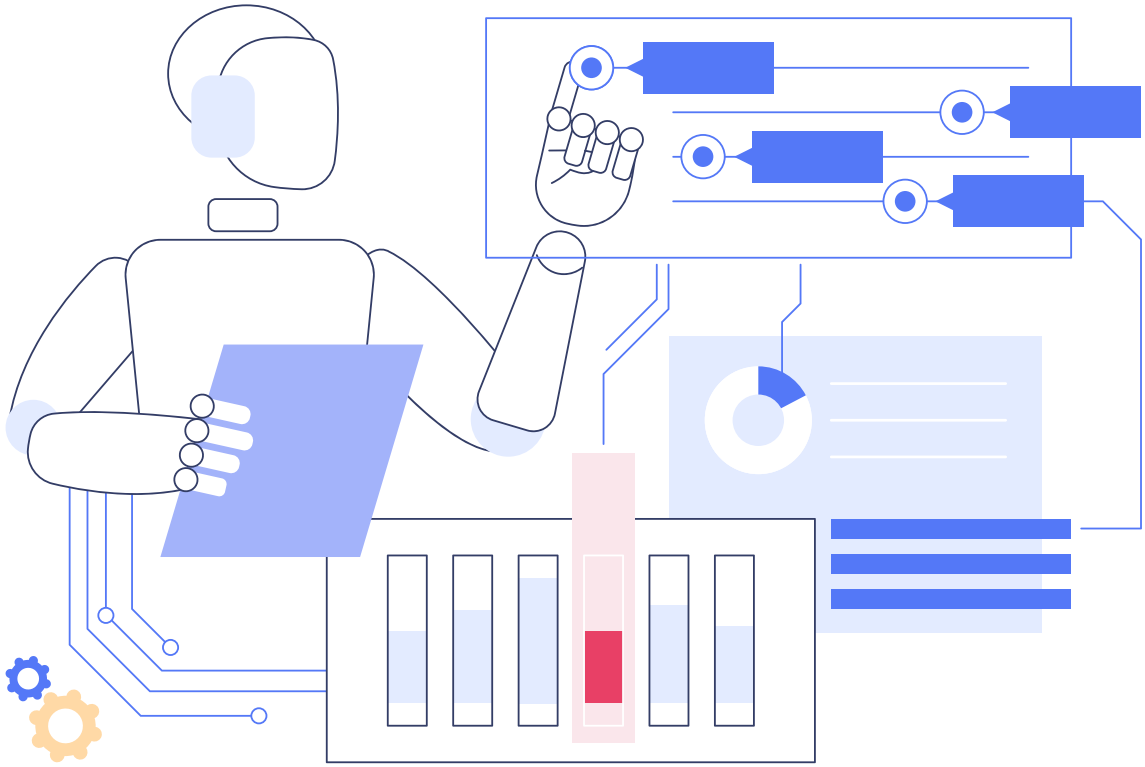
And from there? The goal is simple: to scale Spotfire across their global operations, accelerating decision-making at every level of the organization.

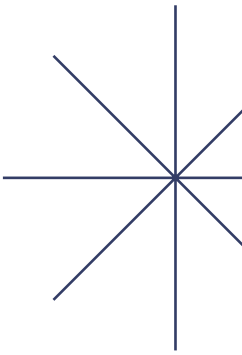
As Moumita Bardhan, Director of Manufacturing Applications at Renesas, sums up:

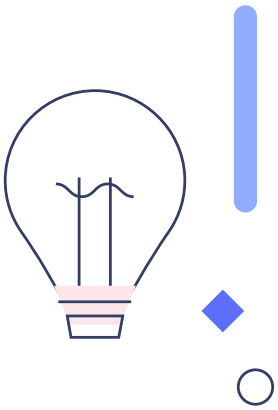
"Spotfire enabled proactive, not reactive, decisions. We improved yield, reduced retest costs, and laid the foundation for predictive analytics."









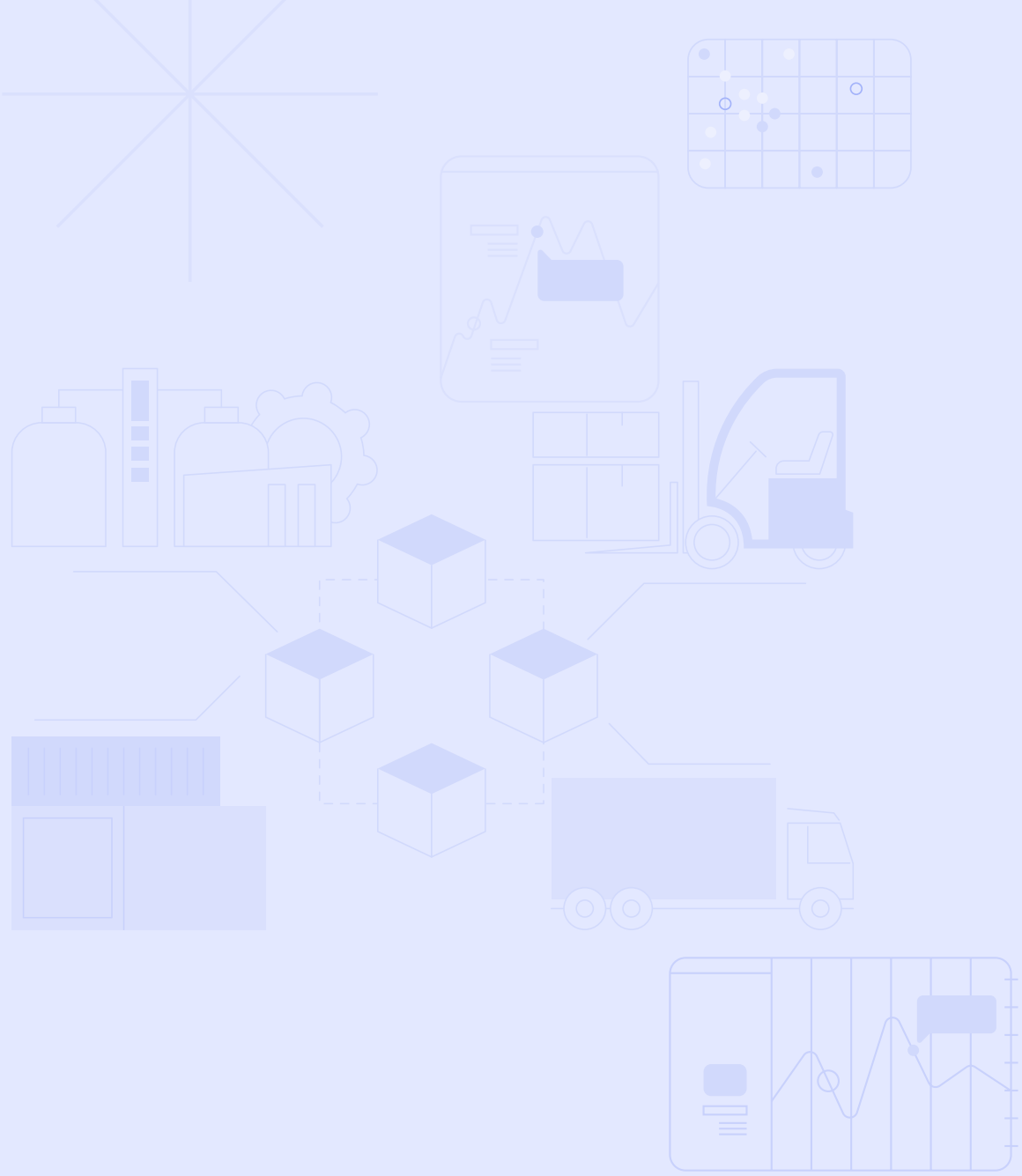


Discover industrial analytics with Spotfire

As AI adoption and industry demand accelerate, the trend for high-tech manufacturing is clear. Clear-cut data insights and advanced analytics are essential components of the production toolkit. That's why leading manufacturers are turning to comprehensive industrial analytics platforms to help them meet production pressure and transform their operations.

As the leading industrial analytics solution for HTM, Spotfire is proud to partner with these companies, giving them the tools they need to keep operations on track, even under the most ambitious targets.

Interested to see what better analytics can do for your operation? Learn more.



Spotfire®

Spotfire is a visual industrial analytics platform that helps organizations analyze complex operational, engineering, and business data to make better decisions. By combining interactive analytics, AI-assisted investigation, advanced data science, and industry-specific workflows, Spotfire enables domain experts to uncover insights, reduce uncertainty, and improve outcomes across complex industrial operations.

Contact us

Fill-in form

Support
support@spotfire.com

Sales
sales@spotfire.com

Training & certification
learning@spotfire.com

Fort Lauderdale
851 Cypress Creek Rd
Fort Lauderdale, FL
33309
United States

Santa Clara
4980 Great America Pky
Santa Clara, CA
95054
United States

Göteborg
Första Långgatan 26
413 28 Göteborg
Sweden