White Paper
Data Center
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IT@Intel: Accelerated Analytics Drives Breakthroughs in Factory Equipment Availability

An accelerated analytics breakthrough helps quickly identify underutilized factory equipment and deliver data that drives improvements and increases equipment productivity

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Executive Summary

For Intel's complex factory environments, quickly identifying tools that are operating below their optimal capacity and finding the root cause is crucial for maximizing production output. With thousands of tools involved in production and each manufacturing tool running from one to 50 operations, there are tens of thousands of tools and operations to monitor, analyze and adjust. Knowing where to focus engineering efforts is a monumental challenge.

To address this challenge, Intel IT worked with the Virtual Factory (VF) experts in Intel's factories to create a powerful analysis method that lets managers quickly traverse an entire factory, or several factories, and identify underutilized equipment. The team built upon an existing platform to create and implement this new data analysis within 48 hours of the initial request. The solution rapidly increased production at one of Intel's factories, generating significant value in the first quarter of usage.

Some unique attributes of our solution include the following:

- The analysis uses an easily traversable grid modeled after actual factory organization to allow fast and intuitive interactions.
- Areas in a factory that need help can be identified in seconds.
- Clearly presented, detailed analyses help find root causes of process behaviors.
- Copy Exactly! helps ensure rapid adoption across all of Intel's facilities while providing self-service flexibility to fit each factory's unique needs.

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Acronyms

DOTS	Data On The Spot (application/platform that we have developed)
MOR	Model of Record
VF	Virtual Factory

Business Challenge

Maximizing factory output is critical for meeting the growing semiconductor needs of Intel's customers. When factory tools operate below Model of Record (MOR), the entire process chain is affected, creating bottlenecks and slowing production. Quickly identifying which tools are affected among the thousands of operations running within the factory is a challenge. Once an opportunity for fine-tuning is identified, sharing that solution across dozens of factories is a huge logistical challenge. This is especially true because MOR availability can vary across facilities.

Engineers and managers need solutions that help them effectively consume and analyze a factory's huge volume of data. Once a problem is identified, the additional resources required to drill down into the data and determine possible solutions takes time. This challenge is further amplified by the need to traverse various datasets, especially when they are in different domains. Organizations need analytics that are easy to consume to quickly identify opportunities for improvement. The delays associated with solving these manufacturing issues can result in increased costs and lost revenue for the company.

Further complicating the improvement of MOR tool availability was Intel's historical practice of protecting MOR availability data from general consumption. Without this data, the ability to perform MOR analysis was limited. With dozens of factories around the world trying to keep pace with rapidly growing customer needs, Intel manufacturing executives approached Intel IT for help with their MOR data analysis dilemma. Given the impact on the organization, there was a clear need to find an immediate solution.

Solution Overview

Intel IT collaborated with Virtual Factory (VF) experts to rapidly build and implement a new, robust diagnostic tool to analyze operational input and output from every factory machine. The tool delivers timely, meaningful data to help managers and engineers quickly and intuitively identify manufacturing tools with available capacity that are running below MOR and make the appropriate improvements.

This flexible and scalable solution delivers results in a simple grid modeled after the actual factory organization. It compares the data for current tool availability with that tool's MOR availability and calculates a summary of statistics to guide the user toward areas of need. The team worked with the Technology Development Group to gain authorization and display equipment MOR data in the existing factory data analytics platform, called Data On The Spot (DOTS). Building on an existing analytics platform and collaborating across teams allowed the creation of the new analytics solution and ultimately led to data-driven breakthroughs.

Because all Intel factories follow a similar hierarchy, this new tool can be used in every facility to display a summary row of production areas. The information includes straightforward statistics that help describe the overall health of each area (Figure 1). As a result, areas in a factory that need attention can be identified within seconds. The data features of the tool also allow users to drill down for additional information with a few clicks.

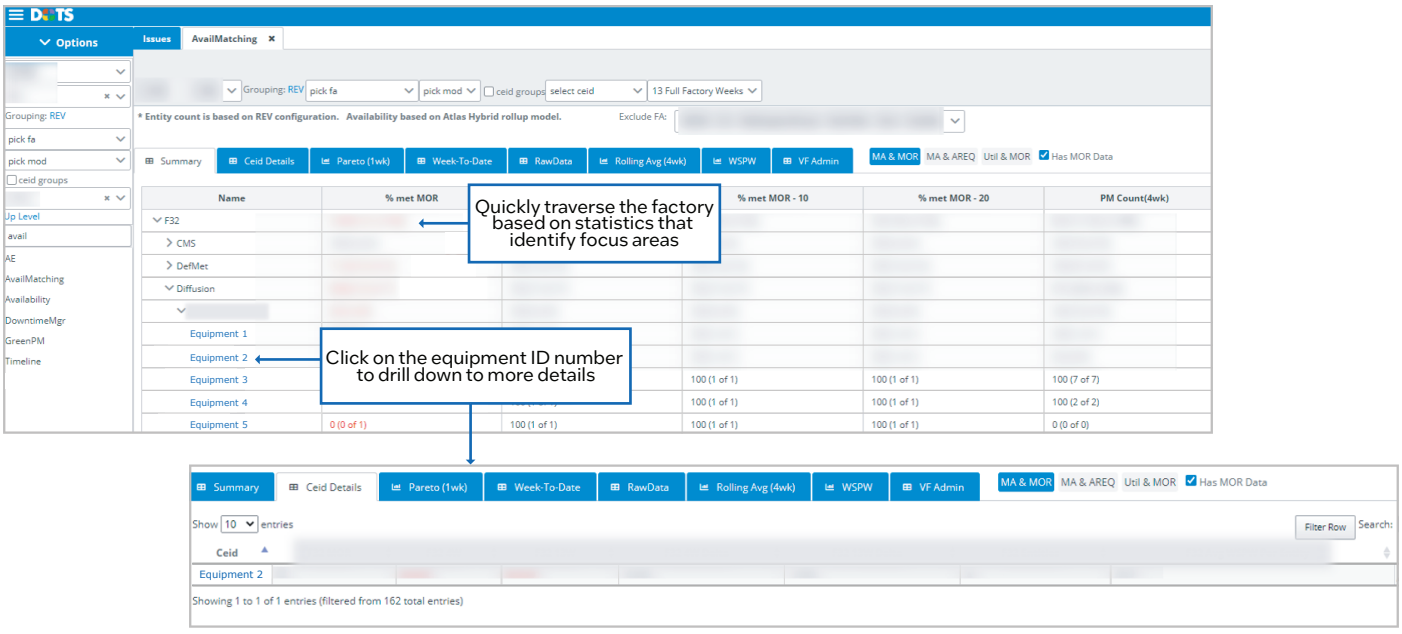

Figure 1. The solution provides an intuitive view of all production areas in a factory. Users can quickly drill down to see more details.

The analysis links to other, increasingly detailed analytics to help identify the root causes of an area's issues. The user can easily access other datasets, saving considerable time researching and discovering which tools are deviating from the fleet's MOR (Figure 2). This data integration enables specific actions to be taken for tools that have the most impact on the production process.

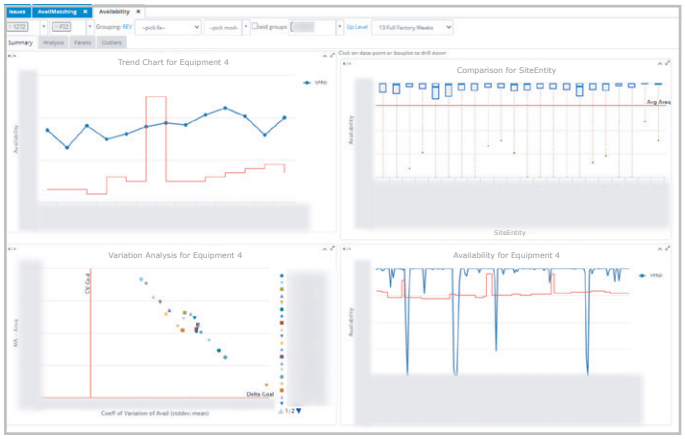

Figure 2. Access to additional sources of data can save valuable research time.

Model of Record (MOR)

Small Changes in the MOR can make Huge Differences in Production Output

Meeting Intel's delivery commitments is a cornerstone of customer satisfaction. It is vital to know how many wafers can move through a factory to completion in a given amount of time. This is accomplished through the "Model of Record" (MOR), which determines the type and number of tools required to produce a specific quantity of semiconductor wafers. Because every tool has a maximum number of wafers it can process, keeping every tool operating at its maximum productivity is a key component to meeting Intel's delivery commitments. This is complicated by the large number of tools in a production line, each performing many operations. Even small changes in the workflow of one tool can have a significant impact on how and when every other tool in the line receives wafers for processing. The MOR is an analysis of this workflow with estimates for each tool's processing capacity necessary to achieve production goals.

Solution Enhancements

After initial success deploying the new analytics solution in a production environment in just two days, we spent the next few days making two enhancements. These changes helped to increase the solution's flexibility and allow for faster decision making. The first enhancement provided a self-service feature for individual factory goal maintenance. MOR data changes depending on the process that is run within the factory. This self-service feature allows manufacturing super-users to update their MOR values as needed. This approach enhances data accuracy and helps increase the overall cadence of solution updates.

The second enhancement integrated week-to-week tactical data in addition to strategic data. This real-time feed enables the manufacturing team to make faster decisions as well as to implement changes on the factory floor and quickly improve MOR availability. The faster the implementation, the stronger the benefit. Figure 3 (orange line) shows how the factories used this analysis to make week-over-week performance improvements to become more productive.

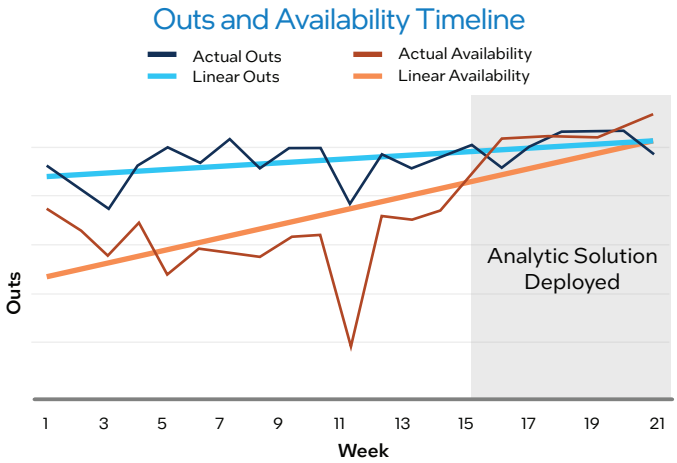

Figure 3. With real-time data, factory productivity increased week over week.

The Right IT Framework Accelerates Solution Delivery

Intel's factories are accelerating production to meet customers' needs, so we wanted to maximize factory output. Therefore, getting a solution into the hands of factory managers and engineers quickly was a key component for its success. Our DOTS analytics framework enables accelerated solution delivery in a matter of hours after an initial request. With an automated build, test and deployment mechanism—along with code reuse and the automation of common tasks—changes can be implemented rapidly and automatically deployed to production.

The new MOR analysis solution provides an ideal example of how the right IT framework enables us to implement, test and deploy quickly: The initial capability request occurred on Thursday and we delivered the first production version of the solution within 48 hours. Twenty-four hours later, we released the second version to production. We released the final version with all enhancements ready for Copy Exactly! distribution within another 72 hours.

Copy Exactly!

Delivering Manufacturing Solutions Worldwide in Record Time

Copy Exactly! is a methodology Intel uses to transfer production solutions, updates or improvements for manufacturing from one site to another to maintain repeatability, efficiency and reliability for manufacturing semiconductor products. Since all Intel factories are designed using similar hierarchies and equipment, the Copy Exactly! process minimizes the risk of introducing errors and problems into high-volume manufacturing by replicating every detail—including hardware and software components—that might affect the manufacturing process.

Structuring Automation Teams to Deliver Results

Such speedy development of vital tools for manufacturing processes is accomplished both by the analytics framework available to the teams and the structure of the automation teams themselves. In the past, we have observed that development teams tend to get locked into a structure based on a theory or hierarchy that creates boundaries to creativity and success. In our experience, it is preferable for a team to focus on delivering the best value to the customer rather than on specific roles people serve on the team. This allows team members the flexibility to perform multiple roles in pursuit of solutions regardless of individual expertise. The key is not to burden a team with unnecessary boundaries or management structure that distracts from focusing on value and delivery.

This structure is often referred to as Agile Persistent Teams (APTs). The APTs are formed based on need and skills and kept together to work on various projects. The persistence of the teams allows the team to develop strong customer relationships and deep business acumen that allow for the best possible solutions to emerge. As the team develops this deep business understanding, the solutions implemented address the use-cases with much higher accuracy. In this specific case, the team has been together for multiple years. Although some members have come and gone, the core team remains remarkably strong, and the "ramp-up" time for new members is decreased.

This APT practices DevOps, which stands for development and operations. The team not only actively develops solutions, but also owns the platform's operations. If the customer experiences a problem, the level 1 support is engaged first. Level 1 addresses common, easy-to-answer questions. If level 1 is not able to provide support, the request "ticket" is escalated to level 2 support. The level 2 team is closely tied to the business and has tremendous business depth. In addition to level 2 support, they also provide site training for the engineering users.

Level 2 helps write support documents and develops training videos. If the level 2 support team cannot answer the question, then level 3 is engaged. In this case, level 3 is the development team.

If a ticket goes to Level 3, and the developers are looking at the issue, it's easy for them to see the exact code. If an opportunity for improvement is found, the team can incorporate it into the next release cycle. In Agile team methodologies, frequent releases are the norm. In this specific team, the planning is done in two weeks, which is called a "sprint." The release process also has been completely automated and is called CI/CD (Continuous Integration and Continuous Deployment). The team pushes code to production on a daily basis. If a problem is found, the time from discovery to having a "fix" or improvement in production is often less than four hours. This rapid response to complex issues as well as quick/easy requests, and the fast time to production, develops a relationship of trust and enables a continuous stream of value delivery that is critical to the business.

Intel IT's manufacturing analytics teams are business unit-oriented and value-focused, with greater flexibility within the team. Therefore, we can deliver creative results to complex problems quickly and effectively. This approach has allowed the team to work with manufacturing experts and deliver a high-impact analysis tool across the entire Intel Manufacturing operation in a matter of days from the initial request.

A Closer Look at the Virtual Factory

Sharing Solutions Across Factories Leads to Increased Manufacturing Efficiency and Quality

Intel implemented a "Virtual Factory" (VF) concept nearly 20 years ago. The foundational assumption is that Intel's factories have many commonalities. Therefore, sharing solutions and information across all sites helps eliminate unnecessary effort and allows every factory to benefit from a breakthrough solution or idea. Whether it is an ergonomic solution, a new Manufacturing Execution System (MES) or an upgrade to a fab tool, once validated, the change is "Copy Exactly!" to all the factories. Our AI-based solution that automates gross failure areas (GFAs) on end-of-line wafers is no exception. We have integrated the solution in the VF network. When the solution finds a new GFA pattern and the yield analysis engineers complete their root cause analysis, the new pattern can be added to the list of known patterns at all fabs—improving yield not only at the fab at which the issue was found, but also at all of Intel's fabs around the world.

Conclusion

Intel IT is committed to making all of Intel's manufacturing processes as efficient and productive as possible. Our accelerated analytics framework and value-focused development teams are critical for meeting this commitment with maximum speed and effectiveness of the solutions that we develop. The MOR availability analysis tool is a good example of how this structure benefits the development of tools that improve manufacturing productivity and provide business value.

With Intel factories fully loaded, maximizing equipment uptime is essential. With greater equipment uptime, materials move within the factory more quickly. This greater velocity helps increase overall factory output over a defined time period. Within 48 hours after the initial request, our accelerated DOTS analytics platform delivered a solution that effectively analyzes the factory equipment availability against the MOR availability in every Intel factory around the globe. The solution then provides useful, intuitive data in a form that maps to the actual factory production. This provides manufacturing managers and engineers with a way to instantly identify areas of need in a production line and develop solutions to maximize tool availability, increasing business value for every facility.

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