FabTime Cycle Time Management Newsletter

Volume 9, No. 9 November 2008

Information

Mission: To discuss issues relating to proactive wafer fab cycle time management

Publisher: FabTime Inc. FabTime sells cycle time management software for wafer fab managers. New features in this month include rolling line yield trend and Pareto charts, and a preliminary version of an interface to allow end users to create and share custom charts.

Editor: Jennifer Robinson

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Welcome

Welcome to Volume 9, Number 9 of the FabTime Cycle Time Management Newsletter! In this issue we have an announcement about the upcoming Winter Simulation Conference, and a subscriber discussion question about success stories in implementing lean and six sigma techniques in wafer fabs. Our software user tip of the month is about looking at variation from a WIP goal. Continuing this theme of looking at WIP variation, our main article discusses WIP bubbles in wafer fabs. A WIP bubble is a larger-than-normal buildup of WIP at a particular point in the line. WIP bubbles result in large queues in front of a few tools, while other tools, sometimes even bottleneck tools, remain idle. A common goal in fabs is to smooth out the WIP bubbles, so that all production areas remain relatively busy. Smoothing of WIP bubbles improves cycle time by reducing arrival variability throughout the fab. In this article, we discuss techniques for avoiding WIP bubbles in the first place (where possible) and for coping with them when they do arise.

We welcome your feedback regarding WIP bubbles and WIP smoothing, and hope to be able to share some subscriber discussion with you in the next issue.

Thanks for reading!—Jennifer

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Community News/Announcements

Winter Simulation Conference '08

We are sharing the following announcement, which we found on the WSC '08 home page (http://wintersim.org/). This year's General Chair is **Tom Jefferson**.

"The Winter Simulation Conference (WSC) is the premier international forum for disseminating recent advances in the field of system simulation. In addition to a technical program of unsurpassed scope and quality, WSC provides the central meeting place for simulation practitioners, researchers, and vendors working in all disciplines and in the industrial, governmental, military, and academic sectors. WSC'08 will feature a comprehensive program ranging from introductory tutorials to state-of-the-art research and practice. The conference includes student presentations, exhibits, training sessions by software vendors, business meetings for professional societies and software user groups, and a general reception. The theme for WSC 2008 is "Global Gateway to Discovery". WSC 2008 will be held in vibrant Miami, Florida at the InterContinental Hotel, December 7-10, 2008…

New to WSC this year is incorporation of the MASM (Modeling and Analysis for Semiconductor Manufacturing) Conference, the leading modeling and analysis conference specific to global semiconductor manufacturing and supply chain operations. MASM 2008 will feature an international panel discussion titled "Modeling and Analysis of Semiconductor Manufacturing in a Shrinking World: Challenges and Successes". Additionally, as part of the conference theme of 'Global Gateway to Discovery', WSC 2008 will feature a track titled 'Simulation Around the World', highlighting the uses of simulation practices in different global regions."

FabTime welcomes the opportunity to publish community announcements. Send them to newsletter@FabTime.com.

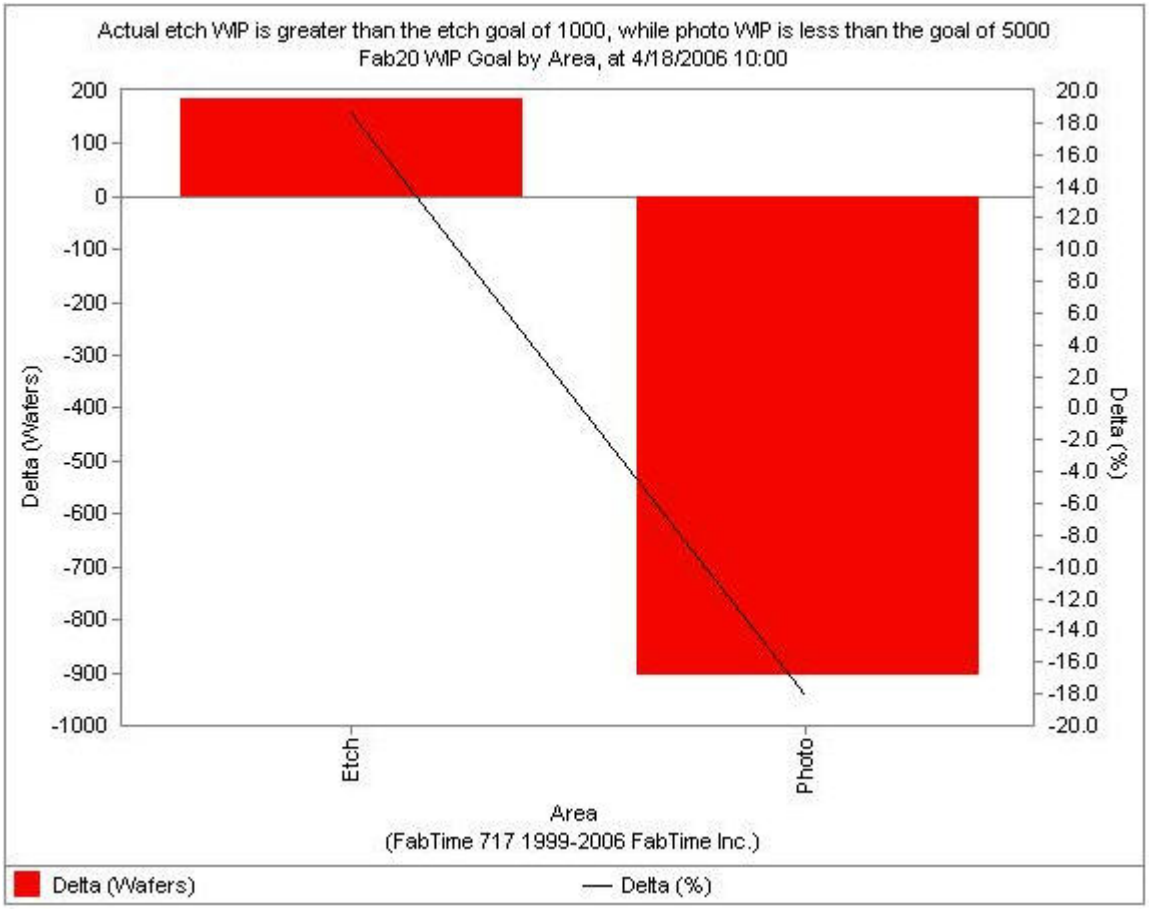
FabTime User Tip of the Month

View WIP Delta from a Goal

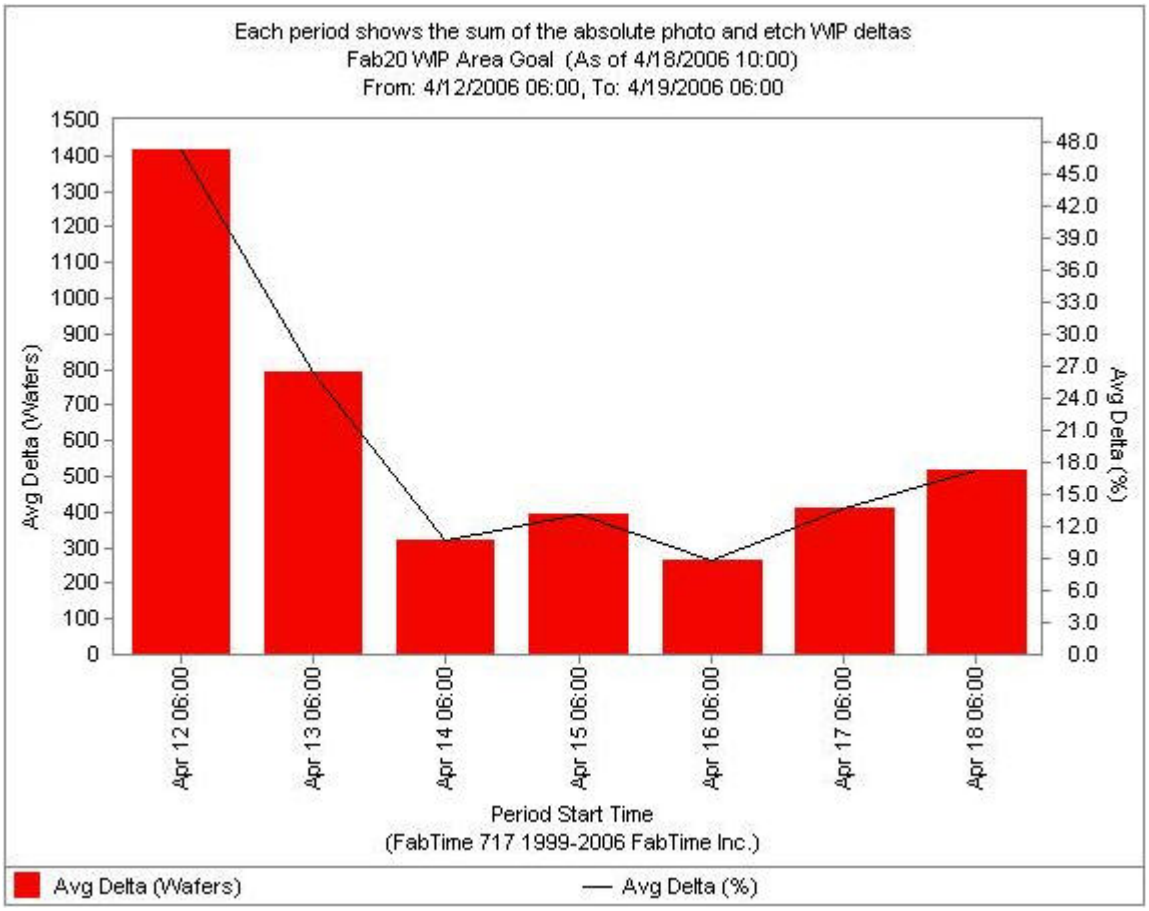
Since Patch91, you have been able to enter WIP goals in FabTime. Users who have permission to set goals will find that "WIP (units)" is now an option in the Result column on the Set Goals page. The WIP goal is entered in units (usually wafers), and may vary over time through the use of effective dates. The period length setting does not affect the WIP goal, since WIP is a point-in-time measurement. We recommend that you sent the period length to 24, for simplicity. WIP goals are entered as a single value, and the idea is to keep the WIP as close to that value as possible (neither greater than nor less than the target).

One you have set a WIP goal, you can view performance to that goal on the WIP Goal Delta Trend and Pareto charts. As with all goals, data will only be displayed if a goal has been created with filters that match what you are looking at. For example,

suppose you create a WIP goal of 5000 wafers for the Photo area, and one of 1000 wafers for the Etch area. If you create a WIP Goal Delta Pareto chart, and slice by area, then you will see a column showing the delta between the actual WIP in Photo at the start of the period and the goal of 5000 wafers, and another column showing the WIP delta in Etch. Each column will display as positive if the actual WIP is more than the goal, and negative if the actual WIP is less than the goal. If, however, you slice the chart by another variable (e.g. operation), and you haven't specifically created goals that are filtered by operation, then you will not see any data on the newly sliced chart. (Also, remember that if you are using a personal goal, you will need to select your name from the "Goal" drop-down on the chart - the default is to display any goals by the System Administrator.) An example of a WIP Goal Delta Pareto by Area is shown below.



The WIP Goal Delta Trend chart is a bit different from other Trend Charts in FabTime. You must specify an underlying slice by variable to view the chart. Results on this chart are a rollup of results from a WIP Pareto by the slice-by variable at the starting time of each period. For example, if the slice-by variable for this chart is Area, FabTime calls the WIP by Area Pareto chart as-of the starting time for each period. From this collection of WIP by Area Pareto results, it calculates total WIP, total goal WIP, and deltas from this goal. Only areas with an applicable goal as-of the period start time are included (only Photo and Etch, in the previous example). The WIP goal trend chart takes the absolute value of all goal deltas before rolling up the values, to keep positive and negative deltas for different objects from cancelling each other out. An example is shown at the top of the next page.



Columns on the WIP Goal Delta Trend and Pareto charts thus always show up as either zero or as red (greater than goal), because the idea is for the delta from the goal to be zero. Any deviation from the goal, positive or negative, shows up on the chart. The smoother the WIP Goal Delta Trend chart is from period to period, the more consistent your WIP is from period to period. Last paragraph of sections in this style

If you have any questions about this feature (or any other software-related issues), just use the Feedback form in the software.

Subscriber Discussion Forum

Lean Techniques

We received the following question from an anonymous subscriber: "Has anyone implemented lean techniques (Six Sigma, Kaizen, Pull System, etc.)? If so what is the success/failure story?"

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Send your questions to Jennifer.Robinson@FabTime.com.

WIP Bubbles in Wafer Fabs

Introduction

A frequent operational issue faced by wafer fabs is the presence of WIP bubbles. A WIP bubble is a larger-than-normal buildup of WIP at a particular point in the line. WIP bubbles are usually caused by down tools - especially down one-of-a-kind tools. WIP bubbles can also be caused by, or worsened by, irregular starts into the line (especially for back-end facilities), batching and setup policies, and other operational issues. WIP bubbles result in large queues in front of a few tools, while other tools, sometimes even bottleneck tools, remain idle. Even after a WIP bubble works its way through one tool group, the problem usually passes downstream. Most fabs run with several near bottlenecks, and the WIP bubble can wreak havoc on each bottleneck in turn. A common goal in fabs is thus to smooth out the WIP bubbles, so that all production areas remain relatively busy. Smoothing of WIP bubbles improves cycle time by reducing arrival variability throughout the fab. In this article, we discuss techniques for avoiding WIP bubbles in the first place (where possible) and for coping with them when they do arise.

Avoiding WIP Bubbles

Sometimes WIP bubbles are unavoidable, as when a critical one-of-a-kind tool is down for three days, waiting for a part to be flown in from the manufacturer. Certain managerial and operational strategies, however, can help your fab to avoid creating or contributing to WIP bubbles. Some of these are directly related to tool management, while others are more general operational issues.

Tool-Related Strategies:

- Respond promptly to tool downtimes, especially on one-of-a-kind tools. Automated alerting systems, by which people are notified immediately about key down tools, can help with this. Automated escalation procedures, by which notification reaches higher into the organization the longer the tool is unavailable, can also help.

- Stagger scheduled downtimes within a tool group (so that no more than one tool is down for maintenance at one time), at least for tool groups with less than 4-5 like tools.

- Look into spare parts / service contract policies, especially for one-of-a-kind tools. Analyze which tools have caused major WIP bubbles in the past year, and consider the cost of spare parts vs. the cost of the WIP bubble. Was your bottleneck starved as a result? Did you miss cycle time targets? Were there business consequences?

- Minimize "soft" one-of-a-kind tools created by tool dedication. Perhaps you have two pieces of a critical equipment type but due to tool performance there are a number of devices that have been dedicated formally (or informally) to run on one tool or the other. If you ensure that both tools are cross-qualified for most devices, or can be quickly cross-qualified in the event of a long downtime, this will help to avoid WIP bubbles.

General Operational Strategies:

- Don't release lots into the fab in large batches - spread lot releases throughout the day, and throughout the week. This is more likely to be a problem in assembly and test facilities than in wafer fabs.

- Don't have tools or areas of the fab that are only operated at intervals (as in, we only run this tool every other shift because it's high capacity, and we can quickly work off the WIP that piles up during the off-shift).

- Consider how and when lots are released from holds to avoid creating a WIP bubble. It's better to stage releases

from hold than to release a big batch to the same operation at one time.

- Don't wait to run lightly utilized batch tools full, or hold tools that you could be running idle while you wait for another lot to arrive with the same setup ID. Both of these behaviors create small WIP bubbles.

Mitigating Existing WIP Bubbles

Despite the best of intentions, sometimes WIP bubbles are unavoidable, especially for smaller fabs that have many one-of-a-kind tools. To some extent, WIP bubbles in wafer fabs will dissipate naturally. This is because, due to reentrant flow, not all of the WIP that piles up in front of a particular down tool is headed for the same downstream tool. However, this dissipation can be a slow process. It's important that, where possible, lot dispatching systems be configured to avoid sending the WIP bubble directly downstream. Here are some strategies to do this.

Dispatch-Related Techniques:

- Look ahead to find the path with the least WIP in front of it. This policy requires looking ahead x number of steps for each lot in queue, and adding up the WIP currently in queue at each of the x future steps. The lot with the least WIP in front of it is given the highest priority.

- Look ahead to which downstream tools are up and running. This policy requires looking one step ahead for each lot, to check whether the next tool is up or down. Lots headed to tools that are available are given a higher priority than other lots. This policy can be extended to look more than one step ahead, especially if a bottleneck tool lies a bit further downstream (though the decision logic becomes a bit more complex).

- Create reservation on downstream tools. This involves using a reservation system so that when a lot starts on the current tool, time is reserved for that lot on the next tool downstream. A concern here is to make sure that you don't violate any time constraints between process steps, which could cause lots to need to be reprocessed (a particularly bad thing during WIP bubble recovery). A reservation system can also be used to optimize downstream batching.

Of course these policies may be blended together, according to the appropriate weightings for the type of tool. Other dispatch-related factors such as lot priority and due date are also still important. Ideally we want blended dispatch rules that cover all situations, and for which the appropriate factors automatically become more important in the aftermath of a WIP bubble. This may or may not be feasible, however, depending on the situation.

A Note about Setups:

During WIP bubble recovery, special attention must be paid to tools that require setups. A typical policy on such tools is a setup avoidance policy, which says to keep processing lots with the same recipe ID for as long as possible. When you're working off a WIP bubble, however, a setup avoidance policy will just keep sending WIP to the same downstream step, instead of smoothing out the WIP bubble. It can be worthwhile to change the setup ID, to get some WIP moving towards other parts of the fab. This is a tricky issue, however, since you also want to avoid losing any capacity on a tool that has a WIP bubble in front of it. Most fabs operate under some sort of cap which says that if a lot has been waiting for more than some period of time, a setup should be performed, even if there is other WIP in queue with the matching setup ID. During WIP bubble recovery, these caps may need to be adjusted (because all of the WIP has been waiting for more than 48 hours, for example), but they shouldn't be ignored.

Other Considerations:

In addition to dispatching, other operational practices may influence recovery time from a WIP bubble.

- Avoid lost capacity on tools that are working off the WIP bubble. This may require operator assignment changes; for example, temporarily overstaffing a tool group so that there is no operator-contributed delay. This argues in favor of some amount of cross-training among operators. You may be able to determine whether this has been a problem historically for your fab by looking for times that key tools spent, during WIP bubble recovery, idle with WIP waiting to be loaded or unloaded.

- Juggle preventive maintenance schedules. If a tool is currently starved because of an upstream WIP bubble, you may be able use that time to perform maintenance (and thus have more availability once the WIP bubbles comes your way.

- In the aftermath of a truly egregious WIP bubble, it is sometimes necessary to turn of starts into the fab. This is never easy to do. However, if all the lots that you release are going to do is sit at the back of a big queue, at risk for developing yield problems, it's sometimes better to wait. This is especially true if the WIP bubble is near the front of the line.

Conclusions

WIP bubbles are a fact of life for many wafer fabs, especially for smaller fabs that have one-of-a-kind tools. WIP bubbles feature large queues in front of some tools, while other tools starve. This uneven distribution of WIP leads to arrival variability and drives up cycle time. Though largely caused by equipment downtime events, WIP bubbles can be caused, and contributed to, by other operating practices. In this article we have discussed techniques for avoiding WIP bubbles in the first place, and for smoothing them back out when they do arise. A significant benefit of advanced dispatching systems is the ability to help fabs recover from WIP bubbles as quickly as possible. In the presence of a WIP bubble, being able to incorporate downstream information into local dispatching decisions is key. Other operational policies are also important in coping with WIP bubbles, of course, and we welcome your feedback and suggestions.

Closing Questions for FabTime Subscribers

What other behaviors and circumstances have you seen that cause WIP bubbles? How do you cope with WIP bubbles in your fab? Do you incorporate WIP smoothing into your dispatch rules?

Further Reading on WIP Smoothing

These papers all touch on smoothing concepts for wafer fabs (though they are not specifically discussed in the article).

- J. Bonal, A. Sadai, C. Ortega, S. Aparicio, M. Fernandez, R. Oliva, L. Rodriguez, M. Rosendo, A. Sanchez, E. Paule, and D. Ojeda, "Management of Multiple-Pass Constraints," *Proceedings of the 1998 Advanced Semiconductor Manufacturing Conference (ASMC98)*, 1998.

- Shu-Hsing Chung, Amy H. I. Lee, and W. L. Pearn, "Product Mix Optimization for Semiconductor Manufacturing Based on AHP and ANP Analysis," *International Journal of Advanced Manufacturing Technology*, Vol. 25, No. 11-12, 1144-1156, 2005.

- C. Y. Chiu, W. L. Chou, S. M. Horng, and R. J. Kuo, "A Wafer Fabrication Dispatching Method for Minimizing Inventory Variability using Fuzzy Inference," *International Journal of Industrial Engineering - Theory, Applications, and Practice*, Vol. 10, No. 4, 621-627, 2003.

- S.-S. Ko, R. Serfozo, A. Sivakumar, "Reducing Cycle Times in Manufacturing and Supply Chains by Input and Service Rate Smoothing," *IIE Transactions*, Vol. 36, No. 2, 145-153, 2004.

- S. C. H. Lu, D. Ramaswamy, and P. R. Kumar, "Efficient Scheduling Policies to

Reduce Mean and Variance of Cycle-Time in Semiconductor Manufacturing Plants," *IEEE Transactions on Semiconductor Manufacturing*, Vol. 7, No. 3, 1994, 374-380.

- A. I. Sivakumar, N. F. Choong and C. S. Chong, "Modeling Causes and Effects of Semiconductor Backend Cycle Time," *Solid State Technology*, Vol. 44, No. 12,51-53, 2001.

Subscriber List

Total number of subscribers: 2854 from 476 companies and universities. 22 consultants.

Top 20 subscribing companies:

- Maxim Integrated Products, Inc. (228)
- Intel Corporation (152)
- Chartered Semiconductor Mfg (80)
- Micron Technology, Inc. (80)
- X-FAB Inc. (71)
- Western Digital Corporation (67)
- Analog Devices (65)
- Texas Instruments (62)
- Infineon Technologies (61)
- ON Semiconductor (58)
- Freescale Semiconductor (57)
- International Rectifier (55)
- NEC Electronics (54)
- TECH Semiconductor Singapore (53)
- Cypress Semiconductor (51)
- STMicroelectronics (49)
- IBM (45)
- NXP Semiconductors (45)
- Spansion (36)
- ATMEL (35)
- Seagate Technology (35)

Top 3 subscribing universities:

- Virginia Tech (11)
- Ben Gurion Univ. of the Negev (8)
- Nanyang Technological University (7)

New companies and universities this month:

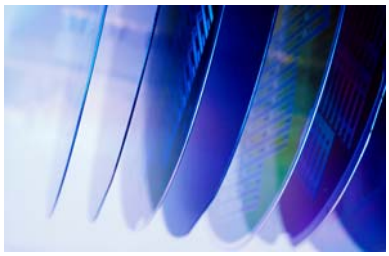
- Aberdare Cables
- Atlantis Forge
- agileTCP
- Clemson
- Ulvac Technologies

Note: Inclusion in the subscriber profile for this newsletter indicates an interest, on the part of individual subscribers, in cycle time management. It does not imply any endorsement of FabTime or its products by any individual or his or her company.

There is no charge to subscribe and receive the current issue of the newsletter each month. Past issues of the newsletter are currently only available to customers of FabTime's web-based digital dashboard software or cycle time management course.

To subscribe to the newsletter, send email to newsletter@FabTime.com, or use the form at www.FabTime.com/newsletter.htm. To unsubscribe, send email to newsletter@FabTime.com with "Unsubscribe" in the subject. FabTime will not, under any circumstances, give your email address or other contact information to anyone outside of FabTime without your permission.

FabTime® Dispatching Module



Dispatch Configuration and Support

We offer our dispatching and planning modules together for a single, fixed monthly fee (on top of your regular FabTime subscription). This includes:

- Dispatch rule and factor configuration.
- Training.
- Dispatch list feed to the MES (if applicable).
- Support and upgrades.

Dispatch Factors

- Batch code at the current tool.
- Lot priority.
- Downstream tool priority.
- Current tool FIFO.
- Current tool idle time.
- Downstream batch efficiency.
- Critical ratio.
- Earliest-due-date.
- Current step processing time.
- Remaining processing time.
- Current step qualified tool count
- WIP level at downstream tools.
- Up to five other site-specific factors.

Interested?

Contact FabTime for technical details.

FabTime Inc.
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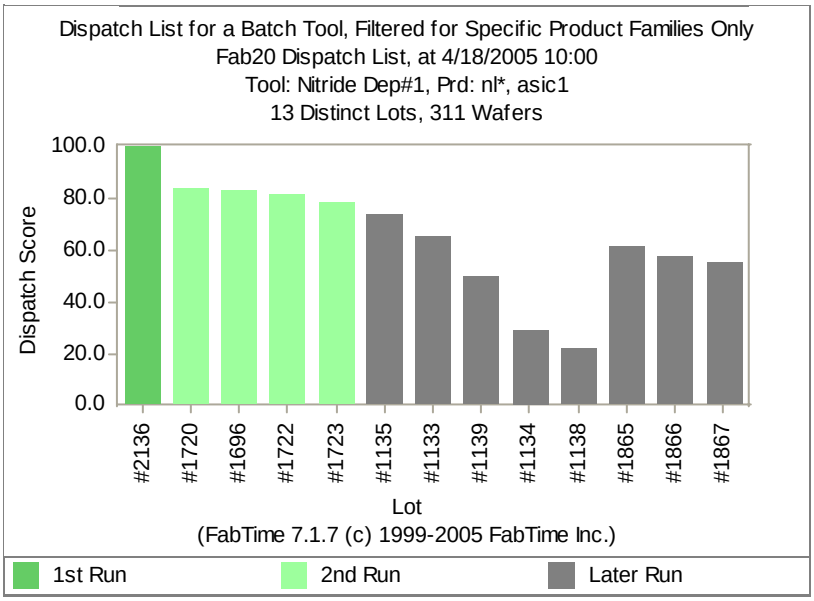
Web: www.FabTime.com

Do your operators make the best possible dispatching decisions?

- Do you struggle to balance lot priorities and due dates with tool utilization and moves goals?
- Do your critical bottleneck tools ever starve?
- Do you use standard dispatch rules, but feel that your fab's situation is more complex, requiring custom blended rules?
- Do you know how well your fab executes your dispatch strategy?

FabTime's dispatching module is an add-on to our **web-based digital dashboard software**. At any point, for any tool in your fab, FabTime will show you the list of all lots qualified to run on that tool. This list will be ordered by the dispatching logic that your site has selected for that tool. This logic can use standard dispatch rules such as Priority-FIFO and Critical Ratio. However, you can also create custom dispatching logic using any combination of dispatch factors (shown to the left).

You can display dispatch lists in FabTime, and/or export them back to your MES. FabTime also includes a dispatch reservation system to hold downstream tools when a lot is started on an upstream tool, as well as dispatch performance reporting.



FabTime Dispatching Module Benefits

- Ensure that wafers needed by management are in fact the wafers that are run, while requiring less manual intervention on the part of management.
- Improve delivery to schedule, and the display of performance to schedule.
- Document the dispatching logic used by the best operators and make this available to all shifts.