FabTime Cycle Time Management Newsletter

Volume 17, No. 3 June 2016

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 development for FabTime include OEE reporting for linked and unlinked moves (for cluster tools that operate both ways) and the addition of pilot avoidance logic to the short-interval scheduler.

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Keywords: Metrics and Goals; Reporting; Fab Management

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Welcome

Welcome to Volume 17, Number 3 of the FabTime Cycle Time Management Newsletter! We hope that everyone is enjoying a good start to the summer. In this issue we have an announcement about the FabTime Virtual User Group. Our FabTime Tip of the Month is about using effective dates to ramp goals over time. We have one subscriber discussion topic, concerning the benefits of foundries vs. in-house fab manufacturing.

In our main topic this month we discuss the pressure that arises sometimes in fabs to focus on a single metric, and the reasons that this isn't a good idea in the complex environment of a fab. We review a number of candidate super metrics, and conclude with a framework for using multiple metrics in an integrated fashion. As always, we welcome your feedback.

Thanks for reading – Jennifer

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Community News/Announcements

Virtual FabTime User Group Open for Membership to FabTime Customers

An online FabTime User Group is currently meeting every six to eight weeks. This group originated via the Fab Owners Association Industrial Engineering group, but has since been expanded to allow membership for any FabTime customers. The group is organized by Dave Kayton from Fairchild Semiconductor, to whom we are especially grateful.

At each meeting participants discuss new and requested FabTime features, as well as technical implementation issues (e.g. how to implement OEE for cluster tools). Members also share their own lessons learned and FabTime tips, for the benefit of other members. FabTime has found this user group invaluable in helping to guide our development efforts. If you are interested in learning more about the FabTime User Group, please contact Jennifer.Robinson@FabTime.com.

FabTime welcomes the opportunity to publish community announcements, including conference notices and calls for papers. Send them to newsletter@FabTime.com.

FabTime User Tip of the Month

Use Effective Dates to Ramp Goals over Time

We've talked previously here about how to set personal goals. However, members of the FabTime User Group pointed out recently that we have not discussed the relatively recent interface changes that make it easier to ramp goals over time. The goal-setting procedure describes here applies both to personal goals (which you can share or not) and to system administrator-set goals (if you are logged in as the system administrator for your site). Either way, clicking "Set Goals" on the Charts page takes you to the goal-setting interface.

At the top of the interface, you'll see goals that you have previously created. This defaults to show you the top 10 as sorted by your defined goal name, but you can change the "From" and "To" fields to specify a range of goals to display. You can also filter by goal type (e.g. "Moves") or by goal name.

To add a new goal, select the goal-type from the "Filter Type" drop-down at the top of the screen and press "Go". FabTime will display goals of this type that you have already created. Follow the link near the top of the page that says "Click here to add a new goal". FabTime then displays an interface for creating a new goal of your specified type (Moves, in the example shown). Here is how to fill in a goal that will (optionally) ramp over time:

1. Create a meaningful name for your new goal (so that you can search for it later if needed).

2. Check the "Shared" box if you would like this goal to be visible by other users. (System administrator-created goals are automatically visible to all users, but personal goals are private by default.)

3. Click "Filters" to add filters for this goal, if needed. See Tip31 or use the Help button for notes about using the (any) filter with goals. Pressing "save" will take

you back out to where the Effective Date and Goal Value tables are displayed (for any new goals of this goal type).

4. Enter an Effective Date, Goal Value, and Period Length in the top row of the table with those column headings. Your goal will be in effect from that date forward, until/unless you fill in another row with a later effective date.

5. To change the goal over time, fill in the second and/or third rows with new, later Effective Dates and different Goal Values. You must enter all three values (Effective Date, Goal, and Period Length) for each row that you use. If your goal is not meant to change over time, use a single row.

6. Once you have at least one row filled in, you can press the "Save" button. FabTime takes you back out to the main screen for that type of goal. This screen will always include three blank rows at the bottom of the table for each defined goal. You can continue ramping the value of the goal over time as needed.

When your goal is displayed on charts, FabTime will use the value that corresponds to each defined date range. For example, if you have a row with Effective Date April 1, 2016 and a value of 20,000, then you have a second row with Effective Date April 15, 2016 and a value of 22,000, FabTime will show a goal line at 20,000 from April 1 to April 15, and then raise the goal line to 22, 000 starting on April 15th. (You can indicate the exact time to make the change, as part of the effective date).

Remember, to view personal goals on a chart, you must select your name (or the name of the person who created and shared the goal of interest) from the "Goal" dropdown at the bottom of the main set of filters to the left of the chart and press "Go". Also, for the goal to display, the set of filters displayed on the chart needs to match the set of filters saved as part of this goal (in step 3 above).

If you have questions about setting goals, please use the Feedback form inside the software. Our thanks to the FOA FabTime User Group, members of which suggested this tip.

Subscribe to the separate Tip of the Month email list (sent in HTML email with detailed illustrations). Thanks!

Subscriber Discussion Forum

Foundries vs. In-House Wafer Fabs

A longtime subscriber asked recently if we had ever written in the newsletter about the benefits of foundries vs. in-house wafer fabs. While we have discussed reasons that foundries should care about cycle time in the newsletter (Issue 14.03), we have not written about this broader topic. We wonder if any newsletter subscribers know of any good references on this topic, or have anything you would like to share on the subject. As always, we welcome your feedback.

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

Why Fabs Need Multiple Metrics

Introduction

Wouldn't it be great if there was a single metric that you could use to monitor the health of your fab? You could track performance to this metric in a highly visible way, and ensure that everyone in the fab was on board with improving it. This is something we've had people ask us about, or seen people try to implement in their fabs.

Unfortunately, however, running a fab is not that simple. Fabs are complex, dynamic entities. Actions that drive improvements in one metric are often harmful in some other way. Fabs have to strike a careful balance between driving up utilization, driving down cycle time, and maintaining high yields. Fabs have to balance keeping things moving (for throughput) and dampening variability (for cycle time). What's really needed is a cohesive framework of metrics that work together to drive the overall goals of the fab in the right direction.

In this article, we review a number of candidate metrics that could theoretically be used as a fab's primary index, and discuss strengths and weaknesses of each. We conclude by sharing a potential framework for setting different metrics at different levels of management, to drive overall cycle time improvement. [A version of this framework was previously shared in Volume 16, Issue 1.]

The Candidates

Here we look at several metrics that could be (or historically have been) used as a primary driver of fab performance.

Moves: It used to be that people more or less did run fabs by focusing on moves (operation completions). Moves are easy to measure. Pretty much everybody tracks them. Moves are generally good for motivating employees.

Not only that, if you know what your fab is starting each day, how many steps it will take to complete each route and something about your scrap profile, you can calculate what you need to achieve, on average, in terms of overall moves. You can also expand that out to obtain lower-level moves goals by area, toolgroup, and operation. The math gets a little cumbersome when you have a lot of different routes and frequently changing product mix, but the data's there, and you can do this in a spreadsheet.

However, if you try to run your fab by focusing only on moves, you are likely to run into problems. This is because moves alone tell you nothing about what's going on with cycle time and variability. If you measure operators solely on the number of moves that they complete, you incentivize them to work primarily on the easier/quicker moves. Lots at operations that take more time or require a setup can languish. You're also likely in this situation to lose capacity during shift change. If operators only receive credit for logging move out transactions, they have little incentive for starting new loads near the end of their shifts.

WIP Turns: As the emphasis on cycle time has spread, fabs have changed from looking only at moves to focusing also on WIP turns. Turns (moves / WIP) give you an idea of the pace at which your line is functioning. The turns rate for the fab as a whole tells you how many times per day (or per shift) you are moving each wafer on average. If you know a weighted average number of steps in the line, this gives you a forward look at cycle time and an early indicator of problems.

Turns are also helpful at the area level, protecting operators from being dinged by WIP shortages. One can't meet a tool- or area-level moves goal if that tool or area is

starved of WIP during the shift. Turns will account for this.

But what would happen if you tried to use turns as your only fab metric? Ultimately, you would keep up your overall turns rate by continuing to drive moves. There's nothing intrinsic to turns as a metric that will make sure that you are working on the right moves. Operators will still get rewarded for moving the quickest, easiest moves first, regardless of cycle time or on-time delivery. Yes, turns will improve longer-term if you reduce the amount of WIP in the fab, but this is difficult to do on a shift-to-shift basis.

Cycle Time: OK then, why not try using cycle time or on-time delivery as your fab's primary metric? Variants here would include days per mask layer and shipped lot x-factor. Certainly cycle time is an important piece of the puzzle. Most fabs need to understand their cycle time for planning purposes, and experience pressure from customers to improve cycle time and/or on-time delivery.

The problem with all of these overall cycle time metrics is that if you are using shipped lot cycle time, or on-time delivery for shipped lots, you are using a trailing metric. These metrics will tell you something about what did happen days or weeks ago, but they are not very useful in driving decisions today.

Various open lot cycle time metrics have been proposed, and individual lot performance to schedule can certainly be useful for dispatching. However, aggregated cycle time metrics still don't tell you very much about what to do on the floor to keep things moving.

Dynamic X-Factor: Dynamic X-Factor is a metric that FabTime has promoted as a good overall indicator of the health of a fab in terms of cycle time. Dynamic X-Factor (DXF) records total WIP in the line divided by WIP that is actually running on tools. Measured frequently (e.g. hourly, as shown below), DXF can be plotted like a control chart. Its average can be shown in the long run to be equivalent to the

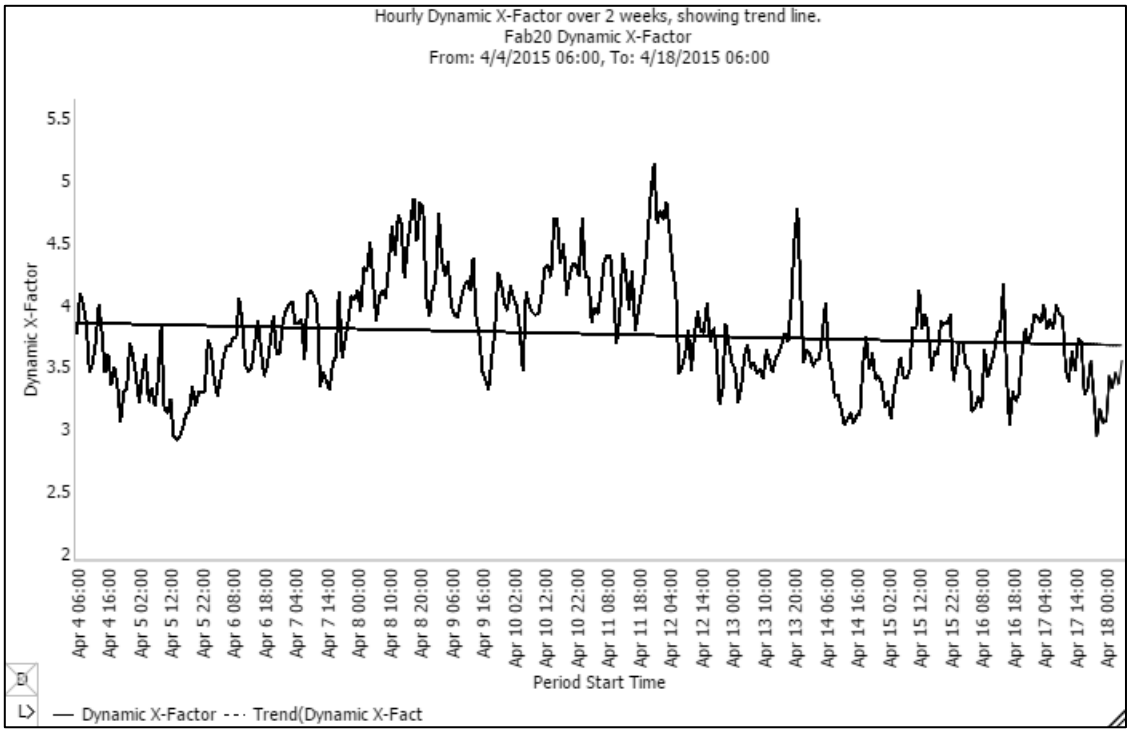

Figure 1. Example of Dynamic X-Factor Trend Chart for a Fab

shipped lot x-factor (total cycle time divided by process time), making it a good early indicator for cycle time problems. DXF also highlights shorter-term and periodic behavior, such as shift change effects. [See more in past newsletter Issues 4.08, 5.03, 9.04 and 15.05.].

DXF can be calculated at the area level. It is a bit tricky to use at the tool group level, however, because if you have no WIP running on tools, DXF will have a zero denominator, and technically be infinite. So, DXF is a very nice overall indicator of whether your fab and the individual areas in your fab are keeping WIP moving at the desire pace. But it is not as helpful for telling you how to manage individual tools or individual lots.

The other central issue with any cycle time-driven metric, of course, is the core conflict between cycle time and utilization. The easiest way to get great cycle time in a fab is to reduce tool utilization on as many tools as possible. This, of course, is not cost effective. Similarly, metrics that focus on cycle time may be in inherent conflict with metrics tracking quality. You may be able to get better yields by running parts more slowly through a particular tool, but there will be a tradeoff here in terms of cycle time and utilization. [See past newsletter Issues 3.4, 5.01, 5.02, 6.05, and 7.06.]

Utilization: Utilization is another high-level metric that fabs do report. We all see the occasional stories about how fab utilization rates across the industry are up or down. Your fab's utilization rate is generally the utilization (percent of maximum possible loading) of your bottleneck tool group at your current product mix. This number tells you something about where you are likely to be in terms of cycle time and cost per wafer (depending on what loss factors have been incorporated into the utilization calculation). However, overall fab utilization tells you very little about what to do on a daily basis. Reporting utilization for all tool groups is useful in predicting where cycle time problems are likely to arise, but this data is likely to vary extensively from shift to shift to shift, due to WIP variability and tool downtime.

OEE: Many fabs have shifted in recent years from a focus on utilization (and/or availability) to a focus on Overall Equipment Effectiveness (OEE. OEE looks by tool at how many wafers could have been processed if the tool was never down or idle and always processed good wafers at optimal speed vs. what was actually produced. Looking at the various loss factors that are used to roll up to an OEE number can be a very useful exercise. You can see what was lost to different types of downtime, to running at less than optimal speed, and to running wafers eventually scrapped or reworked.

However, OEE also penalizes you for having any idle time on a tool, even when that idle time is due to there not being any WIP present. This means that OEE isn't as applicable for non-bottleneck tools (though a variant to adjust for this has been proposed). OEE, unadjusted, is in conflict with cycle time metrics (since OEE wants you to have no idle time on the tools, but idle time is needed for lower cycle times). An example of a non-bottleneck tool group with generally low (but variable) OEE values is shown at the top of the next page.

Also, unless you dig into the detailed sub-states, you don't know what to do to improve. OEE, then, is a key piece of the puzzle, but not suitable to be the only metric that a fab uses. [See past FabTime newsletter issues 2.04, 3.01, 11.03, and 12.05.]

One Possible Framework for Setting Fab Goals to Drive Cycle Time Improvement

If none of the metrics discussed above is suitable to be used in isolation, then what's

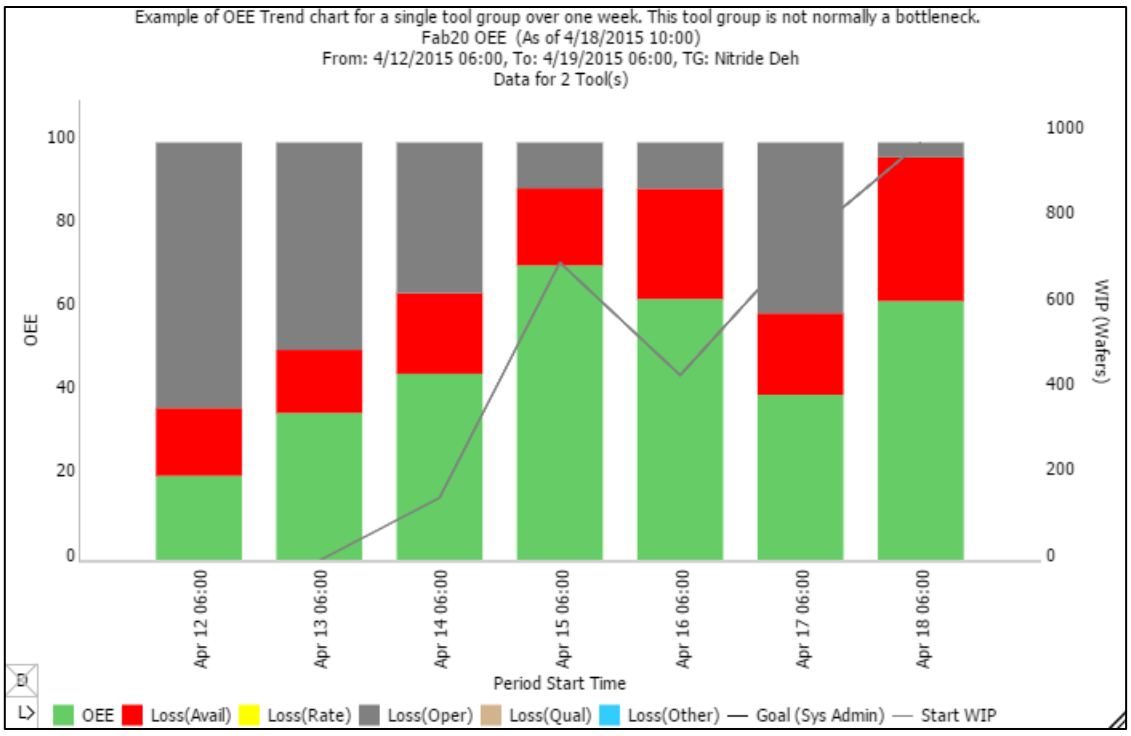

Figure 2. Example of OEE Trend Chart for a Non-Bottleneck Tool Group

needed is a framework for balancing the different goals in a single fab. The following framework for balancing fab goals to improve cycle time was previously shared in Volume 16, No. 1 of this newsletter. It has been revised slightly for this issue.

At the Strategic Level:

1. Ensure that the fab has adequate capacity and flexibility. Plan tool utilizations to include a standby time buffer to allow tools to recover from the impact of variability. Minimize the presence of one-of-a-kind tools and dedicated tools as much as budgets allow. Without these things, achieving good cycle times will be extremely difficult.

2. Understand actual performance relative to theoretical performance in fab cycle times (to know what is the best that could be achieved). Use this knowledge in setting fab-level cycle time goals.

3. Create a culture that comprehends and cares about top-level variability metrics. Consider metrics that focus on reducing lot to lot variation, such as "95% of our lots will be +/- 5 days to original planned shipment date" or that otherwise ensure that WIP is moving towards commitment date at the correct speed.

At the Tactical Level:

1. Monitor and (where possible) limit the sources of variability in the fab. Fab variability sources include product mix, long downtime events, batch lot releases into the fab, batch transfers between process steps, process restrictions, batch loading policies, hot lots, scrap and rework, and setup avoidance dispatch policies. Many of these topics have been discussed in previous FabTime newsletters.

2. Assess line balance. On a daily basis, look at WIP by segment of the line or by operation, and attempt to fill holes and smooth out bubbles. An example is shown at the top of the next page. Consider line balance-focused dispatch rules, and/or short-term adjustment of goals by area to take into account areas with too much, or too little, WIP.

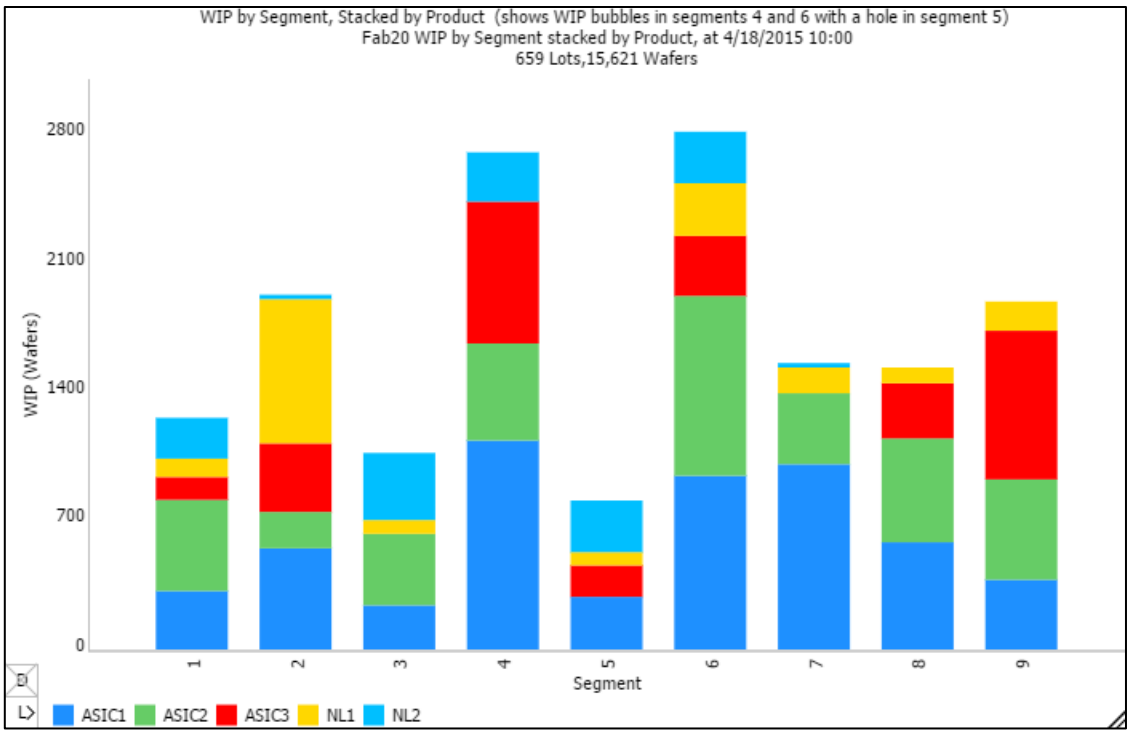

Figure 3. Example of WIP by Segment, Showing Shortages and Excess

3. Set goals for daily targets such as Moves, Moves/WIP (Turns), and Dynamic X-Factor, which are necessary for the production staff to measure and focus on each day. The exact set of goals to use will depend upon your fab's situation.

4. In setting goals by shift, look at ways to avoid conflicts between the different shifts. Consider using the Earned Plan Hours metric as a companion to Moves – this metric was designed to adjust incentives, and reduce undesirable end of shift behavior. (See FabTime Newsletter, Vol. 14, No. 1 for details.)

At the Operational Level:

1. Monitor the above-discussed goals, in a highly visible way, so that people are motivated to follow them.

2. Look at queue delay by tool or tool group to identify short-term problems in cycle time.

3. If possible, use the dispatch system to adjust individual lots that are getting ahead of or behind schedule. Otherwise, look each day at a list sorted by absolute delta between expected shipment date and commitment date, and re-prioritize lots manually if necessary.

4. Look for places where WIP is being held up due to extended unavailable time (scheduled, unscheduled, or engineering), and focus on fixing those problems.

Other Frameworks

The exact framework that will be best for your fab depends, of course, on the specific needs and attributes of the fab. A high volume, low mix fab will likely have a different combination of indices than a low volume, high mix fab, for example. A foundry will be focused on different things than will an independent device maker. A fab running development wafers in a production line will have to take special care, as will a fab that is temporarily operator-constrained.

Conclusions

We've heard anecdotal stories of fabs being pushed to streamline metrics, or

change to some new metric that promises better overall performance. This is, of course, an appealing prospect. If we could have one big dial, and post the performance to this dial everywhere, life would be relatively easy. But things are rarely easy in wafer fabs, in our experience. In this article we've reviewed various metrics that we've seen over time considered as candidates for being THE metric, and discussed why each has limitations if used in isolation.

What's needed to run a fab is a cohesive set of metrics, applicable to different levels of management. We've shared one example here, one that focuses on cycle time (but still considers other aspects of manufacturing performance). Regardless of your fab's situation, we think that you'll get your best performance if you take time to find and promote the set of metrics that's right for you. Despite the appeal in terms of simplicity, you're unlikely to find that a single metric will do the trick.

Questions for FabTime Newsletter Subscribers

Do you agree with the central point of this article (that you need multiple metrics to manage a fab)? Or do you think that there is one "silver bullet" that is good enough, given your fab's particular situation? What have we missed in the discussion here? How often do you change the primary set of metrics used in your fabs?

Further Reading

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Acknowledgement

FabTime's Mike Krist suggested this newsletter topic.

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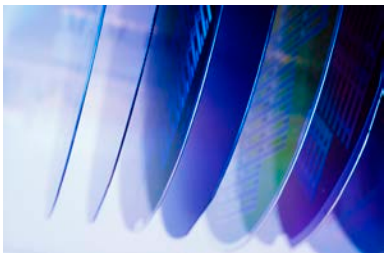
FabTime® Dispatching Module



Dispatch Configuration and Support

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

- Dispatch rule configuration via user-friendly web-based interface for standard factors
- Training.
- Dispatch list feed to the MES (if applicable).
- Support and upgrades.

Custom dispatch rules and consulting from our dispatching expert available for additional fee

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 or staging time at downstream tools.

Interested?

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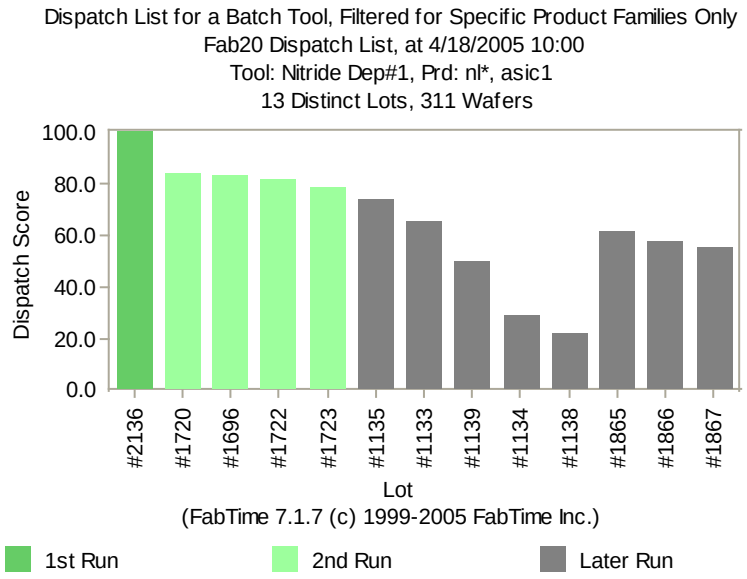
Email: Sales@FabTime.com
Web: www.FabTime.com

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 now (in 2016) also includes an optional **short-interval scheduler**.



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.