FabTime Cycle Time Management Newsletter

Volume 16, No. 5 September 2015

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 about to be released in FabTime include support for multi-step time constraints and time travel penalties in dispatching decisions (via our new short-interval scheduler)

Editor: Jennifer Robinson

Keywords: Variability

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Welcome

Welcome to Volume 16, Number 5 of the FabTime Cycle Time Management Newsletter! We hope you've all had a good summer, and that we've caught you between vacations and with a bit of time to read. We'll be releasing a new FabTime patch later this month that has some exciting new functionality, including improved OEE calculations for cluster tools and a short-interval scheduling capability. We'll describe these more in future issues.

In this issue we have a community announcement about the next Fab Owners Association meeting. Our software tip of the month is about navigating the different "Go" buttons within the FabTime user interface. We have no subscriber discussion this month (though we would certainly welcome your questions or suggested discussion topics for the next issue). In our main article, we provide some specific answers to the question: how do I identify the sources of arrival variability to a particular toolgroup?

Thanks for reading – Jennifer

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Community News/Announcements

Upcoming Fab Owners Association Meeting

The next quarterly meeting of the Fab Owners Association will be hosted by Microchip Technology in Gresham, Oregon. The meeting will be held October 28th and 29th, 2015. While the Thursday meeting will be reserved primarily for device maker members of the FOA, FabTime representatives will be attending the evening social event on October 28th. We hope to see some of you there!

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

Understand the Different "Go" Buttons in FabTime

A question that has arisen in recent FabTime software training classes concerns the execution of the various "Go" buttons within the FabTime interface. Here is a quick summary. Clicking on any "Go" button causes FabTime to re-load the chart page (accepting the changes related to that particular "Go" button). Hitting the "Enter" key from inside any of the text-based filters in the left-hand column is the same as clicking the nearest "Go" button. You cannot hit "Enter" from inside a drop-down filter, however, and must click the "Go" button instead. Also (letters refer to the chart on the next page):

A) All left hand "Go" buttons act only on the filter and sort information in the left hand column. You must click on one of the left hand "Go" buttons (shown as A below, in yellow highlighting), or hit enter from a text-based filter, to execute any changes made to these left pane filters. For example, if you enter a process flow into the "Flow" field shown below and then press any of the "Go" buttons labeled B through E, FabTime will not record your "Flow" change, and you will need to re-enter it once the page re-loads. However, you can press any of the "Go" buttons in the left-hand column - you do not have to use the closest one.

B) The "Go" button under the Quick Jump drop-down will only execute the Quick Jump capability (switching to another chart). If a filter has been modified but not executed with a left-pane "Go" button or Enter key, then it will not be carried forward.

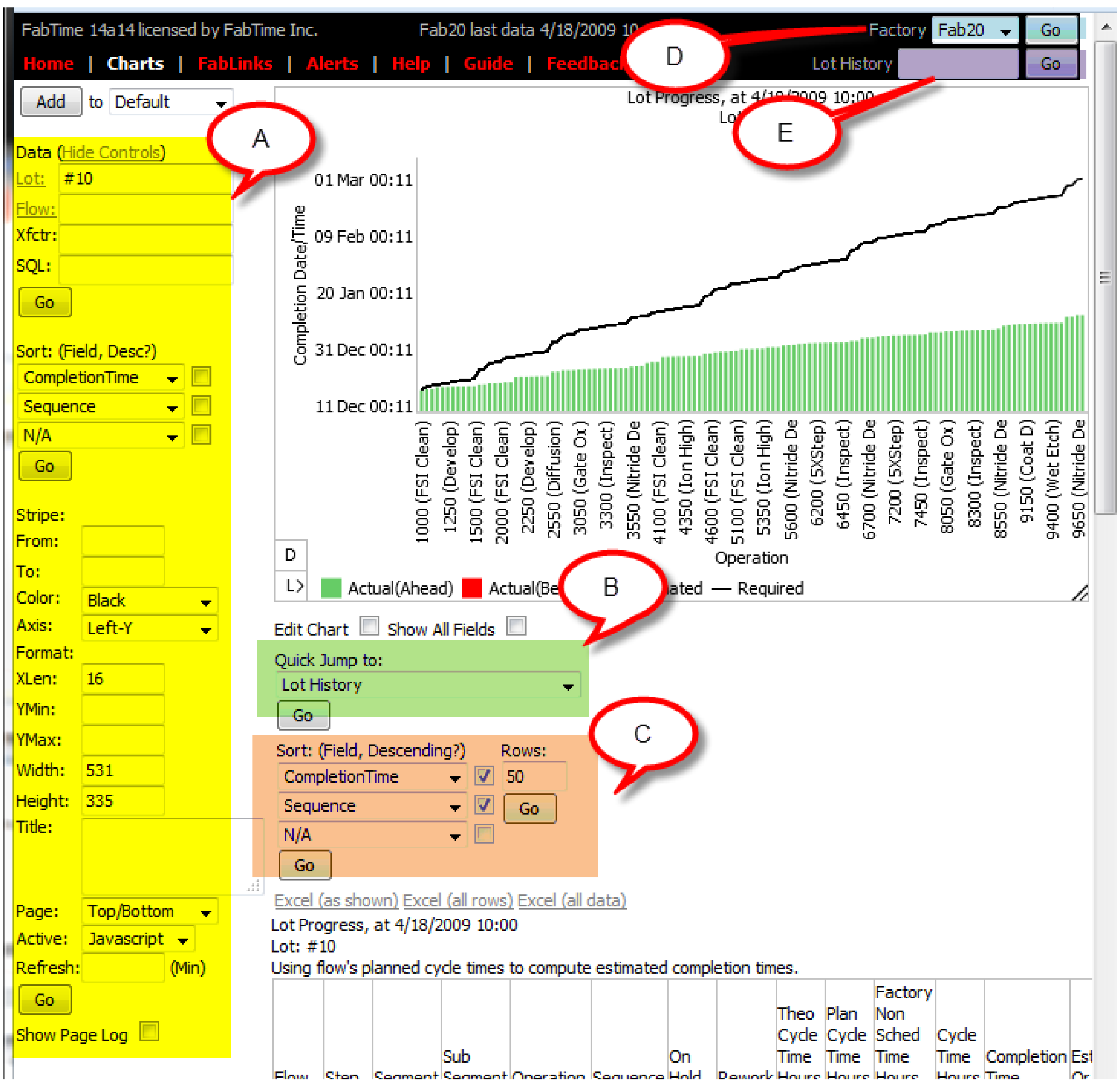
C) The "Go" buttons under the table sort and table row count only act on the table sort/row options. Any modified left hand filters will revert to the previously executed values when these "Go" buttons are executed.

D) and **E)** The "Go" buttons on the upper right corner for Lot History and Factory only operate on the selection that each is partnered with (i.e. the "Go" for Lot History will only execute the Lot History chart and not any other changes on the page.)

F) (Not shown) There are two other "Go" buttons associated with the "Edit Chart" capability, one associated with editing the axis titles and the other associated with editing the chart fields. When using JavaScript charts, you may find that the chart updates to display your edits, even before pressing the associated "Go" button. However, if you wish to save any changes, you do need to press the associated "Go" button prior to adding the edited chart to a home page.

We hope that you find this clarification of the "Go" buttons useful. We are happy to address any questions. Special thanks to FabTime's Sean O'Brien for contributing this tip.

If you have questions about this item, or any other FabTime software questions, just use the Feedback form inside FabTime's software. Subscribe to the separate Tip of the Month email list (with additional discussion for customers only). Thanks!



Subscriber Discussion Forum

FabTime welcomes the opportunity to publish subscriber discussion questions and responses. Send your contributions to Jennifer.Robinson@FabTime.com. There are no subscriber discussion topics in this issue. If you have questions, or topics that you feel would merit discussion by the newsletter community, please let us know.

Identifying Sources of Arrival Variability

Introduction

A customer recently asked us if we had any advice that we could give on determining the cause of arrival variability to a particular toolgroup. We felt that this was likely an issue confronted by many people working in fabs, so we have prepared a response here, as this month's main article.

What Do We Mean by Arrival Variability?

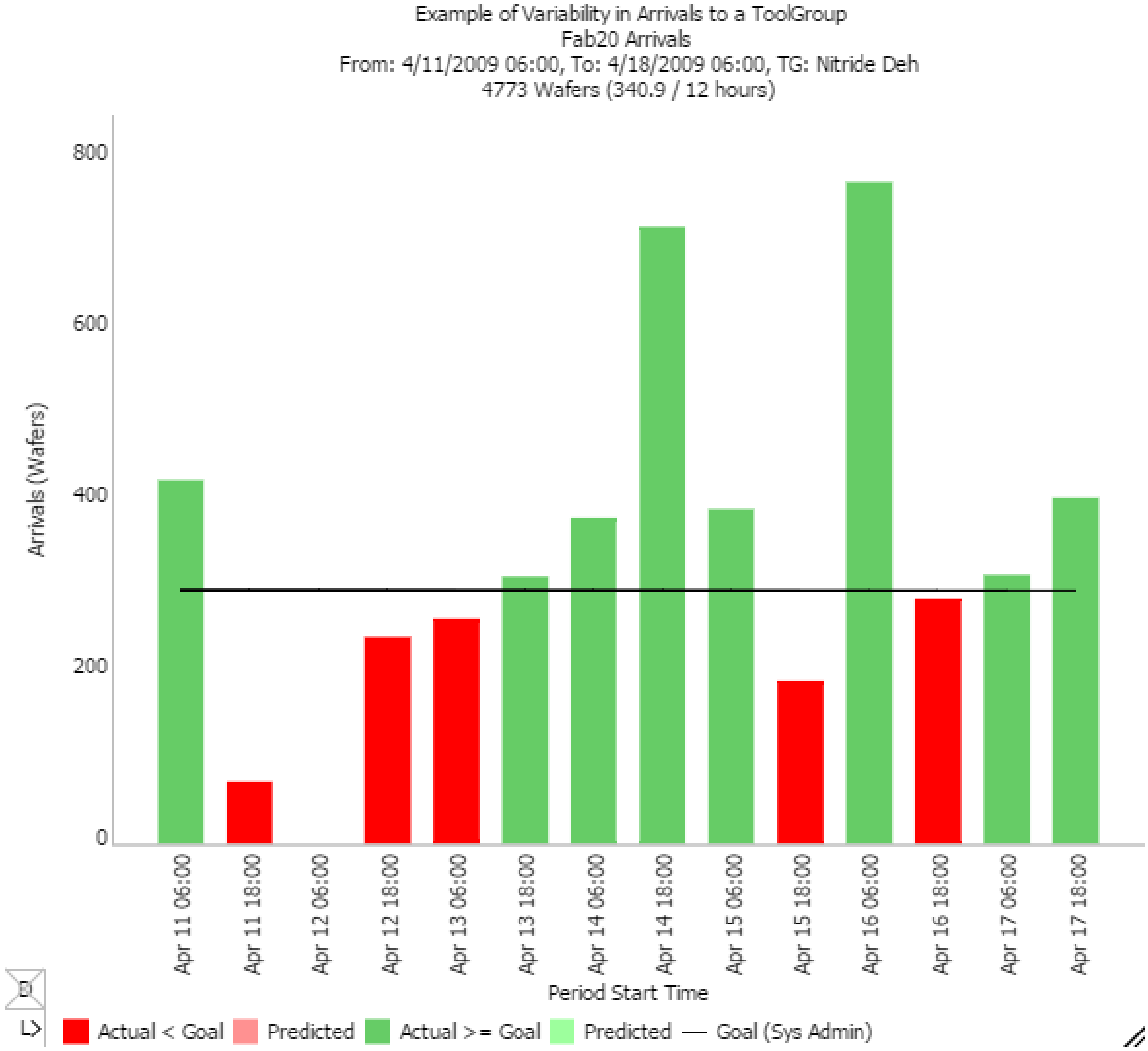
By arrival variability, we simply mean that the number of arrivals to a workstation / toolgroup is not consistent over time, particularly over short time periods. We can estimate arrival variability visually by looking at a graph of arrivals (usually in wafers) per hour or per shift. If there is a wide range in values, we say that the arrivals are variable. Arrival variability is a known contributor to cycle time (see Issue 6.05: The Fundamental Drivers of Fab Cycle Time, for an overview).

A sample chart showing arrival variability to a toolgroup is shown at the top of the next page. Cycle times become high in this toolgroup following the mid-week burst of arrivals.

For a more technical assessment, we can measure the coefficient of variation of the times between arrivals (called interarrival times). Coefficient of variation (or CV) for any set of numbers is measured as the standard deviation of the set of values divided by the average. Standard deviation is a statistical measure of how far individual values are from the average. If the arrival pattern to a toolgroup is quite regular, then the standard deviation, and hence the coefficient of variation, will be low. But if the tool is frequently starved for long periods of time, followed by large bursts of arrivals, the standard deviation will be high. Dividing by the average value normalizes the coefficient of variation, and makes it easier to compare this dimensionless metric CV across toolgroups.

Calculating the CV of times between arrivals for a toolgroup is straightforward, but does require you to store the sequence of the interarrival times. You do this by starting the clock every time a lot arrives, and then stopping and recording a value when the next lot arrives. If several lots arrive in a batch, the time between those arrivals will be recorded as zero (or nearly zero). Once you have the sequence of interarrival times, you can use Excel or some other computational tool to calculate the standard deviation and coefficient of variation. Comparing arrival CVs across toolgroups can give you an idea of where arrival variability is most significant in your fab.

However, in practice, the question about sources of arrival variability often comes from someone who is managing a



particular toolset, and already knows that arrival variability is a problem. Then the next question becomes: what are the upstream sources contributing to this undesirable arrival variability?

Upstream Sources Causing Downstream Arrival Variability

There is no shortage of sources of variability in a fab. But if you are looking to understand what might be contributing to variability in arrivals to your tool, here are some places to look:

1. **Downtime or engineering time at nearby upstream tools.** This unavailable time (whether scheduled or unscheduled) can cause WIP to build up, starving the downstream tool. When the downtime or engineering time is over, particularly if the tool in question is a high capacity tool, the WIP bubble may be worked off quickly, over-feeding the downstream tool. This behavior is most noticeable where there are upstream tools that are one-of-a-kind tools (or run single path operations).

2. **Staffing variability at upstream tools**. Variability in staffing certain tools can lead to similar behavior to that described above due to downtime. We have seen cases where a high capacity tool is only staffed during part of a shift, for example. This leads to a starve-and-burst arrival pattern downstream. This behavior can be exacerbated by layout issues, if operators are responsible for tools that are physically spread out in the fab.

3. Dispatching issues by which large streams of WIP with a particular recipe get processed in a row. This can lead to bursts in arrivals downstream (first we run WIP that feeds one downstream tool, next we run WIP for a while that feeds a different downstream tool, etc.). Often caused by setup avoidance policies, this is the kind of behavior that can be moderated by using a line balance-focused dispatch rule, or a short-interval scheduler.

4. Transfer batching. One of the most significant contributors to arrival variability in some fabs is grouping lots together for transfer. If your fab uses carts to transfer lots between tools, a desire to maximize operator efficiency can lead to filling each cart before it is moved downstream. This means that the downstream tool will wait, and then receive a group of lots arriving all at once. This is exactly the pattern that results in high coefficient of variation of arrival times.

5. Upstream batch tools. Similarly (though usually in a more localized way), upstream batch tools can lead to downstream arrival variability. This is especially true if you have relatively low utilization tools running with a full-batch loading policy. In this scenario, lots wait and wait to form a batch, and then are sent downstream all at once, when the batch is completed. The arrival pattern downstream shows a large gap in arrivals, followed by a burst of them. The longer the batch process times are the more pronounced this effect will tend to be.

6. Batch lot releases into the fab. New lots are often released into the fab according to a schedule, a few lots at a time, with a gap between releases. This results in arrival variability to the early steps in the process flow, though this variability generally bleeds off fairly quickly, as lots get further along the process flow.

A mitigating factor in the above issues is that most fabs are complex reentrant environments. This means that a toolgroup can be both upstream and downstream of itself, as lots revisit for subsequent layers. It also means that tools are often being fed by multiple upstream tools. Even if one of those tools is down, or understaffed, it's likely that other tools will continue to send WIP downstream. These problems are also mitigated, in many cases, by the size of a fab. If you have a toolgroup that is being fed by ten batch tools, the odds of a long period of starvation are greatly decreased vs. a toolgroup that is fed by one or two batch tools.

Diagnostic Techniques

Knowing that the above factors may be contributing to arrival variability is all well and good; but what's needed, in practice, is to know exactly which issues are causing arrival variability at your tool of interest. Here are a couple of techniques to help.

1. Identify the Pattern of the Arrival Variability.

There are two basic types of arrival variability: systematic and intermittent. Systematic sources of arrival variability include dispatching policies, transfer batching, batch processing (sometimes), and lot release. Intermittent sources of arrival variability include unscheduled downtime and staffing variability.

Understanding whether the arrival variability to your tool is systematic or intermittent is fairly easy to do visually. Simply look at the trend of arrivals (in wafers) over an extended time period (weeks or months).

If you see a generally consistent pattern, interrupted at random intervals by more jagged behavior, then you are likely looking at some intermittent problem tied to upstream tool or operator availability. If, however, the arrivals are always bouncing up and down from hour to hour or shift to shift, then your time would be better spent in looking for a larger-scale systematic issue, like dispatching.

2. Investigate the Pattern of Moves at the Tools that Immediately Feed Yours

What you want to do here is look at the trend in moves exiting key tools that feed your tool. If you see an irregular up and down pattern at a particular tool (lots of moves, followed by periods of inactivity), then you want to look more closely into downtime or staffing (or arrival variability!) issues at that tool. A more regular up and down pattern would be characteristic of a batch tool (though, of course, you likely already know if your tool is being fed by batch tools).

On the other hand, if the tools that feed yours seem to have fairly consistent total moves from shift to shift, the next step is to look at moves by recipe. If you observe big swings here, this suggests more of a dispatching issue.

If, in looking at the moves by upstream tool, you don't see anything obvious, this may suggest that transfer batching is your problem. The variability is getting added between steps (see Issue 9.02).

Once you have identified the likely sources of the arrival variability to your tool, the next (and usually more complicated) step is to see what can be done to mitigate this variability. FabTime has discussed a number of techniques in prior newsletters, and will certainly be discussing others in the future, but this is beyond the scope of the current article. What can be done in practice can also depend heavily on the corporate culture at your company.

One final, general recommendation is to annotate your data as you collect it. Keep track of any special conditions in the fab, unexpected results, and so forth. These unexpected results may lead to performance improvement opportunities. And a well-documented dataset will be useful ammunition for driving change.

Conclusions

In this article, we have addressed a fairly specific question that we believe arises regularly in fabs: how do I identify the sources of variability in arrivals to my toolgroup? We have briefly discussed measuring arrival variability, but have focused primarily on defining the most common sources of arrival variability to tools, and providing tips for pinpointing them in practice. This type of analysis can be time-consuming, but the data that is required should not be too difficult to obtain (everything discussed here is standard in FabTime's software). It's also important not to forget human sources of information. There may well be someone who has been working in your fab for a long time who already knows the answer to this question. But -- you have to ask them.

We welcome your feedback!

Questions for FabTime Subscribers

Does your fab do any systematic analysis regarding arrival variability? Do you feel like you have a good handle on what the sources are, such that you've moved on to finding solutions? Or is it simply too difficult to separate out the threads causing variability in one place, given variability in process flows and the reentrant nature of the fab?

Further Reading

J. Robinson and F. Chance. "Arrival Variability and Cycle Time," *FabTime Newsletter*, Vol. 4, No. 5, 2003.

J. Robinson and F. Chance. "The Fundamental Drives of Fab Cycle Time," *FabTime Newsletter*, Vol. 6, No. 5, 2005.

J. Robinson and F. Chance. "Ways that Fabs Create Arrival Variability (and Cycle Time)," *FabTime Newsletter*, Vol. 7, No. 8, 2006.

J. Robinson and F. Chance. "Manual Lot Transfer in Wafer Fabs," *FabTime Newsletter*, Vol. 9, No. 2, 2008.

Subscriber List

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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.

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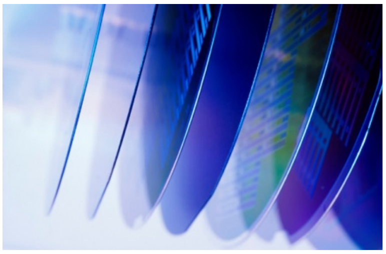
FabTime® Dispatching Module



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?

Contact FabTime for details.

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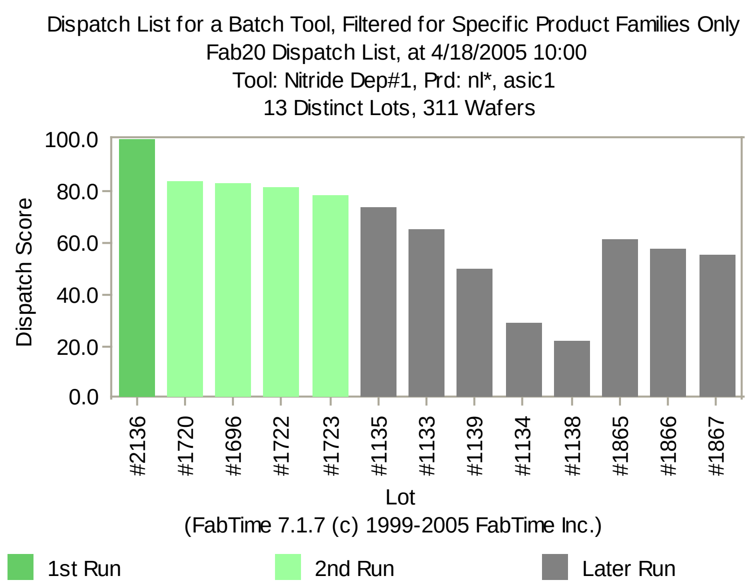
Web: www.FabTime.com

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.