FabTime Newsletter

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Information

Publisher: FabTime Inc. provides reporting and dispatching software and cycle time improvement training for wafer fabs. FabTime's software gives end users access to MES data in an easily manipulated graphical format, and includes more than 165 pre-defined, fab-specific charts. Contact us for a demo.

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Table of Contents

- Welcome
- Community News/Announcements
- FabTime Software Tip of the Month – Do What-If Analysis on Projected Lot Completion Dates by Varying X-Factor
- Subscriber Discussion Forum – Reducing the Number of Hot Lots; Time Constraints and Hidden Bottlenecks; Dispatch Rules for Wafer Fabs; Tool Control Plans
- **Main Topic – Forward-Looking Cycle Time Metrics**
- Current Subscribers

Welcome

Welcome to Volume 24, Number 3 of the FabTime Cycle Time Management Newsletter. It's been an exciting time for FabTime of late. In this issue we have announcements about two new FabTime employees, a new video and page for requesting software demos, and our first-ever booth at SEMICON West. We also have a plethora of subscriber discussion, ranging from responses to last month's cycle time tip about reducing the number of hot lots to selecting fab dispatch rules and making plans for particle checks on multi-chamber tools.

In our software tip of the month, we show how to vary the x-factor on a projected lot completion chart to do what-if analysis on the lot's future cycle time. This tip ties in to our main article, which is about forward-looking cycle time metrics for wafer fabs, something a number of our customers and subscribers have been interested in recently. We discuss the use of planned cycle times to forecast completion dates for individual lots, and then review three different metrics that each predict future average cycle times based on current fab performance: dynamic x-factor, summed operation cycle time, and turns-predicted cycle time (a new metric based on WIP turns). As always, we welcome your feedback.

Thanks for reading! – Jennifer, Frank, Lara, and the FabTime Team

Community News/Announcements

New Demo Request Page and Software Introduction Video

Interested in a super-quick 2-minute video tour of FabTime's reporting software for wafer fabs? Check out our new video and request an online demo. FabTime's software gives you access to your MES data in a graphical format that is easy to manipulate. No matter what MES you use, you can get setup quickly to use FabTime's 165+ fab productivity improvement charts.

Two New FabTime Employees

Laurel Yocum is our new Marketing Intern. Laurel brings a fresh perspective, a passion for creativity, and a dedication to excellence. Her energy and enthusiasm are truly contagious, and we couldn't be more excited to have her on board. As a forward-thinking company, we believe in nurturing young talent, and Laurel embodies the spirit of innovation and drive that we value. We are confident that she will make a positive impact and provide valuable insights as we continue to expand our reach and engage with our audience effectively. You can follow Laurel on LinkedIn here.

Morgan Endresen is our new Business Development Representative. Morgan will play a vital role in formulating effective sales strategies and expanding our customer base. At FabTime, we believe in fostering a collaborative and supportive work environment, and Morgan's enthusiasm and teamwork-oriented mindset align perfectly with our values. We are excited to witness Morgan's contributions and growth within our organization. Together, we will continue to strive for excellence and deliver outstanding results for our customers. You can connect with Morgan on LinkedIn.

SEMICON West

FabTime is pleased to announce our first ever booth at SEMICON West, July 11-13 in San Francisco. FabTime will be in the North Hall, Booth 6384, near the Beer & Wine Garden. Please stop by to say hello to Elaine Jacobson, Erica Flint, and Laurel Yocum, who will be representing FabTime. You can learn about FabTime's software and/or practice your putting and potentially win a FabTime golf ball or other swag. For more details, or if you are an existing customer who would like to meet, please call or text Elaine at 805-235-7887.

Jennifer plans to be at SEMICON on Thursday the 13th attending the Fab Owners Alliance meeting and would be happy to meet up, too. Email her or reach out on LinkedIn to schedule something.

A Few Highlights from Jennifer's LinkedIn

Jennifer continues to share articles about business management, the semiconductor industry, and productivity improvement on her LinkedIn feed. Recent links have included:

- A WSJ article about the structural changes that Intel is making as they shift towards a foundry model that validates FabTime's longtime advice to reduce the number of hot lots in the fab. "Intel said Wednesday that its fabs process such 'expedites' about 2 to 3 times more often than peers, which has caused an 8% to 10% hit to its overall output. If Intel's internal customers have to pay up for those expedited orders, they might think twice." [LinkedIn Post.]
- An article in Jennifer's local San Jose paper about how Applied Materials intends to boost domestic chip making by "leveraging the expertise here in the Bay Area to accelerate the manufacturing process in the U.S. and globally with our partners," according to Sean Randolph, senior director of the Bay Area Council Economic Institute. The new AMAT EPIC facility sounds, well, epic. [LinkedIn Post.]
- An encouraging assessment of onsemi's prospects in this WSJ piece by Dan Gallagher. "OnSemi Chief Financial Officer Thad Trent says the company has about $1,700 of chip content in an EV,

compared with $50 in a combustion car. Ross Seymore of Deutsche Bank wrote in a report Wednesday that OnSemi's new focus should prove 'structurally sustainable' and result in superior earnings and free cash flow." [LinkedIn Post.]

- A thought-provoking piece from FabTime friend **Thomas Beeg** of Fabmatics about the potential risks of the labor shortage in the US semiconductor industry, with some proposed solutions for making work in our industry more appealing to younger people. [LinkedIn Post.]
- An announcement from ATREG, Inc. about the planned expansion of the TSI Semiconductors wafer fab in Roseville, CA, after sale to Bosch. "The German technology company plans to acquire the Californian manufacturing assets of the U.S. chipmaker and invest 1.5 billion USD over the next few years in strategically important semiconductor business for electromobility, subject to regulatory approval. TSI Semiconductors Roseville fab. The Roseville manufacturing location which offers roughly 10,000 square meters of cleanroom space will reinforce Bosch's international semiconductor manufacturing network." [LinkedIn Post.]
- An article from the WSJ about a new chip shortage, this one in AI processors. We liked this quote: "Because there is a shortage, it's about who you know," said Sharon Zhou, co-founder and CEO of Lamini, a startup that helps companies build AI models like chatbots. "It's like toilet paper during the pandemic." [LinkedIn Post.] See also this piece from Time: Investors See AI Chips as New Gold: Here's Why.

For more industry news, connect with Jennifer on LinkedIn.

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

FabTime® Software Tip of the Month

Do What-If Analysis on Projected Lot Completion Dates by Varying X-Factor

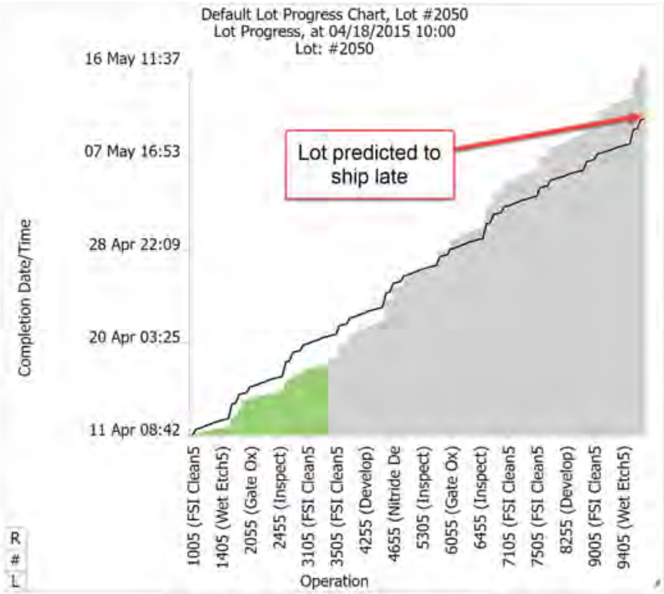
As regular FabTime software users know, the Lot History chart contains a detailed record of all transactions recorded for a given lot as it goes through the fab. A quick-jump away from the Lot History chart, the Lot Progress chart projects the lot forward to generate a predicted shipment date.

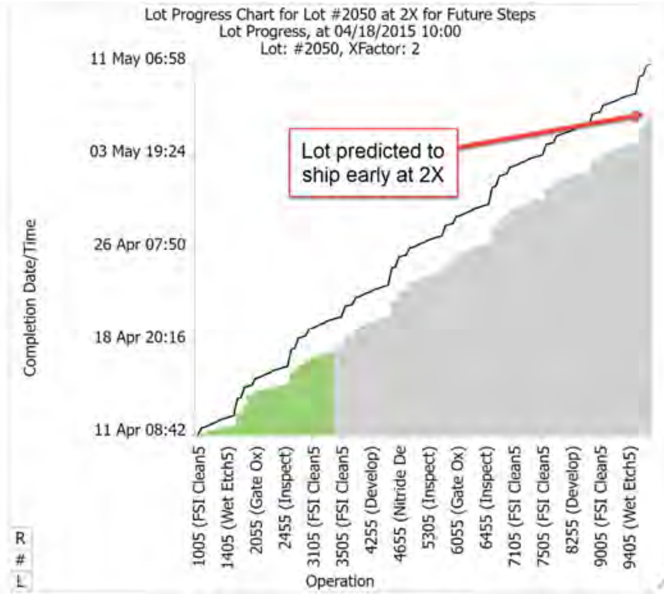
The Lot Progress chart shows red or green bars for each operation that has been completed so far (with the color indicating whether the lot was ahead of or behind schedule at that point). Gray bars show the cumulative planned cycle time for each future step, with the final bar indicating the lot's expected shipment date. The right-most end point of the black line on the chart shows the lot's due date (if available), with the other points on the line scaled proportionately. The planned cycle times used in these gray bars are either imported from your MES or calculated based on a multiple of planned process time (which also usually comes from your MES). That multiple of planned process time is called x-factor.

You can do what-if analysis on the future performance of the lot by modifying the x-factor filter. This scales the gray bars according to a different multiple of planned process time. To do this:

1. Enter a lot # of interest into the search bar and select "Lot # (History)" from the resulting list.
2. Go to "Jump to" in the left-hand corner of the screen and select "Lot Progress."
3. Enter your expected x-factor in the "XFactor:" input box in the left-hand pane and hit "Enter". The gray bars will scale according to your x-factor value. The black line indicating due date will not change.
4. You can experiment with different x-factor values to see what x-factor would be needed to meet the lot's due date. You can also assess the impact of changes to the x-factor on expected shipment dates, as discussed in the main article of the newsletter below. In the example below, the lot is predicted to

be late based on the default planned cycle times. If we can make the lot hot and achieve an x-factor of 2 for the future steps, the lot will be early (the end point of the black due date line does not change).





Not all sites have planned cycle time information. If you don't see any future bars on your Lot Progress charts, contact your internal FabTime administrator. FabTime may be able to work with you to apply a standard x-factor to planned process times, or to estimate future operation cycle times from historical data.

We hope you find this tip useful.

FabTime software customers can subscribe to the separate Tip of the Month email list (with additional discussion for customers only) here: http://www.fabtime.com/tip-of-the-month.php. Thanks!

Subscriber Discussion Forum

Responses to Tip 005: Reduce the Number of Hot Lots

Longtime subscriber **Vincent Corbett** wrote: "Even though the temptation to increase the number of hot lots is always there … your advice is good because average cycle times will increase exponentially."

Regular contributor **John Paul Gauci from Marketech International Corporation** wrote: "Another great article. Hot lots in the automated 300mm fab typically were the result of yield improvement projects that need to get through the line. This is where understanding your X factor and how you plan buffer capacity, along with your business model is critical."

A **follower on LinkedIn** wrote: "Thank you for the tip. It is very helpful. With the increasing of hot lot %, there is CT increase for hot lot population and regular lot population. But why does the average not change?"

FabTime Response: This is only true for "front of the line" hot lots that you prioritize ahead of regular lots (not for hand carry lots). In this case, all you are doing is moving the hot lots to the front of the queue, ahead of the other lots. As long as this doesn't cause extra setups or changes to batch sizes, all this does is transfer queue time from the hot lots to the regular lots. The average doesn't change. That's the theory, and what the queueing model that we use predicts. In practice, there may well be extra setups or other inefficiencies that do increase average cycle time."

Time Constraints Leading to Hidden Bottlenecks

The main article in the last newsletter was about time constraints between process steps. In a recent cycle time management class that Jennifer held, a fab manager pointed out that because of time constraints his company has "hidden bottlenecks" where WIP is held ahead of the clean step and doesn't show up at the tool that it's really waiting for. This makes it hard to identify cycle time bottlenecks properly. The WIP Hours charts in FabTime's software (which show the estimated hours of required processing time for WIP in queue at a tool) support site-specific logic to reposition the held-elsewhere WIP to the tool(s) to which it belongs. This correction, if implemented, results in a better view of bottlenecks based on WIP hours. Does anyone have other solutions for this?

Dispatch Rules for Wafer Fabs

A **long-time subscriber** wrote: "We would like to know more based on your expertise in this wafer fab field.

Let's say we have four choices for dispatch rules to run lots:

1) FIFO – First in, first out
2) SPT – Shortest processing time
3) EDD – Earliest due date
4) CR – Critical ratio

Please offer your advice among these criteria. Which one is the best method to follow?

FabTime Response: Dispatching for wafer fabs is a complex subject – the source of many theses and dissertations. But we can say a few things at a high level based on our experience. Most dispatch rules have strengths and weaknesses. Which is the best rule for a given fab depends upon that fab's situation. FIFO introduces the least variability and can be a good choice for a fab that doesn't have wide variability in due dates across product lines. SPT is appealing to operators, because they can increase their daily moves by running the quickest lots first, but it doesn't take due dates into account, and can result in poor on-time delivery performance (especially for lots with more complex processing). EDD is better for delivery performance on average but can result in pulling too many lots from the end of the line, at the expense of more recently started lots. What we have seen in practice is that most fabs that have variation in due dates by product use a version of CR.

In FabTime newsletter 15.01, we presented the results of a series of simulation experiments. The goal was to evaluate the impact of several commonly used dispatch rules on linearity of shipments. The results showed that, of the rules tested, some had problems with WIP bubbles. This was initially less apparent under CR dispatching than the other rules. However, in the presence of late lots, WIP bubbles were also observed under CR. We concluded that these results called for further investigation of line balance-focused dispatching.

One other note is that for most fabs, the core dispatch rule is applied in conjunction with other factors. High priority lots are selected first (e.g., first use priority, then use FIFO or CR within each priority class). Batch tools, tools with setups, and tools with time constraints between process steps can all call for modifications of the fab's core dispatch rule.

We also wrote about dispatching in Issues 6.04, 6.07, 8.07, 11.05, and 20.6. All past FabTime newsletters are available for subscriber download from our Newsletter Archive. The current password is FabTimeCommunity. We welcome feedback from other subscribers on wafer fab dispatching and will share any responses in the next issue.

Tool Control Plans

An **anonymous subscriber** wrote: "We have done a lot of work over the last couple of years reducing the number of monitors and checks we run on our equipment. We are in the process now of ramping our fab and are installing many new tools with more chambers than we are used to. For example, our prior control plan of including two wafers for particle checks (one per chamber) is now not sufficient for a six-chamber tool. However, introducing a six-wafer particle check is not ideal!

Throughput through these tools is significant so we want to be sure we have sufficient controls in place. We have had some discussions around the best way to do this but just wondered if you have any ideas on what other Fabs are doing, are people relying more on FDC & APC to ensure control?"

FabTime Response: This is a bit outside of our area of expertise, so we are extending the question to our subscribers. If anyone has anything to share, please let us know, and we will pass it along.

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

Main Article: Forward-Looking Cycle Time Metrics

Introduction

It's simple enough to measure the cycle time for lots after they ship, both on an individual and an aggregated basis. But what we would also like to know is, based on current performance, what will the cycle time be for lots that are still in the fab? At the individual lot level, this information can be helpful in predicting which lots will be on time (and which will not). At a higher level, understanding the fab's expected cycle time for lots currently in process can be useful for setting delivery dates for new orders. This information can also give us an early warning of cycle time problems during an upturn (and there will always be one coming eventually), so that we can make operational changes before cycle time and WIP levels become unacceptably high.

In this article, we review several forward-looking cycle time metrics, each of which has been discussed in more detail in past newsletters. We also propose a new metric for predicting the future cycle time of lots in the fab, based on an extension to WIP Turns.

Forecasting Individual Lot Completion Dates

There are two general ways of predicting an individual lot's future cycle time in a fab. One method involves using discrete event simulation. A simulation model can incorporate tool downtimes, operator constraints, current WIP levels, etc. Simulation models require very detailed data to be accurate, however, particularly regarding tool downtimes. Maintaining such detailed models has proven impractical for most fabs.

The second, much simpler, method involves using static projections based on planned cycle time data for each step. In Issue 10.06, we discussed the static projection method, which is straightforward to implement. Static lot shipment projection is a matter of storing a planned cycle time number for each route-step combination for all routes in the fab. At any point, we can add up those planned cycle times for all future steps for a given lot, add that total time to the current time, and get an estimate of when we think that this lot will complete. We can aggregate this data across lots and use it to predict the number of lots that will ship on a given day, or that will arrive at a key tool or operation within a given timeframe. This is what we do in FabTime's software. [See the Software Tip of the Month above for an illustration.]

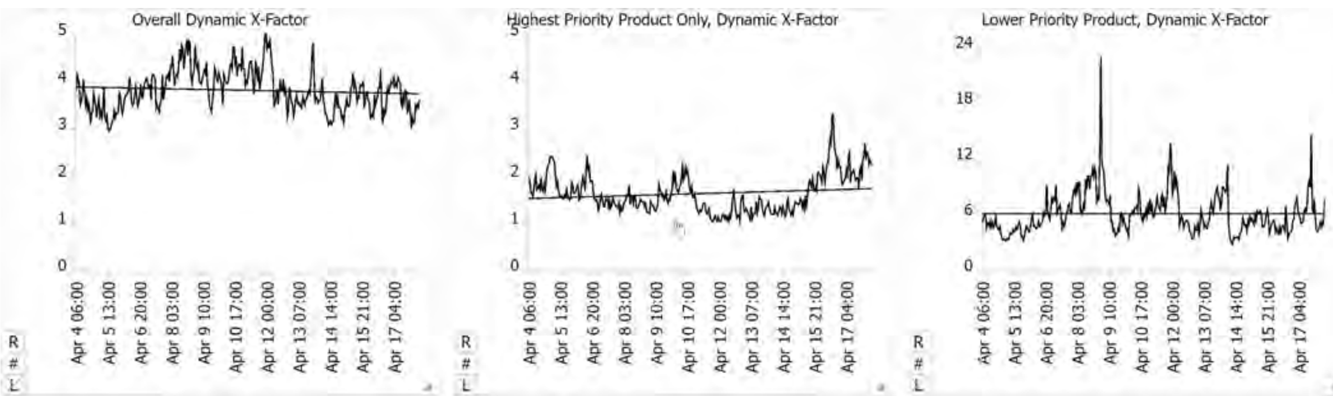
There are some implementation issues to consider with this method. Chief among these is that we need to have access to the planned cycle time data for each step. What we often see people do here is use a planned process time per step and multiply that by a target x-factor that may vary for each route. That x-factor may also be adjusted on the fly to reflect changes in lot priority. Sometimes historical data is also used here.

The primary issue with this method of forecasting individual lot shipment dates using planned cycle times, however, is that it doesn't typically take current fab performance into account. The method is only as good as the quality of the planned step cycle times, and what's realistic there can change depending upon fab conditions.

Fortunately, there are several forward-looking metrics that we can use to predict aggregate future cycle time performance based on current fab conditions. Once we have a better estimate of the overall cycle time performance for lots in the fab, we can convert that that to an expected x-factor and use it to refine the forecasts for the individual lot completion dates. Let's discuss those forward-looking aggregate metrics in turn.

Dynamic X-Factor

A forward-looking metric that has been discussed extensively in this newsletter (most recently in Issue 15.05) is Dynamic X-Factor. Dynamic x-factor is a point-in-time metric that is recorded frequently (e.g., every hour) as Total WIP / (Non-rework, non-hold WIP running on tools). It can be shown (see Issue 9.04) that in the long run, the average of a series of dynamic x-factor observations will be equivalent to the shipped lot x-factor, meaning that it can be used to predict future cycle times based on current performance. Dynamic x-factor is intuitive and easy to calculate and also gives us a window into short-term periodic. It's also easy to filter dynamic x-factor by product, route, or priority, to estimate the future x-factor for different types of lots, as shown in the figure below. The chart on the left shows the overall dynamic x-factor for the fab. The one in the middle shows a low-volume, higher priority product, while the one on the right shows a lower priority product (with a consequently higher x-factor).



We know of several fabs that use dynamic x-factor in a control chart-like fashion, by which they take note if it drifts upward, outside of normal fluctuations. These fabs also use dynamic x-factor to highlight short-term, periodic effects in the fab, such as shift change.

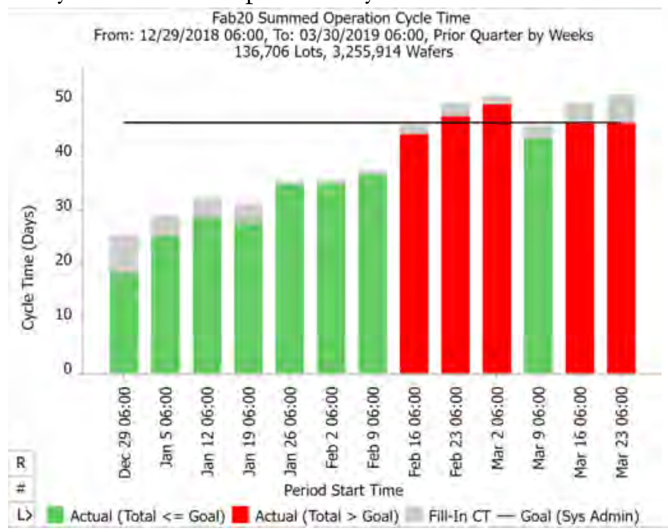
On a short-term basis, we can't necessarily look at the graph of our fab-wide dynamic x-factor and expect it to exactly track with future shipped lot cycle time values on a particular date. The two primary reasons for this are:

1. Product mix changes combined with the time lag between dynamic x-factor and x-factor make short-term comparisons difficult; and
2. Systematic issues in how we measure and report theoretical cycle time, and how we log transactions in the MES, can lead to differences in the reported values for the two metrics. For example, do we have good data on whether lots are in process or not? Are there lots on extended hold that are inflating dynamic x-factor relative to shipped lot cycle times?

Details about these issues, and recommendations for bringing dynamic x-factor and shipped lot x-factor closer together, are included in Issue 9.04. It's also necessary to decide what time frame to use to take an average dynamic x-factor value as a forward cycle time estimate. We recommend using at least a week of data, possibly longer for low-volume products with more lot-to-lot variation.

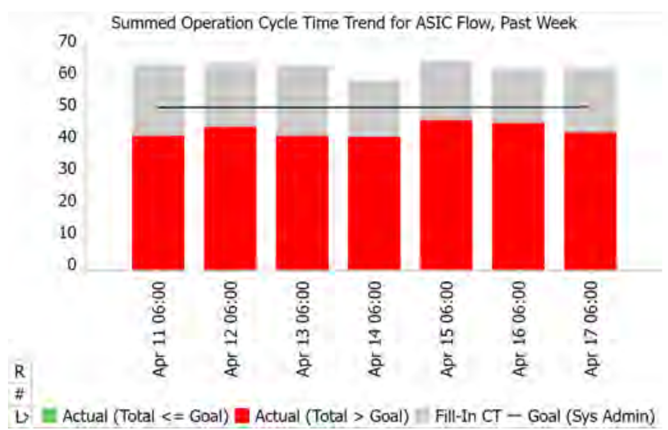
Summed Operation Cycle Time

Another forward-looking cycle time metric that we coded into FabTime at the request of a customer is Summed Operation Cycle Time. The summed operation cycle time chart predicts cycle time based on current operation-level cycle times and, for operations that have not been recently completed, planned cycle times. Operation-level cycle times are estimated and then summed to provide an overall cycle time estimate, which we can pareto by area, operation, tool-group, segment, etc. This is a slightly higher-level, and more forward-looking approach than simply looking at actual operation-level cycle times. It says, based on our current performance and our planned performance, here's what we can expect our future cycle time to be, if the current situation continues. In the example to the right, we can see a worrying increase in the weekly Summed Operation Cycle Time over the course of the quarter.



Complexities to using this metric include the following:

- If we drill down to look at summed operation cycle time by operation, we cannot simply add up the resulting total summed operation cycle times to get the overall average summed operation cycle times, unless each operation is represented by the same number of wafer moves on each flow. This metric is intended to summarize at the flow level first, and then perform a weighted average across flows. If operations are not represented evenly on all flows, then there is no reason for the operation-level summed operation cycle times to add up to the total summed operation cycle time across all flows. This can make analyzing the results confusing.
- As with the individual lot projection method discussed above, we need planned cycle times by step to fill in for operations that haven't been recently completed. Depending on a fab's situation, there can be so much fill-in data that the charts are not useful. Seeing considerable fill in cycle time data, as in the example to the right, can make this chart non-intuitive or implausible to users.



WIP Turns

In issue 16.02 we discussed using WIP turns to get a forward estimate of cycle time. Turns = Moves / Average WIP. By default, FabTime scales raw turns to turns per day, with scaled turns = (raw turns) * 24 / (chart length in hours). WIP turns tell us, on average, how many times per day the fab is moving each wafer. If we also know the average number of steps that each wafer goes through, then we can predict the average cycle time for our current WIP by taking (Average Steps in a Flow) / Turns, where Turns = Steps per Wafer per Day.

For example, if we move each wafer 8 times per day on average, and each wafer requires 400 steps to complete processing, on average, then our cycle time will be 400 steps / 8 steps/day = 50 days. Of course, the number of steps used for this calculation must be consistent with the level at which we are tracking moves. If this is the case, and if we maintain a consistent turns rate, then we can expect average cycle times in the future to be about 50 days.

We noted in our previous article that "The tricky part of using WIP turns to predict overall average fab cycle time lies in knowing the right number of steps to use in the calculation. What you need for the overall average is a weighted average number of steps, where the weighting is by relative proportion of WIP. Because product mix in a fab can change rapidly, the weighted average number of steps may change, too, particularly if you have process flows that vary in complexity." We recommended at the time "not to get hung up on keeping track of this on a daily basis as your mix changes, but to perhaps keep a spreadsheet in which you track the number of steps per major flow."

However, in thinking about that more recently, we would like to suggest another solution.

Turns-Predicted Cycle Time

Our new proposal is that instead of trying to maintain a weighted average of number of steps per flow in the constantly changing environment of the fab, we instead include the number of steps per flow as an attribute of each lot. With this data, for any turns chart we could also sum up the number of steps in the flow across all WIP included on the chart, and then divide by the number of lots. In this way, we would generate a relevant forward estimate of cycle time for whatever WIP was selected, based on how that WIP was moved over the chart's time period. We are, for now at least, calling this metric Turns-Predicted Cycle Time.

There remains some complexity in getting the number of steps on a flow, given differences in what different fabs consider steps. It should be possible to estimate the number of steps on a flow by looking at the historical number of moves for shipped lots. Because turns are calculated as moves / WIP, if we use the number of moves for shipped lots, this will give us an apples-to-apples number for estimating total cycle time from turns. Of course, this will be more difficult for brand new flows with no shipped lots. However, we believe that fabs will probably have some way to estimate the number of steps per flow that could be included as an attribute for new lots.

For example, suppose that we have three 25-wafer lots. One follows a 300-step flow, one a 400-step flow, and one a 500-step flow. We can compute an average number of steps per wafer as 400. Now suppose on a given day we have 750 wafer moves. The turns rate is moves / WIP = 750 / (3*25) = 750/75 = 10 moves/day. The turns-predicted cycle time estimate would be 400 steps / 10 moves/day = 40 days. (Provided, again, that steps are equivalent to the recorded moves.)

Being based on the turns rate, this metric should tick upward quite quickly if the fab starts to either build WIP or slow down in terms of total moves.

Refining Individual Lot Forecasts Using Updated X-Factor Predictions

We can use dynamic x-factor, summed operation cycle time, or turns-predicted cycle time to predict average future cycle times for the fab as a whole, and (probably with more accuracy) for individual products. If we want to use any of these projections to make decisions or commitments based on the information, we should of course first validate the predictions against actual performance. This will help to identify systemic issues that may be biasing a given metric high or low. (Again, see Issue 9.04 for details about this in reference to dynamic x-factor.) Once a given metric is validated, it can be used at a high level to influence future commit dates and to anticipate problems in the fab (e.g., we need more capacity or staff to avoid unacceptable cycle times).

If we want to use this data to refine forecast completion dates for individual lots, then we'll need to follow a process like this. For dynamic x-factor:

1. Estimate average dynamic x-factor for a route and priority class of interest based on, for example, this week's performance.
2. Use that projected x-factor as a multiplier of future step process time estimates to predict individual lot completion dates. This may be more accurate than simply using the planned cycle times by step, as outlined above.

For summed operation cycle time or turns-predicted cycle time, we need one extra step:

1. Estimate overall cycle time for a route and priority class of interest based, for example, this week's performance.
2. Convert that overall cycle time into a predicted x-factor by dividing by theoretical cycle time.
3. Use that predicted x-factor as in Step 2 above.

Conclusions

Forward-looking cycle time metrics are useful for predicting which lots are likely to be late (and adjusting accordingly if possible), for setting commitment dates for future starts, and in general for understanding when cycle time is likely to increase, so that corrective action can be taken. In this article we have discussed a general method for forecasting shipment dates for individual lots, and then reviewed several metrics for predicting future cycle time x-factors and shipped lot cycle times. We have also introduced a new metric for forward-looking cycle time based on the WIP turns rate and the total number of steps per lot. We expect to implement this metric in a future version of our reporting software, and hope that all of you will find it useful.

Closing Questions for Newsletter Subscribers

Do you have a better name for our new metric than Turns-Predicted Cycle Time? What do you think of this metric? What do you use in your fab to measure dynamic, or forward-looking, cycle time? Have you validated your results against actual shipped lot cycle times? If you use WIP Turns to predict cycle time, how do you measure the number of steps in each flow?

Further Reading

- J. Robinson and F. Chance, "Identifying Real-Time Cycle Time Problems," *FabTime Newsletter*, Vol. 4, No. 7, 2003.
- J. Robinson and F. Chance, "Dynamic X-Factor and Shipped Lot X-Factor," *FabTime Newsletter*, Vol. 9, No. 4, 2008.
- J. Robinson and F. Chance, "Forecasting Lot Completion Dates," *FabTime Newsletter*, Vol. 10, No. 6, 2009.
- J. Robinson and F. Chance, "Using Trend Lines to Enhance the Value of Dynamic X-Factor Charts," *FabTime Newsletter*, Vol. 15, No. 5, 2014.
- J. Robinson and F. Chance, "Using WIP Turns for Forward Cycle Time Estimation," *FabTime Newsletter*, Vol. 16, No. 2, 2003.

All past issues of FabTime's newsletter are available for download by subscribers from the FabTime Newsletter Archive. The current password is FabTimeCommunity.

Subscriber List

Total number of subscribers: 2804

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- Infineon (128)
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- GlobalFoundries (85)
- STMicroelectronics (72)
- Skyworks Solutions (67)
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- Wolfspeed (43)
- Carsem M Sdn Bhd (42)
- Qualcomm (37)
- Tower Semiconductor (36)
- Applied Materials (33)
- ASML (33)

Top 3 subscribing universities:

- Arizona State University (6)
- Ecole des Mines de Saint-Etienne (EMSE) (6)
- Ben Gurion University of the Negev (5)

New companies and universities this month:

- Rockley Photonics
- D-SimLab Technologies
- Graphenea
- Moov Technology
- JST Manufacturing

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® Software: If you would like more information about our web-based dashboard for improving fab cycle times, please visit our website. A sample home page and a sample page from FabTime's new Charts menu are shown below.